
Antimicrobial Resistance in Slaughterhouses, Kenya

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Slaughterhouses are hotspots for the transmission of antimicrobial-resistant pathogens. We conducted stakeholder discussions on antimicrobial-resistant pathogens within the slaughterhouse setting. Butchers were described as powerful stakeholders; challenges included limited funding and staff, inadequate infrastructure, and limited laboratory capacity. Slaughterhouse workers understood that their work increased their risk for exposure.

Antimicrobial resistance (AMR) in bacteria is one of the most serious global health threats of this century (1). Slaughterhouses act as disease hotspots because of frequent interactions between humans and animals (2), particularly in rural areas, such as western Kenya (3). Recent work showed that slaughterhouse workers are exposed to several zoonotic pathogens (4–6). However, little is known about the workplace risk for exposure to antimicrobial-resistant bacteria within the slaughterhouse context and the implications of workplace AMR exposure for public health and food safety in the region. This study engaged stakeholders in discussions on AMR within the slaughterhouse setting, with the objective of using baseline information to develop contextually relevant educational material and inform future research and improvements in work conditions.

The Study

This work was embedded within a larger surveillance study conducted in Busia, Bungoma, and Kakamega

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counties in western Kenya (7). In total, we conducted 6 stakeholder discussions exploring AMR in the slaughterhouse context. First, we held focus group discussions (3–9 participants) with the county veterinary officers, subcounty veterinary officers, and meat inspectors in each of the 3 counties. Focus group discussions lasted 2–3 hours, during which other topics not reported in this study (i.e., legislation and animal welfare) were also discussed. Next, we held 3 workshops for slaughterhouse workers from Bungoma (n = 60), Kakamega (n = 90), and Busia (n = 40). Participants were distributed into groups, with a maximum of 20 participants per group, and discussions lasted 45–60 minutes.

The purpose and modus operandi of the discussions were explained, and written consent was obtained from each participant. Discussions were held in English or Kiswahili, as required, and were led by moderators who used an interview guide with broad, open-ended questions (Appendix 1, <https://wwwnc.cdc.gov/EID/article/29/10/23-0017-App1.pdf>). All discussions were recorded and later transcribed verbatim, and translated from Kiswahili to English as needed, by an investigator. Two investigators (K.A.H., L.C.F.) thematically analyzed all transcripts, and inductively derived findings by using an interpretive–descriptive approach to identify themes emerging from the data (8). Each investigator coded all transcripts separately, before discussion and consensus on the main themes (Figure 1; Appendix 2, <https://wwwnc.cdc.gov/EID/article/29/10/23-0017-App2.xlsx>).

From the focus group discussions, we identified stakeholders who play a role in AMR within the slaughterhouse context and how they relate to each other (Figure 2). Butchers emerged as prominent and powerful stakeholders who exerted pressure on others, sometimes impeding them from carrying out

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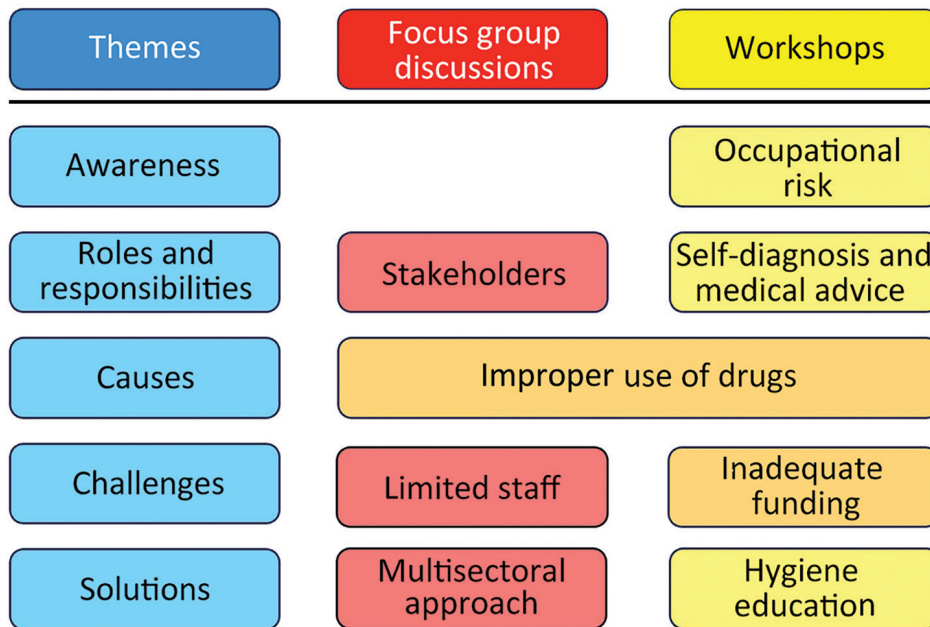


