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Medication Errors in Poultry Practice: Prevalence, Risk Factors, and Economic Consequences in Wakiso District, Uganda

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Abstract

Medication errors (ME) in poultry production pose significant threats to animal health, productivity, and public health. In Uganda, data on such errors in poultry practice remain limited. The study assessed prevalence, associated risk factors, and economic implications of medication errors in poultry practice in Wakiso District, Uganda. A cross-sectional study was conducted from January to November 2024 among poultry farmers, and veterinary practitioners. Structured questionnaires were used to collect data on medication practices, errors, and associated economic impacts. Descriptive statistics were performed using STATA Version 17. Among the 455 respondents that participated in the study, 265 were poultry farmers, 120 veterinary paraprofessionals and 70 veterinary surgeons. Among 455 participants response, 83.5% (380/455; CI: 80.0% - 87.0%) committed MEs, with most prevalent being medication administration errors 87.5% (336/384, CI: 83.8% - 91.2%). Veterinary paraprofessionals (99.2%, 119/120, CI: 97.6% - 100%) and poultry farmers (36.6%, 97/265, CI: 22.4% - 44.4%) were illegally prescribing medicines for poultry. Veterinary surgeons committed the highest monitoring errors with majority (83.6%, 95% CI: 76.5 - 90.7, n = 51) failing to follow up on patient after treatment. Risk factors to MEs were not conducting laboratory tests (AOR = 8.4, CI: 2.1 - 34.4, $p < 0.01$) and lower education levels (AOR = 2.9, CI: 0.7 - 12.5, $p = 0.14$). Significant consequences of ME included increased poultry mortality rates (OR = 9.2, CI: 1.3 - 65.9, $p < 0.05$), birds treated for longer time (OR = 8.1, CI: 1.2 - 55.0, $p < 0.05$) and economic losses (OR = 6.6, CI: 1.7 - 26.7; $p < 0.01$). Medicine administration errors are common among farmers and practitioners for poultry in Wakiso district. Lower education levels and ab-

sence of diagnostic laboratory tests, significantly increased likelihood of medication errors occurrence. High mortality, prolonged treatment durations and economic losses were major consequences.

Keywords

Poultry, Medication Errors, Risk Factors, Economic Implications, Uganda

1. Introduction

Globally, medication errors represent a significant public health concern, accounting for thousands of preventable adverse events each year across both human and veterinary medical practice [1]. Medication errors are a leading cause of avoidable harm contributing to over 1.3 million deaths annually worldwide [2]. According to © 2021 National Coordinating Council for Medication Error Reporting and Prevention:

"*Medication errors are defined as: any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health-care professional, patient, or consumer. In this context, unintended or preventable mistakes in the selection, administration, or management of medications by poultry farmers, veterinary paraprofessionals, or veterinarians may lead to adverse effects or ineffective treatment for farm birds.*"

The rapid increase in human population in Uganda (estimated at over 45 million people), has led to a growing demand for affordable and high-quality animal protein [3]. Poultry production especially broiler and layer chickens has emerged as one of the fastest-growing livestock sectors due to its relatively short production cycle, lower investment costs, and high feed conversion efficiency [4]. In Uganda, the poultry sector contributes significantly to both food security and rural livelihoods, with an estimated poultry population of over 40 million birds, predominantly raised under smallholder systems [5]. However, the industry's growth is increasingly threatened by frequent disease outbreaks, poor biosecurity measures, and substandard husbandry practices [6]. These challenges have driven many farmers and animal health practitioners to rely heavily on antibiotics and growth promoters, often without appropriate veterinary oversight [6]. Unsupervised medication, off-label drug use, and non-adherence to withdrawal periods are common practices in poultry management, contributing to increased drug misuse and the emergence of antimicrobial resistance (AMR) [7].

Uganda's reliance on antimicrobials in livestock is underscored by national data showing annual imports of 167.5 tons of veterinary antimicrobials (2018-2020), with oxytetracycline (a tetracycline) constituting 44.8% of total consumption [8]. Notably, 97% of these antimicrobials belong to the WHO's Critically Important Antimicrobials list, highlighting risks for antimicrobial resistance (AMR). Despite high consumption, regulatory gaps persist, as evidenced by unrestricted access to

antimicrobials through veterinary drug shops (82.4% of farmers in this study) and minimal diagnostic testing. This combination of widespread use and poor oversight creates fertile ground for medication errors, which remain unquantified in Uganda's poultry sector.

However, with the increase in drug use, there is also an increasing chance of medication errors which can occur at any stage of prescription, administration and monitoring of medications resulting in economic, prolonged treatments, and mortality. Medication errors in in poultry production, can have serious consequences due to the narrow therapeutic margins, species-specific dosing complexities, and the potential for toxic residues in animal-derived food products. In Uganda's poultry industry where birds are often managed intensively under suboptimal conditions these risks are heightened by widespread self-administration of drugs by farmers, limited veterinary oversight, and inadequate knowledge of pharmacological principles [9]. Studies have reported that up to 40% of poultry farmers in sub-Saharan Africa administer drugs without veterinary consultation, contributing to improper dosing, misuse of antimicrobials, and treatment failures [10]. Such practices not only compromise animal health and productivity but also pose significant public health threats, including the development of antimicrobial resistance and contamination of the food chain. Despite the growing concerns, no previous studies have specifically investigated the prevalence, associated risk factors, and economic consequences of medication errors in poultry practice. This study, therefore, fills critical knowledge gap by evaluating the extent and impact of medication errors in poultry production in Wakiso district.

2. Methodology

2.1. Study Design and Setting

We conducted a cross-sectional study from January 2024 to November 2024 among veterinarians, veterinary paraprofessionals, and poultry farmers in Wakiso District, Uganda. Uganda comprises 146 districts as of the 2023 administrative update, each varying in population density, agricultural activity, and access to veterinary services. Wakiso District, located in the Central Region, is one of the most populous and economically vibrant districts, encircling the capital city, Kampala.

According to the Uganda National Livestock Census Report, Wakiso District with 17 sub counties, has the largest poultry population in the country, estimated at approximately 5.6 million birds [11]. The district is a key player in Uganda's poultry industry, serving as a major hub for both subsistence and commercial poultry production. The predominant poultry farming systems in Wakiso are intensive, with high input use and short production cycles. These systems are highly dependent on veterinary pharmaceuticals for disease prevention and productivity enhancement, which increases the risk of medication-related errors.

