

# Effect of mobile applications on livestock disease management in Abuja, Nigeria

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**ABSTRACT:** This study investigates the adoption of mobile applications for livestock disease management among farmers in Abuja, focusing on socio-economic characteristics, the role of mobile apps in early disease detection, factors influencing adoption, and barriers to usage. Using a multi-stage sampling approach, a total of 300 farmers participated in the study, with data obtained through structured questionnaires administered to farmers. The findings revealed that 70% were male, with 60% aged between 30–49 years and an average age of 45.2 years. Most respondents (82%) had at least basic education, 62% were cooperative members, and 41% had access to credit. The mean farm size was 4.2 hectares, and the mean farming experience was 15.7 years. Farmers widely acknowledged the benefits of mobile applications in disease management. The roles identified were: providing real-time alerts about disease outbreaks (80%), assisting in early symptom identification (70%), offering guidance on preventive practices (62%), enhancing communication with veterinarians (58%), facilitating livestock health record-keeping (56%), and enabling quick reporting of disease incidents (50%). Logit regression analysis revealed significant predictors of mobile app adoption: educational level, cooperative membership, and access to credit ( $p \leq 0.01$ ); farming experience and farm size ( $p \leq 0.05$ ); and gender and age ( $p \leq 0.10$ ). Marital status and contact with extension agents were non-significant predictors ( $p > 0.10$ ). Kendall's Coefficient of Concordance ( $W = 0.74$ ) identified barriers to adoption, ranked as follows: high cost of mobile data (4.25), limited internet access (4.12), low digital literacy (3.80), and inconsistent network coverage (3.65), demonstrating high consensus. To address these challenges, targeted training programs to improve digital literacy among farmers are recommended.

**Keywords:** Abuja, disease management, socio-economic, mobile applications, livestock.

## INTRODUCTION

Livestock farming is a cornerstone of Nigeria's agricultural sector, underpinning both food security and rural economies. With an extensive array of livestock—over 20 million cattle, 40 million sheep, and 70 million goats—Nigeria stands as a significant player in Africa's livestock economy (Food and Agriculture Organization [FAO], 2021). Livestock contributes substantially to the livelihoods of rural communities, with millions of smallholder farmers relying on cattle, goats, sheep, and poultry as primary income sources and nutritional assets (Ajala and Gana,

2023; Sennuga *et al.*, 2024). Despite its economic importance, however, livestock farming in Nigeria is plagued by critical challenges in disease management. Diseases such as Foot-and-Mouth Disease, African swine fever, and Peste des petit ruminants are highly prevalent, spreading rapidly and posing severe risks to livestock health, productivity, and financial stability for farmers (Ayoade *et al.*, 2022).

Such diseases, many of which are highly contagious and difficult to control, significantly undermine livestock

productivity, reducing growth rates, milk yields, and, ultimately, income for farmers (Olaitan *et al.*, 2024b). However, despite the grave impact of these diseases, access to veterinary services remains limited, especially in rural and remote areas where infrastructure is sparse and veterinary professionals are few. Farmers face geographical barriers, high costs, and in many cases, a lack of awareness of disease symptoms and preventive practices (Oni *et al.*, 2021). Consequently, disease outbreaks can spread unchecked, leading to preventable livestock mortality, economic losses, and threats to food security. This complex landscape highlights a pressing need for innovative, accessible, and efficient solutions to bridge the gap in veterinary care, helping farmers better detect, report, and manage livestock diseases in a timely manner (Ajala and Gana, 2023).

The advent of mobile technology across Africa offers promising solutions to some of agriculture's most persistent challenges, including those related to livestock disease management. Over the past decade, mobile technology has spread rapidly, with mobile penetration rates in Africa exceeding 50%—making mobile phones a viable and accessible medium for disseminating agricultural and veterinary information even in rural areas (World Bank, 2020). Mobile applications and SMS-based platforms specifically designed for agriculture have demonstrated the potential to connect farmers with critical resources, allowing them to receive timely alerts, access veterinary advice, and even report disease outbreaks. Such platforms can empower farmers by equipping them with knowledge about disease symptoms, preventive practices, and immediate reporting tools, enabling rapid intervention that can minimize disease spread and loss of livestock (Mumba *et al.*, 2020).

Countries like Kenya and Uganda have been at the forefront of this trend, with mobile apps like iCow and VetAfrica making notable impacts by connecting farmers to veterinary support, disease prevention resources, and guidance for managing livestock health (Odhiambo and Wangari, 2020; Abubakar *et al.*, 2024). The success of these applications has demonstrated the practicality and scalability of mobile solutions in rural African contexts, reducing reliance on in-person services and helping to address the critical gap in veterinary access that characterizes much of the continent. However, the potential for mobile technology in livestock management in Nigeria, though promising, remains constrained by specific local challenges such as limited network infrastructure, digital literacy gaps, and financial barriers (Adedeji *et al.*, 2021). Without adequate mobile coverage and affordable data plans, particularly in Nigeria's rural north and central regions, adoption rates for agricultural apps remain low, limiting the reach of these solutions and their potential to transform disease management practices among Nigerian farmers. Addressing these challenges is essential to ensuring that mobile technologies can reach their full potential and enable real, lasting improvements in livestock disease management (Olaitan *et al.*, 2024a).

