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Animal Husbandry Practices and Perceptions of Zoonotic Infectious Disease Risks among Livestock Keepers in a Rural Parish of Quito, Ecuador

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Abstract. Small-scale livestock production plays an essential role as a source of income and nutrition for households in low- and middle-income countries, yet these practices can also increase risk of zoonotic infectious diseases, especially among young children. To mitigate this risk, there is a need to better understand how livestock producers perceive and manage risks of disease transmission. Twenty semistructured, in-depth interviews were conducted with small-scale livestock producers in a semirural parish of Quito, Ecuador. Interviews explored livestock-raising practices, including animal health-care practices and use of antimicrobials, family members' interactions with livestock and other animals, and perceptions of health risk associated with these practices and activities. Interviews were analyzed for common themes. Awareness of zoonotic disease transmission was widespread, yet few study participants considered raising livestock a significant health risk for themselves or their families. Several study households reported handling and consuming meat or poultry from sick or dead animals and using animal waste as a fertilizer on their crops. Households typically diagnosed and treated their sick animals, occasionally seeking treatment advice from employees of local animal feed stores where medications, including antimicrobials, are available over the counter. Despite a basic understanding of zoonotic disease risk, this study identified several factors, such as the handling and consumption of sick and dead animals and purchasing medications for sick animals over the counter, that potentially increase the risk of zoonotic disease transmission as well as the development and spread of antimicrobial resistance.

INTRODUCTION

Despite considerable progress in reducing infection-related early childhood death worldwide, infectious diseases in children remain a significant public health concern, particularly in low- and middle-income countries (LMICs). In 2013, for example, 9.2% of the 6.2 million deaths in children under 5 years of age were the result of diarrhea-related illness, making it the second leading cause of early childhood death due to infection.[1] Mortality from diarrhea in Ecuador has decreased significantly over the past decade, yet in 2010, it still accounted for an estimated 8.7% of noninjury deaths in Ecuador among children between 1 and 59 months.[2]

There is increasing evidence that fecal contamination associated with animals in the household environment may be an important risk factor for diarrhea and environmental enteric dysfunction in children.[3] Geophagy is a common behavior in young children in resource-poor settings, and the soil consumed is often found to be contaminated with animal feces.[4,5] In addition to fecal contamination, the presence of livestock in the household environment can increase zoonotic infectious disease risk by leading to more frequent human–animal interactions and possible contamination of food for human consumption (see Figure 1 for a conceptual diagram of common zoonotic pathogens and transmission pathways).[6–8]

In South America, small-scale livestock production is a common practice among households. Pica-Ciamarra and others estimated that 84.5% of rural households and 28.4% of urban households in Ecuador raise livestock.[9] In neighboring Peru, the 2007–2008 Demographic and Health Survey found that 86% of rural and 34% of urban households reported owning livestock.[10] The number of urban and peri-urban (suburban) livestock producers will probably increase due to the growing demand for animal products as well as the need to generate income in urban settings.[11] Furthermore, research suggests that animal agriculture in suburban or peri-urban communities may result in the highest risk for zoonotic disease transmission due to generally poor living conditions, shared living spaces, and competition for resources.[6,12]

Existing studies show that contact with food-producing animals such as livestock and poultry increase the risk of diarrhea in children.[13] Studies have revealed several common enteric pathogen–animal combinations and identified positive associations between chicken ownership and transmission of *Campylobacter* spp.[14,15] and *Salmonella* spp.[16]; positive associations have also been found between farm animal exposure and pathogenic strains of *Escherichia coli*.[17–19] Despite risks of zoonotic infectious diseases, livestock play an essential role as sources of income and nutrition for households, and consumption of animal products have been shown to be protective against stunting in children.[20]

Inappropriate or unregulated use of antimicrobials in both humans and livestock can contribute to the development and spread of antimicrobial-resistant bacteria, particularly in LMICs.[21,22] Research suggests that the use of antimicrobials with food animals, which is often used to speed animal growth and decrease the incidence of disease, also contributes to this risk.[6,23–26] The use of antimicrobials for growth promotion is of particular concern for resistance selection because of the animals' constant exposure to subtherapeutic levels of antimicrobial concentrations.[27,28] In the United States, an estimated 70% of all antimicrobials consumed are by livestock, and globally, it is estimated that antimicrobial use with animals is at least equivalent in scale to use in humans.[29] Many primary risk factors contributing to resistance have been identified including those related to consumer behavior