Veterinary services in the district are offered through a mix of public and private providers, including licensed veterinarians, paraprofessionals, and community animal health workers. However, challenges such as limited regulation, in-

consistent access to veterinary oversight, and self-medication by farmers contribute to a potentially high risk of medication errors.

2.2. Study Population and Selection Criteria

The study population comprised poultry farmers (defined as persons rearing chickens under extensive, semi-intensive and intensive systems for commercial or subsistence purposes), veterinarians, and veterinary paraprofessionals actively engaged in poultry health management and medication use within Wakiso District, Uganda. Extensive poultry farmers were persons keeping free-range chickens (typically 10 - 50 birds) with minimal input in terms of housing, feeding, and veterinary care. Semi-intensive poultry farmers; individuals managing medium-sized flocks (51 - 500 birds) with partial confinement, supplementary feeding, and periodic veterinary interventions while Intensive poultry farmers; persons operating commercial poultry enterprises with over 500 birds, raised under full confinement and receiving routine veterinary care and commercial feeds. Participants were included if they were directly involved in prescribing, administering, or monitoring veterinary medications for poultry. Poultry farmers were required to have at least one year of continuous experience in raising poultry flocks and managing farm operations, while veterinarians and veterinary paraprofessionals (paravets) were required to have been practicing in Wakiso District for a minimum of one year.

Veterinary paraprofessionals in this study were defined as persons with a diploma in animal husbandry, authorized by the Uganda Veterinary Body to practice veterinary medicine/science to carry out specific designated tasks under the responsibility and direction of a veterinary surgeon, whereas veterinarians were classified as persons with a bachelor's degree in veterinary medicine, registered or licensed by Uganda Veterinary Body to practice veterinary medicine/science. Farmers were included basing on the scale of operation, maintained active flocks and used veterinary pharmaceuticals during the study period. Participants were excluded if they were veterinarians or paraprofessionals not actively practicing in Wakiso District, or if they had been involved in poultry health management or pharmaceutical use for less than one year.

2.3. Sample Size Determination

The required sample size for this study was determined using Yamane's formula [12], a conventional method used for calculating sample sizes from a finite population with the veterinary list being obtained from the Uganda Veterinary Board while the list for poultry farmer was obtained from Wakiso district Local government:

$$n = \frac{N}{1 + N(e)^2}$$

where n = sample size, N = total number of poultry farmers, e = margin of error (5%).

The study targeted veterinarians, veterinary paraprofessionals, and poultry

farmers in Wakiso District. The total estimated population included 610 poultry farmers, 83 veterinarians, and 210 veterinary paraprofessionals, giving a combined total of 903 stakeholders. Applying the formula with a 95% confidence level and 5% margin of error yielded the following sample sizes (Table 1).

Table 1. Sample Size for different stakeholders handling medicines.

Stakeholder	Total number registered with authority and district	Sample size
Poultry farmers	610	241
Veterinarians	83	69
Veterinary paraprofessionals	210	137
Total		447

$$n = \frac{10 \times 447}{100}$$

$$n = 44.7$$

To account for potential non-response, the sample size was adjusted by an additional 10%: Given the study employed cluster sampling grouping poultry farmers and paraprofessionals based on sub-counties and farm categories (extensive, semi-intensive, intensive) the potential effect of intra-cluster correlation (ICC) was also considered. Clustering can reduce the effective sample size due to the homogeneity of responses within clusters. Thus, ICC estimates derived from related studies or pilot data were used to guide sample inflation where necessary, ensuring adequate statistical power for subgroup analyses. The final target was a minimum of 492 participants, with efforts made to recruit proportionate numbers across all stakeholder groups in Wakiso District.

2.4. Sampling Procedure

The sampling frame comprised all registered veterinarians, veterinary paraprofessionals, and poultry farmers operating within Wakiso District. The district consists of 17 sub-counties, each varying in poultry production intensity and professional distribution. Veterinarians were selected through convenience sampling due to their limited number (n = 83) and scattered distribution across the district. Participants were enrolled consecutively until the target sample size (n = 69) was achieved.

Veterinary paraprofessionals were selected through cluster sampling, followed by simple random sampling within selected clusters. Wakiso District comprises 17 sub-counties with an estimated total of 210 veterinary paraprofessionals. Each sub-county represented a cluster with an approximate average of 13 paraprofessionals. We used a random number generator to select sub-counties for inclusion. Within each selected sub-county, simple random sampling was conducted to select 13 paraprofessionals. This approach allowed for geographic representation while minimizing logistical challenges associated with reaching all paraprofes-

sionals across the district. A total of 137 veterinary paraprofessionals were included in the final sample.

Poultry farmers were selected using a multi-stage sampling technique to ensure proportional representation of farm sizes and locations. Stage One—Stratified Sampling: A complete list of poultry farmers in all 17 sub-counties was compiled. The list was stratified based on farm size (small, medium, and large scale) and geographical location (sub-county). This stratification helped capture the diversity in farm practices and production scales.

Stage Two—Inclusion and Systematic Sampling: Large- and Small-Scale Farmers; All willing poultry farmers in these categories from selected sub-counties were included to maximize participation and capture detailed practices that may vary by scale. Medium-Scale Farmers: Due to their moderate numbers, systematic random sampling was applied. Every second farmer was selected from a randomly determined starting point on the list, allowing for a manageable and unbiased sample.

Stage Three—Snowball Sampling for Small-Scale Farmers: In areas where small-scale farmer lists were incomplete or informal, snowball sampling was used. Initial respondents referred other eligible participants. This approach was suitable for accessing hidden or hard-to-reach populations who may not be registered in formal agricultural databases.

2.5. Study Tool Development and Validation

We conducted an extensive literature review using keywords related to human and veterinary medication errors, with a particular focus on poultry practice. The literature informed the development of key constructs such as the prevalence, classification, risk factors, and consequences of medication errors. Based on the findings, we generated a pool of relevant questions to guide the construction of a comprehensive data collection instrument.

The primary tool developed was a structured questionnaire designed to assess both farmer and veterinary medication practices (the drugs given, the dose, the prescription, administration or monitoring of patients after treatment among others) and the outcomes of the treatment. Both closed- and open-ended questions were included to capture quantitative data as well as contextual insights. A medication error tracking form was developed to identify the types of medication errors (e.g., prescribing, administration, monitoring), contributing factors (e.g., inadequate training, wrong dosage calculation, poor communication), and associated clinical or economic outcomes in the questionnaire.

