One Health 10 (2020) 100165

Contents lists available at ScienceDirect

One Health

journal homepage: www.elsevier.com/locate/onehlt

Data on antimicrobial use in livestock: Lessons from Uganda

Orsolya Mikecz[a,*], Ugo Pica-Ciamarra[a], Ana Felis[a], Gerald Nizeyimana[b], Patrick Okello[c], Chiara Brunelli[a]

[a] Food and Agriculture Organization of the United Nations, Viale delle Terme di Caracalla, 00153 Rome, Italy
[b] Food and Agriculture Organization of the United Nations Representation in Uganda, Plot 88 Buganda Road, Wandegeya, Kampala, Uganda
[c] Uganda Bureau of Statistics, Statistics House, Plot 9 Colville Street, Box 7186, Kampala Colville St, Kampala, Uganda

ARTICLE INFO

Keywords:
Antimicrobial resistance
Antibiotics in livestock
Survey data

ABSTRACT

In 2016, the General Assembly of the United Nations recognised inappropriate Antimicrobial Use (AMU) in livestock as one of the leading causes of increasing Antimicrobial Resistance (AMR). This is happening at a time when livestock production is expected to increase dramatically particularly in Africa, in response to the large rise in aggregate demand due to population growth, urbanisation and increasing income levels. Therefore, understanding the characteristics and appropriateness of AMU in livestock in this region is of utmost importance, yet data is seldom available. We propose to collect information on AMU in livestock by including related questions in nationally representative agricultural surveys that are carried out regularly (annually or every 2–3 years) by National Statistical Offices. This approach, with its limitation though, is a viable and cost-effective way to gather essential information on AMU in livestock farming. The Uganda Bureau of Statistics (UBOS) in collaboration with the Food and Agriculture Organization of the United Nations (FAO) piloted the introduction of key AMU questions in the Annual Agricultural Survey (AAS), gathering data from 6 thousand agricultural households nation-wide. Results show that AMU is considerable among livestock keeping households (35%), who use antibiotics not only for curative treatment (~58%) but also for disease prevention (~44%) and growth promotion (~5%). Data from the AAS also allows users to explore linkages between antibiotics use, livestock production practices (e.g. herd composition and size, feeding, breeding techniques, etc.) and other household / farm characteristics (e.g. location, education, household size, etc.), thereby effectively informing policy decisions.

1. Introduction

Antimicrobial resistance (AMR) is becoming an increasingly important concern worldwide because it reduces the efficiency of prevention and treatment of infections caused by bacteria, parasites, viruses and fungi [1]. AMR develops naturally over time, as microorganisms change when exposed to antimicrobial drugs. However, improper use of antibiotics is accelerating the process at great lengths. For instance, it is estimated that about 700 thousand people die annually from drug resistant strains of common bacterial infections and that, if no significant changes are introduced to reduce improper antimicrobial use (AMU), up to 10 million people may die annually by 2050 as a consequence of AMR [2].

In 2016, the General Assembly of the United Nations recognised inappropriate AMU in animals as a leading cause of AMR [3]. It is therefore crucial that we have reliable evidence on AMU in livestock to control usage effectively. However, little AMU data is available, particularly in developing countries. In addition, there are no standard recognised tools available for collecting AMU data in livestock farming.

The Global Action Plan on AMR, endorsed at the Sixty-eighth World Health Assembly in May 2015, points out that data on antibiotic use is lacking from lower-income countries. The Plan recommends that the World Organization for Animal Health (OiE), supported by FAO and the World Health Organization (WHO), builds and maintains a database on AMU in animals [4]. The OiE started releasing the "Annual report on antimicrobial agents intended for use in animals" in 2015. In 2017, 155 countries provided information to OiE, out of which 118 gave quantitative data. The information is based on import and sales records, with no country sourcing data from farm level records, agricultural cooperatives, producer organisations or farm shops (Fig. 1). Those who could not provide quantitative information named lack of a regulatory framework, tools and human resources as the main barriers of data collection [5].

Out of the 54 African states, 44 countries reported some information on AMU to OiE, with 33 of them providing quantitative data. The report notes, however, that estimates of data coverage were the lowest in

* Corresponding author at: FAO, Viale delle Terme di Caracalla, 00153 Rome, Italy.
E-mail address: orsolya.mikecz@fao.org (O. Mikecz).

https://doi.org/10.1016/j.onehlt.2020.100165
Received 5 June 2020; Received in revised form 25 August 2020; Accepted 26 August 2020
Available online 02 September 2020

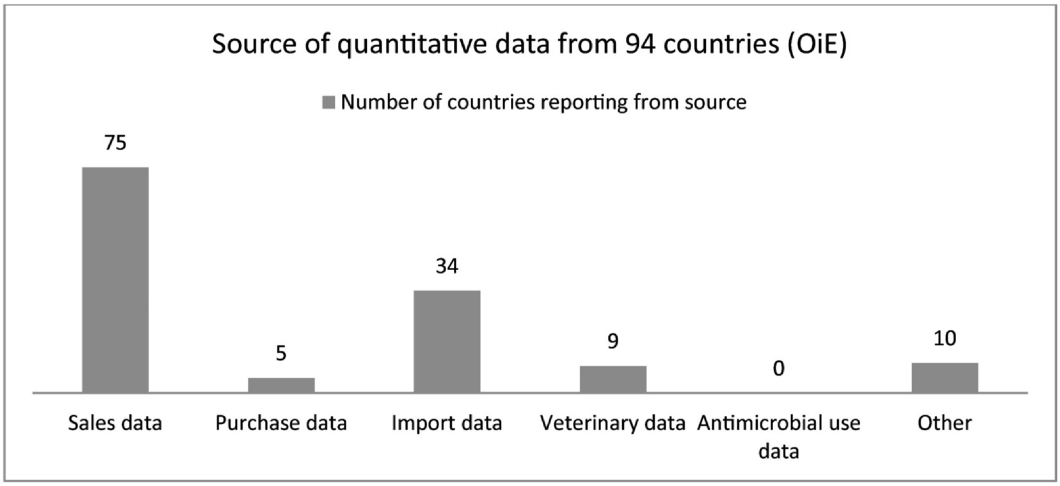

Fig. 1. Validated Data Sources Selected from 94 Countries Reporting Quantitative Data to OiE [5].

African countries, and many of them were experiencing data quality issues. It does not provide figures by country for confidentiality reasons and warns that all results have to be handled with caution.

Van Boeckel et al. [6] used registered veterinary sales data from 38 high-income countries and other supplementary material to estimate AMU for a sample of 190 countries. This is the largest cross-country dataset available on AMU and estimates are provided on the average consumption in mg per Population Corrected Unit (PCU). However, the dataset does not provide details on how many and what type of farms use antibiotics, with what frequency or for what purpose.

Both OiE [5] and Van Boeckel et al. [6] heavily rely on sales data to generate estimates on AMU in animal agriculture. However, the Federal Drug Administration (FDA) of the United States – often cited for estimating that about 80% of antibiotics sales in the US are intended for use in food producing animals – warns that sales data on antibiotics for animals should be used with caution. This statistic can be misinterpreted if one does not take into account that (i) there are many more animals than humans, (ii) animal and human physical characteristics, such as weight, differ significantly and hence also duration and dosage of antibiotic administration, and (iii) sales data does not correspond to usage as, for example, veterinarians may prescribe antibiotics intended for human use to animals [7].

