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Contribution of Animal Husbandry Practices to Environmental Contamination:

A Qualitative Study across Four Eco-Regions of Northwestern Coastal Ecuador.

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By

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BSPH

University of Miami, 2020

Thesis Committee Chair: Bethany A. Caruso, PhD, MPH

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Abstract

Contribution of Animal Husbandry Practices to Environmental Contamination:

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Improved water, sanitation, and hygiene (WASH) are vital to health through prevention of infections from pathogens, particularly in low- and middle-income countries (LMICs). Yet current WASH-focused interventions alone may not be sufficient due to their focus on safe management of human feces in environments where animal fecal contamination may be prominent. Animals are a significant source of income, food, transportation, and companionship in urban and rural regions of LMICs. These populations bear the greatest burden of possible onsite animal fecal exposure and fecal-oral transmission of enteric pathogens that give rise to health consequences such as diarrhea, environmental enteric dysfunction, anemia, and impaired child growth and cognitive development. Animal husbandry contributes substantially to human welfare, supplying meat and dairy products to the global population. One claimed advantage of animal husbandry is promotion of environmental health through the proper management of animal waste, yet this may not be true in all contexts. To investigate animal husbandry practices that contribute to environmental contamination and identify any variation in husbandry practices across an urban-rural gradient, thematic analysis of 29 translated go-along in-depth interview transcripts with animal owners in northwestern coastal Ecuador was conducted in MaxQDA. The data demonstrated that animal living conditions such as corralled or free range determined the distribution of animal feces in and around households and throughout communities and natural areas. While some animal owners properly disposed of animal feces, others left or intentionally put them in the environment. Across the eco-regions studied, most animal owners managed their animals' feces in a way that contributed to fecal contamination of the environment. This is consistent throughout LMICs where feces are omnipresent in communities and solid waste management systems are inefficient. The suboptimal practice of safe waste management behaviors and apparent lack of awareness of environmental fecal contamination risks are two potential targets for environmental health interventions in these and other communities.

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1 Introduction

1.1 Background

Improved water, sanitation, and hygiene (WASH) are vital to health through prevention of infections from pathogens, particularly in low- and middle-income countries (LMICs). Yet current WASH-focused interventions alone may not be sufficient. For example, sanitation efforts focus on safe management of human feces in environments where animal fecal contamination may be prominent, and hygiene promotion programs do not widely engage handwashing after handling of animal feces.[1] Research to understand the role of animal-sourced environmental contamination is growing to fill gaps in public health investigations and interventions.

There is evidence that domestic and community bacterial, viral, and parasitic contamination can be attributed to animal feces. A study in Kenya yielded significant associations between enteropathogenic contamination of drinking water and household animal ownership and with in-home presence of animal waste.[2] Increased enteric pathogen diversity in water and soil throughout Kenyan communities was associated with domestic animal presence, specifically chickens, cattle, goats, and sheep.[3] Zoonoses comprise more than two thirds of pathogens that infect humans and nearly 75% of emerging diseases are of zoonotic origin.[4] Yet zoonoses research primarily focuses on respiratory and vector-borne pathogens without much attention to fecal pathogens, which are often transmitted through WASH-related pathways such as fluids, fingers, fields and food.[5,6] See Figure 1.

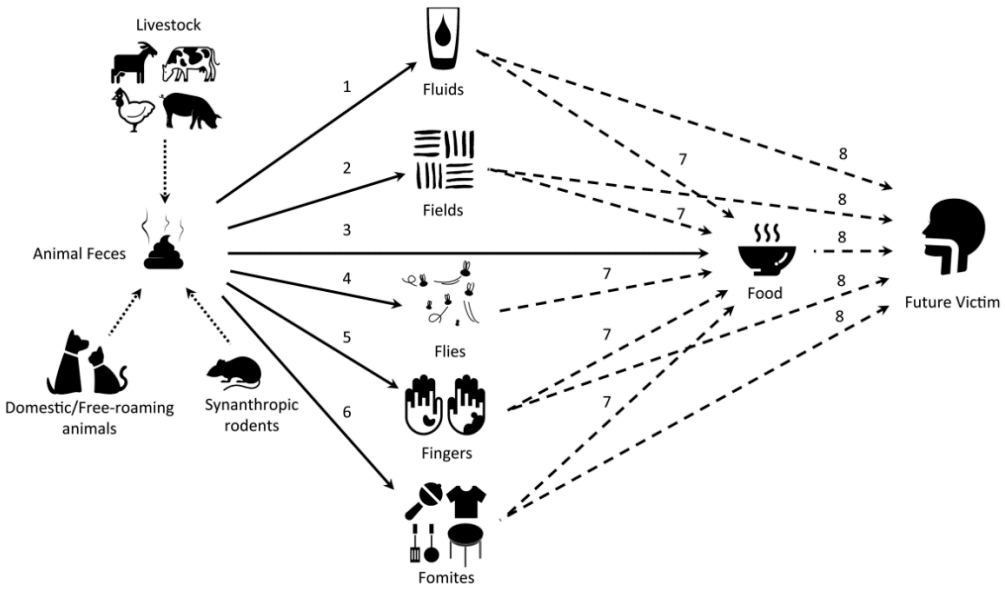

Figure 1: Modified F-diagram showing transmission routes of animal feces to humans.[6]