The initial version of the questionnaire was prepared in English, the formal language used in veterinary training and practice. However, to ensure inclusivity and accessibility for poultry farmers, the tool was translated into Luganda, the most commonly spoken local language in Wakiso District. To enhance the content validity, clarity, and structure of the tool, a panel of experts from the fields of Public Health, Epidemiology, Pharmacology, and Veterinary Medicine to independently

reviewed and provided feedback on the draft instrument. The panel reached consensus on the relevance, clarity, and appropriateness of all items, particularly those related to the classification and reporting of medication errors.

Following expert validation, the tool was pretested in two villages within Mukono District that were selected due to their mixed populations of poultry farmers and veterinary professionals. A total of 20 participants (10 veterinary surgeons, 10 paraprofessionals, and 15 poultry farmers) were included in the pilot test. Respondents provided feedback on the clarity, relevance, and flow of the questionnaire items. Questions that were found to be ambiguous or difficult to understand were revised or reworded.

To assess the tool's internal consistency, a Cronbach's alpha reliability test was performed. The scale assessing factors contributing to medication errors yielded an alpha of 0.841, while the outcome-related section had an alpha of 0.769, indicating acceptable to high reliability. The final version of the questionnaire was structured according to the key study objectives and respondent categories (veterinarians, paraprofessionals, and poultry farmers), and was used for large-scale data collection across Wakiso District.

2.6. Variables

The outcome variables in this study were the prevalence of medication errors, risk factors contributing to medication errors, and the consequences of these medication errors. These were assessed using a structured medication error tracking form, which was designed to systematically document drug-related events. The form included fields for drug type, dosage, route of administration, indication, prescriber, and any observed deviations or errors, including wrong drug, wrong dose, wrong route, or failure to observe withdrawal periods.

The prevalence of medication errors was assessed by surveying veterinarians, veterinary paraprofessionals, and poultry farmers regarding the medications they administered in their poultry farming practices over the past 12 months. A medication error was defined as any preventable event that could result in inappropriate medication use or potential harm to poultry. Respondents' answers were documented and classified using a medication error tracking system, with each response coded as "1" for the presence of an error or "0" for the absence of an error, based on farmer recall and verification against entries in the medication tracking form.

Risk factors contributing to medication errors were evaluated through structured questions embedded within the medication tracking form. These captured data on farming practices, access to veterinary services, and the farmer's knowledge regarding medication use. Each identified risk factor was coded as a binary (yes/no) or categorical variable, depending on the nature of the factor assessed.

Consequences of medication errors were measured by inquiring whether such errors had resulted in any negative outcomes, such as treatment failure, reduced productivity, increased veterinary costs, or poultry mortalities. Respondents re-

ported outcomes in five categories: no consequence (coded as 0), long treatment durations [1], mortalities [2], increased veterinary costs [3], and economic losses due to reduced productivity [4].

The independent variables included both sociodemographic and practice-related characteristics of the poultry farmers. These were: Age of Respondents: Measured as a continuous variable in years and later categorized into age brackets (<30, 30 - 45, and >45 years) for analysis. Gender: A binary variable coded as 1 for male and 2 for female. Level of Education: Captured as an ordinal categorical variable, coded as 1 = No formal education, 2 = Primary, 3 = Secondary, and 4 = Tertiary. Years of Poultry Farming Experience: Measured as a continuous variable, reflecting the length of time each respondent had been engaged in poultry farming.

Medication Practices: Assessed through 10 structured yes/no questions covering how medication was sourced, administered, and monitored. Each correct practice was scored as 1 and incorrect as 0, giving a possible total score ranging from 0 to 10. Scores were interpreted as follows: high (8 - 10), moderate (5 - 7), and poor (<5) practice levels, based on modified Bloom's cutoffs. Laboratory Test Availability: Determined by asking whether the respondent routinely conducted diagnostic tests before administering medications. Responses were binary (Yes = 1, No = 0).

2.7. Data Collection Procedure

Data were collected between January and July 2024 using an interviewer-administered, structured questionnaire. The research team consisted of trained veterinary surgeons and paraprofessionals who conducted face-to-face interviews with study participants. Prior to data collection, the research team underwent training on questionnaire content, administration procedures, and ethical considerations. Participants were identified through a combination of phone calls, visits to local agricultural extension offices, and collaboration with community-based organizations. Village local leaders also assisted in identifying eligible veterinarians, veterinary paraprofessionals, and poultry farmers.

Before each interview, the research assistant provided a clear explanation of the study's purpose, objectives, procedures, potential benefits, and ethical considerations including voluntary participation, the right to withdraw at any time, and assurances of confidentiality and anonymity. Written informed consent was obtained from all participants. Each interview lasted approximately 45 minutes. The questionnaire captured information on the occurrence of medication errors in poultry practice, associated risk factors, and consequences. A standardized medication error tracking form was used to record specific incidents in detail. Prior to the main study, a pilot test of the questionnaire was conducted in Mukono District with 10 veterinary surgeons, 10 paraprofessionals, and 15 poultry farmers to evaluate clarity, relevance, and validity. Revisions were made based on the feedback received. All completed questionnaires were digitized using Microsoft Excel,

cleaned for accuracy and completeness, and exported to STATA version 17 for statistical analysis.

2.8. Data Processing and Management

At the end of each interview, the research team reviewed all questionnaires for completeness and consistency. During fieldwork and data cleaning, we conducted a case-by-case assessment to identify and address any missing or inconsistent responses. Questionnaires with substantial missing data on key study variables were excluded from the final dataset. Data were entered into EpiData Version 4.2 using a double-entry approach, whereby two independent data entrants input the same data. Discrepancies between the two entries were reconciled by cross-checking with the original questionnaires to ensure accuracy and consistency. We regularly backed up all data to prevent loss due to technical issues. Final datasets, supporting documentation, and research outputs were securely archived to enable long-term storage and accessibility for future research.

2.9. Data Quality Control

Data collection was conducted by trained research assistants with academic backgrounds in animal health, including diploma and degree qualifications. Before field deployment, all assistants underwent rigorous training covering research ethics, study procedures, and standardized use of data collection tools. A pilot test of the questionnaire was conducted in Mukono District to identify ambiguities and logistical issues. Based on pilot feedback, we revised the data collection instruments accordingly.