The fact that there is no dataset providing accurate information on AMU in animals comes with no surprise if one considers that even countries with developed surveillance systems have little information on the (appropriate) use of antibiotics in animals. For example, the United Kingdom has a pioneer human and animal health surveillance system and was one of the first countries to establish National Action Plans (NAPs) for AMR (starting in 2000), even before the Global Action Plan. The UK 2013–2018 NAP was the first fully integrated 5-year strategy for tackling AMR through a One Health (OH) approach. The current Plan's timeframe is 2019–2024 [8], and the only livestock related quantitative information it contains is the sales data of antibiotics in food-producing animals (37 mg/kg in 2017). The NAP refers to the UK One Health Report published in 2015, as source of data on human and animal antibiotic use, sales and resistance. The UK OH Report [9] states that currently no data of antibiotic usage are available by animal species and, similarly to the NAP-AMR, presents the total quantity of antibiotics used based on sales data. Beyond no possibility to disaggregate by species, farm size or purpose of use, such data do not consider wastage, and in the case of the OH Report, neither exports nor imports and, therefore, can only be considered as a proxy of total usage.

The AMU information challenge that the UK is facing is exponentially higher in sub-Saharan countries where the large population growth, increasing income levels and urbanisation are driving a major increase in the demand for animal source foods, which is estimated to be 246% for meat and 196% for milk between 2012 and 2050 [10]. Livestock production is expected to significantly increase in response to the growing demand, therefore it is crucial for SSA countries to well understand farmers' behaviour on antimicrobial use and design policies and programmes that ensure its proper use. Yet AMU data is very scarce and, as noted in the OiE report, even where data is available, the coverage is often small and the quality is mixed.

A number of empirical studies on AMU in animal farming have been carried out recently in the region, but they are based on small samples and results cannot be extrapolated to the national level. Basulira et al. [11], for instance, investigated AMU in beef production by studying antimicrobial residues in a sample of 134 cattle carcasses in Uganda. Manishimwe et al. [12] assessed the appropriateness of AMU in Rwanda surveying 229 farmers. Tufa et al. [13] interviewed 220 livestock owners around the town of Bishoftu, Central Ethiopia, to gain a better understanding of AMU. Furgasa and Tufa [14] note that the lack of a proper regulatory system makes it difficult to gather reliable data on AMU in animal farming in Ethiopia.

The WHO, OiE and FAO maintain a Global Database for Antimicrobial Resistance [15] on the status of development and implementation of any countries' National Action Plan on AMR. The data is based on a self-assessed survey and has been completed by 31 African countries. Out of the 31 countries, 22 have developed AMR National Action Plans, out of which 15 have an operational plan and monitoring arrangements, and 4 have identified funding sources and are implementing the plan. We have also found articles mentioning the launch of the NAP-AMR for Botswana and Sudan, though the plans are not yet available in the Global Database. Table B.1 in Appendix B contains the links to these articles and other available NAPs. Fig. 2 shows the 22 + 2 countries that have developed a NAP-AMR, and an additional 7 where the plan is under development. Table B.2 in Appendix B contains the list of Sub-Saharan African countries from the Global Database for AMR, including the implementation status of the NAP. The development of the NAPs is crucial in taking action to limit the spread of AMR but, as noted above, they often contain little evidence due to lack of data, which makes evidence-based implementation, monitoring and evaluation challenging. The NAP-AMR of Uganda, for example, states that "Nationally aggregated data on the amount of antimicrobials used in either animals or humans are limited; the National Drug Authority (NDA) keeps records of all antimicrobials imported into the country and periodically collates them, but they are not currently widely shared. Misuse of antimicrobials in both humans and animals was well noted with dispensing over the counter, in unlicensed drug stores and in open vans in markets" [16].

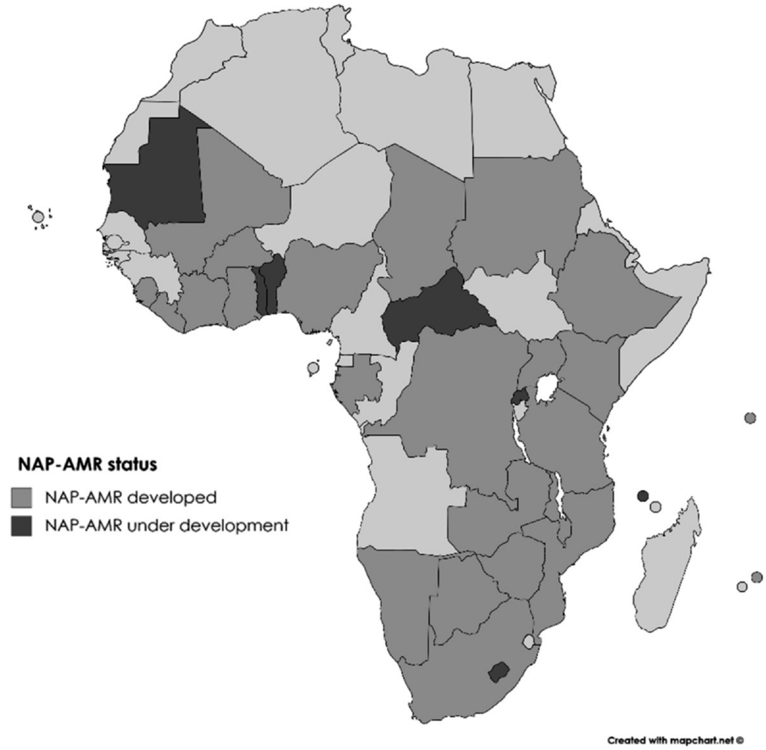

Fig. 2. Countries progress with development of NAP-AMR (Source: Authors' compilation using Global Database for Antimicrobial Resistance, WHO website and reliefweb.int. Image created with mapchart.net).

Any implementation of the livestock section of the AMR National Action Plan should base on evidence that is, as far as possible, representative of the entire country's livestock sector. National Statistical Offices (NSOs) have the mandate and capacity to collect nationally representative, good quality information. These entities regularly collect nation-wide data, including information on livestock, through Population Censuses, Agricultural Censuses, or nationally representative sample surveys, such as the Demographic and Health Surveys and the Living Standard Measurement Surveys and agricultural surveys. National governments can use data from these surveys to understand the social and economic structure and dynamics, identify constraints and opportunities, and design policies and programmes for the livestock and other sectors.

Adding questions on AMU in animal farming in agricultural-related sample surveys could be an effective way to generate key AMU information for evidence-based decision-making. In particular, these surveys allow linking of information on antimicrobial use with other characteristics of the farm or the holding - such as location, size, production quantity, marketing activities etc. - thereby providing key insights to decision-makers. One should consider, however, that sample surveys conducted on households and farms are costly and time-consuming and their objective is to generate robust statistics on typical households and farms. For this reason, statistics generated from a subsample of farms and households, such as those keeping livestock, always contain some non-random errors. Secondly, the survey sample may not adequately represent the entire universe of livestock-keepers. For example, some farm surveys may exclude nomadic populations, or the livestock-keepers in the non-household sector, such as private companies. Further, accuracy issues may arise from the sample size, in particular when the share of livestock-keepers in the sample is low. Finally, enumerators, and in many cases the respondents, are neither livestock specialists nor specialised in AMR and, therefore, questions on AMU should be simple and understandable to the general public.