As prevalent as animals are, animal waste management has not been prioritized in global sanitation policy, and it is not considered in most studies that call for onsite feces management.[7,8] This is exemplified in LMICs, where animals are a significant source of income, food, transportation, and companionship in both rural and urban areas, and these populations bear the greatest burden of possible onsite animal fecal exposure.[2,6,9] In a study of stunting, diarrhea, and household ownership of livestock in Sub-Saharan Africa, 37-92% of households surveyed per country owned livestock, with up to 42 animals per household on average.[10] 85% (approximately 29.7x109 kg) of all waste biomass is generated by domestic animals which are ubiquitous across urban and rural communities.[7] Around 60% of all mammals on Earth are domesticated livestock, almost double the proportion that are humans.[10] Among all birds, 75% are domesticated poultry.[10] The domestication of animals puts humans in frequent contact with such animal byproducts, specifically feces, and calls for its proper management.

1.2 Health Burden

Inadequate cleaning of animal habitats and animal byproducts such as feces, especially near domestic environments, can enable contamination of environments and lead to fecal-oral transmission of enteric pathogens. Exposure to these pathogens can lead to diarrhea, environmental enteric dysfunction, anemia, and impaired child growth and cognitive development.[6,9,11,12]

The five pathogens of highest concern when it comes to animal feces exposure are Cryptosporidium, Campylobacter, non-typhoidal Salmonella, Toxoplasma gondii, and Lassa virus.[13] Cryptosporidium causes the most diarrheal deaths in children under five while non-typhoidal Salmonella is the third leading cause of all diarrheal deaths.[13] These five pathogens have a broad range of hosts with the most common being poultry, cattle, and pigs and combined cause more than one million deaths annually through all possible transmission routes.[13–15] Other farm animals, dogs, cats, and other pets, rodents, birds, and reptiles also host and transmit these enteropathogens.[13] The health burden attributable to animal feces exposure is unknown, but as more and more WASH interventions are designed, implemented, and evaluated that do not account for animal-sourced contamination fail to improve health, it has become evident that animal waste plays a role.[16–21]

1.3 Animal Husbandry

While there are many negative impacts of animal and animal feces exposure, the implications of animal ownership and contact are not unidirectional. Specifically, keeping animals can lead to adverse pathogen exposure, resulting in acute and chronic ailments, but can also facilitate improved quality of life in many ways. Animal husbandry, constituted primarily by

dairy farming, poultry farming, fish farming and bee farming, contributes substantially to human welfare, supplying meat and dairy products to the global population. [22] Access to animal-sourced protein supports human growth, development, and immunity, while fibers and other products can also be utilized and/or generate income.[23–25] At personal and population levels, higher income is positively correlated with good health.[26] Other beneficial outcomes are land management through grazing and provision of employment for farmers in all countries.[22] One claimed advantage of animal husbandry is promotion of environmental health through the proper management of animal waste, yet this may not be true in all contexts.[22]

1.4 Study Purpose

Animal feces exposure can contribute to negative human health impacts such as diarrheal illness through the introduction of new zoonotic pathogens and the amplified transmission of pathogens harbored by both animals and humans. There is substantial evidence indicating that individuals in LMICs are frequently exposed to animal feces, though information about sources of animal fecal contamination remains limited.[1–4,6,8–13,19,20] There is a need to understand the processes of environmental fecal contamination by animals, especially that of domesticated animals in and around households. Additionally, there is a need for enhanced understanding of behavioral and social drivers of pathogen transmission from animals to humans. Penakalapati et al. (2017) identified gaps in animal feces exposure research throughout levels of the socio-ecological model, such as exposure risk knowledge, knowledge of exposure prevention behaviors, animal containment practices, traditional community husbandry practices with consideration for gender- and age-specific responsibilities, and animal health standards. Their adapted model is shown in Figure 2. This study seeks to inform understanding of household behaviors and community/social factors influencing animal feces prevalence in the environment,

including animal management practices, individual- to society-level attitudes about animal ownership and husbandry practices, and the interaction of humans with animals and animal feces.