In Nigeria, where livestock farming is integral to both rural livelihoods and the national economy, mobile applications hold unique promise to bridge critical gaps in disease management, provided they are tailored to meet local needs and challenges (Lai-Solarin *et al.*, 2024a). The agricultural sector accounts for roughly 23% of Nigeria's GDP, yet access to digital resources remains starkly uneven between urban and rural populations (National Bureau of Statistics [NBS], 2022). While urban farmers and larger commercial operations may have greater access to veterinary services and digital tools, smallholder farmers in remote areas—who constitute the majority of Nigeria's livestock producers—often lack both (Lai-Solarin *et al.*, 2024b).

Recognizing the potential of mobile technology to transform livestock disease management, a growing number of stakeholders, including government agencies, NGOs, and private companies, have begun exploring mobile applications that can support farmers with disease surveillance, reporting, and veterinary information (Obadina and Shittu, 2023). Applications such as Livestock247 and the Nigeria Centre for Disease Control's (NCDC) digital surveillance platform have already made strides in improving disease detection and data collection on livestock health. Livestock247, for instance, provides not only disease monitoring tools but also connects farmers with veterinary services and buyers, offering an integrated platform that addresses the multiple needs of livestock farmers (Ayoade *et al.*, 2022).

Additionally, some platforms offer options like SMS-based updates, designed specifically for farmers without access to smartphones or stable internet connections, which broadens accessibility and ensures that critical disease information can reach even the most remote farming communities. This study aims to evaluate the impact of mobile applications on livestock disease management in Nigeria. To accomplish this, the following objectives are put forward to:

1. investigate the socio-economic characteristics of livestock farmers using mobile apps in the study area.
2. examine the role of mobile applications in early disease detection and management in the study area.
3. analyze factors influencing the adoption of mobile apps for livestock disease management in the study area.
4. identify barriers to mobile app adoption for disease management among livestock farmers in the study area.

## Theoretical framework

### **Technology Acceptance Model (TAM)**

The Technology Acceptance Model (TAM), developed by Davis in 1989, provides a framework for understanding the factors influencing users' adoption of new technologies. At its core, TAM posits that two primary beliefs—*perceived*

*usefulness* and *perceived ease of use*—directly impact a user's attitude toward technology, which subsequently influences their behavioural intention to use it, leading to actual adoption. In this study, TAM is particularly valuable for assessing how Nigerian livestock farmers decide whether or not to use mobile applications designed for livestock disease management.

In the TAM framework, *perceived usefulness* refers to the extent to which a user believes that using a particular technology will enhance their performance. In the context of livestock disease management, this translates to whether farmers believe that using mobile applications can improve their ability to detect, prevent, and respond to disease outbreaks. For instance, mobile apps might provide critical information on disease symptoms, preventive measures, and emergency response steps, which could help farmers minimize livestock losses and manage disease outbreaks more effectively. If farmers perceive these applications as beneficial for improving livestock health and securing their income, they are more likely to view the technology favourably and adopt it.

*Perceived ease of use* in TAM addresses how easy or difficult users feel it is to utilize the technology. This factor is particularly crucial in rural and resource-constrained environments, where many farmers may have limited digital literacy and may not be familiar with complex mobile applications. For Nigerian livestock farmers, ease of use could include whether the app has a user-friendly design, supports local languages, offers offline functionality, or provides visual aids for those with low literacy levels. If farmers perceive the app as too complicated, time-consuming, or requiring skills they do not possess, they are likely to be discouraged from using it, even if they recognize its potential benefits. Applying TAM to this study enables a structured analysis of the factors influencing farmers' adoption of mobile applications for disease management.

### Conceptual framework

The conceptual framework for this study explores the relationship between the independent variables and the dependent variable (the effectiveness of disease management) being mediated by the intervening variables. The independent variables (socio-economic characteristics) in this study are factors that directly influence or mediate the effectiveness of disease management. The dependent variable in this study is the effectiveness of livestock disease management. This variable assesses the impact of mobile application adoption on actual disease outcomes in livestock populations. The intervening variables are contextual factors that can influence the relationship between the independent variables and the dependent variable. These include social and environmental factors that affect how mobile applications are used or perceived, regardless of their inherent usefulness or ease of use. The key inter-

vening variables are: social influence, policy and support from Government/NGOs and cultural compatibility.

## MATERIALS AND METHODS

### Study area

Situated in North-Central Nigeria, Abuja serves as the nation's Federal Capital. This metropolitan area encompasses more than 8,000 square kilometres and sits at an elevation of 536 meters above sea level. As recorded in the 2006 census, Abuja's population stood at 776,298 residents (National Population Commission, 2006). The Federal Capital Territory shares borders with four states: Kogi, Niger, Nasarawa, and Kaduna. Administratively, Abuja is divided into six district councils: AMAC (Abuja Municipal Area Council), Abaji, Bwari, Gwagwalada, Kuje, and Kwali. The region's climate reflects its location within the northern Guinea Savannah Grassland and Middle Belt zones, characterized by a tropical southern forest ecosystem.

Abuja is a growing urban centre surrounded by diverse rural and peri-urban communities where agriculture, including livestock farming, plays a significant role. This area provides an ideal location for examining the dynamics of technology adoption in livestock management due to its blend of urban infrastructure, rural agricultural practices, and its status as a hub for government initiatives and policy development. Smallholder and subsistence farming dominate these surrounding areas, with livestock such as cattle, goats, poultry, and sheep forming integral parts of household livelihoods. The prominence of livestock farming around Abuja makes it an appropriate area for examining how digital innovations like mobile applications can assist in addressing livestock health challenges.