2.10. Statistical Data Analysis

All data were analyzed using STATA version 17.0 (Stata Corp LLC, Texas, USA). Categorical variables, including medication error types and reported consequences, were summarized using frequencies and proportions. Continuous variables, where applicable, were described using means and standard deviations or medians with interquartile ranges (IQR), depending on data distribution. The study population's baseline characteristics were also described using descriptive statistics to provide an overview of the prevalence and distribution of medication errors among veterinarians, veterinary paraprofessionals, and poultry farmers.

To explore factors associated with medication errors, bivariable logistic regression analyses were performed for each independent variable. Separate bivariable models were constructed for each medication error type prescription, administration, and monitoring since these differ in underlying causes and implications. The occurrence of each medication error was treated as a binary outcome (yes/no).

All variables with a p-value < 0.2 in the bivariable analysis or those supported by prior literature (e.g., personnel type, education level, production system, laboratory testing practices) were considered for inclusion in the multivariable logistic

regression models. Backward elimination was applied to refine the models, retaining variables with p-values < 0.05 in the final analysis.

All multivariable models were assessed for multicollinearity using variance inflation factors (VIFs), with a cutoff of 10 to flag collinearity concerns. Statistical significance was defined as $p < 0.05$, and adjusted odds ratios (AORs) with their corresponding 95% confidence intervals (CIs) were reported. Robust standard errors were used to account for clustering where appropriate.

2.11. Ethical Considerations

The study protocol received ethical approval from the Makerere University College of Health Sciences, School of Biomedical Sciences Institutional Review Board (IRB), under reference number SBS-2023-465. Administrative clearance was obtained from the Wakiso District Local Government, and permission to conduct the study was granted by relevant community leaders in accordance with local regulations and cultural norms. Written informed consent was obtained from all poultry farm owners or managers before data collection. All completed survey tools were securely stored in lockable cabinets accessible only to the research team.

3. Results

3.1. Sociodemographic Characteristics, Management Practices on Medication Use

A total of 492 participants were recruited in the study with a response rate of 92.0% (455/492). The sociodemographic results of the respondents are summarized in Table 2. These socio-demographic characteristics revealed a male-dominated sample, with 67.0% (n = 301) male and 32.9% (n = 148) female participants. The majority of respondents had attained a diploma (44.9%, n = 201) or a bachelor's degree (28.1%, n = 126), while a small proportion had postgraduate qualifications (1.3%, n = 6). Poultry farmers constituted the largest group responsible for medication (58.2%, n = 265), followed by veterinary paraprofessionals (26.4%, n = 120) and veterinary surgeons (15.4%, n = 70). Intensive production systems were the most common (65.6%, n = 296), compared to semi-intensive (26.8%, n = 121) and extensive systems (7.5%, n = 34).

The most frequently treated conditions were colibacillosis (35.2%, n = 160) and Gomboro disease (15.8%, n = 72), while other conditions such as salmonellosis (12.5%, n = 57) and coccidiosis (11.2%, n = 51) were less common. Veterinary drug shops were the primary source of medicines (82.4%, n = 375), with fewer respondents relying on veterinary pharmacies (14.1%, n = 64) or human drug shops (3.1%, n = 14). The median years of experience varied by role, with poultry farmers having the most experience (median = 6 years, IQR = 3 - 10), followed by veterinary surgeons (median = 5 years, IQR = 4 - 8) and veterinary paraprofessionals (median = 3 years, IQR = 2 - 5). Flock sizes also varied significantly, with a median of 500 birds (IQR = 200-2000) and a median of 49.5 sick birds (IQR = 19 - 156). The mean age of respondents was 35.7 years (SD = 9.3).

Table 2. Sociodemographic characteristics, management practices on medication use.

Socio-demographic characteristic	No. of respondents	Percentage (%)
Gender, n = 449		
Male	301	67.0
Female	148	32.9
Level of education, n = 449		
No education	12	2.7
Primary	11	2.5
Secondary	92	20.5
Diploma	201	44.9
Bachelors	126	28.1
Postgraduate	6	1.3
Personnel in charge of medication, n = 455		
Poultry farmer	265	58.2
Veterinary surgeon	70	15.4
Veterinary paraprofessional	120	26.4
Type of production, n = 451		
Extensive	34	7.5
Intensive	296	65.6
Semi-intensive	121	26.8
Recent condition treated, n = 455		
Salmonellosis	57	12.5
Newcastle	36	7.9
Colibacillosis	160	35.2
Fowl cholera	28	6.2
Coccidiosis	51	11.2
Gumboro	72	15.8
Bumblefoot	31	6.8
Others	20	4.4
Source of medicines used, n = 453		
Human drug shop	14	3.1
Veterinary drug shop	375	82.4
Veterinary pharmacy	64	14.1
Years of experience	**Median**	**IOR**
Poultry farmers	6	3 - 10
Veterinary surgeon	5	4 - 8
Veterinary paraprofessional	3	2 - 5
Flock size		
Number of birds	500	200 - 2000
Number of sick birds	49.5	19 - 156
Age (Years)	**Mean**	**SD**
	35.7	9.3

3.2. Medication Error Rates Across Different Types of Personnel and Medicines

The analysis of medication error rates revealed significant variation across per-

sonnel types and medicines (Table 3). Amoxicillin, representing 10.7% (n = 44) of the medicines used, had the lowest prescription error rates among veterinary surgeons (4.2%, 95% CI: 0.6 - 8.0), compared to veterinary paraprofessionals (10.6%, 95% CI: 6.0 - 15.2) and poultry farmers (9.6%, 95% CI: 5.1 - 14.2). Similarly, administration errors were lowest for veterinary surgeons (4.4%, 95% CI: 1.3 - 7.5) and highest for poultry farmers (10.1%, 95% CI: 5.3 - 14.9). Monitoring errors, however, were more prevalent among veterinary surgeons (8.9%, 95% CI: 3.6 - 14.2) compared to poultry farmers (1.1%, 95% CI: 0.0 - 2.4).