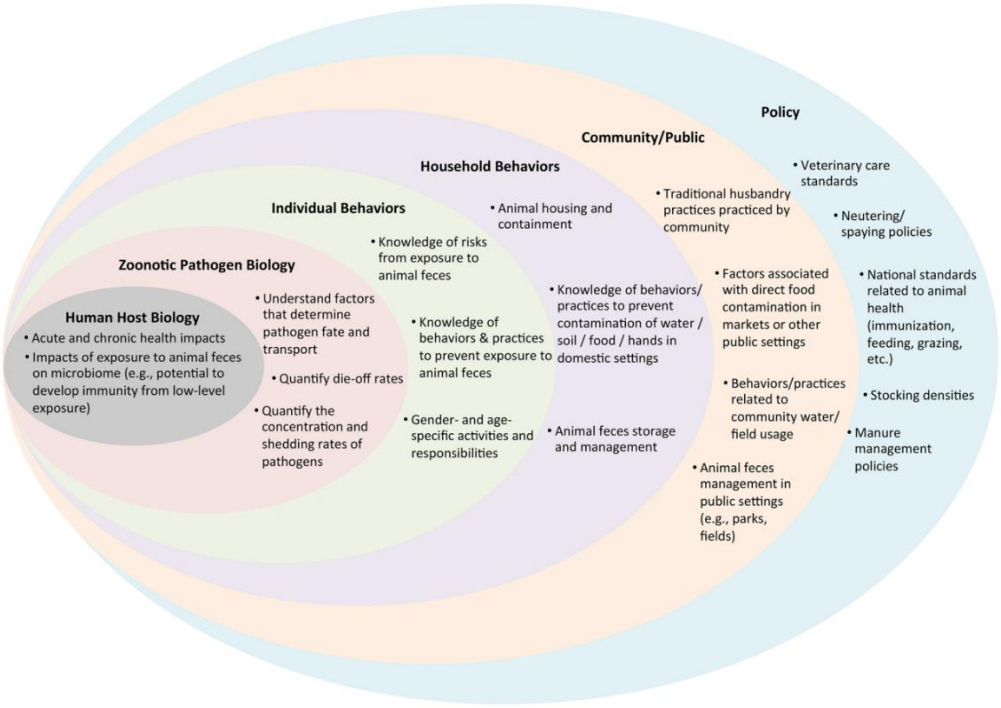

Figure 2: Adaptation from the socio-ecological model illustrating priority research gaps in assessing human health impacts from exposure to poorly managed animal feces.[6]

This study also contributes to the necessary expansion of research on animal husbandry as it relates to human health. Identifying behaviors that contribute to environmental fecal contamination will help guide intervention design and improve environmental and community health status. The primary aim of this study is to investigate various animal husbandry practices employed by community members in urban communities, semi-rural communities, rural communities with access to roads and rural communities without access to roads in northwestern coastal Ecuador and understand their contribution to environmental fecal contamination and to

compare and contrast animal husbandry practices and fecal contamination across four different study sites along an urban-rural gradient.

2 Methods

2.1 Study Setting

This research took place in four eco-regions that stratify an urban-rural gradient in northwestern coastal Ecuador. The study sites include rural communities without road access (population from ~10-500), rural communities with road access (unsure of population sizes), the semi-rural town of Borbón (population of ~5,000) and the urban city of Esmeraldas (population of ~162,000).[26] These four study sites experience high enteric pathogen transmission and host similar social, cultural and genetic factors.[26] Animal ownership is common in the study area. Only 60% of the population has access to treated drinking water, and only 40% have access to sanitation.[26] The study sites in Northwestern Coastal Ecuador are shown in Figures 3 and 4 in the appendix.

2.2 Study Design, Data Collection and Participants

2.2.1 Parent Studies

This study is embedded within a larger study, Enteropatógenos, Crecimiento, Microbioma, y Diarrea (ECoMiD), a community-based longitudinal study that follows a birth cohort of 360 infants to identify and analyze interactions between the environment, enteric infections and gut health.[27] Recruitment of pregnant women for ECoMiD began in May 2019 and mother-child dyads are followed until the infant is two years old.[27] The specific aims (SAs) of this parent study examine: SA1) how environmental conditions affect the infant gut microbiome and pathobiome; SA2) whether the infant gut microbiome modifies the impact of enteric pathogen infections on acute and chronic outcomes; and SA3) how the gut microbiome responds to and recovers from enteric pathogen infection.[27]