Abuja has relatively better infrastructure than many other parts of Nigeria, with more reliable internet connectivity and mobile network coverage, which are essential for the effective use of mobile applications. The city and its surrounding communities have benefited from investments in telecommunications and digital services, facilitating higher mobile phone penetration rates. However, there remains a notable divide between urban and rural areas, with rural communities around Abuja often facing limited network access, higher data costs, and lower levels of digital literacy. These disparities make Abuja an interesting area for studying the challenges and potential of mobile technology in disease management, as it represents both the opportunities and barriers that mobile applications face in reaching underserved farming communities.

### Population of the study and research design

The population of this study consists of livestock farmers within and around the Federal Capital Territory (FCT), Abuja, Nigeria. This includes smallholder and subsistence

farmers who rear livestock such as cattle, goats, sheep, and poultry. These farmers represent a broad range of demographics, including diverse age groups, literacy levels, and varying degrees of experience in agriculture and technology use. The target population also includes other relevant stakeholders in the livestock industry, such as veterinarians, agricultural extension officers, and local agricultural cooperatives that work closely with livestock farmers. By focusing on this population, the study aims to gather insights into the extent of mobile application usage for livestock disease management and understand the challenges and facilitators of technology adoption in both urban and peri-urban farming settings.

This study adopts a mixed-methods research design, combining both quantitative and qualitative approaches to comprehensively analyze the impact of mobile applications on livestock disease management among farmers in Abuja. The mixed-methods design enables the collection of both numerical data on mobile app adoption rates and disease management outcomes, as well as in-depth qualitative insights into farmers' attitudes, challenges, and experiences. The quantitative component involves a survey administered to a sample of livestock farmers within the FCT. This survey is designed to capture data on key variables, such as the role of mobile applications in early disease detection and management and the perceived benefits of mobile apps in reducing livestock mortality rates. The qualitative component consists of semi-structured interviews and focus group discussions with a subset of livestock farmers, veterinarians, and agricultural extension officers. These interviews are aimed at gathering nuanced insights into the contextual factors that influence mobile app adoption and barriers to mobile app adoption for disease management.

### Sample size and sampling techniques

The study employs a multistage sampling technique to select a representative sample of livestock farmers in the Federal Capital Territory (FCT), Abuja. This approach allows the study to capture the diversity of livestock farming practices across various geographical and demographic groups, providing a well-rounded understanding of mobile application adoption and disease management in the area. The first stage of the multistage sampling process involves dividing the FCT into clusters based on administrative regions and geographical zones, ensuring that both urban and rural areas are represented. Abuja is divided into six area councils: Abuja Municipal, Gwagwalada, Bwari, Kuje, Kwali, and Abaji. These councils span densely populated urban centres, as well as rural areas with different levels of access to mobile technology and veterinary resources. From these six area councils, three are selected at random to form the primary study clusters. This selection process allows the study to capture diverse farming practices and technology adoption

patterns across different parts of the FCT, ensuring that findings are reflective of both urban and rural conditions.

In the second stage, specific communities within each of the three selected area councils are chosen to represent various farming environments—urban, peri-urban, and rural. For each area council, three communities are randomly selected, resulting in a total of nine communities across the study area. This distribution allows the study to encompass a variety of socioeconomic and infrastructural contexts, providing a comprehensive perspective on livestock farming practices in Abuja. Each community is proportionately represented based on the population and intensity of livestock farming, which ensures that findings are not skewed towards any particular type of farming environment.

In the third stage, respondents within each community are further stratified based on specific characteristics, such as livestock type (e.g., cattle, goats, sheep, and poultry) and demographic factors, including age, gender, and farm size. This stratification ensures that the study captures diverse disease management needs and technology adoption patterns relevant to different types of livestock. It also allows for the inclusion of farmers across different demographics, ensuring a balanced representation of smallholder farmers, larger livestock owners, and individuals with varying levels of farming experience. This step is critical in understanding how different groups within the farming community interact with mobile applications for disease management.

The final stage involves randomly selecting respondents within each stratum, giving each individual an equal chance of participating in the study. Approximately 100 farmers are selected from each of the three area councils, totalling 300 respondents. This random selection minimizes selection bias, allowing for a sample that accurately reflects the population of livestock farmers in Abuja. The distribution across councils—such as 100 respondents from Abuja Municipal (urban and peri-urban farmers), 100 from Kuje (peri-urban and rural farmers), and 100 from Kwali (primarily rural farmers)—captures a wide range of farming practices, access levels to veterinary services, and digital literacy levels.

### Data collection

The primary data collection tool for this study was a structured questionnaire, carefully designed to gather detailed information from livestock farmers in Abuja. This questionnaire was administered to a representative sample of farmers, with each session lasting about an hour to give respondents ample time to provide thorough and accurate answers. To enhance the questionnaire's validity and reliability, a pilot study was conducted with a small group of livestock farmers who were not included in the main sample. This pre-testing allowed the research team to identify and address any ambiguities or issues within the

questionnaire's structure and content. Based on feedback from this pilot phase, necessary adjustments were made to improve question clarity, relevance, and effectiveness in capturing data aligned with the study's objectives. These refinements ensured that the final questionnaire was well-suited for collecting valuable insights into the challenges and benefits associated with ICT-based approaches for livestock disease management. Additionally, trained enumerators administered the questionnaire to aid respondent understanding and promote accuracy in responses.