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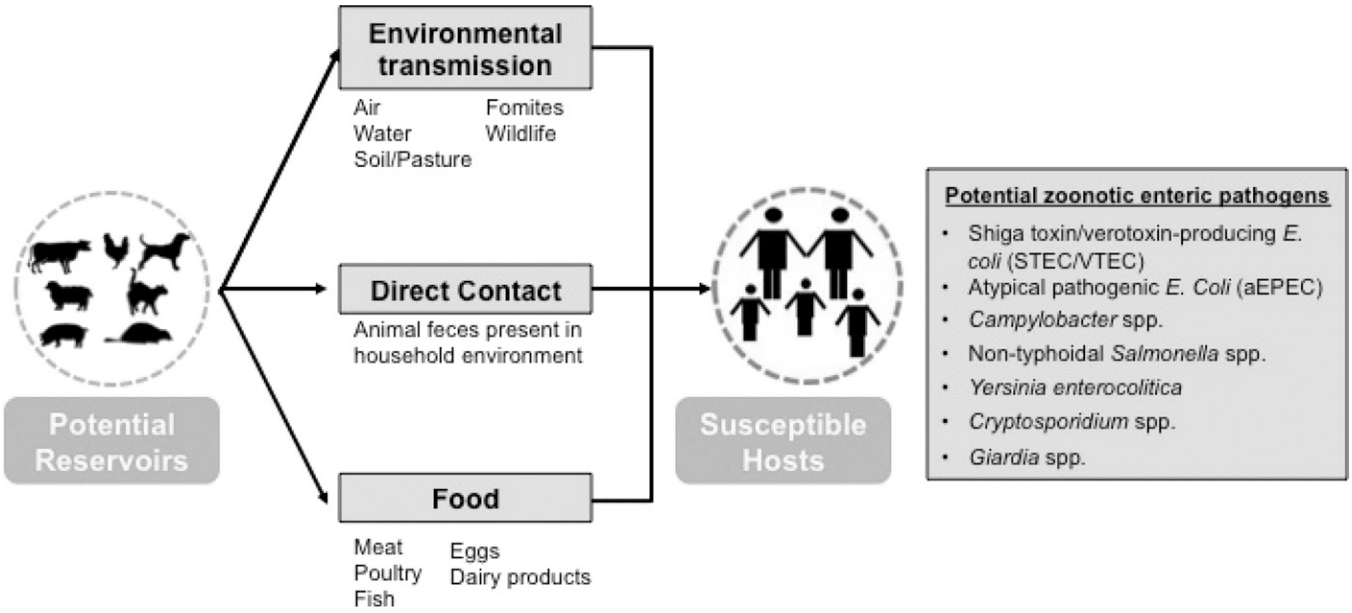

FIGURE 1. Common zoonotic enteric pathogens and transmission pathways. This figure appears in color at www.ajtmh.org.

(e.g., noncompliance, misinformation, self-administration) as well as the behavior of providers and suppliers (e.g., overprescription, lack of training, poor drug quality, patient pressures). In developing countries, these risk factors may be magnified due to poverty, ineffective health-care systems, weak public health infrastructure, and a lack of monitoring and surveillance of antimicrobial use.[30–32]

To our knowledge, limited studies have examined beliefs and perceptions regarding zoonotic infectious diseases, agricultural antimicrobial use, and the risk associated with the development of drug-resistant bacteria in South America. Given the importance and scale of small-scale livestock production in LMICs, developing a better understanding of household beliefs regarding zoonotic disease transmission and perceptions of risk associated with these practices may contribute to the design and implementation of more effective zoonotic disease-prevention strategies.

MATERIALS AND METHODS

Semistructured interviews were conducted between May and June 2015 in Otón de Velez, Yaruquí, a rural parish approximately 40 km west of Quito, Ecuador. Yaruquí has an estimated population of 18,000 and consists of 22 neighborhoods.[33] This community was selected for the study because it is characterized by high levels of small-scale livestock production, and research has documented a high prevalence of zoonotic enteric infections in children.[34] The sampling frame for this study consisted of all households in Otón de Velez with a child under 5 years of age in which the household reported raising livestock. Research conducted by a member of the research team during the previous year identified approximately 60 households to be within this sampling frame. The data collection team, which included a community liaison, approached each household and conducted a series of screening questions to determine eligibility based on the presence of children and livestock. If determined to be eligible, households were asked to participate in the study and given additional information about the study protocol, interview process, and human subject protections. This recruitment strategy was repeated over the course of 3 weeks until the target number of interviews (20) was reached. Only one eligible household declined to participate in the study. All interviews were conducted in Spanish by teams of two or three researchers and the community liaison with the household's self-reported primary animal caretaker; all respondents were female. Interviewees were offered a food basket (valued at US$10) as a token of appreciation for their participation in the study. Interviews took place in the respondents' homes or yard and were audio recorded using a handheld recording device. The duration of interviews ranged from 15 to 40 minutes. Within 30 days of the interview, bilingual research team members transcribed the interview recordings in Spanish and subsequently translated the transcripts into English.