An ECoMiD sub-study, Enteropatógenos, Crecimiento, Microbioma, y Diarrea – Animal Exposure (ECoMiD-AnEx) is a mixed methods study that seeks to understand how animal exposure influences infant gut health. ECoMiD-AnEx leverages qualitative methods to understand if, how, where, when, why, to what extent, and under what conditions children are exposed to animals and animal-sourced contamination along an urban-rural gradient in northwestern coastal Ecuador, and to identify feasible strategies for minimizing exposure.[28] This qualitative study recruited and enrolled mother-child dyads in the ECoMiD cohort study who own animals (n=32), mother-child dyads who in the ECoMiD cohort study and did not own animals (n=26), [28] and individuals who are not ECoMiD cohort study participants but care for and/or work with animals in the study area were recruited and enrolled (n=29). Interviews from the participants who are not part of the cohort study and care for animals are the focus of this qualitative analysis.[28] Specifically, this study utilizes data collected from this non-cohort group to shed light on animal ownership practices that influence animal-sourced contamination in the environment where all three groups are being exposed.

2.2.2 Data Collection

We conducted 29 go-along in-depth interviews (IDIs) with animal owners in Esmeraldas (n=4, urban), Borbón (n=15, semi-urban), rural road communities (n=6) and rural river communities (n=4) between March 30 and April 21, 2021 to a) understand how animals are cared for (e.g., animal feces management, corralling, feeding) and by whom; b) discern the perceived benefits and challenges of animal ownership and livelihood; and c) determine who is responsible for making decisions about animal ownership and management. The employment of in-depth interviews in this study is advantageous as it uses open-ended questions to gain a

thorough understanding of subjective attitudes and practices across study sites about animal ownership.[29] Furthermore, the go-along methodology employs a combination of participant observation and interviewing by the interviewer and participant inhabiting the areas in which they are discussing.[29] Go-along IDIs enable the production of more descriptive narratives than typical IDIs.[29] They facilitate more in-depth coverage of topics and observation of them, such as animal's living conditions.[29] The interview guide included questions about animals owned currently and in the past, reasons for animal ownership, animal living conditions, animal health, and sanitation measures the participant takes personally and those taken by others in their community, and queries about if/how these all vary by animal species. The analyses presented in this paper focus specifically on animal habitat sanitation and feces management practices on individual and community levels, exploring the intersection between these and the eco-region in which each participant resides.

Participants were identified through the help of the ECoMiD study staff and recruited if they had extensive exposure to animals[28] Purposive sampling was employed in each of the four eco-regions to ensure a variety of animal types were included to accurately represent community animal ownership.[28] Animal owners were interviewed in Spanish by a UCSF social scientist or local trained research assistant. Basic demographic data were also collected from participants through a short survey administered by the interviewer. In-depth interviews were audio-recorded, transcribed, and translated from Spanish into English. For participants who refused to be audio recorded, the interviewer took detailed notes during the interviews and promptly created a transcript afterwards based on the IDI guide. Short survey documents were scanned and saved in an online folder and their contents were entered into excel for data organization and analysis.

Audio recordings were stored in an online folder as well. All recordings, transcripts and survey data were deidentified and password protected.

2.2.3 Data Analysis

Thematic analysis of translated in-depth interview transcripts was performed. A codebook was developed based on the interview guide and iteratively developed through close reading until saturation of topics was reached and the codebook was considered finalized. Coded segments informed memos for each topic which ultimately led to the conceptualization of key themes in the data. Organization, memoing, and thematic analysis of the translated transcripts was carried out using MaxQDA software.[30]

2.3 Ethical Considerations

Prior to data collection, all participants provided written consent and received a copy of the consent form. Participants' right to skip questions and end interviews at any time was emphasized by the interviewer. This study was approved by the Emory University (IRB00101202) and Universidad San Francisco de Quito (2018-022M) Institutional Review Boards.

3 Results

3.1 Study Participants

The study population consisted of 29 female animal owners from four eco-regions in Northwestern Coastal Ecuador. Four lived in urban Esmeraldas, 15 lived in Semi-rural Borbón, six lived in rural road communities and four lived in rural river communities. Participants range in education level from zero to 12 years. Their total average years of education is 6.4, or 3.5 years in Esmeraldas, 7.9 years in Borbón, 7.2 years in the rural road region and 2.8 years in the rural river region. All participants are of either Afro-Ecuadorian (n=20, 69.0%) or Mestizo (n=9, 31.0%) ethnicity. See Table 1 for participant demographics.

3.2 Animal Type

A total of 696 animals were owned by the 29 participants. Across all eco-regions, participants owned 24 animals on average, with a median of 13 animals. On average, urban participants owned of ten animals each, semi-rural participants owned 17 animals each, rural road community participants owned of 52 animals each, and rural river community participants owned 24 animals each. The animals most abundantly owned by participants were creole chickens (n=277), chickens (n=226), ducks (n=77), dogs (n=39) cats (n=32) and pigs (n=26). The distribution of these animals across households was as follows: Cats were owned by 82.8% of participants, dogs by 72.4%, creole chickens by 58.6%, pigs by 41.4%, ducks by 37.9%, and chickens by 20.7% of participants. Other animals owned by the study sample included cows, donkeys, sheep, parrots, turkeys, chachalacas (a type of bird), pigeons, guinea pigs, and turtles. See Table 2 for a full list of animals owned by participant.