## Data analysis

The data collected in this study were analyzed using a combination of descriptive and inferential statistical techniques to comprehensively address each research objective. Descriptive statistics, including percentages, frequency counts, and means, were employed to meet Objectives (i) and (ii), which focus on investigating the socio-economic characteristics of livestock farmers and examining the role of mobile applications in early disease detection and management. To address Objective (iii), which explores factors influencing the adoption of mobile applications for livestock disease management, a logistic regression model was used. This model allowed the study to identify significant relationships between adoption and various socio-economic and institutional factors. For Objective (iv), which assesses the perceived benefits of mobile applications in reducing livestock mortality rates, a 4-point Likert scale was employed. Lastly, to achieve the objective (v), Kendall's Coefficient of Concordance (W) was used to identify and rank barriers to mobile app adoption for disease management among livestock farmers. All analyses were conducted using the Statistical Package for the Social Sciences (SPSS), version 24, which provided an efficient platform for conducting both descriptive and inferential analyses to gain deeper insights into the study's objectives.

## Model specification

### Model for Likert Scale Rating

To assess farmers' perceived benefits of mobile applications for livestock disease management, a 4-point Likert scale mean score was used, measuring respondents' levels of agreement on the effectiveness of mobile apps in achieving specific benefits, such as early disease detection and reducing livestock mortality. Respondents were asked to rate various statements related to mobile app utility on a scale from "very great extent" to "very low extent," providing insight into the perceived extent of mobile app utilization and its impact on livestock management practices. The 4-point Likert scale assigned values as follows:

Very great impact (VGI) – 4  
Great impact (GI) – 3  
Low impact (LI) – 2  
Very low impact (VLI) – 1

To calculate the mean Likert score ( $X_s$ ), the following formula was used:

$$X_s = \frac{\sum fn}{Nr}$$

Where:  $X_s$  = Mean score,  $\Sigma$  = Summation, F = Frequency of each response category (4, 3, 2, 1), n = Assigned Likert value for each response category, and Nr = Total number of respondents

A decision rule was established at a mean score of 2.5, where scores above 2.5 indicated a positive perception of mobile app utilization for livestock disease management, and scores below 2.5 suggested limited perceived benefit. This approach enabled the study to quantify farmers' levels of agreement and determine which aspects of mobile applications were perceived as most beneficial for livestock disease management in the study area.

### Logit Regression Model

A logistic regression model was applied to identify the socio-economic determinants influencing the adoption of mobile applications for livestock disease management. This model is ideal for exploring factors that may either facilitate or inhibit mobile app use among livestock farmers in the study area. The implicit form of the model is represented as:

$$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10})$$

The explicit form of the Logit model is given as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + e$$

Where: Y = Likelihood of adopting mobile applications for livestock disease management,  $X_1$  = Age of the respondent,  $X_2$  = Years of experience in livestock farming,  $X_3$  = Gender,  $X_4$  = Household size,  $X_5$  = Marital status,  $X_6$  = Educational attainment,  $X_7$  = Farm size,  $X_8$  = Access to credit,  $X_9$  = Access to extension services,  $X_{10}$  = Cooperative membership,  $\beta_0$  = Constant (intercept), e = Error term

By using this model, the study identifies which factors most significantly affect adoption, offering valuable insights into key drivers or barriers that impact the effective use of mobile applications for livestock health management in the study area.

### Kendall's Coefficient of Concordance

To address Objective (v), Kendall's Coefficient of Concordance ( $W$ ) was utilized. Each barrier was ranked by respondents based on perceived severity, and the total rank scores were then analyzed using Kendall's  $W$ . This coefficient ranges from 0 (indicating no agreement) to 1 (indicating perfect agreement), with higher values representing stronger consensus among respondents on the primary challenges they face. Kendall's  $W$  is calculated as follows:

$$W = \frac{12 \sum (R_i - \bar{R})^2}{m^2 (n^3 - n)}$$

Where:  $W$  = Kendall's Coefficient of Concordance,  $R_i$  = Sum of ranks for each barrier,  $\bar{R}$  = Average rank,  $m$  = Number of respondents (livestock farmers), and  $n$  = Number of barriers.

## RESULTS AND DISCUSSION

### Socio-economic characteristics of livestock farmers

The socioeconomic characteristics of livestock farmers is shown in Table 1. The gender distribution among livestock farmers in the study area indicates that 70% are male, while 30% are female. This male predominance aligns with similar studies on livestock farming demographics in Nigeria, where men generally constitute the majority in agricultural activities (Ajala and Gana, 2023). Men's dominance in this sector may be attributed to cultural roles and greater access to resources, which often position them as primary decision-makers in farming activities (Oni and Agbede, 2022).

The marital status of livestock farmers in the study area shows that a majority, 70%, are married, while 18% are single, 8% are widowed, and 4% are divorced or separated. Married farmers may have additional motivations to secure their livestock's health and productivity to support their families, which could impact their openness to adopting mobile applications for disease management (Obadina and Shittu, 2023).

The educational levels of livestock farmers in the study area reveal that 36% have completed secondary education, while 30% have attained primary education. Additionally, 16% possess tertiary education, and 18% have no formal education. This distribution suggests that a majority of farmers (82%) have at least basic literacy skills, which could influence their ability to use mobile applications effectively for livestock disease management (Ayoade *et al.*, 2022).