For Enrofloxacin, which accounted for 18.0% (n = 74) of medicines, prescription errors were highest among veterinary paraprofessionals (18.0%, 95% CI: 12.0 - 24.0) and poultry farmers (16.1%, 95% CI: 10.0 - 22.2), while veterinary surgeons had lower rates (7.1%, 95% CI: 3.1 - 11.1). Monitoring errors for Enrofloxacin were notably high among veterinary surgeons (15.0%, 95% CI: 9.2 - 20.8).

Oxytetracycline, representing 17.5% (n = 72) of medicines, followed a similar trend, with veterinary paraprofessionals reporting the highest prescription (17.5%, 95% CI: 12.0 - 23.0) and administration errors (17.5%, 95% CI: 12.0 - 23.0), while poultry farmers had the lowest monitoring errors (1.8%, 95% CI: 0.0 - 4.3). Across all medicines, veterinary surgeons consistently demonstrated lower prescription and administration error rates compared to veterinary paraprofessionals and poultry farmers, but higher monitoring errors. Poultry farmers, on the other hand, had the lowest monitoring error rates across all medicine types, rarely exceeding 2%.

Table 3. Medication error rates across different types of personnel and medicines.

Proportion of medicines used for treatment, % (n/412)	Personnel	Prescription Errors % (95% CI)	Administration Errors % (95% CI)	Monitoring Errors % (95% CI)
Amoxicillin 10.7 [44]	Veterinary Surgeon	4.2 (0.6 - 8.0)	4.4 (1.3 - 7.5)	8.9 (3.6 - 14.2)
	Veterinary Paraprofessional	10.6 (6.0 - 15.2)	10.7 (6.0 - 15.4)	7.5 (2.9 - 12.1)
	Poultry Farmers	9.6 (5.1 - 14.2)	10.1 (5.3 - 14.9)	1.1 (0.0 - 2.4)
Amprolium 9.2 [38]	Veterinary Surgeon	3.6 (0.3 - 6.8)	3.8 (0.4 - 7.2)	7.7 (3.1 - 12.3)
	Veterinary Paraprofessional	9.2 (5.2 - 13.2)	9.2 (5.2 - 13.2)	6.5 (2.1 - 11.0)
	Poultry Farmers	8.3 (4.0 - 12.6)	8.7 (4.3 - 13.1)	1.0 (0.0 - 2.1)
Enrofloxacin 18.0 [74]	Veterinary Surgeon	7.1 (3.1 - 11.1)	7.4 (3.3 - 11.5)	15.0 (9.2 - 20.8)
	Veterinary Paraprofessional	18.0 (12.0 - 24.0)	18.0 (12.0 - 24.0)	12.4 (7.4 -17.4)
	Poultry Farmers	16.1 (10.0 - 22.2)	17.0 (10.8 - 23.2)	1.9 (0.1 - 3.6)
Gentamicin 6.1 [25]	Veterinary Surgeon	2.4 (0.0 - 4.9)	2.5 (0.1 - 5.0)	5.1 (1.4 - 8.8)
	Veterinary Paraprofessional	6.1 (2.1 - 10.2)	6.1 (2.1 - 10.2)	4.2 (1.0 - 7.5)
	Poultry Farmers	5.4 (1.3 − 9.5)	5.7 (1.4 - 10.0)	0.6 (0.0 - 1.8)
Oxytetracycline 17.5 [72]	Veterinary Surgeon	6.9 (2.8 - 11.0)	7.2 (2.9 - 11.5)	14.6 (8.5 - 20.7)

Continued

	Veterinary Paraprofessional	17.5 (12.0 - 23.0)	17.5 (12.0 - 23.0)	12.0 (7.0 - 17.0)
	Poultry Farmers	15.7 (10.0 - 21.4)	16.5 (10.5 - 22.4)	1.8 (0.0 - 4.3)
Sulfadiazine & Trimethoprim 6.3 [26]	Veterinary Surgeon	2.5 (0.0 - 5.2)	2.6 (0.1 - 5.1)	5.3 (1.3 - 9.2)
	Veterinary Paraprofessional	6.3 (2.0 - 10.6)	6.3 (2.0 - 10.6)	4.3 (1.0 - 7.6)
	Poultry Farmers	5.7 (1.5 - 9.9)	6.0 (1.4 - 10.7)	0.7 (0.0 - 2.1)
Tetracycline 6.6 [27]	Veterinary Surgeon	2.6 (0.0 - 5.3)	2.7 (0.0 - 5.6)	5.5 (1.4 - 9.6)
	Veterinary Paraprofessional	6.6 (2.1 - 11.2)	6.6 (2.1 - 11.2)	4.5 (1.0 - 8.0)
	Poultry Farmers	5.9 (1.4 - 10.5)	6.2 (1.3 - 11.1)	0.7 (0.0 - 2.2)
Tylosin 9.2 [38]	Veterinary Surgeon	3.6 (0.5 - 6.7)	3.8 (0.5 - 7.1)	7.7 (3.1 - 12.3)
	Veterinary Paraprofessional	9.2 (4.8 - 13.7)	9.2 (4.8 - 13.7)	6.5 (2.0 - 11.0)
	Poultry Farmers	8.3 (4.0 - 12.6)	8.7 (4.1 - 13.2)	1.0 (0.0 - 2.1)
Others 16.5 [68]	Veterinary Surgeon	6.5 (2.5 - 10.5)	6.8 (2.7 - 10.9)	13.8 (8.0 - 19.6)
	Veterinary Paraprofessional	16.5 (11.3 - 21.6)	16.5 (11.3 - 21.6)	11.4 (6.5 - 16.3)
	Poultry Farmers	14.8 (9.4 - 20.2)	15.6 (10.3 - 20.9)	1.7 (0.0 - 4.3)

CI: Confidence Interval, n = number of participants who committed an error.

3.3. Prevalence of Medication Errors in Poultry Practice

The prevalence of medication errors in poultry practice was high at 83.5% (380/455; CI: 80.0% - 87.0%)) (Table 4), with prescription errors occurring in 82.3% (95% CI: 80.0 - 87.0, n = 232) of cases, administration errors in 87.5% (95% CI: 83.8 - 91.2, n = 336), and monitoring errors in 38.5% (95% CI: 32.5 - 44.5, n = 148). Among personnel, veterinary paraprofessionals were responsible for 100% of prescription errors (95% CI: 97.6 - 100.0, n = 119) and administration errors (95% CI: 96.6 - 100.0, n = 109), while poultry farmers committed 89.7% of prescription errors (95% CI: 84.0 - 95.4, n = 87) and 94.4% of administration errors (95% CI: 90.8 - 98.0, n = 202).