3.3 Reasons for Animal Ownership

There was substantial heterogeneity in reasons for people owning their animals. Four key themes emerged when animal ownership motivations were discussed. The first theme was the ownership of animals for personal/family livelihood. Pigs, ducks, chickens, hens, and cows were owned by various participants to sell and generate income. Some participants raise these animals with this specific purpose from the time of acquisition, while others recognize the opportunity to sell their animals if necessary in the case financially challenging times, “to cover any unexpected expenses.” (P17, semi-rural)

Another key reason for owning animals was for personal/family sustenance. Pigs, ducks, chickens, and hens were owned for familial consumption. Hens were also kept to produce eggs for consumption. Bird consumption was spoken about as a common, casual occurrence, while pigs were raised for years with the intention of feeding large groups of people during holidays, such as New Year’s Eve. Similar to income generation reasoning, participants either raised animals with the intention of consuming them or they found comfort in knowing their animals could sustain their family if they had to resort to eating them.

A third theme was the ownership of animals for utility. Cats were kept for mouse and rat control, often given credit for a rodent-free home, and dogs were kept for protection of the home and family members, as they were known to bark and alert their owners when they sensed trouble. Donkeys were utilized for labor, such as carrying loads between households and workspaces. Chickens and pigs were kept to feed food scraps such as plantain leaves and rice to, reducing the burden of accumulating waste and leftovers from meals for large families. Dogs and cats were also fed food scraps, frequently meat such as the uneaten parts of chickens, though this

was not referenced as a reason for their presence in the home. One participant described the varied reasons for owning different types of animals:

> I: Ok, so you have always had pigs and hens…What is the benefit, for example, of having hens. Let's talk first about hens.
>
> P: Because sometimes you don't have money for food…I have my hen; I kill her, and we can all eat.
>
> I: Ok, what about the pig?
>
> P: It is the same thing with pigs, sometimes I don't have money and if the pig is big, I sell it and I have some resources, sometimes my children get sick, so it gives me some money to get me out of any difficulty.
>
> I: Ok. What are the benefits of having a dog and a cat?
>
> P: I like the cat because he kills the rats and the dogs because they watch out the house, especially at night, whenever someone is around or they hear something, they bark.
>
> (P16, semi-rural)

Finally, animals were owned for personal and familial enjoyment. Dogs, cats, hens, ducks, turkeys, parrots, pigeons, pigs, turtles and guinea pigs were kept for companionship or general enjoyment by different participants. Their sounds, energy and simply their presence were sources of joy. The love of animals in general was shared by many participants, their partners and their children. Animals were often described as being an integral part of participants' families. One participant described:

> "When I am a bit down, they become my refuge. I raise them, I play with them. I love to raise my animals." Another participant stated, "P: I like raising them because a woman who does not raise animals is like a man, like she doesn't have anything at home. I love to raise animals…Let's say I like it because I don't have small children and when I want to feel happy for a while I go to the backyard and laugh with my animals, feeding, fighting them…I like it." (P22, rural-road)

For each animal type, the reason for their ownership varied between participants. Two participants with the same animal could have that animal for different reasons. For example, overall pig and bird ownership motivation was split between personal consumption and income generation, depending on the household. One participant who raised pigs for consumption said,

> I: Okey, what are the benefits for the family about having a pig?
>
> P: Well, it is an animal that has a benefit. You invest in the animals, you raise him but then, how do I say this, ha, ha, ha…
>
> I: Is it for the family consumption?
>
> P: Of course. (P18, semi-rural)

Another pig owner raised pigs to generate income,

> I: The pig, what is the motive, or the reason to raise him?
>
> P: Also because we grow them to feed him and sell him. (P20, rural-road)

A third pig owner simply enjoyed having pigs,

> I: What are your motivations to have your animals?
>
> P: Umm, the dogs because I like to have them, and the pigs also, those are animals that I do like to have. (P21, rural-road)

Many participants gave multiple reasons for having one type of animal. Animals who were owned for sustenance or livelihood also had utility. For example, the same participants who owned chickens to generate income, fed them the family's food scraps to reduce waste. Many people who owned certain animals primarily for sustenance, livelihood or utility, also cited companionship as a motivating factor for having them at the household.

