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Drivers of Animal Disease and Nontherapeutic Antibiotic Practices Among Smallholder Farmers in Burkina Faso

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ABSTRACT

Limiting the nontherapeutic use of antibiotics (ABU) in livestock is increasingly viewed as a critical component of global efforts to slow the emergence of antimicrobial resistance (AMR). Yet, such use may still play a role in day-to-day disease management on farms. If reductions in nontherapeutic ABU are to be achieved without compromising animal health, farmers may need viable alternative strategies to prevent disease and mitigate risk. It is therefore essential to first determine whether nontherapeutic ABU is actually linked to improved health outcomes in livestock. Equally important is the identification of non-antibiotic factors that contribute to healthier herds and reduce the perceived need for routine antibiotic use, alongside factors that encourage producers to adopt better antibiotic stewardship practices. To address these issues, we analyzed data from the AMUSE survey, which captures smallholder farmers' knowledge, attitudes, and practices regarding AMR. The study included 320 herds belonging to 216 smallholder farms in Burkina Faso, representing cattle, small ruminants, and poultry. Binary logistic regression models were used to explore predictors of both animal disease occurrence and the use of antibiotics for nontherapeutic purposes. Analyses showed a positive relationship between nontherapeutic ABU and the presence of disease in herds, although further work is needed to unpack potential reverse causation. Herds managed by farmers who predominantly relied on public veterinary services or who had more years of formal schooling were less likely to report disease. In contrast, farmers who typically sought assistance from community animal health workers were more likely to employ antibiotics nontherapeutically, while consultation with public veterinarians was associated with lower use. For goats and sheep, receiving diagnostic or treatment support from any type of animal health professional was linked to increased nontherapeutic ABU. These results point to the importance of strengthening public veterinary services and improving educational opportunities as part of efforts to promote prudent antibiotic use while safeguarding animal health. They also suggest that some non-veterinarian animal health providers may prioritize immediate clinical outcomes over stewardship considerations, underscoring the need for targeted training and policy support.

Keywords: Antimicrobial resistance, Livestock production, Antibiotic stewardship, One Health, Epidemiology, Burkina Faso

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Introduction

Antimicrobial resistance (AMR)—the capacity of microorganisms to withstand antimicrobial agents—poses an escalating threat to human and environmental health as well as to the stability of global food systems. Rising levels of antimicrobial use (AMU) in human populations have contributed significantly to the acceleration of AMR [1]. Livestock production constitutes one of the largest sources of antibiotic consumption worldwide and has therefore become a central focus of numerous national and international policy efforts [2, 3]. Many of these initiatives call for reductions in what is termed "irrational" AMU, typically encompassing nontherapeutic applications such as prophylactic, metaphylactic, or growth-promoting use [4–6].

However, framing all nontherapeutic antibiotic practices as inherently inappropriate overlooks important complexities. Although some studies indicate that curbing such use in smallholder settings does not harm—and may even improve—animal health [7, 8], other research provides strong evidence that sub-therapeutic antibiotic doses can enhance animal health and productivity [9]. Previous work from this research consortium has likewise shown that nontherapeutic antibiotic use can help prevent disease in smallholder herds [10]. Potential growth-promoting effects may also be economically significant for smallholder farmers and relevant for national food security, particularly in contexts like Burkina Faso where rapid population growth coincides with persistent food insecurity [11, 12]. Moreover, smallholder livestock producers operate within complex economic and social networks involving traders, suppliers, creditors, pharmaceutical vendors, animal health workers, and others [13]. Imposing strict legal bans on antibiotic use in such systems may be impractical and could drive farmers toward unregulated or counterfeit products, ultimately exacerbating AMR risks.

These considerations underscore the challenge of promoting responsible antibiotic use on smallholder farms in ways that do not compromise animal health, farm livelihoods, or farmers' willingness to adopt new practices. Addressing this challenge requires clarity on three key issues.