The age distribution of livestock farmers in the study area reveals that a significant portion falls within the 30–49 years range, accounting for 60% of the sample (28% are aged 30–39 and 32% are aged 40–49). This age group represents a relatively youthful and potentially adaptable

**Table 1.** Socio-economic characteristics of respondents (n = 300).

Variable	Freq (n =300)	Percent
Gender		
Female	90	30.0
Male	210	70.0
Marital status		
Single	54	18.0
Married	210	70.0
Widowed	24	8.0
Divorced	12	4.0
Educational level		
No formal education	54	18.0
Primary school	90	30.0
Secondary school	108	36.0
Tertiary education	48	16.0
Age (Mean = 45.2 yrs)		
20-29 years	45	15.0
30 -39 years	84	28.0
40 -49 years	96	32.0
50 – 59 years	48	16.0
60 years and above	27	9.0
Years of farming experience (Mean = 15.7 yrs)		
< 5 years	36	12.0
5 – 10 years	66	22.0
11 – 20 years	108	36.0
More than 20 years	90	30.0
Farm size (Mean = 4.2 ha)		
< 1	30	10.0
1 – 3	105	35.0
4 – 6	90	30.0
> 6	75	25.0
Cooperative membership		
Member	186	62.0
Non-member	114	38.0
Contact with extension agents		
Yes	228	76.0
No	72	24.0
Access to credit		
Yes	123	41.0
No	177	59.0

Source: Field Survey (2024).

workforce, which may positively impact the acceptance and use of mobile applications for disease management (Oni *et al.*, 2021).

The analysis of farming experience among livestock farmers in the study area shows that 36% have 11–20 years of experience, while 30% have more than 20 years. Another 22% have 5–10 years of experience, and only 12% have less than 5 years. This high level of experience, with a mean of 15.7 years, indicates a well-established group of farmers who likely possess substantial practical knowledge of livestock management (Afolabi and Nwankwo, 2021).

The farm size distribution among livestock farmers indicates that 35% operate on 1–3 hectares, while 30% have 4–6 hectares. A smaller proportion, 10%, manage farms of less than 1 hectare, and 25% operate on farms larger than 6 hectares, with an average farm size of 4.2 hectares. This predominance of small to medium-sized farms is typical in Nigeria, where limited access to land restricts expansion (Ajala and Gana, 2023; Sennuga *et al.*, 2024).

The analysis of cooperative membership among livestock farmers shows that 62% are members of agricultural cooperatives, while 38% are non-members. This high membership rate aligns with studies indicating that cooperatives play a significant role in providing rural farmers with access to resources, information, and collective bargaining power (Obadina and Shittu, 2023). Cooperative membership is often associated with improved access to training, credit, and technological tools, which can enhance disease management practices (Ayoade *et al.*, 2022; Oyediji *et al.*, 2024).

The data on contact with extension agents reveal that 76% of livestock farmers report having contact with extension agents, while 24% have no such contact. Previous research highlights that regular extension services are associated with higher adoption of agricultural innovations, including mobile applications for disease management, as agents often serve as trusted sources of guidance and support in implementing new tools and techniques (Ogunleye and Akinola, 2022).

The findings on access to credit among livestock farmers show that only 41% have access to credit facilities, while a majority, 59%, do not. Limited access to credit is a common issue in rural farming, often restricting farmers' ability to invest in disease management tools and technologies (Oni and Adewale, 2022). Access to credit has been shown to significantly influence the adoption of agricultural innovations, as financial resources allow farmers to purchase necessary inputs, including mobile applications for improved livestock health management (Adedeji *et al.*, 2021).

### **The role of mobile applications in early disease detection and management**

The most frequently acknowledged benefit in Table 2 was

that "Mobile applications provide real-time alerts and notifications about potential disease outbreaks in the region," with 80% of respondents agreeing. This high percentage underscores the importance of timely alerts in allowing farmers to respond quickly to disease threats. Real-time information is crucial for initiating immediate preventive actions, such as isolating sick animals or applying control measures to limit the spread (Ayoade *et al.*, 2022).

Another widely supported role is that "Mobile apps assist farmers in identifying early signs and symptoms of diseases in livestock, reducing the risk of escalation," with 70% of respondents affirming this. This finding aligns with Adedeji and Alabi (2020), who found that mobile technology aids farmers in early disease detection, leading to more effective disease control and fewer economic losses.

The role of mobile applications in providing guidance on preventive practices was also notable, with 62% of farmers selecting the statement "Mobile applications offer guidance on preventive practices, such as vaccination schedules and biosecurity measures to prevent disease spread." Access to preventive information supports healthier herd management by helping farmers understand essential health measures (Oni *et al.*, 2021).

Communication with veterinarians was another key benefit, with 58% of respondents agreeing with the statement "Mobile apps enhance communication with veterinarians, allowing for faster consultations and diagnoses in case of suspected outbreaks". Obadina and Shittu (2023) support this view, noting that mobile applications facilitate direct connections between farmers and animal health experts, which aids in timely and informed disease management.

The role of mobile apps in record-keeping also received considerable support, with 54% of respondents agreeing with the statement "Mobile applications help farmers maintain accurate records of livestock health, including past diseases and treatments." Mobile applications streamline record-keeping by consolidating health information, which supports effective long-term disease management strategies (Mumba *et al.*, 2020).