Figure 1. Themes identified from focus groups and in workshops in study of antimicrobial resistance in slaughterhouses, Kenya. Focus group discussions included county veterinary officers, subcounty veterinary officers, and meat inspectors; workshops included slaughterhouse workers. Blue indicates overall themes; red indicates results from focus group participants; yellow indicates results from workshop participants; orange indicates answers shared by both groups of participants.

their work properly. For instance, a meat inspector stated, “Because you will find a carcass has already been prepared, you come and inspect you find the injection sites are all full of drugs, now when you tell this person this animal is supposed to be condemned, my friend you will be looking for trouble, you might even be forced to run.”

Participants recognized improper use of drugs as a factor driving resistance. Improper use included underdosing or overdosing animals and indiscriminate prescribing by professionals, such as medics and veterinarians. For example, a county veterinary officer stated, “If we vets also continue looking at all animals like they are ‘antibiotic deficient,’ that is the disease we treat, this problem will continue escalating.”

Focus groups also identified challenges in dealing with bacterial AMR related to limited staff and inadequate funding, which led to underinvestments in infrastructure and equipment. Some slaughterhouses did not have access to reliable sources of clean water or lacked a perimeter fence, compromising biosecurity. Some slaughterhouse waste was disposed of indiscriminately, contaminating the surrounding environment. Participants cited the absence of surveillance to detect resistant pathogens and the lack of legislation requiring observance of withdrawal periods (periods during which animals are kept from the food chain while medications leave the body) on the farm as further hinderances.

Many participants noted that efforts to combat AMR required a multisectoral approach involving many stakeholders. In particular, they mentioned

medics as a key group to include in public sensitization efforts because of the respect they command in the community.

In workshops for slaughterhouse workers, participants recognized they should seek medical advice before purchasing drugs, but admitted to often self-medicating or administering medications without a prescription because drugs, including some antibiotics, could be purchased directly from a chemist without prescription. The most popular antibiotic purchased for humans was amoxicillin and the most popular for livestock was oxytetracycline (Appendix 1).

Participants had experienced drug failure with antimalarial drugs in humans and with ectoparasitic and anthelmintic drugs in livestock. They understood that drugs often did not work because of misdiagnosis or misuse, including underdosing or not finishing the course. Participants provided various reasons for not finishing the course. A slaughterhouse worker in Bungoma said, “Sometimes you visit the chemist or clinic where a dose is prescribed for you but you don’t have enough cash so maybe the drugs cost like 600 and you have 200. So, because the doctor wants money, they tell you to go with a little drug and ask after how many days will you get the money? You tell him tomorrow. You take the drugs for a few days and notice a change then stop, which also contributes because you have not finished the dose.”

The workers understood that resistance was caused by a germ, and therefore transmitted in similar ways. They were also aware that their work increased

their risk of infection because of their frequent contact with animals. A slaughterhouse worker in Busia said, "So, maybe there are diseases that affect the animals and is [sic] undergoing treatment. The animal is taken to the slaughterhouse without completing the treatment, when slaughtering the animal, there is the interaction between human and the animal. In case there are injury to the human, there may be mixing of blood of the animal and human blood and hence we can also be affected."

Hygiene, both personal and at the workplace, was recognized as a key element in dealing with resistance. However, the uncertainty and poor pay associated with slaughterhouse work did not enable workers to purchase the required clothing and equipment. A slaughterhouse worker from Kakamega said, "...the pay you get is just enough to make ends meet but anything outside can't be covered. The pay is too little for people who do hardy work in the slaughterhouse."

Education was considered essential to understanding and mitigating the risk for bacterial AMR. For instance, a slaughterhouse worker in Busia stated, "Educate us on how we would be handling maybe the meat before it reaches [consumption]... Which other ways are we handling where, educating us on

getting a knife, cutting meat, how to hang the meat so that it doesn't get bacteria from the ground, like you said, dust usually contains bacteria, so you educate us before undertaking the work."