First, it is necessary to understand the extent to which nontherapeutic antibiotic use contributes to disease prevention in smallholder systems—examined here by assessing the association between nontherapeutic AMU and reported animal disease. This helps determine whether restricting such use poses risks to food security or household income, given the strong negative impacts of livestock disease on both.

Second, identifying non-antibiotic factors that correlate with disease occurrence can highlight alternative practices that may protect animal health and serve as complementary interventions to reduce reliance on antibiotics.

Third, examining the determinants of nontherapeutic antibiotic use itself can reveal the social, economic, and management factors that shape stewardship behaviors and may offer points of leverage for improving antibiotic governance on smallholder farms.

To address these three research questions, we drew on data from the AMUSE survey [14], administered to smallholder livestock producers in the peri-urban zones surrounding Ouagadougou. AMUSE—developed by the International Livestock Research Institute—is a standardized instrument designed to capture knowledge, attitudes, and practices (KAP) related to antibiotic use and antimicrobial resistance in smallholder production systems [14]. The tool has been implemented in several countries, including Burkina Faso [15], Ethiopia [16], Senegal [17, 18], and Uganda [10, 19], contributing to a growing evidence base that supports AMR-related policy development at national and global scales. Its standardized format facilitates cross-country comparison, and similar analyses have previously been conducted using AMUSE data from Senegal [17] and Uganda [10].

In this study, binary logistic regression models were employed to identify factors associated with reported animal disease and with the nontherapeutic use of antibiotics among surveyed farms. The overarching aim was to assess whether nontherapeutic antibiotic use contributes to disease prevention in this setting, to identify non-antibiotic practices that support herd health and might lower reliance on such antibiotic use, and to determine which factors may encourage improved stewardship among livestock keepers.

Materials and Methods

Study Area

Ouagadougou, the capital of Burkina Faso, is the country's most densely populated urban center, with an estimated 2.4 million residents. The farms included in the study were situated in peri-urban neighborhoods on the outskirts of the city.

Study Population

The survey covered 216 smallholder livestock farms located in peri-urban Ouagadougou (Figure 1). These farms raised a mix of poultry, cattle, and small ruminants (sheep and goats). Because many farms kept more than one species, the dataset consisted of 320 distinct flocks or herds. Each flock or herd was analyzed as an independent observational unit.