Even then, farm sample surveys represent one of the most comprehensive and accurate sources of information on the livestock sector and are widely used by national governments as an input to design developmental programmes and strategies. For example, they represent the backbone of several Livestock Master Plans, which guide sector investments in several developing countries. Their limitations, however, should be well understood before adding any question on AMU in the survey questionnaire.

This paper first reviews available AMU data in livestock farming, showing that current plans and actions are often based on limited information. It then presents a method to enhance effectively the quantity and representativeness of AMU data by leveraging on large-scale country surveys administered on a regular basis by the National Statistical Office as part of the agricultural sector statistical system of Uganda and some illustrative results are shown.

2. Material and methods

To test the value of collecting data on AMU through nationally representative farm surveys, the Uganda Bureau of Statistics (UBOS) and the FAO piloted the introduction of questions on the use of antibiotics in animal farming in the Uganda Annual Agriculture Survey (ASS) 2018. Uganda lacks detailed data on AMU to support the implementation of the NAP just like other countries, and the AAS represented a good opportunity to improve the quantity and quality of AMU data because UBOS regularly carries it out nation-wide.

The Annual Agriculture Survey (AAS) has been administered throughout 2018 on a sample of six thousand agricultural households.[1] The sample is representative at the Zonal Agricultural Research Development Institute (ZARDI) level for rural households. There are 10 such zones, aligned to the 10 agro-ecological zones in the country. Appendix A includes the list of districts belonging to each ZARDI. The

[1] A sample of 607 enumeration areas (EAs) with an average of 12 agricultural households per EA were selected that sum to an expected sample size of around 7 thousand households. However, due to the response rate, there are 5914 households in the actual sample.

sample did not cover urban areas in 2018. The AAS currently does not target the non-household sector (i.e. corporations, cooperatives, institutions) therefore the sample contains mostly small- and middle scale farms. This has implications on the interpretation of the results presented in the Discussion.

The AAS is implemented with enumerators interviewing the households twice per season (post-planting and post-harvest), for a total of four visits in the agricultural year. The AAS questionnaire contains 38 modules and the data includes around two thousand variables. The livestock questionnaire is administered during the post-harvest visit of the second season and it aims to generate data on stock, production and input for the previous 12 months. The sample interviewed in the post-harvest visit of the second agricultural season includes 5914 farm households out of which 4588 keep animals. The livestock questionnaire is administered only to households who reported having raised livestock in the past 12 months.

In the questionnaire section on inputs and production, the animal species are grouped into "cattle and pack animals", "small ruminants and pigs" and "poultry and rabbits". One household may keep different species within and between these groups. In the case of the first group, there are 1854 households keeping cattle, out of which 18 keep donkeys or camels additionally. No households keep donkeys or camels and no cattle. In the following, we label this group as "cattle". In the second group, 2068 households keep small ruminants but no pigs, 646 households keep pigs but no small ruminants and 807 households keep both species. We label the group "small ruminants and pigs". In the case of poultry and rabbits, there are 2946 households keeping poultry but no rabbits, 38 households keeping rabbits but no poultry and 64 households keeping both. Since the number of households keeping rabbits is very few, we label this group "poultry" and exclude from the calculation the households that keep rabbits and no poultry. Poultry includes chicken, turkeys, ducks and geese. Table 1 below contains basic statistics on herd size and livestock production practices in the sampled farms.

From Table 1, the 1854 cattle keeping households in the sample represent around 2.48 million such households in Uganda. The average herd size is five heads of cattle, ranging from households keeping one cattle (21% of the sample) up to households keeping 100–123 heads (0.2%). Nearly half of the cattle keepers vaccinate all their animals and 19% raise exotic breeds; 16% sell either milk or meat to the market.

The 3521 households keeping small ruminants and/or pigs represent 4.26 million of such households in Uganda. The average herd size is six heads, ranging from households keeping only one head (10%) up to households keeping 100–150 heads (0.15%). Four percent of the small ruminant and/or pig keepers raise exotic breeds and only 1% of them sell either milk or meat.

Finally, the 3 thousand poultry keeping households in the sample, that is about 3.62 million households in Uganda, keep on average 11 birds per flock, with 7% keeping only one bird and 0.3% keeping between 100 and 3600 birds. Five percent of such households keep exotic breeds; about 6% sell eggs and 0.22% sell meat. Female headed households represent 21, 23 and 24% of all households keeping cattle, small ruminants and/or pigs and poultry, respectively.

Table 2
Distribution of households between regions.

Region	Number of HHs in sample	Cattle		Small ruminants and pigs		Poultry	
		% HHs keeping	av. herd size	% HHs keeping	av. herd size	% HHs keeping	av. herd size
Central	645	35	6	82	5	54	16
Eastern	1284	55	3	69	4	76	9
Northern	1255	59	5	81	8	67	8
Western	1404	21	8	83	5	65	14

Table 2 presents the distribution of livestock keeping households in the sample across the regions, and the percentage of households keeping each species and average herd size. More than half of the livestock keeping households located in the Northern and Eastern region keep cattle, though the average herd size is smaller than in the other two regions. Around 80% of livestock keeping households keep small ruminants and/or pigs in the Central, Northern, and Western regions. The highest share of poultry keepers (76%) can be found in the Eastern region, with an average flock size of 9 birds.

In order to include AMU questions in the AAS survey, UBOS consulted AMR experts at FAO, who suggested 11 questions (Appendix D) to gather information on AMU in animal farming. These targeted the reason, frequency and source of antibiotics, as well as farmer's knowledge on antibiotics, vaccines and AMR. After taking into consideration the objectives of the AAS survey, the sample size and the cost dimension, it was agreed to include five questions in the livestock module of the survey, eliciting information on:

- the type of antibiotics used;
- the purpose of using antibiotics;
- the frequency of usage;
- who advises on the use of antibiotics;
- farmer's opinion on whether frequent use of antibiotics can alter the effect of the drugs.

Details on the formulation of these questions can be found in Appendix E.

3. Results

Table 3 presents the share of livestock keepers who reported to have used at least one type of antibiotic in the last 12 months. More than one

Table 1
Sample farms: herd size and livestock production practices.

	Cattle	Small ruminants and pigs	Poultry
Number of farms in sample (observations)	1854	3521	3010
Number of farms represented (weighted)	2.48 million	4.26 million	3.62 million
Average herd size (heads)	5	6	11
% farms raising exotic animals	19	4	5
% farms vaccinating all animals	47	22	12
% farms using feed	26	32	29
% farms with less than 1 Livestock Unit[a]	21	54	57
% of farms with more than 5 Livestock Unit[a]	15	8	7
% of farms selling produce (market activity)	16	1	7
% of female headed households	21	24	23

[a] 'Livestock Units' standardise live animals by species mean-live-weight and represent a convenient method for quantifying a wide range of different livestock types and sizes. We use the conversion factors recommended in FAO Guidelines for the preparation of livestock sector reviews [17]. Conversion factors are presented in Appendix C.