Materials. We used a semistructured interview guide modified from an existing instrument applied in a previous study of animal husbandry practices in rural Bangladesh.[35] The interview instrument was designed to elicit an open-ended conversation with individuals regarding their livestock-raising practices, including animal health-care practices and use of antimicrobials, their family members' interactions with livestock and other animals, and perceptions of health risk associated with these practices and activities. Specific constructs for the interview instrument were based on evidence from previous studies in LMICs highlighting common livestock-raising behaviors and practices associated with zoonotic disease transmission. These included the presence of shared living spaces with animals, including shared sources of drinking water, improper disposal or reuse of animal waste, lack of handwashing after interacting with animals, and the use of antimicrobials with food producing animals.[35–39]

Additional open-ended questions were included to address economic, cultural, and psychological factors of the risk environment for zoonotic disease transmission as defined by Goodwin and others. Macrolevel factors of the risk environment included human migration, changes in land use (specifically the

transition from rural to urban or peri-urban agriculture), and factors related to the built environment, such as the lack of public health infrastructure (e.g., sanitation) and urban planning/occupant density.[7,40] Microlevel factors included local environmental conditions as well as the psychological or cultural motivations for animal–human interaction, animal management decision-making, and perceptions of risk for disease transmission.

Finally, questions regarding large-scale livestock operations present in the study community were also included in the discussion guide. This construct was added to address existing research suggesting that areas "where large-scale production units are in proximity to traditional, small-scale production" are at especially high risk for zoonotic disease transmission, as well as findings that industrial agriculture is a significant reservoir for antimicrobial drug–resistant *Salmonella* and *Campylobacter* in LMICs.[6,41,42] The interview guide was pretested with two community members in Yaruquí and modified based on feedback to improve clarity, flow, and face validity of the questions.

Analysis. Interview transcriptions were analyzed by one researcher using a three-stage coding process consistent with a grounded theory approach to qualitative data analysis.[43,44] First, interview transcripts were coded against a coding scheme that closely aligned with principal constructs in the open-ended interview guide. Examples of codes include "use of antibiotics with livestock" and "precautions to mitigate the risk of illness." To reduce errors in omission or judgment, we modified this open coding scheme throughout the data collection and analysis period based on discussions with the field research team and the subsequent axial and selective coding processes. In these latter stages of analysis, we identified underlying properties and categories in the data to develop key themes and interrelations among reported behavior and perceptions. All analyses were conducted using NVivo qualitative software (Melbourne, Australia).[45] The Institutional Review Board of the Universidad San Francisco de Quito approved all study procedures and materials in advance.

RESULTS

Characteristics of the sample of 20 households in Yaruquí are presented in Table 1. Consistent with our sampling criteria, all households had at least one child under 5 years of age, and eight of the households reported having two or more children under this age. The total household size ranged from 3 to 10 individuals, with the majority having three to five persons. Eight of the 20 interviewees reported having completed education beyond primary school. Sixteen of the 20 individuals interviewed reported owning their own property, and 70% reported owning their own home. Chickens (85%), guinea pigs (85%), pigs (60%), and rabbits (20%) were the most commonly raised animals across the 20 households we visited. Other animals included ducks, quail, and livestock such as cows, horses, and sheep.

TABLE 1
Characteristics of households included in the study

	Households interviewed (N = 20)
No. of people in household	Mean = 5.5
3–5	12 (60%)
6–8	5 (25%)
≥ 9	3 (15%)
No. of children under 5 years of age in household	Mean = 1.5
1	12 (60%)
2	6 (30%)
≥ 3	2 (10%)
Respondent self-reported educational attainment	
Primary	12 (60%)
Secondary	7 (35%)
Some university or above	1 (5%)
Self-reported household assets	
Working television	20 (100%)
DirecTV or satellite television	3 (15%)
Functioning car or truck	4 (20%)
Computer	6 (30%)
Internet	4 (20%)
Own home	14 (70%)
Own property	16 (80%)
Food animals raised on property	
Chickens	17 (85%)
Guinea pigs	17 (85%)
Pigs	12 (60%)
Rabbits	8 (20%)
Other food animals	8 (20%)