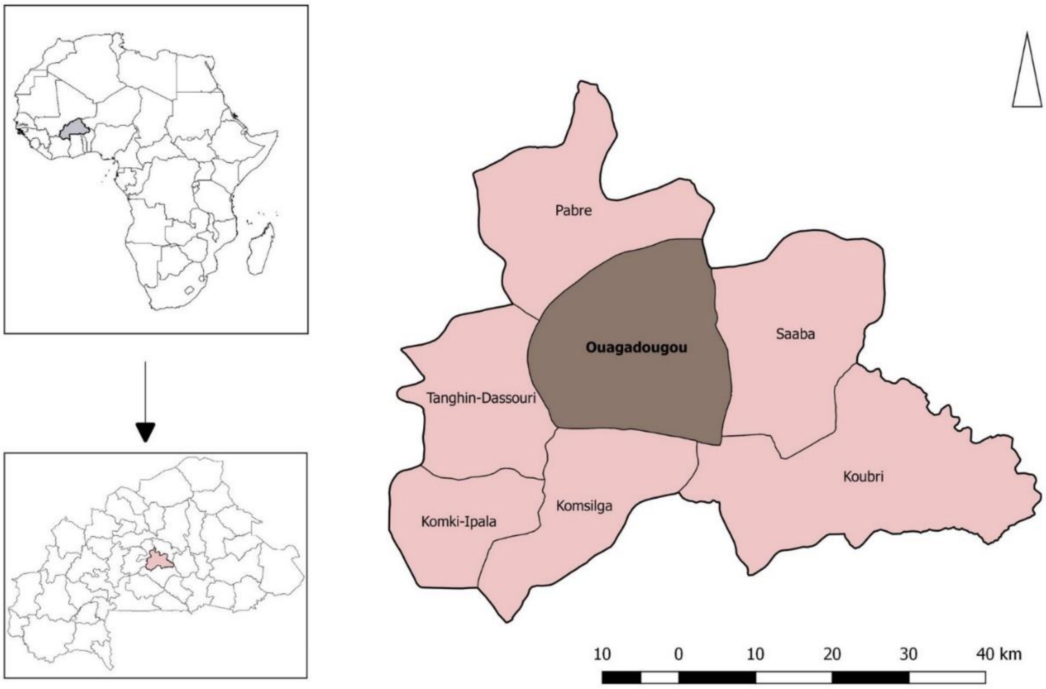

Figure 1. Map of the study area

Study design

This research relies on information obtained through the AMUSE instrument and therefore follows a retrospective design, using data originally collected by the International Livestock Research Institute (ILRI) as part of an earlier investigation. The dataset was explored through descriptive summaries and further examined using binary logistic regression to identify statistical associations.

Method of data collection

The analysis uses secondary data generated from a survey implemented between March and July 2020 in peri-urban Ouagadougou, Burkina Faso, which focused on documenting smallholder farmers' knowledge, attitudes, and practices surrounding antibiotic use [15]. During the fieldwork phase, the study team had temporary access to identifying information such as respondents' names and gender in order to manage data entry and verification. Data collection was conducted electronically using Open Data Kit (ODK), an open-source platform that enables surveys to be administered and recorded via smartphones. One person representing each farm was interviewed, with enumerators conducting interviews in either French or Mooré depending on the respondent's preferred language.

Sampling method and sample size calculation

Farmers were recruited from a directory of livestock producers in the Ouagadougou region during the same March–July 2020 period. For each listed farm, the manager—whether the owner or an appointed worker—was approached and invited to participate. Eligibility was limited to smallholder livestock farms; operations that were commercial in scale or not engaged in livestock production were excluded. The number of farms included reflects the sampling strategy of the original study for which the data were gathered [15], and the present research uses that dataset in full. The initial sample size had been calculated to detect differences between farms that consulted a veterinary professional before purchasing antibiotics and those that did not, applying an α of 5% and a 95% confidence interval. The calculation assumed that 12.1% of farms sought veterinary advice, based on estimates from earlier work [15, 20].

Data management and statistical analysis

All statistical procedures were conducted using RStudio version 2023.03.01 + 446 [21] in combination with R version 4.1.2 [22]. After cleaning, survey responses were compiled into a cross-sectional dataset. Farms maintaining multiple species contributed more than one observation, as each flock or herd was analyzed separately. Two variables were identified as the primary outcomes: whether the herd or flock had experienced disease in the preceding six months, and whether antibiotics had been used for nontherapeutic purposes. The survey recorded both prophylactic and fattening use; because all respondents reporting antibiotic use for fattening also reported prophylactic use, these categories were combined and treated as a single indicator of nontherapeutic antibiotic use for the purposes of analysis.

Binary logistic regression was applied to evaluate how different covariates influenced the probability of each outcome. In both the bivariate and multivariate analyses, statistical significance was examined at the 1% ($p < 0.01$), 5% ($p < 0.05$), and 10% ($p < 0.1$) thresholds. Following the approach used in other AMUSE-survey–based studies, as well as the original Burkina Faso analysis [10, 15, 17], any result with $p < 0.1$ was treated as statistically meaningful. All model specifications included a control for flock or herd size, since the likelihood of reporting at least one case of disease or nontherapeutic antibiotic use naturally increases with the number of animals.

Both categorical and continuous variables served as covariates in the logistic regressions. Categorical variables comprised indicators such as whether the farmer used antibiotics prophylactically, believed antibiotics could be used for fattening, sought care from a specific type of animal health provider, received diagnosis and treatment from a professional, as well as dummy variables for livestock species. Continuous covariates included the total number of animals in the flock or herd and the individual's level of formal education. For the categorical variables, the regression tables report adjusted odds ratios, corresponding to the odds of the outcome when the variable equals 1 relative to 0. For continuous variables, the tables report adjusted odds ratios associated with a one-unit increase in the covariate.