Table 3
Percentage of households using antibiotics.

	All households		Male headed households		Female headed households	
	% using AB	*s.d.*	% using AB	*s.d.*	% using AB	*s.d.*
Livestock (all)	35.1	0.48	36.0	0.48	32.6	0.47
Cattle	53.7	0.50	53.7	0.50	53.4	0.50
Small ruminants	25.0	0.43	25.4	0.44	24.0	0.43
Poultry	6.6	0.25	7.2	0.26	4.9	0.22

third of livestock owners (35%) have reported the use of antibiotics.

The table also shows the share of antibiotic users among the keepers of certain livestock species and by the sex of the household head. Antibiotics use is most prominent among cattle keepers (more than half of them use antibiotics). At the same time, only 7% of poultry keepers reported using antibiotics. It is important to remind that the survey sample consists of agricultural households and does not include commercial enterprises. Indeed, the only two farms in the sample keeping over one thousand birds, and that hence could be considered as small-scale commercial farms,[2] have reported usage of antibiotics. On average, the percentage of male-headed households using antibiotics is slightly higher than the percentage of female-headed households, but such difference is probably driven by a multiplicity of hidden factors, such as different education levels, number of adult members in the family, etc.

Fig. 3 presents the share of livestock farms using antibiotics by the 14 sub-regions covered in the sample. The sub-regions in the Western region and, to some extent, in the Central region have the lowest share of households using antibiotics, while the Northern and Eastern regions have the highest share. In Eastern and Northern Uganda, as noted above, a larger share of households keep livestock than in Southern and Western Uganda.

As noted above, the data is representative at the ZARDI level. We show the share of antibiotics users among livestock keeping households in each ZARDI in Table 4. The results vary from as low as 5.6% in Kachwekano in the Western region, up to almost 60% in Nabuin in Northern region.

The data shows a strong relationship between the herd size and the use of antibiotics. Table 5 shows the share of farms using antibiotics by species and herd size. Antibiotics use is more common among farms that keep larger flocks or herds: 97, 84 and 63% of farms owning more than 51 cattle, small ruminants or poultry birds use antibiotics, respectively and this share decreases gradually as herd size goes down.

An interesting result of the survey refers to the purpose for farmers of AMU. As noted in the introduction, larger datasets are mostly available from import and sales records, giving little insight on actual consumption, let alone the purpose of use. It is a very important indicator in understanding AMU related behaviour among farmers, since this is what legislation aiming at controlling AMU can target. In many countries, AMU for growth promotion for example is prohibited. Table 6 shows that more than half of AMU is intended for curative treatment, which is a correct behaviour. However, the second most common and non-marginal reason for AMU is prophylaxis, ranging from 35 to 50% of the farms. Results are homogenous between the keepers of different animal species, the rank being (1) curative treatment, (2) preventive measures, (3) growth promotion and (4) other.[3] Usage to promote animal growth is highest among small ruminant keepers at 6%, while it is 3% for cattle and poultry keepers respectively.

The survey also inquired about the frequency of antibiotics usage, another important factor for understanding the appropriateness of use. Most farms (between 43% and 60%) reported to have been using antibiotics occasionally, while one-fourth (22 to 26%) reported usage only once. Among poultry keepers, 14% reported regular weekly usage while in cattle and small ruminants this was true for only two and 1% of farms, respectively as in Table 7. These results are consistent with the previous finding that in most cases farmers use antibiotics for curative treatment.

The data includes information of source of advice on antibiotics (see Table 8). The main source of advice on antibiotics was the private veterinary officer in all household groups, with 39% of households keeping poultry, 36% of households keeping cattle and 34% of households keeping small ruminants and pigs. In the case of cattle keepers and small ruminant and pig keepers, 29 and 35% of the households made the decision to use antibiotics without consulting anyone. Among households keeping poultry, the second most common source of advice came from the input dealer, such as pharmacists or drug shops. Public vets advised 13 to 16% of the households, while extension officers only 4%. It is to note that, overall, only about half of the farmers using antibiotics for their livestock do so under the recommendation of a professional.

Table 9 presents results on whether the respondent agrees with the statement “If antibiotics are often given to animals, the antibiotic will become less effective in curing sick animals”. The question was asked only to those respondents who have reported use of antibiotics. This variable can be interpreted as a proxy for awareness on AMR, and results suggest very low general knowledge: only 36 to 37% of respondents agree with the claim, while 63 to 64% either disagree or do not know. One can assume that awareness on AMR is higher among those who use antibiotics, therefore results suggest that general awareness is even lower than the data in Table 9, though more evidence is needed to substantiate this claim.

We looked at differences in awareness of AMR using the opinion question by herd size and by region. Table 10 shows the share of households using antibiotics by region, and the share of those households that agree with the statement. In the Northern region, where antibiotics use is 49%, only 26% of the users agree that frequent use can reduce effectiveness. In the Eastern and Western region, more than half of the antibiotics-user/livestock-keepers are aware that frequent usage may have negative consequences. The results of this table suggest that in case of planning an awareness raising campaign, focusing on the Northern region would have the largest impact.

Table 11 shows the share of households using antibiotics by herd size, and the share of those households that agree with the statement. Results on the opinion question are similar across the groups owning 0 to 5 Livestock Units (34 to 38%), and there was a slightly higher share of households agreeing with the claims among households owning more than 5 Livestock Units (41%).

4. Discussion

The results in this paper represent, to our knowledge, the first estimate of AMU in animal agriculture based on a nationally representative surveys in sub-Saharan Africa. Results are plausible and, therefore, further research and experimentation is recommended to ensure the regular inclusion of AMU questions in nationally representative surveys. Such data, indeed, is fundamental to monitor the implementation of the livestock component of the AMR National Action Plan. There are two aspects to consider carefully, however, when interpreting the results, which hold true for all statistics generated through sample-based household surveys: reporting errors and sample representativeness.

First, as these surveys collect data on a wide range of subjects, the enumerator cannot be specialised in all topics covered and not all respondents are able to accurately report on all questions. Some errors in

[2] The two farms keep over 1000 birds of exotic breeds with the main purpose being to sell the animals and breed them.