Conclusions

Our analysis identified butchers as powerful stakeholders; elsewhere butchers have been described as uncooperative and profit-driven (9,10). However, their influence could be leveraged to positively influence others, and they should be included in future education campaigns or intervention strategies. Limited finances were a recurring theme, leading to poor health-seeking behaviors despite interviewees being aware of recommended good practices. Many slaughterhouse workers understood how diseases are transmitted and the importance of hygiene measures, suggesting that engagement activities previously conducted in this area (7,11) or developed as part of this work (12) have been effective. However, translation of knowledge into practice is often hampered by the limited resources and external pressures that the workers face.

In conclusion, long-term investments in slaughterhouses are needed to create an enabling environment that reduces the occupational risk to workers and safeguards the food they produce (13). Those

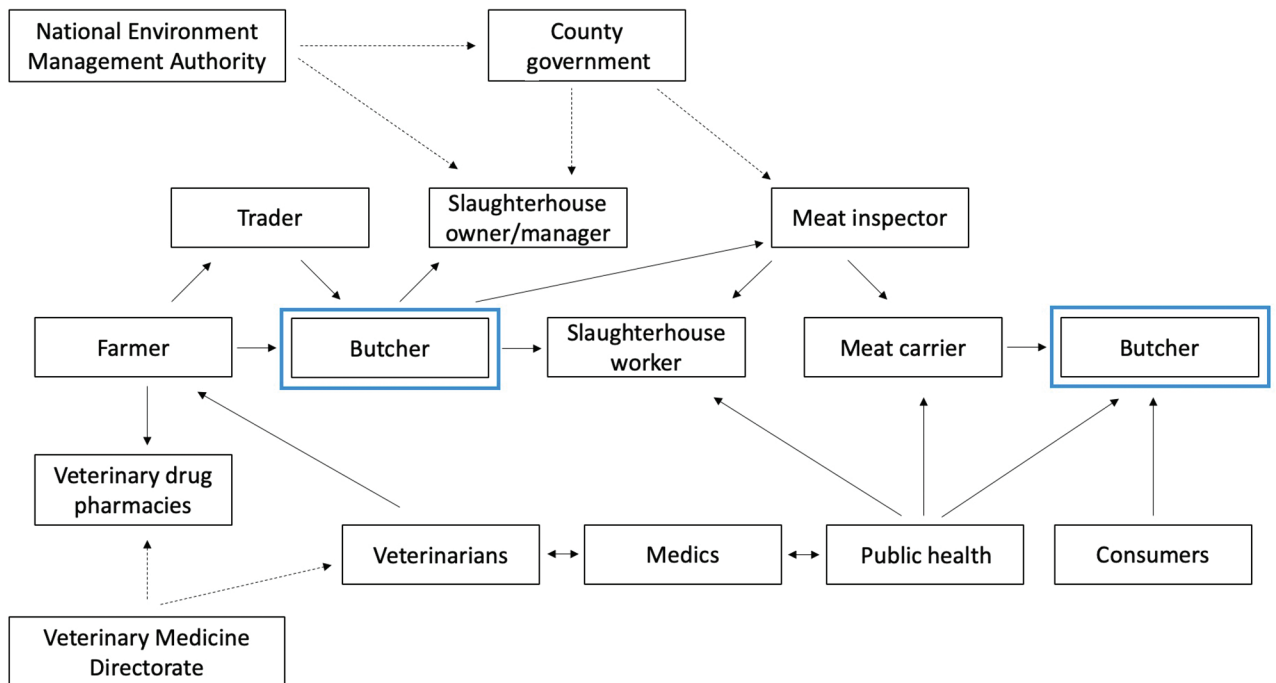


Figure 2. Relationship between stakeholders in study of antimicrobial resistance in slaughterhouses, Kenya. The chart shows relationships within the slaughterhouse context identified in focus group discussions conducted with county veterinary officers, subcounty veterinary officers, and meat inspectors, and in workshops conducted with slaughterhouse workers in western Kenya. Dotted arrows indicate stakeholders with authority to introduce or enforce regulations; solid arrows indicate relationships between stakeholders. Blue boxes indicate a stakeholder whose influence could be leveraged to positively influence others. Further information about stakeholders can be found in Appendix 1 (<https://wwwnc.cdc.gov/EID/article/29/10/23-0017-App1.pdf>).

investments need to be accompanied by investments in laboratory networks and surveillance efforts to better detect and mitigate AMR spread within the slaughterhouse context (14).