Selection of variables for the multivariate models followed a two-step process. First, each outcome was separately regressed on each covariate in a set of bivariate models, controlling only for flock or herd size. These analyses were conducted independently for each livestock species—cattle, poultry, sheep, and goats—and again using the full sample, in which species indicators were included. Subsequently, multivariate models were estimated for each outcome (both by species and for the combined dataset), incorporating only those covariates that were statistically significant in the bivariate regressions. Running species-specific models made it possible to identify whether the factors associated with animal disease or nontherapeutic antibiotic use differed across livestock types.

Ethical approval

Ethical clearance for the research was granted by the Ministry of Health of Burkina Faso under reference number 2020-9-186. Written, signed informed consent was obtained from all participants prior to data collection.

Results

The initial step involved estimating individual bivariate regressions to determine which explanatory variables would be suitable for later multivariate modelling. Only variables showing statistical significance in these preliminary models were retained, and the corresponding results are provided in the Supplementary Material.

Across species, the simple models revealed several noteworthy patterns related to the presence of disease. Among small ruminants (goats and sheep) and cattle, farms that reported using antibiotics preventively were also more likely to report disease within their flocks or herds. When the full dataset was examined collectively, this same positive association between prophylactic antibiotic use and disease remained evident. By contrast, two factors—higher formal education and primarily consulting public veterinary services—were associated with a lower probability of reporting disease at the whole-sample level. None of the variables tested showed a significant link to disease occurrence when chickens were analyzed on their own.

Patterns linked to nontherapeutic antibiotic use also varied across species. In the chicken subset, habitual reliance on community animal health workers corresponded with greater use of antibiotics for nontherapeutic purposes. Conversely, receiving diagnostic and treatment services from a professional, as well as depending mainly on public veterinarians, appeared to reduce the likelihood of such use. For goats and sheep, however, having a professional provide diagnosis and treatment showed a positive association with nontherapeutic use. When all species were pooled together, regular engagement with community animal health workers increased the odds of nontherapeutic antibiotic use, whereas consistent use of public veterinary services decreased those odds. No covariates exhibited a significant relationship with nontherapeutic use in cattle-only models.

Multivariate analyses for both outcome variables were subsequently estimated **(Tables 1 and 2)**, incorporating only the predictors that demonstrated statistical significance in the initial bivariate stage.

Table 1. Determinants of animal disease (adjusted odds ratio)

	Occurrence of disease in last 6 months		
	Goats and Sheep	Cattle	Whole sample
	(1)	(2)	(3)
Uses antibiotics prophylactically	17.559***	4.080*	2.044*
	$p = 0.001$	$p = 0.072$	$p = 0.062$
Primarily goes to a public vet			0.532*
			$p = 0.083$
Level of formal education			0.747**
			$p = 0.035$
Number of animals in the flock / herd	1.008	1.098**	1.000
	$p = 0.702$	$p = 0.039$	$p = 0.916$
Cow dummy			0.069***
			$p = 0.00000$
Goats and sheep dummy			0.039***
			$p = 0.000$
Constant	0.056***	0.084***	8.137***
	$p = 0.001$	$p = 0.002$	$p = 0.00003$
N	59	49	312

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table 2. Determinants of habitually using antibiotics for nontherapeutic purposes (adjusted odds ratio)