Veterinary surgeons had the lowest error rates, with 39.4% (95% CI: 28.7 - 50.1, n = 26) for prescription errors and 41.0% (95% CI: 29.0 - 53.0, n = 25) for administration errors. The most common prescription errors included inappropriate dosing (67.0%, 95% CI: 61.4 - 72.6, n = 189) and longer duration of therapy than recommended (46.5%, 95% CI: 40.8 - 52.2, n = 131). Administration errors were predominantly due to inappropriate dosing (74.2%, 95% CI: 69.4 - 79.0, n = 285) and longer therapy duration (51.8%, 95% CI: 46.4 - 57.2, n = 199). Monitoring errors were most frequently attributed to failure to act on monitoring results (22.1%, 95% CI: 17.1 - 27.1, n = 85), with veterinary surgeons being the most likely to commit such errors (83.6%, 95% CI: 76.5 - 90.7, n = 51).

Table 4. Prevalence of specific medication errors in poultry practice.

Proportion of Medication Errors	Personnel in charge of error committed, % (95% CI), (n)			
Prescription errors	**Overall 82.3(80.0 - 87.0) (232) n = 282**	**Veterinary Surgeon, n = 66**	**Veterinary paraprofessional, n = 119**	**Poultry farmers, n = 97**
		39.4 (28.7 - 50.1) [26]	**100.0 (97.6 - 100.0) [119]**	**89.7 (84.0 - 95.4) [87]**
Drugs not appropriate for indication	28.4 (23.1 - 33.7) [80]	12.1 (4.7 - 19.5) [8]	35.3 (24.9 - 45.7) [42]	30.9 (21.4 - 40.4) [30]
Short dosing frequency	18.4 (14.0 - 22.8) [52]	9.1 (2.3 - 15.9) [6]	15.1 (8.3 - 21.9) [18]	28.9 (19.7 - 38.1) [28]
Drug-drug interaction	3.9 (1.7- 6.1) [11]	3.0 (0.0 - 7.0) [2]	6.7 (2.1 - 11.3) [8]	1.03 (0.9 - 3.0) [1]
Inappropriate dose	**67.0 (61.4 - 72.6) (189)**	24.2 (15.0 - 33.4) [16]	**84.0 (77.3 - 90.7) [100]**	**75.3 (66.4 - 84.2) [73]**
Long duration of therapy than recommended	**46.5 (40.8 - 52.2) [131]**	16.7 (8.3 - 25.1) [11]	47.9 (38.8 - 57.0) [57]	65.0 (54.9 - 75.1) [63]
Invalid route of administration	6.0 (3.2 - 8.8) [17]	4.6 (0.0 - 9.8) [3]	8.40 (3.4 - 13.4) [10]	4.1 (0.2 - 8.0) [4]
Multiple drugs for the same indication	7.1 (4.2 - 10.0) [20]	12.1 (3.8 - 20.4) [8]	8.4 (3.4 - 13.4) [10]	2.1 (−0.7 - 4.9) [2]
Administration errors	**87.5 (83.8 - 91.2) (336) n = 384**	**Veterinary surgeon, n = 61**	**Veterinary paraprofessional n = 109**	**Poultry farmers n = 214**
		41.0 (29.0- 53.0) [25]	**100.0 (96.6 - 100.0) [109]**	**94.4 (90.8 - 98.0) (202)**
Wrong medication administered to the patient	26.6 (21.7 - 31.5) [102]	11.5 (5.7 - 21.8) [7]	31.2 (23.3 - 40.4) [34]	28.5 (22.9 - 34.9) [61]
Inappropriate dose	74.2 (69.4 - 79.0) [285]	14.8 (6.5 - 23.1) [9]	**95.4 (91.8 - 99.0) [104]**	**80.4 (73.7- 87.1) [172]**
wrong route of administration	6.8 (4.3 - 9.3) [26]	11.5 (3.5 - 19.5) [7]	11.0 (5.1 - 16.9) [12]	3.3 (0.9 - 5.7) [7]
Short dosing frequency	20.3 (15.9 - 24.7) [78]	3.3 (0.0 - 8.5) [2]	14.7 (8.1 - 21.3) [16]	28.0 (17.1 - 38.9) [60]
Long duration of therapy than recommended	**51.8 (46.4 - 57.2) [199]**	21.3 (12.4 - 30.2) [13]	17.4 (7.8 - 27.0) [19]	78.0 (70.7 - 85.3) [167]
Multiple drugs for the same indication	4.2 (1.8 - 6.6) [16]	4.9 (0.0 - 10.3) [3]	6.4 (1.6 - 11.2) [7]	2.8 (0.5 - 5.1) [6]
Monitoring errors	**38.5 (32.5 - 44.5) [148] n = 384**	**Veterinary surgeon n = 61**	**Veterinary professional n = 109**	**Poultry farmers n = 214**
		83.6 (76.5 - 90.7) [51]	68.8 (60.1 - 77.5) [75]	10.3 (5.6 - 15.0) [22]
Monitoring not performed	10.2 (6.9 - 13.5) [39]	19.7 (10.8 - 28.6) [12]	22.9 (15.1 - 30.7) [25]	0.9 (0.0 - 2.1) [2]
Necessary monitoring not ordered	19.3 (14.6 - 24.0) [74]	**65.6 (54.5 - 76.7) [40]**	28.4 (20.0- 36.8) [31]	1.4 (0.0 - 3.3) [3]
Monitoring results not acted upon	**22.1 (17.1 - 27.1) [85]**	23.0 (13.4 - 32.6) [14]	51.9 (42.6 - 61.2) [54]	7.9 (3.9 - 11.9) [17]

CI: Confidence Interval, n = number of participants who committed an error.

3.4. Associated Risk Factors for Medication Errors in Poultry Practice

The analysis of risk factors associated with medication errors in poultry practice revealed several significant contributors (Table 5). Empirical treatment is common in poultry practice. Not conducting laboratory tests to confirm the diagnosis and hence tailor specific treatment significantly increased the odds of medication errors by 6.9 times (CI: 2.8 - 17.0, $p < 0.001$) in the crude analysis and by 8.4 times (CI: 2.1 - 34.4, $p = 0.003$) in the adjusted analysis compared to farms where lab tests were conducted. The involvement of poultry farmers and veterinary paraprofessionals in charge of medication significantly raised the odds of medication errors by 6.5 times (CI: 2.6 - 16.0, $p < 0.001$) relative to veterinary surgeons.