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References

- World Health Organization. Global Antimicrobial Resistance and Use Surveillance System (GLASS) [cited 2023 Aug 12]. <https://www.who.int/initiatives/glass>
- Fasanmi OG, Ayodeji IO, Oloso NO, Fasina FO. Retrospective studies of abattoir zoonoses in Nigeria: public health implications. *Perspect Agric Vet Sci Nutr Nat Resour*. 2017;12:1–12. <https://doi.org/10.1079/PAVSNNR201712058>
- Cook EAJ, de Glanville WA, Thomas LF, Kariuki S, Bronsvort BMC, Fèvre EM. Working conditions and public health risks in slaughterhouses in western Kenya. *BMC Public Health*. 2017;17:14. <https://doi.org/10.1186/s12889-016-3923-y>
- Cook EAJ, de Glanville WA, Thomas LF, Kariuki S, Bronsvort BMC, Fèvre EM. Risk factors for leptospirosis seropositivity in slaughterhouse workers in western Kenya. *Occup Environ Med*. 2017;74:357–65. <https://doi.org/10.1136/oemed-2016-103895>
- Cook EAJ, de Glanville WA, Thomas LF, Kiyong'a A, Kivali V, Kariuki S, et al. Evidence of exposure to *C. burnetii* among slaughterhouse workers in western Kenya. *One Health*. 2021;13:100305. <https://doi.org/10.1016/j.onehlt.2021.100305>
- Cook EAJ, Gitahi N, de Glanville WA, Thomas LF, Kariuki S, Kang'ethe E, et al. Prevalence and risk factors for exposure to *Toxoplasma gondii* in slaughterhouse workers in western Kenya. *BMC Infect Dis*. 2021;21:944. <https://doi.org/10.1186/s12879-021-06658-8>
- Falzon LC, Alumasa L, Amanya F, Kang'ethe E, Kariuki S, Momanyi K, et al. One Health in action: operational aspects of an integrated surveillance system for zoonoses in western Kenya. *Front Vet Sci*. 2019;6:252. <https://doi.org/10.3389/fvets.2019.00252>
- Maykut P, Morehouse R. *Beginning qualitative research: a philosophical and practical guide*. 1st ed. London: Routledge; 1994.
- Murungi MK, Muloi DM, Muinde P, Githigia SM, Akoko J, Fèvre EM, et al. The Nairobi pork value chain: mapping and assessment of governance, challenges, and food safety issues. *Front Vet Sci*. 2021;8:581376. <https://doi.org/10.3389/fvets.2021.581376>
- Ameso EA, Bukachi SA, Olungah CO, Haller T. Ethnography of the slaughterhouse: a case of Nanyuki slaughterhouse in Laikipia County, Rift Valley, Kenya. *Pastoralism*. 2017;7:32. <https://doi.org/10.1186/s13570-017-0107-z>
- Falzon LC, Ogola JG, Odinga CO, Naboyshchikov L, Fèvre EM, Berezowski J. Electronic data collection to enhance disease surveillance at the slaughterhouse in a smallholder production system. *Sci Rep*. 2021;11:19447. <https://doi.org/10.1038/s41598-021-98495-7>
- Murungi MK, Momanyi K, Odinga CO, Bor N, Ogendo A, Ogola J, et al. Antimicrobial resistance (AMR) educational video, 2019 [cited 2023 Aug 12]. <https://www.youtube.com/watch?v=T472S-zYZf0&t=0s>
- Grace D, Dipeolu M, Alonso S. Improving food safety in the informal sector: nine years later. *Infect Ecol Epidemiol*. 2019;9:1579613. <https://doi.org/10.1080/2008686.2019.1579613>
- Bett K, Vijaykumar C, Slotin J, Kiambi S, Wesangula E, Tanui E, et al. People power: using citizen-generated data to address antimicrobial resistance in Kenya [cited 2023 Aug 12]. <https://www.data4sdgs.org/sites/default/files/2021-09/AMR-report-V4.pdf>