	Using antibiotics nontherapeutically		
	Chickens and other poultry	Goats and Sheep	Whole sample
	(1)	(2)	(3)
Primarily goes to a community animal health worker	7.265***		2.358**
	$p = 0.004$		$p = 0.020$
Primarily goes to a public vet	0.432*		0.512*
	$p = 0.094$		$p = 0.096$
Professional provides diagnosis and treatment	0.438	4.797**	
	$p = 0.114$	$p = 0.020$	
Number of animals in the flock / herd	1.001**	0.983	1.001**
	$p = 0.013$	$p = 0.497$	$p = 0.042$
Cow dummy			0.072***
			$p = 0.00000$
Goats and sheep dummy			0.073***
			$p = 0.000$
Constant	3.664***	0.239**	2.940***
	$p = 0.008$	$p = 0.037$	$p = 0.004$
N	212	59	320

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

In the multivariate models **(Table 1)**, preventive antibiotic use continued to show a positive association with reported disease among goats and sheep, cattle, and the pooled sample. When all species were analyzed together, two factors—higher levels of formal education and mainly consulting public veterinarians—were linked to a reduced likelihood of disease.

For nontherapeutic antibiotic use **(Table 2)**, regularly relying on community animal health workers remained a significant positive predictor for poultry and for the combined dataset. In contrast, predominant use of public veterinary services was consistently linked to lower odds of prophylactic or other nontherapeutic antibiotic use in poultry and across all flocks and herds. Among goats and sheep, receiving diagnosis and treatment from an animal health professional continued to correlate positively with nontherapeutic use, though this relationship no longer held for poultry.

Discussion

Overall, the analysis indicates that routine prophylactic antibiotic use is associated with higher reported levels of disease in smallholder livestock systems. In contrast, farmers with more formal schooling and those who relied primarily on public veterinarians tended to report fewer disease events.

Patterns in nontherapeutic antibiotic use followed a similar provider-related trend: farmers who depended largely on community animal health workers were more likely to use antibiotics for nontherapeutic reasons, whereas those engaging public veterinarians showed lower use. For small ruminants, any form of professional diagnosis and treatment—regardless of provider type—was linked to greater nontherapeutic use.

The positive relationship observed between nontherapeutic antibiotic use and disease warrants careful interpretation. Evidence from controlled trials in other settings suggests that such habitual use may offer little protective benefit, and in some cases may worsen health outcomes on smallholder farms [8]. Conversely, stewardship interventions that combine reduced antibiotic use with improved biosecurity and non-antimicrobial supplements have been shown to enhance poultry health [7].

Nonetheless, evidence on the role of nontherapeutic antibiotics remains mixed. Earlier AMUSE-based research from Uganda pointed to a protective effect against disease [10], and work in Senegal suggested productivity benefits associated with such use [17]. Broader literature also notes that sub-therapeutic dosing can yield gains in animal performance [9]. The correlation found here may also reflect reverse causation: farms experiencing more disease in the preceding six months might adopt more cautious, preventive antibiotic routines thereafter, leading to an apparent positive association between disease and nontherapeutic use.

The inverse association between disease occurrence and the use of public veterinary services indicates that these providers may play an important role in maintaining herd and flock health. This aligns with findings from Uganda, where engagement with animal health services was linked to improved disease outcomes in smallholder systems [10]. Notably, similar benefits were not observed for other categories of animal health providers. The absence of a protective effect from private veterinarians—irrespective of their level of training—raises concerns about potential financial motives that may influence prescribing practices. Stakeholders participating in the SEFASI consortium's 2022 Dakar workshop highlighted the possibility that private practitioners may be inclined to promote costly or unsuitable treatments in ways that are not always aligned with optimal animal health [23].

The study also found that farmers who primarily relied on community animal health workers were more likely to engage in nontherapeutic antibiotic use. Likewise, in small ruminants, receiving diagnosis and treatment from any type of animal health professional was positively associated with such use. These patterns suggest that many practitioners prioritize the immediate goal of resolving clinical or potential disease risks over antibiotic stewardship considerations. This interpretation is consistent with insights from UK poultry industry consultations, where veterinarians emphasized that ensuring animal welfare—often through antibiotic use—remains an overriding professional obligation [23]. In contrast, the negative association observed for public veterinarians may reflect their stronger exposure to national AMR initiatives in Burkina Faso, including efforts to embed stewardship principles in veterinary practice and to shift prescribing norms [24]. For private-sector veterinarians in particular, the financial incentive to dispense more drugs—or to rely on broad-spectrum products to avoid treatment failure—has been identified in earlier consortium discussions as a potential driver of overprescribing [23].