[3] Preventive measures are slightly more common among poultry keepers (50%, curative treatment 47%)

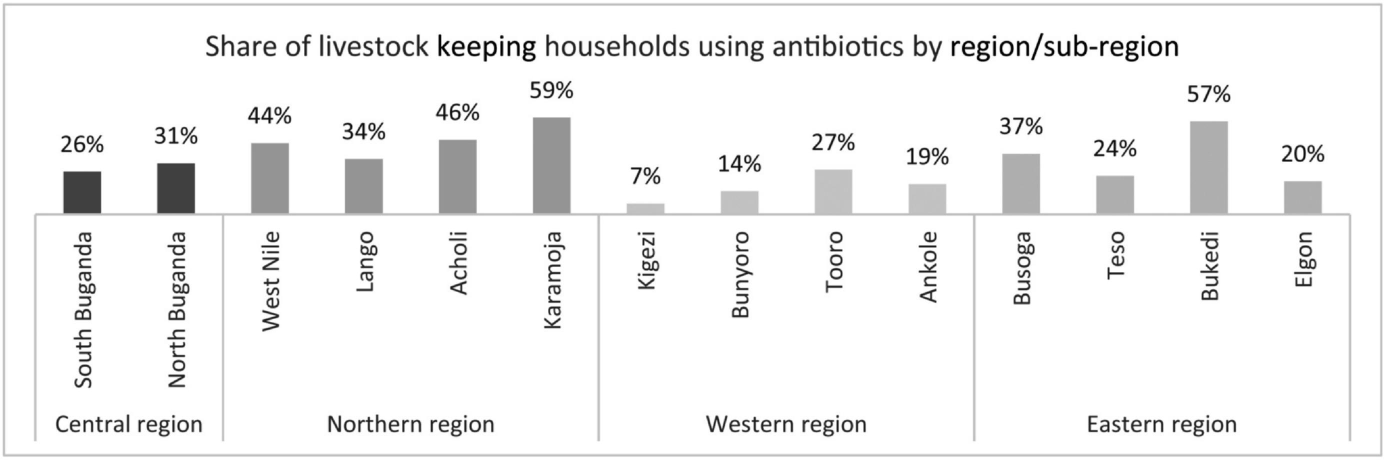

Fig. 3. Share of livestock keeping households using antibiotics by region and sub-regions.

Table 4
Antibiotics use among livestock keepers at the ZARDI level.

ZARDI	Region	% using AB	*Standard deviation*
Abi	Northern	43.5	0.50
Buginyanya	Eastern	37.5	0.48
Bulindi	Western	14.5	0.35
Kachwekano	Western	5.6	0.23
Mukono	Central	29.3	0.46
Ngetta	Northern	38.0	0.49
Nabuin	Northern	58.9	0.49
Serere	Eastern	24.3	0.43
Mbarara	Central/Western	21.2	0.41
Rwebitaba	Western	27.3	0.45

Table 5
Herd size and antibiotics usage, by species.

	Share of households using antibiotics among households keeping.		
	Cattle (%)	Small ruminants (%)	Poultry (%)
1 head/bird	38	13	3
2–5 heads/birds	53	22	4
6–20 heads/birds	66	34	7
20–50 heads/birds	81	73	16
51 + heads/birds	97	84	63

Table 6
Purpose of antibiotics use.

Purpose	Cattle (%)	Small ruminants and pigs (%)	Poultry (%)
Curative treatment	55.0	58.3	46.3
Prophylaxis	40.0	34.7	49.8
Growth Promotion	3.3	5.9	3.1
Don't know/Other	1.7	1.1	0.7

Table 7
Frequency of antibiotics use by keepers of different species.

Frequency of AB use	Cattle (%)	Small ruminants and pigs (%)	Poultry (%)	Total (%)
Regularly, weekly	1.8	1.1	13.8	1.8
Regularly, monthly	15.5	11.7	15.0	15.5
Occasionally	59.1	60.0	43.4	59.1
Once	21.9	25.8	25.7	21.9
Don't know	1.7	1.4	2.0	1.7

Table 8
Source of advice on antibiotics use by keepers of different species.

Source of advice	Cattle (%)	Small ruminants and pigs (%)	Poultry (%)
NGO	1.0	0.3	0.5
Public vet	16.4	12.6	13.4
Private vet	35.7	34.2	39.1
Extension worker	4.1	3.9	4.4
Input dealer	10.5	10.6	20.3
Own decision	29.3	34.9	15.8
Other	3.0	3.4	6.5

Table 9
Respondents' Opinion on effectiveness of overuse of antibiotics.

"If antibiotics are often given to animals, the antibiotic will become less effective in curing sick animals"			
AB become less effective?	Cattle	Small ruminants	Poultry
Fully Agree	14	15	14
Agree	21	21	23
Disagree	33	34	32
Completely Disagree	9	9	9
Don't Know	22	21	21

Table 10
Antibiotics use and awareness of AMR by region.

Region	% using AB	% agree that frequent AB use reduces effectiveness
Central region	30	16
Eastern region	34	54
Northern region	49	26
Western region	18	51

Table 11
Antibiotics use and awareness of AMR by herd size.

Herd size	% using AB	% agree that frequent AB use reduces effectiveness
LU < 0.5	15	38
LU ≥ 0.5 & < 1	32	36
LU ≥ 1 & < 5	52	34
LU > 5	74	41

the datasets are therefore expected. The high response rate of the AMU questions, however, suggests that the questions were on average well understood. That said, as discussed above, the formulation of some questions could be improved to get information that is more accurate from the respondents.

Secondly, depending on the sample design, farm surveys may not adequately represent the universe of livestock-keeping farms, resulting in sampling errors in livestock statistics.[4] To evaluate the national level usage of antibiotics, it is necessary to complement the information from the survey with information on the non-household sector. The AAS survey targets household holdings and does not include corporations, cooperatives and institutions (e.g. government farms) and, as the data has suggested, the larger the farm, the higher the probability of usage of antibiotics. In many African countries, however, the commercial livestock sector is still small. In Uganda for instance, only 4% of the poultry population is estimated to be raised in commercial farms, and 8% of the cattle population is kept on ranches [18]. However, as demand and income levels increase, it is expected that intensive production systems will expand in the coming decades, which calls for ensuring that not only household but also enterprise / business and other surveys gather data on AMU. That said such sample bias is inevitable when collecting agricultural data from a household survey but, if one considers these limitations, it can give valuable information.

5. Conclusion

The increasing risk of antimicrobial resistance is becoming a recognised considerable threat in many countries, yet we have very little information and evidence on how antibiotics are used today. Antibiotics in animals have been declared on of the main causes of increasing AMR by the General Assembly of the United Nations in 2016, yet even developed countries have only superficial information on who is using antibiotics in food producing animals, for what purpose and with which frequency. The lack of data is more pronounced in developing countries.

National governments regularly carry out nationally representative household and farm surveys. Tapping into these surveys as a source of information can be a cost-effective way of gaining better understanding of AMU. UBOS and FAO, therefore, piloted the inclusion of AMU questions in the Uganda Annual Agricultural Survey 2018, interviewing 6 thousand agricultural households in rural areas. The results of this experiment suggests that relying upon the existing system of agricultural statistics can be an effective way to build reliable and longitudinal information on AMU in livestock farming, thus contributing to design and monitor evidence-based policies and programmes on the appropriate use of antibiotics in animal agriculture.

The data showed that a considerable share of households are using antibiotics in animals in Uganda: 35% of the respondents representing around 2 million households reported to have used at least one type of antibiotic in their animals in the past 12 months. The rate of usage is highest among cattle keepers (54%), and among households owning large herds: 74% of households keeping more than 5 Livestock Units reported antibiotic usage. The main reason for using antibiotics was for curative treatment, but only a little more than half of the households (58%) used antibiotics for this motive. Forty-four percent of households using antibiotics reported to have used them as a preventive measure, and 5% meaning around 90 thousand households have used them as growth promoters. Only about half of the households reported to have used antibiotics after the advice of a recognised professional. We have not investigated correlations and causalities across variables, which we leave for future research. Results are representative for rural households and do not cover commercial enterprises, holdings in urban areas and pastoralists. Therefore, a more accurate picture on national level use of antibiotics requires additional data collection instruments.