Veterinary surgeons examining the farms were associated with a lower likelihood of medication errors, with the odds being 0.2 times (CI: 0.1 - 0.6, p-value < 0.001) compared to poultry farmers. Extensive or semi-intensive production systems showed an increased odds of medication errors by 2.9 times (CI: 0.8 - 10.0, p-value = 0.1) in the crude analysis and by 5.1 times (CI: 0.6 - 43.7, p-value = 0.1) in the adjusted analysis compared to intensive systems, although this was not statistically significant. Education level indicated that those with secondary education and below had an increased odds of medication errors by 2.9 times (CI: 0.7 - 12.5, p-value = 0.17) compared to those with tertiary education with odds of medication errors by 1.0 times. Veterinary paraprofessionals examining the farms had an increased odds of medication errors by 2.1 times (CI: 0.5 - 9.4, p-value = 0.4) compared to poultry farmers.

Table 5. Associated risk factors contributing to medication errors in poultry practice.

Factor	Crude analysis			Adjusted analysis		
	Odds ratio	(95%CI)	p-value	Odds ratio	95%CI	p-value
Age (Years)	1.02	0.95 - 1.05	0.908			
Farm visited/day	1.23	0.72 - 2.08	0.435	1.24	0.67 - 2.27	0.482
Years of experience	0.98	0.92 - 1.04	0.505	0.98	0.83 - 1.16	0.889
Sex						
Male	1.09	0.42 - 2.76	0.859	1.82	0.45 - 7.32	0.400
Female	1.00			1.00		
Level of education						
Secondary and below	2.85	0.65 - 12.53	0.165			
Tertiary	1.00					
Who examined the farms						
Poultry farmer	1.00					
Veterinary Surgeon	**0.17**	**0.05, 0.61**	**0.007**			
Veterinary paraprofessional	2.05	0.45, 9.36	0.353			
Personnel in-charge of medication						
Poultry farmer and Veterinary paraprofessional	**6.50**	**2.63 - 16.03**	**<0.001**			

Continued

Veterinary Surgeon	1.00					
Type of production						
Extensive/semi-intensive	2.89	0.83 - 10.01	0.093	5.06	0.58 - 43.68	0.140
Intensive	1.00			1.00		
Lab tests done						
Yes	1.00			**1.00**		
No	**6.86**	**2.77 - 16.97**	**<0.001**	**8.41**	**2.05 - 34.43**	**0.003**

3.5. Associated Consequences of Medication Errors in Poultry Practice

Medication errors had several associated consequences with significant impacts. The odds of death were 9.2 times (CI: 1.3 - 6.5, p-value = 0.027) higher when medication errors occurred. The likelihood of economic losses increased by 6.6 times (CI: 1.7 - 26.7, a p-value = 0.008) higher when medication errors occurred. The likelihood of reduced egg production increased by 4.9 times (CI 1.1 - 21.3, p-value = 0.035) following medication errors. The odds of delayed maturity were 4.5 times (CI: 1.02 - 19.6, p-value = 0.046) higher when medication errors occurred (Table 6).

The odds of reduced weight were 3.4 times (CI: 1.24 - 9.59, p-value = 0.018) higher in the presence of medication errors. The likelihood of birds being treated for a longer duration increased by 8.1 times (CI: 1.18 - 54.99, p-value = 0.033) higher when medication errors occurred (Table 6).

Table 6. Associated consequences of medication errors in poultry practice.

Associated consequences of medication errors	Unadjusted Odds ratio	95%CI	p-value
Death	9.23	1.29 - 65.90	0.027
Reduced egg production	4.88	1.11 - 21.28	0.035
Delayed maturity	4.49	1.02 - 19.59	0.046
Reduced weight	3.44	1.24 - 9.59	0.018
Birds treated for longer time	8.07	1.18 - 54.99	0.033
Economic losses	6.63	1.65 - 26.67	0.008

These findings highlight the severe impacts of medication errors on poultry health, productivity, and farm profitability, underscoring the need for effective interventions to minimize such errors and their consequences.

4. Discussion

This study investigated the prevalence, risk factors, and associated consequences of medication errors in poultry practice in Wakiso District from January to November 2024. The findings revealed a notable gender disparity among poultry practitioners, with males constituting the majority (67.1%) and females representing a smaller proportion (32.9%) (Table 2). This imbalance aligns with traditional gender roles in agricultural communities, where males are often more involved in

medication-related tasks and farm management decisions. Additionally, the study found that the highest level of education for most participants was secondary education (44.9%) (**Table 2**), indicating limited advanced training in veterinary medicine or veterinary practise related disciplines among many practitioners.

This educational gap likely contributes to higher incidences of medication errors due to insufficient knowledge of proper dosage, drug interactions, and administration techniques. These findings align with previous studies that highlighted gender imbalances in African agriculture, favouring males as a result of prevailing cultural norms [13]. However, recent evidence indicates increasing female involvement in urban and peri-urban farming, suggesting evolving gender roles [14]. These findings underscore the need for targeted interventions to improve gender equity and educational opportunities in veterinary pharmacology and disease management, such as access to further education and continuous professional development in veterinary therapeutics and safe medication practices.

This study reveals significant differences in medication error rates across personnel types veterinary surgeons, paraprofessionals, and poultry farmers and among various commonly used veterinary medicines. The observed prescription error rates among veterinary paraprofessionals and poultry farmers who are not legally permitted to prescribe raise substantial concerns regarding compliance with veterinary pharmaceutical regulations. For example, prescription error rates for Enrofloxacin and Oxytetracycline were significantly higher among paraprofessionals (18.0% and 17.5%, respectively) and poultry farmers (16.1% and 15.7%) compared to veterinary surgeons (7.1% and 6.9%). This is consistent with findings indicating that undertrained personnel in low-resource settings often misinterpret drug labels or depend on empirical, non-standardized dosing regimens, thereby increasing the risk of antibiotic misuse and resistance development [15]. This discrepancy suggests widespread unauthorized prescribing and underscores a critical need for stricter enforcement of veterinary drug use policies. Similar patterns have been reported in prior studies. For instance, studies have reported high rates of antibiotic misuse and prescription errors in poultry farms where non-veterinary personnel make treatment decisions [7]. Similarly, frequent inappropriate antibiotic use in livestock has been reported in Uganda, largely attributed to limited access to qualified veterinary professionals, reflecting similar trends observed in this study [16].