The broader purpose of this study was to identify factors associated with animal health outcomes and nontherapeutic antibiotic use on smallholder livestock farms in Burkina Faso, with the ultimate aim of informing interventions that reduce reliance on antibiotics without jeopardizing livestock health. Taken together, the findings point to the expansion of public veterinary service access as a promising approach for supporting both stewardship and animal health. Increasing farmers' opportunities for formal education may also contribute to improved health outcomes and help buffer potential risks associated with reducing antibiotic use. Although the importance of veterinary training for strengthening antimicrobial stewardship [25] and the value of farmer-focused AMS education interventions [15–17] have been well documented, the role of general formal education in shaping stewardship-related behavior among smallholders in this setting remains underexplored in the literature.

Limitations

Several constraints inherent to the dataset restricted the analytical possibilities of this study. The very small number of farms administering antibiotics formulated for human use to their animals made it impossible to meaningfully analyze this practice as a separate outcome. Likewise, only a limited subset of farmers had participated in awareness-raising or vaccination campaigns, preventing these factors from being included as covariates. In addition, some livestock species—such as pigs, rabbits, horses, and donkeys—were present on too few farms to support species-specific analysis.

Information on drug administration covered only the preceding four weeks. As a result, the study could not examine whether more frequent antimicrobial use contributed to disease occurrence, particularly given the potential for reverse causality. Because the AMUSE survey provides only point-in-time data, it does not capture temporal changes in management practices or health outcomes. A cohort design following farms over time could better clarify how specific factors influence animal health and antibiotic use dynamics. Similarly, while this study relied on observational data, experimental or intervention trials would allow a more robust assessment of strategies aimed at improving stewardship without compromising productivity or animal health.

Finally, antibiotic-use decisions among smallholder farmers occur within a broader system involving creditors, drug sellers, landlords, market intermediaries, and animal health professionals, among others [13]. Effective stewardship interventions must therefore consider the incentives, constraints, and interactions across this wider network.

Conclusion

Drawing on survey data from smallholder livestock farms in Burkina Faso, this study found that herds and flocks routinely receiving prophylactic antibiotics were more likely to have experienced disease. This outcome runs counter to the initial expectation that prophylactic use might serve a protective function, but reverse causality remains a plausible explanation. Higher levels of formal education and primarily consulting public veterinarians were both associated with a reduced likelihood of disease.

The analysis also showed that farmers who mainly sought assistance from community animal health workers were more likely to use antibiotics for nontherapeutic purposes, while reliance on public veterinarians was associated with reduced nontherapeutic use. For sheep and goats, the involvement of any animal health professional in diagnosis and treatment was linked to increased nontherapeutic antibiotic use.

Taken together, these findings suggest that strengthening access to formal education and to public-sector veterinary services could promote improved antibiotic stewardship while reducing health risks associated with curbing nontherapeutic use. They also indicate that certain categories of animal health providers may prioritize immediate animal health concerns over stewardship objectives.

Future research should include controlled on-farm trials and qualitative inquiries to more precisely investigate the relationship between nontherapeutic antibiotic use and disease, to understand the prescribing incentives faced by different provider types, and to evaluate the impact of scaling up public veterinary service provision on stewardship practices and animal health. Importantly, any policy designed to improve antimicrobial stewardship must account for the broader network of actors that shape antibiotic access and decision-making within smallholder livestock systems.

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Ethics Statement: The studies involving humans were approved by the Ethical Committee of the Ministry of Health, Burkina Faso, with reference number 2020-9-186. Informed (written and signed) consent was obtained from each participant before they were interviewed. Consequently, all participants gave their consent to participate in the study. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and institutional requirements. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

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