This paper illustrates a simple method to collect information on AMU in livestock and focus on the methodological implications that users should consider. We hope to make the case for data collectors and data users to further collect and analyse such data. An advantage of the approach of expanding existing farm / household surveys to collect data on AMU is that it gives possibility to discover many characteristics of users of antibiotics, with huge coverage and at a low cost. This is critical to generate evidence for decision-makers. However, adding questions on AMU in these surveys is costly in terms of time and resources. Finding the right balance between sufficient amount of information and low cost is the key to success. The pilot study can be considered a successful attempt; there was a very high level of respondents giving internally coherent information. By uncovering how and why antimicrobials are being used in livestock production, Uganda can better target national awareness campaigns and AMR programs to stay ahead of AMR. Collecting data will help in tracking progress of the implementation of the Uganda National Action Plan on AMR and the One Health Strategic Plan.

Funding statement

This work was implemented under the FAO Africa Sustainable Livestock 2050 Project (OSRO/GLO/602/USA), supported by the United States Agency for International Development (USAID) under the Emerging Pandemic Threats 2 programme. The Annual Agricultural Survey 2018 received technical and financial assistance through the FAO Project “Implementation of AGRIS in Four Pilot Countries” (GCP/GLO/677/USA), supported by USAID.

Declaration of Competing Interest

None.

Appendix A. List of ZARDIs and zones (Source: FAO, AAS documentation)

The AAS is a national survey representative at the ZARDI level. The National territory has been divided in 10 ZARDIs which are aligned to 10 Agro-ecological zones in Uganda. Each agro-ecological zone include districts with similar climate, land use and cropping patterns. The following are the 10 Zardis considered for the AAS:

- Abi: districts included are Arua, Nebbi, Moyo, Adjumani, Koboko, Yumbe, Maracha-Terego and Zombo
- Buginyanya: districts included are Sironko, Mbale, Iganga, Jinja, Tororo, Mayuge, Namutumba, Namayingo, Luuka,Kamuli, Kaliro, Buyende, Bugiri, Pallisa, Kibuku, Butaleja, Busia, Budaka, Manafwa, Kween, Kapchorwa, Bulambuli, Bukwo and Bududa;
- Bulindi: districts included are Hoima, Masindi, Kiryandongo, Kibaale, and Buliisa;
- Kachwekano: districts included are Kabale, Rukungiri, Kanungu and Kisoro;
- Mukono: districts included are Mukono, Mpigi, Kayunga, Kalangala, Kampala, Luwero, Masaka, Nakasongola, Mubende, Wakiso, Nakaseke, Buikwe, Buvuma, Mityana, Kiboga, Kyankwanzi, Gombe, Kalungu, Bukomansimbi, Butambala and Lwengo;

[4] The sampling error is the difference between the estimated value and the true but unknown value of the population

- Ngetta: districts included are Lira, Apac, Dokolo, Lamwo, Nwoya, Agago, Albetong, Amolatar, Kole, Otuke, Oyam, Pader,Kitgum, Amuru and Gulu;
- Nabuin: districts included are Moroto, Nakapiripirit, Kotido, Napak, Amudat, Kaabong and Abim;
- Serere: districts included are Serere, Kumi, Bukedea Amuria, Ngora, Katakwi, Soroti and Kaberamaido;
- Mbarara: districts included are Mbarara, Ntungamo, Bushenyi, Kiruhura, Lyantonde, Sheema, Rubirizi, Mitoma, Isingiro,Ibanda, Buhweju, Sembabule, and Rakai;
- Rwebitaba: districts included are Bundubugyo, Kabarole, Kamwenge, Kasese, Kyegegwa, Kyenjojo and Ntoroko.

Being an urban area, Kampala has been excluded from the survey. Also Ntoroko district was not included in the sample.

Appendix B. List of Sub-Saharan African countries' National Action Plans on AMR

Table B.1
Summary of links National Action Plans, authors' compilation.

SSA countries	AMR - NAP timeframe	Link
Botswana	2017–2022	https://www.afro.who.int/news/who-botswana-advocates-anti-microbial-resistance-amr-2018-ngwato-land-board-wellness-event
Ethiopia	2015-2020	https://www.who.int/antimicrobial-resistance/national-action-plans/library/en/
Ghana	2017-2021	http://www.moh.gov.gh/wp-content/uploads/2018/04/NAP_FINAL_PDF_A4_19.03.2018-SIGNED-1.pdf
Kenya	2017-2022	https://www.who.int/antimicrobial-resistance/national-action-plans/library/en/
Mauritius	2017-2021	https://www.who.int/antimicrobial-resistance/national-action-plans/library/en/
Nigeria	2017-2022	https://ncdc.gov.ng/themes/common/docs/protocols/77_1511368219.pdf
South Africa	2014–2024	http://www.health.gov.za/index.php/antimicrobial-resistance
Sudan	2018-?	https://reliefweb.int/report/sudan/ministry-health-sudan-who-and-partners-launch-amr-national-action-plan-enar
Tanzania	2017-2022	https://www.afro.who.int/sites/default/files/2017-07/NATIONAL%20ACTION%20PLAN%20FNL%2010%20May%202017.pdf
Uganda	2018-2023	https://cddep.org/wp-content/uploads/2018/12/GoU_AMR-NAP.pdf
Zambia	2017-2027	https://www.afro.who.int/sites/default/files/2018-08/ZNPHI%20Document.pdf
Zimbabwe	2017-2021	http://www.livestockzimbabwe.com/Updates/Zimbabwe%20AMR%20NAP%202_1.pdf

Table B.2
AMR self-assessment survey - African countries responses [15].

Country name	5.1 Country progress with development of a national action plan on AMR	5.4 Country policies and regulation on antimicrobial use [Country has laws or regulations on prescription and sale of antimicrobials, for human use.]	5.4 Country policies and regulation on antimicrobial use [Country has laws or regulations on prescription and sale of antimicrobials for animal use.]	5.4 Country policies and regulation on antimicrobial use [Country has laws or regulations that prohibits the use of antibiotics for growth promotion in the absence of risk analysis.]
Angola	A - No national AMR action plan.	Yes	Yes	Yes
Benin	B - National AMR action plan under development.	Yes	Yes	No
Burkina Faso	C - National AMR action plan developed.	Yes	Yes	Don't Know
Central African Republic	B - National AMR action plan under development.	Yes	Yes	Don't Know
Chad	D - National AMR action plan, operational plan and monitoring arrangements	Yes	Yes	No
Comoros (the)	B - National AMR action plan under development.	No	No	No
Côte d'Ivoire	C - National AMR action plan developed.	Yes	Yes	Yes
Democratic Republic of the Congo	C - National AMR action plan developed.	No	No	No
Ethiopia	E - National AMR action plan is being implemented with funding sources	Yes	Yes	Yes
Gabon	C - National AMR action plan developed.	Yes	No	No
Ghana	D - National AMR action plan, operational plan and monitoring arrangements	Yes	No	No
Guinea	A - No national AMR action plan.	Yes	Yes	Don't Know
Kenya	E - National AMR action plan is being	Yes	Yes	Yes