Purpose of raising livestock. Nearly all respondents who raised chickens and guinea pigs reported using animals for their own consumption or to sell to neighbors, family members, or local stores as a source of additional income. When asked about the primary purposes of raising chickens, one respondent explained: "to eat … or occasionally I cannot afford the bus fare for my kids, so I take [the chickens] and sell them… to help with [costs of] the house" (INT 14). No respondents pointed to the sale of livestock or animal products as their family's primary source of income, suggesting this practice serves a more supplementary role in situations when additional income is needed. Among households that raised more than one type of animal, there was significant variation in the primary purpose of raising certain animal species. For example, smaller animals such as poultry and guinea pigs appeared more likely to be used for in-home consumption than pigs and cows, which were often raised exclusively for the purpose of being sold. When asked about raising livestock for personal consumption, respondents most often noted that they preferred the taste and smell of animals they had raised themselves to those produced in larger industrial farms. Several respondents commented on the difference between the chickens produced at the household level and those from the nearby large-scale farm, exemplified by this respondent's comment:

> *I prefer to raise my own [chickens] so I can eat my own [chickens]… they are better-tasting. That is what I do. I don't buy them [from other places], I am afraid because they smell bad.* (INT 9)

Other respondents suggested that animals raised in backyard settings are healthier to eat than animals raised in commercial environments because of additives generally believed to be used in larger operations: "it is not healthy, not healthy to eat [animals from industrial farms]. It's because there are lots of antibiotics that normally cause harm…it is like food dyes" (INT 11).

In households where crops were the primary source of income (most commonly, strawberries or alfalfa), respondents noted the usefulness of raising animals for the production of fertilizer for their agricultural products. Other respondents

commented that they derived personal enjoyment from raising animals, and some noted the cultural significance of having and caring for animals—especially chickens, pigs, and guinea pigs—as a family practice that had been passed down for generations. When asked about the primary reason for raising chickens, one respondent commented:

> *It's because it was the custom of our ancestors, of our parents, of our mothers. They had always been accustomed to having [animals] too. They told us, "you have to have a chicken or a small animal…"* (INT 18)

Changes in animal stock over time. Although many respondents noted that raising animals is something their families have always done, several reported that they had downsized the scale of their livestock-raising operations from previous generations, primarily due to a lack of physical space and availability of food for the animals. The primary catalyst for these changes, according to most respondents, was the recent construction of Quito's international airport in a parish adjacent to the study community. Most individuals we interviewed reported having migrated sometime in the last 30 years, a move that resulted in significant changes in their livestock-raising practices. When asked about the primary differences between her family's life in Otón de Vélez and the area where they lived before the construction of the airport, one respondent explained:

> *Over there, it was more spacious; there was more space. There were farms over there where you could have lots of animals far from the house. In contrast, as you see here, everything is roofed-in, hard to grow enough to feed [the animals]. And before, over there, on the land that wasn't used by [owners of the farms], they let us have [our own] animals. We are quite uncomfortable [here], over there had more freedom to do whatever, to play or for whatever job.* (INT 15)

Upon reflecting on how their livestock-raising practices have changed since migrating, several respondents described how they brought animals from the other side of the river when they moved, only to find that there was not enough to feed the animals:

> *We brought cattle, a lot of pigs, but now we can't have [the large animals]. … it is because when they are small they eat very little, but when they grow we can't grow enough food on the land. And to buy it is very expensive.* (INT 10)

In addition to the scarcity of food resources, others noted that there is simply not enough room in the parish to support raising large animals. As a result, many had more recently transitioned to raising smaller animals that require less space, such as chickens, guinea pigs, and pigs. However, when asked about plans for raising livestock in the coming years, most households had plans to either maintain or expand the number and types of animals they currently have. Few respondents cited resources or space constraints as reasons for decreasing the size of their production in the coming years. One respondent described her plans to increase her family's livestock operations the following year by building "something to put pigs in, and a shed for the chickens … so I can [sell them] to earn money and help out my husband" (INT 16).

Use of *balanceado* (commercial animal feed). The use of *balanceado* (the local term for commercial animal feed) was prevalent across respondents with different animals. In total, all but three respondents reported using *balanceado* with at least one of their animals at some point in the past year. Respondents reported using *balanceado* primarily to speed animal growth and to increase the size of their animals. As one respondent explained: "I use it to help [my animals] get fat and to grow faster. It is to make them fatter…without it they will end up being skinny" (INT 16). Some interviewees also mentioned using *balanceado* (either by itself or mixed with other animal feeds) to prevent animals from getting sick because of the vitamins included in the feed.