The ability to quickly report disease incidents to local health authorities and veterinary services was supported by 50% of farmers, who agreed with the statement "Apps allow farmers to report disease incidents quickly to local health authorities and veterinary services, facilitating faster intervention." This rapid reporting enables timely responses and containment efforts, which are crucial in preventing disease spread, especially in contagious outbreaks (Ajala and Gana, 2023).

A smaller but still significant percentage (46%) of respondents supported the statement "Mobile applications support monitoring of livestock health over time, helping farmers track disease patterns and improve herd management." Consistent health tracking allows farmers to anticipate disease periods, aligning with Ogunleye and Akinola's (2022) findings on the value of longitudinal health

**Table 2.** The role of mobile applications in early disease detection and management.

S/N	Statements	Frequency	Percentage (%)
a	Mobile applications provide real-time alerts and notifications about potential disease outbreaks in the region, enabling rapid responses	240	80%
b	Apps allow farmers to report disease incidents quickly to local health authorities and veterinary services, facilitating faster intervention	150	50%
c	Mobile applications offer guidance on preventive practices, such as vaccination schedules and biosecurity measures to prevent disease spread	186	62%
d	Mobile apps enhance communication with veterinarians, allowing for faster consultations and diagnoses in case of suspected outbreaks	174	58%
e	Mobile applications help farmers maintain accurate records of livestock health, including past diseases and treatments	162	54%
f	Mobile apps assist farmers in identifying early signs and symptoms of diseases in livestock, reducing the risk of escalation	210	70%
g	Mobile applications support monitoring of livestock health over time, helping farmers track disease patterns and improve herd management	138	46%
h	Mobile apps provide educational resources that increase farmers' knowledge on recognizing symptoms and implementing disease control measures	126	42%

Multiple responses (Source: Field Survey, 2024).

monitoring for proactive disease control.

Finally, 42% of farmers agreed with the statement "Mobile apps provide educational resources that increase farmers' knowledge on recognizing symptoms and implementing disease control measures." Access to educational content on mobile apps is particularly beneficial for farmers in rural areas who may not have access to formal training. Adedeji *et al.* (2021) observed that mobile apps provide critical information that supports continuous learning for farmers, helping them make informed health decisions.

### Factors influencing the adoption of mobile apps for livestock disease management

The model statistics in Table 3 provide important insights into the performance and fit of the logistic regression model analyzing the factors influencing the adoption of mobile applications for livestock disease management. Based on 300 observations, the model's Likelihood Ratio Chi-Square (LR Chi<sup>2</sup>) of 45.67 indicates the goodness-of-fit of the model. The Pseudo R<sup>2</sup> of 0.312 means the model explains 31.2% of the variability in mobile app adoption. While pseudo R-squared values are typically lower than traditional R-squared values in linear regression, a value above 0.30 is generally considered a good fit for logistic regression in social sciences (McFadden, 1974).

Additionally, the model's overall P-value of 0.000 confirms its high statistical significance and, as a whole, is a good fit for the data, supporting the hypothesis that at least one of the independent variables has a significant influence on the likelihood of adopting mobile applications.

The Log Likelihood value of -102.34 further provides an indication of the model's fit to the observed data, with higher (less negative) values suggesting a better fit. Among the nine factors tested, seven factors had coefficients that were statistically meaningful: gender, age, educational level, farming experience, farm size, cooperative membership, and access to credit, while marital status and contact with extension agents were not statistically significant.

Gender was significant at the 10% level ( $p = 0.059$ ), with a positive coefficient ( $\beta = 0.312$ ). This result indicates that male farmers are slightly more likely to adopt mobile applications compared to female farmers. Similar trends have been observed in studies by Ayoade *et al.* (2022), which suggest that gender disparities in resource access and decision-making autonomy often lead to higher technology adoption rates among male farmers. This difference could stem from cultural or socio-economic factors that favour men's involvement in technology-driven agricultural activities.

Age was also significant at the 10% level ( $p = 0.053$ ) but had a negative coefficient ( $\beta = -0.029$ ), indicating that younger farmers are more inclined to adopt mobile applications for livestock management. This finding aligns with Adedeji *et al.* (2021), who observed that younger farmers are generally more open to technological innovations due to their familiarity with digital tools and greater adaptability. Older farmers may face challenges such as lower digital literacy or resistance to adopting new practices, which can reduce their likelihood of using mobile applications.

Educational level emerged as highly significant at the 1% level ( $p = 0.006$ ), with a positive coefficient ( $\beta = 0.210$ ).

**Table 3.** Logit regression table showing the socio-economic determinants of the adoption of mobile applications for livestock disease management.

Variable	Coefficient	Standard error	Z- value	P-value
Constant ( $\beta_0$ )	-0.210***	0.350	-3.46	0.001
Gender	0.312*	0.165	1.89	0.059
Age	-0.029*	0.015	-1.93	0.053
Marital Status	0.088	0.090	0.98	0.327
Educational Level	0.210***	0.076	2.76	0.006
Farming Experience	0.135**	0.054	2.50	0.012
Farm Size	0.092**	0.044	2.09	0.037
Cooperative Membership	0.534***	0.137	3.90	0.000
Contact with Extension Agents	0.081	0.105	0.77	0.442
Access to Credit	0.476***	0.162	2.94	0.003
Number of Observation	300.00			
LR Chi <sup>2</sup> (9)	45.67			
Pseudo R <sup>2</sup>	0.312			
P-Value	0.000			
Log likelihood	-102.34			

Note: \*\*\*, \*\* and \* indicate significance at 1%, 5% and 10% probability level respectively (Source: Field Survey, 2024).