(continued on next page)

Table B.2 (*continued*)

Country name	5.1 Country progress with development of a national action plan on AMR	5.4 Country policies and regulation on antimicrobial use [Country has laws or regulations on prescription and sale of antimicrobials, for human use.]	5.4 Country policies and regulation on antimicrobial use [Country has laws or regulations on prescription and sale of antimicrobials for animal use.]	5.4 Country policies and regulation on antimicrobial use [Country has laws or regulations that prohibits the use of antibiotics for growth promotion in the absence of risk analysis.]
	implemented with funding sources			
Lesotho	B - National AMR action plan under development.	No	No	No
Liberia	D - National AMR action plan, operational plan and monitoring arrangements	Yes	No	No
Malawi	D - National AMR action plan, operational plan and monitoring arrangements	No	No	No
Mali	C - National AMR action plan developed.	Yes	Yes	No
Mauritania	B - National AMR action plan under development.	Yes	Don't Know	Don't Know
Mauritius	D - National AMR action plan, operational plan and monitoring arrangements	Yes	Yes	No
Mozambique	D - National AMR action plan, operational plan and monitoring arrangements	Yes	No	No
Namibia	C - National AMR action plan developed.	Yes	Yes	Yes
Nigeria	D - National AMR action plan, operational plan and monitoring arrangements	Yes	No	No
Rwanda	B - National AMR action plan under development.	No	No	No
Seychelles	C - National AMR action plan developed.	No	No	No
Sierra Leone	D - National AMR action plan, operational plan and monitoring arrangements	No	No	No
South Africa	D - National AMR action plan, operational plan and monitoring arrangements	Yes	Yes	No
Togo	B - National AMR action plan under development.	No	No	No
Uganda	D - National AMR action plan, operational plan and monitoring arrangements	Yes	Yes	No
United Republic of Tanzania	E - National AMR action plan is being implemented with funding sources	Yes	Yes	Yes
Zambia	E - National AMR action plan is being implemented with funding sources	Yes	Yes	Yes
Zimbabwe	D - National AMR action plan, operational plan and monitoring arrangements	Yes	Yes	Yes

Appendix C. Livestock Unit coefficients for Sub-Saharan Africa [17]

Species	Conversion (head/TLU)
Cattle	0.5
Sheep	0.1

Goats	0.1
Pigs	0.2
Chickens	0.01
Camels	0.7
Donkeys	0.3

Appendix D. Initial potential AMU/AMR Questions

(ARE YOU TREATING SICK ANIMALS)
1.1 During the last 12 months, have your * (animals) received some curative treatments when one or more animals was sick?
1 = yes, all animals at least once.
2 = some animals.
3 = no animals.
4 = I'm not sure.
(WHO IS ADMINISTERING – ACCESS TO/USE OF EXPERTS)
1.2 Who administered the curative treatment to your (animals)?
1 = Traditional or local healer.
2 = Private vet clinic.
3 = District vet clinic.
4 = NGO / Project.
5 = Me or someone in my household (if answer #5 please specify if any veterinary training).
6 = Other (please specify).
Pre-existing 1.3. (COSTS OF CURATIVE TREATMENTS).
(DISTINGUISHING BETWEEN TYPES OF TREATMENT - ARE YOU USING ANTIMICROBIALS OR ALTERNATIVES)
2.1 When you use curative treatments for sick animals, which *type* of medicine do you use most often?
1 = traditional medicine such as herbs.
2 = (define antibiotics using local pilot tested terminology and common product examples).
3 = other (please specify).
4 = I don't know.
(HOW OFTEN ANTIMICROBIALS USED)
2.2 During the past 12 months, how often were your animal(s) given (define antibiotics using local pilot tested terminology and common product examples)?
1 = not at all.
2 = once or twice in a year.
3 = once or twice in a month.
4 = usually every day.
5 = other (please specify).
(WHO IS ADMINISTERING ANTIMICROBIALS SPECIFICALLY)
2.3 Who administered the (define antibiotics using local pilot tested terminology and common product examples) to your (animals)?
1 = Traditional or local healer.
2 = Private vet clinic.
3 = District vet clinic.
4 = Community animal health worker.
5 = Me or someone in my household (if answer #5 please specify if any veterinary training).
6 = other (please specify).
(GROWTH PROMOTION / PREVENTION)
2.4 Do you or someone else give a (define antibiotics using local pilot tested terminology and common product examples) to your animal(s) when they are not showing signs of sickness?
1 = No.
2 = Yes, to prevent them from getting sick.
3 = Yes, to help them grow faster.
4 = Other (please specify).
(EVALUATE UNDERSTANDING OF INFECTION PREVENTION VS TREATMENT)
2.5 What do vaccinations do?
1 = cure sick animals.
2 = prevent animals from becoming sick.
3 = cure sick animals and prevent animals from becoming sick.
4 = fatten animals / help them grow faster.
5 = I don't know.
2.6 What do (define antibiotics using local pilot tested terminology and common product examples) do?
1 = cure sick animals.
2 = prevent animals from becoming sick.
3 = cure sick animals and prevent animals from becoming sick.
4 = fatten animals / help them grow faster.
5 = I don't know.
(EVALUATE WHETHER HAVE SEEN EVIDENCE OF AMR OR IMPROPER/INSUFFICIENT TREATMENTS)

2.7 Have you experienced situations where (define antibiotics using local pilot tested terminology and common product examples) did not work?

1 = Yes, frequently.
2 = Yes, sometimes.
3 = No, never.

(LAST QUESTION – could go into human health section or both in animal health and human health)

3. Do you believe that if (antibiotics defined according to local terminology and using common example) are used too much that they will stop working?

1 = No.
2 = Yes.
3 = I don't know.

(GAUGING CONSUMER CONCERN ABOUT ANTIMICROBIAL RESIDUES / AWARENESS ABOUT AMR RISK VIA FOOD)

Question for general Household Questionnaire:

4. Would it matter to you if you ate meat or other animal products such as eggs and milk that contained (define antibiotics using local pilot tested terminology and common product examples)?

1 = No.
2 = Yes.
3 = I don't know.

Appendix E. Formulation of questions

1. the type of antibiotics used

Determining whether a farmer used antibiotics on animals was the first goal of the exercise. However, as not all farmers are aware of which substances may be antibiotics, a list of 15 commonly used antibiotic used on livestock in Uganda was provided to the enumerators accompanied with visual aids of major labels.

The question was phrased: “In the past 12 months, has any member of your household used any of these medicines called antibiotics on [LIVESTOCK GROUP], such as…”. The farmers had to answer “yes or no” while being shown the pictures of the 15 antibiotics. S/he could also add to the list. In interpreting the data, we assumed that everyone who answered the question could tell whether they have used the listed substance, but it is possible that the respondent answered “yes” or “no” in case of doubt. In any case, the use of images allows to identify as antibiotics some of the medicines used and is supposed to reduce the error that may come from not knowing which medicines are antibiotics. Introducing a “don't know” option may further improve the data in future AAS surveys.