Respondents who reported using *balanceado* did not always use it with all of their animals, and several reported only using *balanceado* when the animals were newborn or still very young. The use of *balanceado* was most common with pigs; more than three-quarters of households reported feeding pigs *balanceado*. Its use was less common with chickens and guinea pigs, possibly because these animals are less likely to be sold for income. Only a quarter of families raising rabbits reported using *balanceado*. The use of *balanceado* was also common among the few households that raised calves, sheep, and other large animals. Several respondents also reported feeding *balanceado* to companion animals (i.e., dogs).

Knowledge of antibiotics in *balanceado*. Respondents varied in their knowledge of whether the *balanceado* they use with their animals contained antimicrobials (referred to as "antibiotics" in the discussion guide for ease of interpretation). Among the respondents who reported using *balanceado* at some point with any of their animals, half believed antibiotics were present in the *balanceado* they used and a slightly smaller portion of the respondents did not know; only one respondent did not believe there were antibiotics in the *balanceado* they used, noting that "there are vitamins, but not antibiotics" (INT 4). Among those who did believe antimicrobials were included in the *balanceado* they use with their animals, most reacted positively and primarily pointed to the presence of antibiotics as an important strategy for helping animals grow faster and preventing parasites, especially when the animals are young. One respondent commented that the presence of antimicrobials in the animal feed she uses is especially important because she raises her animals indoors:

> *The [feed we use] has antibiotics, vitamins. Because of that the animals grow faster. We use medicines more because we raise them inside, because otherwise they die. The animals that are in the fields don't get sick.* (INT 13).

A review of the listed ingredients in commonly used *balanceado* brands obtained from local agricultural stores revealed that none of the store-bought animal feeds did in fact contain antimicrobials.

Animal health-care practices. Nearly all respondents reported having experience managing sick animals in the previous year, yet strategies for treating or curing them varied among households. The diversity in animal health-care practices is evident in the sample of participant responses presented in Table 2. One common strategy for managing sick animals included

TABLE 2
Study participant perspectives on zoonotic disease risks associated with small-scale livestock production in a semirural parish of Quito, Ecuador

Selected themes
Animal health-care practices
Normally I will medicate them myself. Only if it is very necessary I will go see a veterinarian. (INT 1)
When the animal is sick, we give them whatever pill we have. Sometimes they get better and sometimes they die. It doesn't cure them all. (INT 13)
I know my animals are sick when they get weak. For example, the chickens will walk around with their wings drooping and the will be sneezing. So I give them water with lemon, and it cures them. (INT 14)
I give antibiotics when the animals have diarrhea. And when they are born, we inject them with vaccines and antibiotics. I know they are antibiotics. The [local department of agriculture] comes by and vaccinates all of the pigs. (INT 1)
When the chickens are small I give them vaccines every two months. Every four months when they are big. They don't get sick. (INT 14)
A chicken was sick, I isolated it from the others so it wouldn't get the others sick. [What did you do with it?] I killed it, and we ate it. If it dies on its own, I get rid of it. (INT 16)
Knowledge and perception of zoonotic disease transmission
The dog can carry bad diseases, and it lives with us. It worries me. Nobody can really help us. Two years ago we started vaccinating the pigs. [But] the pigs too, in this climate, living out on the land with the sun and the wind, they can transmit diseases. (INT 13)
I would worry about [my children getting sick] if my animals were sick. But my animals are healthy and therefore I don't worry. (INT 2)
I don't know the diseases, but I do worry about [my children getting sick from animals]. The dogs, especially, they carry diseases in their fur. (INT 18)
Diseases, I don't think so because the main feed that we give the dog is balanceado. Also we try to take care of [the other animals]. And also because we don't have a cat anymore, and they say the cat can make the baby sick. (INT 4)
Hygiene practices
I don't let [my children] touch the animals, and they always wash their hands. When their clothes get dirty I make them change. (INT 11)
I make sure they wash their hands before eating and after using the bathroom and all of that. And that they don't have any contact with the animals' mouths. (INT 2)
Only hand washing and healthy eating. My son never ever has been sick with diarrhea. (INT 7)
[I wash] their hands. The youngest has been sick with diarrhea. It was because she put her dirty hands in her mouth. (INT 16)

using medications the respondents already had for treating family members (especially children) with similar symptoms. For example, when asked to describe the last time one of her animals was sick, one respondent recalled: "About three weeks ago there was a chicken that was sick; it had a fever. So I gave it Paracetamol for children because I had it, and it cured it" (INT 3). The use of traditional remedies, such as feeding animals mixtures of water with lemon or chili, was also common. Most respondents reported home remedies to be effective, especially with smaller animals.