This suggests that farmers with higher levels of education are more likely to adopt mobile applications for livestock disease management. Education equips farmers with the ability to understand and utilize mobile applications effectively, as noted by Obadina and Shittu (2023). Higher education levels also correlate with increased awareness of the benefits of technology and better decision-making in adopting new tools for agricultural purposes.

The farming experience was significant at the 5% level ( $p = 0.012$ ), with a positive coefficient ( $\beta = 0.135$ ), indicating that more experienced farmers are more likely to adopt mobile applications. This finding may reflect experienced farmers' deeper understanding of the challenges associated with livestock diseases and their recognition of the value of technological tools in addressing these challenges. Studies by Mumba *et al.* (2020) support this result, showing that experienced farmers often have a higher capacity to assess and adopt innovations that improve productivity.

Farm size was also significant at the 5% level ( $p = 0.037$ ) with a positive coefficient ( $\beta = 0.092$ ), indicating that farmers with larger farms are more likely to adopt mobile applications. Larger farm sizes are often associated with greater resource availability and a stronger incentive to prevent disease outbreaks that could lead to substantial losses. Ajala and Gana (2023) observed similar results, noting that larger-scale farmers are typically more willing to invest in tools that enhance disease management and productivity.

Cooperative membership was highly significant at the 1% level ( $p = 0.000$ ) with a positive coefficient ( $\beta = 0.534$ ). This result highlights the critical role cooperatives play in facilitating mobile app adoption. Cooperatives provide members with access to shared resources, training, and

information, which can significantly enhance their ability to adopt and utilize mobile applications. Oni and Adewale (2022) emphasized the importance of social networks, like cooperatives, in promoting technology adoption by reducing barriers such as lack of awareness or financial constraints.

Access to credit was also highly significant at the 1% level ( $p = 0.003$ ) with a positive coefficient ( $\beta = 0.476$ ). Farmers with access to credit are more likely to adopt mobile applications, as financial resources enable them to afford smartphones, data plans, and other related costs. Credit also allows farmers to invest in complementary technologies or services that enhance app utility, such as veterinary consultations or preventive measures. Ogunleye and Akinola (2022) found that financial support is a critical enabler of technology adoption, particularly in rural agricultural settings.

Conversely, marital status and contact with extension agents were not significant predictors, with p-values of 0.327 and 0.442, respectively. The lack of significance for marital status suggests that being married, single, or widowed does not substantially influence mobile app adoption. This result contrasts with some studies that associate marital status with decision-making and risk tolerance in agricultural practices (Ayoade *et al.*, 2022). Similarly, the non-significance of contact with extension agents may reflect variations in the quality and frequency of interactions or the fact that extension services are not always linked to mobile technology adoption. Oni and Agbede (2021) noted that while extension agents provide valuable information, their impact on technology adoption depends on how effectively they integrate digital tools into their advisory services.

**Table 4.** Ranking of barriers to mobile app adoption for livestock disease management using Kendall's coefficient of concordance.

Barrier	Mean Rank	Rank
High cost of mobile data prevents regular app usage	4.25	1 <sup>st</sup>
Limited internet access in rural areas	4.12	2 <sup>nd</sup>
Low digital literacy among farmers makes app navigation difficult	3.80	3 <sup>rd</sup>
Inconsistent network coverage disrupts real-time updates	3.65	4 <sup>th</sup>
Lack of awareness about available mobile applications	3.45	5 <sup>th</sup>
Lack of technical support for troubleshooting app-related issues	3.30	6 <sup>th</sup>
Limited compatibility of apps with basic smartphones	3.12	7 <sup>th</sup>
Language barriers due to apps not supporting local dialects	2.85	8 <sup>th</sup>

Source: Field Survey, 2024.

### Barriers to mobile app adoption for disease management among livestock farmers

The results of Kendall's Coefficient of Concordance analysis in Table 4 highlight the key barriers to adopting mobile applications for livestock disease management, ranked by their perceived severity among farmers. Kendall's W value of 0.74 indicates a high level of agreement among respondents, and the corresponding chi-square value (155.67,  $p < 0.01$ ) confirms that this consensus is statistically significant. These findings provide valuable insights into the primary obstacles faced by farmers in utilizing mobile applications effectively.

The highest-ranked barrier was the high cost of mobile data, with a mean rank of 4.25. This finding underscores the financial constraints many farmers experience, which hinder their ability to use mobile applications consistently. Mobile applications often require regular updates and internet connectivity, incurring costs that are burdensome for smallholder farmers with limited financial resources. Studies by Ayoade *et al.* (2022) corroborate this finding, emphasizing that data costs remain a significant obstacle to technology adoption in rural agricultural contexts. The financial burden associated with mobile data discourages farmers from fully engaging with applications designed to improve livestock disease management.

Limited internet access in rural areas was the second most significant barrier, with a mean rank of 4.12. Farmers in remote areas often lack reliable internet infrastructure, preventing them from accessing the features of mobile applications that require online connectivity. This limitation affects real-time updates, disease alerts, and communication with veterinary services. Ogunleye and Akinola (2022) reported similar findings, noting that rural areas in Nigeria suffer from inadequate network coverage, which hinders the widespread adoption of mobile technology in agriculture. Without stable internet access, farmers cannot fully utilize mobile applications for disease prevention and management.