There were also 227 observations among the “Other antibiotic, please specify” category where the respondent could not name the antibiotic s/he was using but knew that s/he was using one. In many of these cases, the farmers said that the medicine was given directly by the veterinarian and they could not identify the packaging shown on the pictures. To increase the probability that that such farmers are included, it is advisable to include a filter question asking “Have you used any antibiotics in [LIVESTOCK GROUP] in the last [REFERENCE PERIOD]?”

Furthermore, the question focuses on direct use of antibiotics and does not mention the use of animal feed containing antibiotics. This may lead to an underestimation of the real level of AMU in animals and - where possible - a question on use of feeds containing antibiotics could improve the data. Alternatively, the current question can be modified as follows:“In the past 12 months, has any member of your household used any of these medicines (or feed containing these medicines) called antibiotics on [LIVESTOCK GROUP], such as…”.

2. the purpose of using antibiotics

The questionnaire included information on why antibiotics were used, which is important to have a better understanding of responsible AMU. The question was: “What was the main purpose for giving antibiotics to [LIVESTOCK GROUP]?” The response options were “Curative treatment”, “To promote animal growth”, “As a preventive measure”, “For vaccination purposes”, “Don't know” and “Other (specify)”.

An ex post analysis suggests the response option “For vaccination purposes” may be considered a preventive measure and is therefore advisable to be omitted from the list of possible answers to improve clarity. In interpreting the data, therefore, we have grouped these two options in one category labelled “prophylaxis”.

3. the frequency of usage of antibiotics

Understanding the frequency of usage is also critical to appreciate whether livestock farming can eventually contribute to AMR in humans. The question was formulated as: “In the last 12 months, how often did you give antibiotics to your [LIVESTOCK GROUP]?”. Possible answers included: “Regularly, at least once per week”, “Regularly, at least once per month”, “Occasionally”, “Don't know / Don't remember”.

4. who advises on the use of antibiotics

This question aims to understand whether farmers are giving antibiotics under some veterinary control, as it should be. It was formulated as “Who gave you advice to use antibiotics for [LIVESTOCK GROUP]?”. Possible answers include: “NGO (Non-Governmental Organization)”, “Public Veterinary Officer”, “Private Veterinary Officer”, “Extension worker”, “Input dealer (drug shop, pharmacy)”, “my own decision – consulted no one” and “other (specify)”.

5. farmer's opinion on whether frequent use of antibiotics can alter the effect of the drugs

The objective of this question is to appreciate farmers' knowledge of the possible negative effects of overuse of antibiotics, which is expected to influence their behaviour. The question was formulated as” How much do you agree with the following statement: If antibiotics are often given to animals, the antibiotic will become less effective in curing sick animals". Possible answers are "fully agree", "agree", "disagree", "completely disagree" and "don't know". It is worth noting that, typically, respondents in a survey tend to agree with open claims and, therefore, results could be biased.

References

[1] World Health Organization, Antimicrobial Resistance, https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance, (2020).

[2] Review on Antimicrobial Resistance, Antimicrobial Resistance: Tackling a Crisis for the Health and Wealth of Nations, https://amr-review.org/sites/default/files/AMR%20Review%20Paper%20-%20Tackling%20a%20crisis%20for%20the%20health%20and%20wealth%20of%20nations_1.pdf, (2014).

[3] General Assembly of the United Nations, Political Declaration of the High-Level Meeting of the General Assembly on Antimicrobial Resistance, https://digitallibrary.un.org/record/842813, (2016) (accessed 10 February 2020).

[4] World Health Organization, Global Action Plan on AMR, https://apps.who.int/iris/bitstream/handle/10665/193736/9789241509763_eng.pdf?sequence=1, (2015).

[5] World Organization for Animal Health (OiE), Annual Report on Antimicrobial Agents Intended for Use in Animals, https://www.oie.int/fileadmin/Home/eng/Our_scientific_expertise/docs/pdf/AMR/Annual_Report_AMR_3.pdf, (2019).

[6] T.P. Van Boeckel, E.E. Glennon, D. Chen, M. Gilbert, T.P. Robinson, B.T. Grenfell, S.A. Levin, S. Bonhoeffer, R. Laxminarayan, Reducing antimicrobial use in food animals, Science 357 (6358) (2017) 1350–1352, https://doi.org/10.1126/science.aao1495.

[7] Food and Drug Administration, Summary Report on Antimicrobials Sold or Distributed for Use in Food-Producing Animals, https://www.fda.gov/media/119332/download, (2018).

[8] HM Government, Tackling Antimicrobial Resistance 2019–2024. The UK's five-Year National Action Plan, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/784894/UK_AMR_5_year_national_action_plan.pdf, (2019).

[9] HM Government, One Health Report, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/447319/One_Health_Report_July2015.pdf, (2015).

[10] Food and Agriculture Organization of the United Nations, Africa Sustainable Livestock 2050, Africa Livestock to 2050: A Second Food Revolution (Unpublished results), (2020).

[11] Y. Basulira, S.A. Olet, P.E. Alele, Inappropriate usage of selected antimicrobials: comparative residue proportions in rural and urban beef in Uganda, PLoS One 14 (1) (2019), https://doi.org/10.1371/journal.pone.0209006.

[12] R. Manishimwe, K. Nishimwe, L. Ojok, Assessment of antibiotic use in farm animals in Rwanda, Trop. Anim. Health Prod. 49 (6) (2017) 1101–1106, https://doi.org/10.1007/s11250-017-1290-z.

[13] T.B. Tufa, F. Gurmu, A.F. Beyi, H. Hogeveen, T.J. Beyene, D. Ayana, F.T. Woldemariyam, E. Hailemariam, F.D. Gutema, J.A. Stegeman, Veterinary medicinal product usage among food animal producers and its health implications in Central Ethiopia, BMC Vet. Res. 14 (1) (2018) 409, , https://doi.org/10.1186/s12917-018-1737-0.

[14] W. Furgasa, T. Tufa, Review on antimicrobial usage in food animals: challenges in Ethiopia and its future perspectives, Sch. J. Agric. Vet. Sci. (2018), https://doi.org/10.21276/sjavs.2018.5.9.1 https://www.researchgate.net/publication/328066185_Review_on_Antimicrobial_Usage_in_Food_Animals_Challenges_in_Ethiopia_and_its_Future_Perspectives (dataset).

[15] Global Database on Antimicrobial Resistance, https://amrcountryprogress.org/#docs, (2018).

[16] Government of Uganda, Antimicrobial Resistance National Action Plan, https://cddep.org/wp-content/uploads/2018/12/GoU_AMR-NAP.pdf, (2018).

[17] FAO, Guidelines for the Preparation of Livestock Sector Reviews. Animal Production and Health Guidelines. No. 5. Rome, Page 51, http://www.fao.org/3/i2294e/i2294e00.pdf, (2011).

[18] FAO, Africa Sustainable Livestock 2050, Production Systems Spotlight Uganda, http://www.fao.org/3/i8713en/i8713en.pdf, (2018).