The study reported a high prevalence of medication errors in poultry practice (83.5%) (**Table 3**), with administration errors being the most common (87.5%). Veterinary paraprofessionals exhibited the highest error rates (100%), followed by poultry farmers (94.4%). The primary contributing factors included inadequate education, lack of laboratory tests, and insufficient medication experience. These findings are consistent with reports identifying administration errors as the most prevalent (85.0%) and linking them to inadequate training and limited diagnostic testing [17]. Conversely, other studies have shown that prescribing errors occur more frequently than administration errors [18].

These findings align with Uganda's broader challenges in antimicrobial stewardship. A recent report indicated that 57.1% of imported veterinary antimicrobials fall within the EMA's "low-risk" (Category D) classification; however, their misuse such as incorrect dosing or empirical use without diagnostics heightens the risk of antimicrobial resistance [8]. For instance, oxytetracycline, the most consumed antimicrobial (44.8% of imports), was also associated with high prescription errors (17.5% among paraprofessionals) in our study. This synergy between unregulated consumption and poor medication practices underscores the need for integrated interventions, including the diagnostic support by calling up affordable laboratory services to reduce empirical treatment, Farmer training, targeting high-error groups like the paraprofessionals regarding drug administration, as well as policy enforcement, aligning Uganda's AMR National Action Plan with veterinary drug distribution reforms.

Prescription errors in this study were the second most common (82.3%), driven by factors such as inadequate veterinary officers not readily available to prescribe medicines for the farmers, limited supervision, and oversight by the regulatory authorities. This is consistent with reports indicating a high prevalence of prescription errors (75.0%) caused by incorrect dosages, drug interactions, and misdiagnosis [19]. Monitoring errors were the least common (38.5%), with veterinary surgeons showing the highest rates (83.6%), likely due to high costs of following up with most farmers not willing to pay for the follow up charges and heavy workloads. These findings emphasize the urgent need for systemic changes in veterinary service delivery and support, including increasing the number of veterinary surgeons at the district level and robust regulatory frameworks to reduce medication errors. Conversely, poultry farmers had the lowest monitoring errors across all drugs, which might be attributed to the regular observation of birds as part of daily husbandry. However, this should not be misconstrued as a strength, since low monitoring errors from farmers may stem from a lack of formal reporting or recognition of adverse drug events. The findings are further supported by reports showing that, although trained veterinarians tend to make fewer prescribing errors, they often lack structured follow-up systems, particularly in decentralized and rural settings [20]. Meanwhile, non-professionals may overlook errors altogether, leading to underreporting rather than improved safety.

The major risk factor for medication errors was the failure to conduct laboratory tests (**Table 4**). The absence of diagnostic testing often leads to misdiagnosis, resulting in prescription, administration, and monitoring errors. These findings align with reports emphasizing the impact of inadequate testing on medication errors. However, other studies have noted that, while laboratory testing is essential, additional factors such as communication breakdowns also contribute significantly [21]. This discrepancy highlights the complexity of medication error prevention and the need for comprehensive strategies addressing multiple risk factors. In Wakiso District, where laboratory testing is often unavailable and medication decisions are made empirically, such errors are likely to amplify AMR, pos-

ing risks to animal health, food safety, and public health. These findings underscore the need for integrated interventions that combine antimicrobial stewardship education with policies promoting evidence-based drug use. Strengthening regulatory oversight of veterinary drug distribution, ensuring access to affordable diagnostics, and implementing mandatory training and certification for drug prescribers and administrators are essential. Embedding AMR awareness into veterinary curricula, supporting community-based veterinary extension services, and subsidizing diagnostic infrastructure in rural areas could transform medication practices. By addressing medication errors and AMR as interconnected issues, Uganda can improve poultry productivity, safeguard public health, and align with global One Health initiatives.

The personnel involved in medication management significantly influenced error rates. Veterinary surgeons were less likely to make errors compared to veterinary paraprofessionals and poultry farmers, likely due to their higher level of education and expertise in medication selection, administration, and management. This finding aligns with reports indicating that physicians are less likely to make medication errors than nurses, a difference attributed to variations in education and training [21]. These results underscore the importance of education in mitigating medication errors, as veterinary surgeon with tertiary education typically possess greater knowledge, critical thinking skills, and adherence to best practices.

The study highlighted significant consequences of medication errors, including increased economic losses, higher mortality rates, and prolonged treatment durations. Economic losses were primarily due to increased mortality from incorrect dosing and inadequate monitoring (**Table 5**). These findings align with reports demonstrating that antibiotic misuse in poultry production contributes to increased mortality rates and economic losses [22]. The study's findings emphasize the critical importance of effective medication management practices in poultry farming to maintain flock health, optimize treatment efficiency, and ensure economic sustainability.

5. Study Limitations

Some participants were uncooperative, which may have affected data collection. Also collected data is liable to potential social desirability bias due to self-reporting and our cross-sectional design limits causal inference.

6. Conclusion

Medication errors are prevalent in poultry practice in Wakiso district Uganda, with veterinary paraprofessionals and poultry farmers contributing to the highest burden with most common error being administration errors (87.5%). Major risk factors included the lack of laboratory services for diagnosis and low levels of education. The consequences of medication errors included increased mortality, prolonged treatment durations, adverse drug reactions, reduced egg production, and economic losses. These findings highlight the need for targeted interventions, such as farmer

trainings, continuous professional development training programs for veterinary paraprofessionals and veterinary surgeons, diagnostic support such as mobile diagnostics and rapid diagnostic tools, and regulatory frameworks, to reduce medication errors and their impacts on poultry health and farm productivity.

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Authors' Contributions

Rogers Dankaine conceived the study, drafted the initial manuscript, and participated in the study design, implementation, statistical analysis, and interpretation of findings. Godfrey Bbosa and Isaac Kimbowa contributed significantly to the study design, statistical analysis, and interpretation of results. Patrick Vudriko was involved in the study design and provided critical input during manuscript development. All authors reviewed and approved the final version of the manuscript.

Data Sharing Statement

Data are available from the lead author, Rogers Dankaine.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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