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Appendix

Further Information about Stakeholders

Farmers are the primary source of animals and should ensure that animals sold for slaughter are healthy and not under treatment. Animals are bought by butchers, either directly or indirectly through traders, and taken for slaughter. Butchers were considered powerful stakeholders because they often had political connections, and they sometimes impeded other stakeholders, including meat inspectors, from executing their work properly. Slaughterhouses are either owned by private individuals or by the county government, who are responsible for procuring equipment and maintaining the slaughterhouse environment. Before the slaughterhouse is constructed, the National Environment Management Authority performs an environmental assessment of the site, after which they monitor the slaughterhouse building environment and waste disposal process. Meat inspectors should be present in all slaughterhouses. They ensure that slaughterhouse workers have been trained, are licensed, and are wearing clean and adequate clothing. They conduct antemortem and postmortem inspections and condemn unsafe meat. They inspect the meat box used to transport meat from the slaughterhouse to the butchery before issuing certificates of transport. Public health inspectors from the Ministry of Health check the cleanliness of butcheries and issue medical certificates for all slaughterhouse workers and meat carriers. Consumers could drive change by choosing to buy inspected meat from clean butcheries. Livestock antibiotics can be purchased from veterinary drug pharmacies (agrovets). The Veterinary Medicine Directorate ensures that drugs are sold on

prescription and that the withdrawal period is respected. A multisectoral approach that involved medics was considered desirable when dealing with antimicrobial resistance.

Data Collection Tool for Focus Group Discussions with Sub-County Veterinary Officers

Thank you for agreeing to participate in this meeting. Through the following questions we hope to better understand issues related to animal welfare, antimicrobial resistance, public health and food hygiene in the slaughterhouse context. There are no right and wrong answers, so please feel free to express your thoughts and opinions.

We shall first start with a couple of more general questions.

[Governance]

1. Which pieces of legislation govern your work?

1a. Of these, are there any County-specific legislations?

1b. If yes, were you involved in their development?

1c. Of the legislations that you've mentioned, which are specifically related to slaughterhouse activities (e.g., welfare at slaughter, meat inspection)?

1d. Are you able to implement these legislations?

1e. In your opinion, are these legislations sufficient to carry out your work?

1f. How would you compare your experience in implementing these legislations before and after devolution?

[Challenges]

2. Besides legislation issues mentioned above, what other challenges do you encounter in your work?

We're now going to ask you a set of questions related to the following sub-topics: Animal welfare, Antimicrobial resistance, Public Health and Food Hygiene.

Let's start with Animal Welfare:

[Awareness]

3. Are you aware of *Animal Welfare* within your work context?

[Activities]

4. What activities related to *Animal Welfare* do you carry out during your work?

[Actors involved]

5. Who do you interact with when implementing *Animal Welfare* activities during your work?

[Concerns/Challenges]

6. What are your main concerns/challenges when trying to implement *Animal Welfare* during your work activities?

7. How do you think *Animal Welfare* will change in 10 years' time?

8. How would YOU want *Animal Welfare* to change in 10 years' time? (*"If you were king for a day, what would you change?"*)

Thank you for that. Now we shall move on to issues related to Antimicrobial resistance.

[Awareness]

9. Are you aware of *Antimicrobial resistance* within your work context?

[Activities]

10. What activities related to *Antimicrobial resistance* do you carry out during your work?

[Actors involved]

11. Who do you interact with when implementing *Antimicrobial resistance* activities during your work?

[Concerns/Challenges]

12. What are your main concerns/challenges when trying to implement *Antimicrobial resistance* concepts during your work activities?

13. How do you think *Antimicrobial resistance* will change in 10 years' time?

14. How would YOU want *Antimicrobial resistance* to change in 10 years' time? (*"If you were king for a day, what would you change?"*)

Now, for the last set of questions we'll focus on public health and food hygiene.

[Awareness]

15. Are you aware of *Public health and Food hygiene* within your work context?

[Activities]

16. What activities related to *Public health and Food hygiene* do you carry out during your work activities?

[Actors involved]

17. Who do you interact with when implementing *Public Health and Food Hygiene* activities during your work?

[Concerns/Challenges]

18. What are your main concerns/challenges when trying to implement *Public Health and Food Hygiene* during your work activities?

19. How do you think *Public Health and Food Hygiene* will change in 10 years' time?

20. How would YOU want *Public Health and Food Hygiene* to change in 10 years' time? (*"If you were king for a day, what would you change?"*)

We've now almost reached the end of the questions. Before ending...

21. Could you EACH please rank the following challenges (list put together during discussion), starting with those you think should be dealt with first? We can then discuss them together after.

(*hand out piece of paper to each participant so they can write things down).