The third-ranked barrier, low digital literacy among farmers, had a mean rank of 3.80. Many farmers struggle

to navigate mobile applications due to unfamiliarity with digital tools or limited education on their usage. This challenge is particularly pronounced among older farmers or those with lower levels of formal education, as they may lack the skills required to operate smartphones and applications effectively. Adedeji *et al.* (2021) highlighted that digital literacy plays a critical role in determining farmers' ability to adopt and use mobile technologies for agricultural purposes. Mobile applications that are complex or poorly designed exacerbate this issue, further discouraging adoption.

Inconsistent network coverage, with a mean rank of 3.65, was the fourth-ranked barrier. Many respondents noted that intermittent network availability disrupts their ability to receive real-time disease updates or communicate with veterinarians promptly. This barrier is especially problematic in rural settings where network infrastructure is underdeveloped. Ajala and Gana (2023) emphasized that reliable network connectivity is essential for enabling the full functionality of mobile applications, particularly those that rely on real-time data transmission for disease management.

Lack of awareness about available mobile applications ranked fifth, with a mean rank of 3.45. This result indicates that some farmers are unaware of existing mobile applications designed to support livestock health. Limited awareness reduces the likelihood of app adoption, as farmers may not know how these tools can benefit their disease management practices. Oni and Adewale (2022) noted that awareness campaigns and demonstrations significantly impact the adoption of agricultural technologies, particularly in rural areas where access to information is limited.

The sixth barrier, lack of technical support for troubleshooting app-related issues, had a mean rank of 3.30. Farmers often encounter technical problems, such as app crashes or difficulty accessing specific features, but lack access to support services to resolve these issues. This finding aligns with Obadina and Shittu (2023), who observed that inadequate technical support discourages technology use among rural farmers, as unresolved issues

lead to frustration and eventual abandonment of the tools.

Limited compatibility of apps with basic smartphones, ranked seventh with a mean rank of 3.12, further highlights accessibility challenges. Many farmers use basic smartphones with limited storage, processing power, or software compatibility, making it difficult to install and run advanced applications. Adedeji and Alabi (2020) observed similar constraints, noting that app developers often overlook the hardware limitations of devices commonly used in rural areas.

The lowest-ranked barrier, language barriers due to apps not supporting local dialects, had a mean rank of 2.85. While this issue was less critical compared to other barriers, it remains a concern for some farmers who are not fluent in the languages commonly used in app interfaces, such as English. Providing local language support can enhance usability and inclusivity, particularly for farmers in rural regions who are more comfortable using indigenous languages (Oni *et al.*, 2021).

## Conclusion and Recommendations

This study highlights the significant role of mobile applications in improving livestock disease management in Abuja. Farmers who adopted these applications were predominantly male, aged 30–49, and possessed basic literacy skills, with most having secondary-level education. Membership in cooperatives, access to credit, larger farm sizes, and greater farming experience were key socio-economic factors driving adoption. Mobile applications proved highly beneficial by providing real-time alerts on disease outbreaks, facilitating early detection, guiding preventive measures, improving communication with veterinarians, and enabling effective record-keeping. These findings enunciate the potential of mobile technology to enhance disease management practices and overall livestock health outcomes.

However, adoption is hindered by systemic and individual challenges. Key barriers include the high cost of mobile data, limited internet access in rural areas, inconsistent network coverage, low digital literacy, and lack of awareness about available applications. Despite these obstacles, farmers demonstrated strong agreement on the value of mobile apps for livestock disease management in the region.

Addressing these barriers and leveraging the identified benefits will require targeted interventions and strategic efforts to enhance access, usability, and adoption of mobile applications among livestock farmers. These findings provide a foundation for developing actionable recommendations aimed at promoting wider adoption of mobile technology for livestock disease management:

1. To alleviate the financial barrier identified as the top-ranked challenge, partnerships with telecommunication companies should be formed to provide affordable

data packages or subsidies for farmers using mobile applications for livestock disease management.

2. The study highlights limited internet access as a significant barrier. Investments in rural telecommunications infrastructure are needed to improve network coverage and ensure consistent connectivity, enabling farmers to fully utilize mobile applications.
3. Given that low digital literacy ranks as a major barrier, targeted training programs should be implemented to educate farmers on using mobile applications. Such programs should include practical demonstrations and be tailored to local literacy levels.
4. Since cooperative membership significantly influences mobile app adoption, efforts should focus on strengthening cooperatives and encouraging farmers to join. Cooperatives can serve as platforms for collective training, resource sharing, and app adoption initiatives.
5. Lack of awareness about available mobile applications was identified as a barrier. Awareness campaigns, possibly through extension agents, cooperatives, and local organizations, can inform farmers about the benefits of mobile apps and how to access them.
6. Access to credit emerged as a significant driver of mobile app adoption. Financial institutions should develop flexible credit schemes to help farmers afford smartphones, data plans, and other resources needed to adopt and use mobile applications effectively.
7. Applications should be designed to address the specific needs of livestock farmers, incorporating local languages and cultural nuances. Features like offline functionality and compatibility with basic smartphones will enhance accessibility and usability among diverse farmer demographics.

## CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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