Almost all respondents pointed to lack of appetite as the primary symptom of illness in animals. Other common symptoms included diarrhea, self-isolation, and lethargy. Several guinea pig caretakers noted that guinea pigs do not show symptoms and are often simply found dead for unknown reasons. When asked about the primary causes for animals getting sick, respondents mentioned a range of potential causes, ranging from climate, strong odors from nearby industrial farming operations, noise from the airport, and insufficient or poor-quality food. Reflecting on why her calf was recently sick, one respondent commented:

> *It almost died, and the vet told me it had been because I began giving it powdered milk. I could not find any fresh milk. And I [had been] giving it too much. The vet told me I can only give it fresh milk and also give it an injection for the fever.* (INT 15)

In the case of larger animals or animals that did not respond to home remedies, some respondents reported that they consulted individuals at local agricultural supply stores where they purchased animal-specific medications (often the same locations where they purchase *balanceado*). Less often, veterinarians were consulted for advice and prescriptions for medications. Regardless of the type of animal, some households reported that they do not attempt any in-home treatment and choose to consult these experts immediately:

> *My chickens are sick, so I am giving them medication from the veterinarian in Yaruquí, the same place where my husband bought the chickens. [Normally] I tell him what is going on and they give me medication to give them and explain how [to give the medicine].* (INT 17)

Some respondents also alluded to occasional, government-sponsored vaccination campaigns through which residents were encouraged to vaccinate their animals, including pets. Whether medications were obtained from local agricultural supply stores, veterinary clinics, or other sources, most animal caretakers were unaware whether the medications they were using were antibiotics. During the interviews, respondents often used the terms "vaccines" and "vitamins" interchangeably with "antibiotics" or expressed unfamiliarity with the term "antibiotics."

Finally, some respondents reported killing sick animals and selling or consuming the animals themselves, depending on the size of the animal (once sick, larger animals were more likely to be killed and eaten than small animals) or how sick the animal had been. Similarly, upon finding an animal that had already died, many respondents also sold or consumed the animal, provided it had only recently died: "when [the animal] is warm or recently dead, [we eat it]. But if it has already been two or three days, no: we throw it out" (INT 17).

A few respondents claimed that their animals never get sick. When asked about why their animals were so healthy, they credited the use of *balanceado*, antimicrobials, and routine vaccinations, particularly when animals are young. Only one respondent expressed concern regarding the overmedication

of animals, noting that "too much medicine, if the animals are well medicated, [can] pass on to the people and make them sick" (INT 14).

Knowledge and perceptions of large-scale commercial farms. All respondents were aware of large-scale farming operations in the community (defined in the interview guide as farms raising more than 1,000 animals), some of which belonged to or employed close friends or family members. The commercial farms mentioned included one pig farm, one turkey farm, and several large chicken-producing operations. The perceptions of these farms varied; many respondents cited both positive and negative impacts on their community:

> *On one hand they are good because they provide jobs. But for the health, no, because if you live near the sheds the smell is very strong, you can't have a house in front [of one of those farms].* (INT 13)

Respondents were most likely to recognize the employment opportunities provided by these farms, and they also pointed to the importance of these farms as a source of food security because they provide ready access to meat if they are unable to raise animals for their own consumption. The most common perceived health risk associated with nearby commercial farms was the impact of their strong odors (associated with the use of animal waste as a fertilizer) on animal and child health. Many respondents considered the odor to be both a nuisance and a health risk:

> *Sometimes the smell bothers us, the smell from the fertilizer is very strong, very strong. . . .and it makes my kids sick. They are almost always sick with a cold. The colds are because of the strong smell.* (INT 15)

There was a widespread perception of antibiotic use in large-scale farms for the purpose of raising animals to gain weight quickly. When asked about the use of antibiotics in these settings and whether it had an impact on the health of the community, few respondents felt strongly one way or another and generally alluded to the unfavorable taste or smell of the meat produced by large-scale producers as the only negative effect of antibiotic use in these settings. No respondents mentioned specific health risks for themselves or their children related to the use of antibiotics in the large-scale farms in the context of antimicrobial drug resistance, although many shared the perception that eating animals that had been raised with too many antibiotics could be harmful to health.