3.4 Animal Living Conditions

The ways in which animals were kept were often dependent on the types of animals owned by each participant. Across all eco-regions, dogs and cats were consistently reported to be allowed to roam freely within the participants' houses and yards. Most participants allowed dogs

and cats to leave their property and roam through the community. Participants recognized certain instinctual behaviors among dogs and cats and let them act on them. Cats were said to climb, hunt and sometimes search for mates. Dog owners described their dogs' tendencies to roam through the streets, interact with other dogs, explore local hills, fields or woods, and go to places unbeknownst to the owner. One dog owner in Borbón kept her dog tied up due to its aggressive behavior. Pigs were consistently reported to be kept in enclosures with a range of sizes. All but two pig-owning participants (n=13) kept their pigs in a pigsty, while the other two described letting them roam around their enclosed yards. Hens, chickens and ducks were often reported to be free range in participants' yards, but some are kept in chicken coops/hen houses or on enclosed patios. Among those who freed them during the day, the practice of corralling them at night was common. Some participants who do not ever keep their birds corralled together said it is to prevent an outbreak of the plague:

> I: Okay. Who decides this method lady ¿?? [name], about the way of managing the animals? The fact they are a bit loose for example, that the hens are loose without a run. Who decides this method? And why do you keep them like that?
>
> P: Because the hens when locked down, more than anything those ones, those, those hens, we keep them loose because sometimes the plague comes, and it's better to keep them loose, they have a cleaner environment, and are locked up the ……
>
> I: Do they live more?
>
> P: They live too locked up, because of the heat, everything falls on them, so they can't be locked up. (P14, semi-rural)

Cows, donkeys, and turtles are kept in large enclosed outdoor spaces (e.g., a fenced in backyard) while guinea pigs and parrots are kept in enclosed indoor spaces.

The majority of individuals tailor the living conditions to the specific animal. When people have more than one type of animal, they recognize the need to provide more than one animal living

space. Participants could often list as many animal locations as they had animals, or more if they had animals such as cats and dogs that frequently moved between spaces on their own accord. One household had distinct enclosures for each type of animal that they owned.

> P: The cat goes up a bit around here in the house. The dogs are mostly up there in the house, outside on the corridor, or on the entrance by the door. The pigs are in their pigsty, or else when I go downstairs, the dog comes behind me, down here. (P13, semi-rural)

Few participants kept all their animals in the same manner. In some groups of animals kept by the same household, none required a distinct space, so the yard was home to them all and they lived compatibly among each other.

Daytime animal living conditions could differ from nighttime animal living conditions. Chickens, for example, could roam about the yard all day but were guided to their coop when the sun went down, and free roaming dogs were beckoned into the house to sleep indoors with the family at night.

3.5 Animal Defecation Locations

Various animal defecation locations, varying by animal type, were reported by the participants, including in the animals' habitat (n=16), in the home (n=6), on the house's patio (n=3), beneath the house or in the yard of the house (n=17), in the street (n=6), far from the house in a known location (n=7) and far from the home in an unknown location or "everywhere" (n=15). These locations are shared by all eco-regions with a few exceptions: Among urban animal owners, none reported not knowing the location of their animals' feces. Even when their animal left the property to defecate, they knew the location, usually on the street or near a relative's house. Semi-rural participants did not report animals defecating on their patio. Rural

road communities often have animals defecate far from home, and never in a location known by their owner.

I: Where does the cat defecate?

P: I don't know sister, ha,ha,ha…But not here…ha, ha, ha. (P25, rural-road)

Rural river animal owners did not report any animal defecation in their homes or on their patios. The yard is the most common location for animal defecation among urban participants (75.0%), the animal's habitat among semi-rural (66.6%) and the yard or an unknown location among rural road (80.0%). The yard, the habitat, far away known locations and far away unknown locations were reported with the same frequency (50.0%) in rural river communities. While the majority of animal owners have animals defecating in a variety of locations, two participants reported only one defecation location. A participant in urban Esmeraldas only had animals that defecated in their habitats, and a participant in semi-rural Borbón only had animals that defecated far away in locations unbeknownst to herself.

Different animals defecated in different locations, some with an expansive range of places. Cats and dogs, given free reign of their owner's property and freedom to roam about communities, defecate in the homes' front and back yards, under the house, in the streets, near neighbors' homes and sometimes on the patio or inside the house. Defecation inside the home is not encouraged by the participants but happens when the animal cannot exit and was reported by participants who preferred to have their cats and/or dogs sleep inside the house, such as one who stated that the "dog and the cat sometimes can't get out at night and if they are not able to go out early in the morning they poop here. But I usually get up early and I open the door for the dog, and he goes down." (P3, urban) Cats and dogs also travel off their owners' properties to nearby

fields, hills or water sources to do their business, or the participant does not know where they go at all. One participant whose cat and dog defecate wherever they desire, says:

> P: The cat poops in that pile of dirt. About the dog we don't have any idea because sometimes she is here and suddenly, she goes out running, I assume that she goes out to do her business. Sometimes, I see she pees in the backyard, but we don't know where she defecates. Now that she is older, we don't know where she goes. She just leaves running and then she comes back sweeping the ground with her butt like she is cleaning it and then she returns to her place. We don't know where she does it. We do know about the cat; we always see him digging when he is doing his thing. (P18, semi-rural)

Some animals' defecation locations were determined by the boundaries of their living space. Chickens/hens, ducks, chachalacas, and pigs defecated in their habitats, which for chickens/hens was either the house's enclosed patio, or in the yard in cases where they were able to roam. Chicken feces was described as very abundant in both scenarios. The donkeys and cows defecated where they stood in the yard. Parrots consistently defecated inside the house, sometimes all throughout the living spaces, or in their cage if they had one. Guinea pigs defecated in their habitat in the house and turtles in the yard that they roamed through.

Animal defecation in the environment could either be unintentional or intentional. When defecation occurred off the owner's property, in many cases cats and dogs naturally sought out a location in their surrounding environment to urinate and defecate. Some participants mentioned training their cats and dogs to go far away to do their business to avoid feces deposition near the home. Participants expressed both concern about animal feces in and near the home, especially those who had small children running around, and the lack of willingness to clean up animal feces in general and would rather defecation happen elsewhere due to either reason.

3.6 Animal Feces Management

Many themes emerged through the discussion of animal feces management. Firstly, there was great heterogeneity across animal feces management methods and management methods varied along the urban-rural gradient in which the participants resided. The distance of feces from the home influenced its management, as illustrated in Figure 3, and certain management choices could result in feces being left in varying distances from the home. The existence of community-wide feces management systems, such as home-to-home solid waste collection, was a key theme, as well as the influence that certain feces odors had on the owners' choice of management method. Intention of the animal owner was a topic of interest, when putting or leaving feces in the environment. Physical barriers were used by animal owners for animal feces when responding to it.

Many different methods of feces management methods were reported by animal owners. Feces management methods reported among participants from most to least utilized were: taking no action (n=22), throwing into the environment (n=17), throwing into the trash (n=11), burying (n=2), throwing it into a septic tank (n=2), burning (n=2), using it as fertilizer (n=2), throwing it into the sewer (n=1) and mopping it (n=1).

Some feces management methods were used by individuals across the urban-rural gradient, while others were only utilized by members of specific eco-regions. Methods of feces management common across all eco-regions included throwing it in the trash, throwing it into the environment, and taking no action at all. Unique to the urban study setting were the use of a piping system to manage pigsty waste, and the burial of feces. Semi-rural community members uniquely practiced disposal of animal feces in sewers in the community. They also engaged in mopping of bird feces out of coops and off patios in the case of chickens, and off the household floor in the case of parrots. Rural road community animal owners disposed of onsite feces in

septic tanks. The aggregation and burning of feces, along with other household waste was practiced in semi-rural and rural river communities and using feces as fertilizer was practiced by rural road community animal owners, but only for donkey feces and bird feces along with the sawdust cleared from the birds' habitat. The process of converting feces to fertilizer was not described, but it was piled up in the yard to be utilized for that purpose. One participant with many types of animals described her varied waste management practices:

> P: In the pig's patio, if it doesn't go when it rains, the other guy comes by and we clean up with a broom, shovel, and water, and we throw everything at the septic tank.
>
> I: Okay, and the feces to the septic tank?
>
> P: Everything goes there.
>
> I: Aah okay, everything to the septic tank. The chicken feces, how do you eliminate that?
>
> P: Not that of course, they do it all over the place and are on the patio.
>
> I: Okay. Where do the dogs and cats defecate?
>
> P: They go outside to do their needs.
>
> I: Outside of the house. Far away?
>
> P: Far away… You can't find their dirtiness around there.
>
> I: You can't find their feces… And what about the donkeys?
>
> I: Where they are tied up.
>
> I: Okay, for example where they are, they defecate there?
>
> P: Yeah.
>
> I: And how do you eliminate those feces?
>
> P: We have to pick them up.
>
> I: Okay, and where do you throw them away?
>
> P: Over there because that is fertilizer, it's very different because it's fertilizer.
>
> (P24, rural-road)

The distance of animal feces from households often determined animal owners' management of it. Some animal owners who took action to mitigate environmental fecal

contamination by removing feces from the environment did so when it was in or near their home. Feces were always removed from inside the home and animals' enclosures and almost always picked up off the yard, though sometimes they were buried instead. Removal of animal feces from the environment also occurred when animals defecated near the home of others, or in response to direct pressure from other community members. When animals defecated near neighbors' houses the owner either collected it to avoid problems or was instructed to do so by the neighbor, as was experienced by one participant who reported:

> I: Have you ever had to pick up feces of these animals elsewhere?
>
> P: Yes, sometimes when they poop in front of my neighbor's house, they would ask me to clean it up, and I have to do it. (P22, rural-road)

When not near a household, animal feces were often left where it laid. Animal feces on the street were rarely picked up. When animals in semi-rural and rural communities defecate in secluded or natural areas, nothing was done, and it remained in the environment.