22. Of the three themes we've discussed today (i.e., animal welfare, antimicrobial resistance, and public health and food hygiene), which one do you think would be easiest to address?

Before ending, could we kindly ask you to write on a piece of paper what you found most and least useful about this meeting? Thank you.

(*provide them with a piece of paper to write).

Thank you for your time. Do you have any other thoughts or comments you would like to share with us?

Thank you.

Questions for Slaughterhouse worker workshops:

a) Animal Welfare

- What do you think this is?
- What do you do about it? **strengths*
- What can be done in your workplace? **opportunities*
- What keeps you from making these changes? **weaknesses/threats*
- Any other challenges?
- How do you like to receive information?

b) Antimicrobial resistance

- What do you think this is?
- What do you do about it? **strengths*
- What can be done in your workplace? **opportunities*
- What keeps you from making these changes? **weaknesses/threats*
- Any other challenges?
- How do you like to receive information?

c) Public health and food hygiene

- What do you think this is?
- What do you do about it? **strengths*
- What can be done in your workplace? **opportunities*
- What keeps you from making these changes? **weaknesses/threats*
- Any other challenges?

- How do you like to receive information?

d) Human welfare and worker satisfaction

- Where did you learn how to do your work?

- How do you feel about your work?

- How do you get paid?

- What are the challenges you face?

- How do you like to receive information?

Appendix 1 Table. The drugs used in humans and for livestock, and the reasons given for taking a particular drug, as mentioned by slaughterhouse workers in western Kenya during workshops on antimicrobial resistance in the slaughterhouse context.

Drug Class	Drug	Product Name	Reason for Use
Humans			
Antibiotic	Amoxicillin	NS	Throat pain; Cough
	Ciprofloxacin	Ciproflax	Cough; Cold
	Ethambutol	Actol	Diarrhea
	Neomycin, Bacitracin & Polymyxin	Grabacin	Wounds
	Trimethoprim/Sulfamethoxazole	Septrin	Cough; Cold
Anthelmintic	NS	NS	Worms
Anti-histamine	Celestamine	NS	Cold
	Ceptrizine	NS	Cold; Cough
	Chlorphenamine maleate	Piriton	Lack of appetite; Cough; Insomnia; Cold
Anti-inflammation	Aspirin	Mara Moja	Weakness; Malaria; Strong cough
	Diclofenac	NS	Fever; Toothache
	Ibuprofen	Brufen	Cough; Body pains
	Indomethacin	Indocid	
	Paracetamol	Panadol	Headache, Stomach ache; Body pains; Fever
		Sona Moja	Headache; Dizziness
		Hedex	Headache; Throat pain; Weakness
Anti-malarial	Artemisinin-Based Combination Therapy	NS	Malaria
	Artemether-Lumefantrine	NS	Malaria
	Metakelfin	NS	Fever; Headache; Joint pains
Anti-protozoal	Metronidazole	Flagyl	Diarrhea; Stomach upsets
Combination medicine	Chlorpheniramine maleate, Dextromethorphan, Hydrobromide, Paracetamol & Phenylephrine	Flugone	Cough
	Chlorpheniramine maleate & Phenylpropanolamine hydrochloride	Coldcap	Cold
	Glycyrrhiza extract, Menthol, Oil of Anise, Oil of Peppermint, Tincture of Capsicum, Oil of Pine, Oil of Eucalyptus & Creosote	Cofta	Throat pain
Multivitamin	B-complex minerals	Action	Headache
Oral Rehydration Solutions	NS	NS	Diarrhea
Traditional medicine	Aloe vera	NA	Malaria; Pain; Foot wounds
	Eggs & Soda ash	NA	Cough
	Herbs	NA	Worms
	Lemon, Garlic & Ginger	NA	Cough
	Neem	NA	Skin rashes
Livestock			
Antibiotic	Oxytetracycline hydrochloride	Egocin	Chicken disease; Lack of appetite
	Tetracycline	Tetrax	Swollen abdomen
Anthelmintic	Albendazole	Albafas	NS
	Levamisole	Nilzan	NS
Ectoparasiticide	Amitraz	Triatix	NS
	Chlorpyrifos & Cypermethrin	DuoDip	NS
Hormones	Oxytocin	Vetox	Chicken disease
Multivitamin	Vitamin B12 & Phosphorus	Catasol	Increase appetite
Traditional medicine	Herbs	NA	Foot problems
	NS	NA	Diarrhea

*NA, not applicable; NS, not specified.