Knowledge and perception of zoonotic disease transmission. Virtually all respondents were aware that animals could transmit diseases to themselves or members of their families. They differed, however, in the extent to which they considered this to be a risk in their own households (see Table 2 for a sample of participant responses related to this theme). Many stated that they had little or no concern in this regard because it had never happened. Some such respondents suggested this is because children under 5 years of age do not interact with livestock, and therefore, disease transmission is unlikely. In contrast, some participants reported significant concern and provided examples of instances in which their children had been sick, possibly from a zoonotic source. As presented in Table 2, many who expressed concern felt that dogs and cats were the most likely sources of disease because they more frequently interact with children during play. No respondents considered the use of antibiotics for their personal livestock to be a potential risk factor for the health of their families or neighbors.

Hygiene practices. Whether perceived as a significant risk or not, most respondents appeared to be aware of the risks associated with contact with animals and took measures to mitigate these risks. Respondents rarely allowed any animals, including dogs and cats, inside their homes during mealtimes and very few reported allowing any animals (normally dogs and cats) in bedrooms while family members were sleeping. As a precaution, some also did not allow their children near their livestock, and very few reported that children routinely assist with tasks that involve interaction with livestock or their living spaces. All respondents pointed to hygiene, particularly handwashing before eating, as the primary strategy for preventing their children from getting sick. Other prevention measures included boiling water and routine house cleaning.

DISCUSSION

Small-scale livestock production is an important source of income and nutrients for many households in LMICs, including Ecuador. For this reason, promoting small-scale livestock and poultry production has been the focus of many development and antipoverty programs and will probably remain important.[46] This study examined common livestock-raising practices, including animal health care and use of antibiotics, in a rural parish near Quito, Ecuador, where more than three-quarters of households raise livestock, fowl, and domestic animals.

Like other research conducted in LMICs, this study found small-scale livestock production to be an important source of income and food security for the families in the community.[47–49] This finding poses interesting comparisons with recent studies of backyard poultry ownership in high-income countries (HIC), where urban backyard chicken ownership is a growing practice.[50,51] In HICs, backyard egg production does not play a significant role in family income or nutrition as poultry owners more often view their chickens as pets or a hobby activity.[52]

Migration related to the construction of the new Quito airport caused many households to downsize their backyard farming operations due to limited space, scarce resources, and the high cost of animal feed. Rural–urban migration in other countries could have similar effects on livestock keepers, especially with regard to raising fewer animals and smaller animal species because of limited space and resources. Although the direct human health impact of these changes in Yaruquí is beyond the scope of this study, extant literature highlights the potential role of rural–urban migration and land-use changes in the transmission of disease-causing pathogens.[7] In light of this recent migration and resulting change in livestock-raising practices, it is possible that our findings may not be generalizable to other similarly sized, rural communities near Quito or in neighboring countries in South America. For example, given our finding that veterinarian-prescribed medical treatment was a more common treatment approach for large animals, the reported decrease in the number of large livestock raised in this community may result in fewer veterinarian consultations and more homeopathic treatments than would be expected elsewhere.

Among the households included in this study, the use of store-bought animal feed was widespread for the purpose of speeding growth and preventing disease. Animal caretakers were often unaware of whether the commercially manufactured feed they used contained antibiotics. These findings are similar to those found in animal caretakers in rural Bangladesh, where medicated feeds were used, but where users lacked knowledge about their ingredients.[35] Given the widespread use of commercial feed in this community, the introduction of nonantimicrobial growth-promoting feed mixtures at a reasonable price, such as those containing enzymes, probiotics, and other nutrients, may be a promising strategy to limit the overall use of antimicrobials in animal husbandry. These alternative feeds, which may offer comparable growth-promoting benefits to antimicrobials and improve overall animal health, could allow households to substitute away from antimicrobials for growth promotion as well as contribute to a reduction in the use of antimicrobials for treatment purposes.[6,53]

Consistent with household livestock production practices found in other studies, animal caretakers in Yaruquí used home remedies to treat sick animals, but also consulted with veterinarians or government officials in some cases.[35,54] Some home remedies included administering human medications to treat animals suffering from common human illnesses such as diarrhea and congestion, a finding that is consistent with animal health-care practices in Bangladesh.[35] Importantly, this study found that some remedies consisted of purchasing antimicrobials at nearby agriculture supply stores for at-home administration. Ecuador's lax restrictions regarding the purchase of antimicrobials over the counter in local animal feed shops, as well as the presence of these stores in the periphery of Otón de Velez, may have implications for higher rates of unregulated use of antimicrobials in this community and in similar communities in Ecuador. On the other hand, the use of vaccinations, vitamins, and other preventive measures was rare. Additionally, no respondent emphasized the importance of keeping animal-living environments sanitary as a strategy for keeping animals healthy. Both preventive treatment (such as vaccines) and efforts to improve animal sanitation have been proposed as promising interventions to curb the overuse of antimicrobial drugs in developing countries.[7,29]

Participants in this study were familiar with large-scale poultry or pig farms in their community and expressed both positive and negative perceptions toward these commercial operations. The vast majority of respondents commented on the strong odor from the use of fertilizer as the principal negative aspect of these farms. Positive aspects included employment opportunities and easy access to poultry. Most respondents believed these farms use medicated feeds with their animals to produce animals at this scale. In particular, respondents believed that the large-scale farms used antimicrobials and suggested that consumption of meat from these farms could be less healthy or even dangerous for health. Importantly, no respondents expressed concerns about human health beyond the consumption of meat of animals treated with antimicrobials. Existing research has documented that farming operations are often associated with the dispersion of antimicrobial-resistant pathogens into the environment and watershed via animal waste, houseflies, and farm runoff.[42] Given these additional routes of potential dissemination, more efforts to raise the public's awareness of the environmental risk factors associated with the use of antimicrobials in large-scale animal husbandry may be needed.

The present study found widespread awareness of the possibility of disease transmission between animals and humans, albeit this knowledge appeared to be limited with regard to potential risk factors for transmission. Moreover, there was substantial variation in the extent to which households considered transmission to be a risk in their own home, with many respondents reporting little or no concern. Although comparisons across studies should be cautioned due to methodological differences, findings from a household survey of livestock-raising practices in rural Cambodia suggest a similar incongruity between knowledge and perceived risk: while two-thirds of households in the study were aware of zoonoses, only 6% of respondents considered disease transmission between livestock and humans to be likely.[55] Interestingly, despite evidence indicating increased risk of *Salmonella* infection from contact with backyard poultry, a study of backyard poultry owners in Los Angeles, CA, indicated that only one half of owners believed that poultry in urban areas could lead to more illness in humans.[56,57] Past zoonotic disease outbreaks in Yaruquí or educational campaigns in the area may have contributed to the relatively high level of awareness of zoonotic disease transmission observed in our study.

Good hygiene (specifically, handwashing before eating or preparing food) was the most common practice study participants used to mitigate the risk of their children getting sick through contact with animals. In contrast, under half of urban poultry holders in the United States, reported handwashing after handling birds. Furthermore, in the United States, nearly all urban poultry holders did not report utilizing any biosecurity measures on the farm to prevent pathogen transmission.[52]

Our study has several limitations. Despite our efforts to maximize consistency and quality in our analysis by way of three stages of coding and recurring discussions with the data collection team, our analysis process is limited and potentially biased by having only one researcher perform the initial coding process. Additionally, many respondents were unfamiliar with the term "antibiotics" (referred to as *antibióticos* in the interview guide) or confused antibiotic drugs with vitamins, vaccines, and other medications. Consequently, it is difficult to draw strong conclusions regarding the prevalence of antimicrobial use to treat sick animals in the community. The lack of familiarity with the term and the risks associated with antibiotic misuse, however, is revealing and points to a potential need for improved access to training and information for animal caretakers. This finding corroborates existing literature highlighting antimicrobial-user factors (e.g., noncompliance, misinformation, overmedication) and antimicrobial-provider factors (e.g., extensive advertising, financial interests) as primary risk factors responsible for antimicrobial resistance in developing countries.[30]

This exploratory study examined animal husbandry practices among small-scale livestock and poultry producers in a rural community where, due to recent migration and land-use changes, the animal agriculture community has experienced significant changes in size and scope of livestock-raising operations. These recent changes, along with the presence of several large-scale commercial farms and lax restrictions regarding the purchase of antimicrobials for animal treatment, makes this community a unique location for studying the confluence

of risk factors that may contribute to the spread of zoonotic pathogens. Our semistructured interviews with animal owners in this community revealed widespread awareness of zoonotic disease risk due to contaminated food or direct contact with animals. The qualitative data suggest that a wide variety of approaches are being used to treat sick animals, some of which include the use of over-the-counter antimicrobial drugs. Future research aimed at gaining a better understanding of the specific medications used and from where treatment advice is obtained would contribute significantly to our understanding of how antimicrobial usage in animal husbandry may lead to antimicrobial drug-resistant pathogens.

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