> I: The… Where does your cat and dog defecate?
>
> P: The cat has a piece of foam, of "caneca" with some sand, because at the beginning he did his needs here inside, but then he stopped using it, he goes downstairs and does it on the street. Umm, the dog, all of them, they mostly run over there, because that is empty, they go over there, or they go to the hills… They used to do it here before, one had to wake up every morning to, to pick it up, but not anymore, no. They go out and look for the parts where there are not many people, on the empty lots around here, and they go there. Even if one tries, when they do it around here to pick it up and throw it away, sometimes one doesn't notice where they do it because you can't see it. (P10, semi-rural)

Figure 3 displays examples of the variety of animal feces management behaviors reported by participants in response to animal feces in a range of locations.

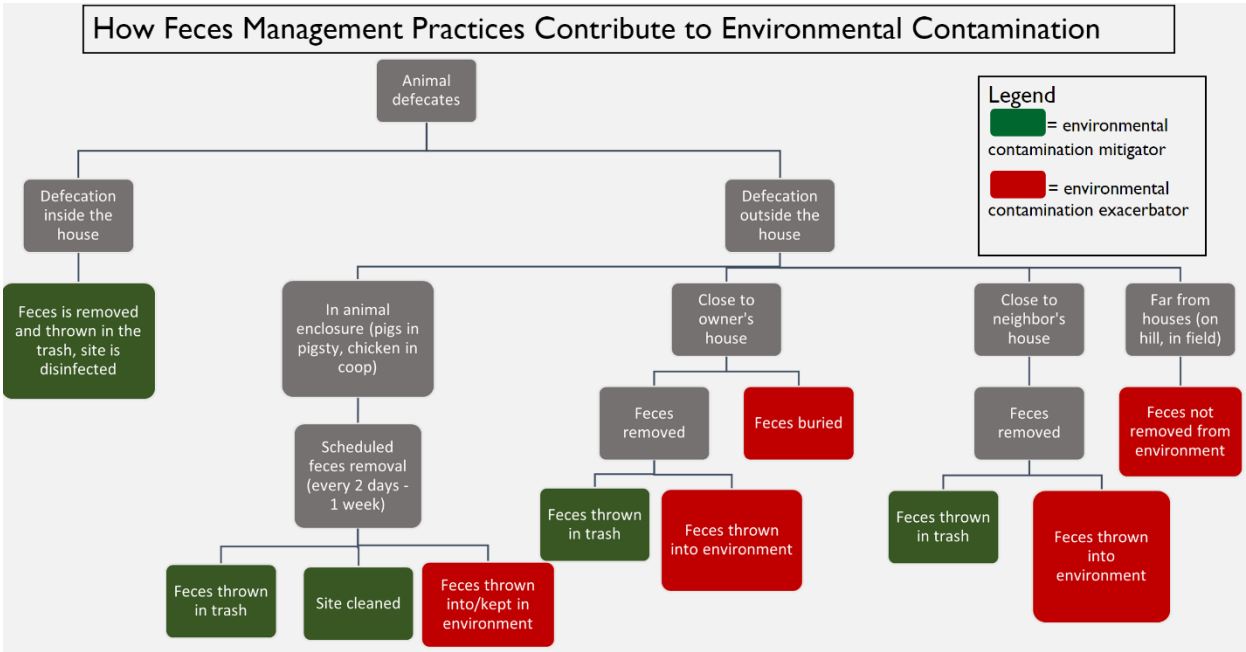

Figure 3. Diagram illustrating participants' feces management practices and their determinants

Disposing of feces into the environment took many forms and ranged in distance from the household. Animal feces were often relocated far from the property they resided on. Some feces were reported to be sent down a trench toward a river or piped out of the habitat into an unspecified location in the environment. Many animal owners also reported tossing feces into empty plots of land, fields, hills, rivers, or "far away… Towards the vegetation," (P9, semi-rural) far from themselves, their homes and the homes of others. Animal owners did not always make the effort to remove feces from their properties. Some feces that remained outside, such as chicken and duck feces, were simply swept off the owner's patio into their house's yard. When animal owners buried their animals' feces, it was both on and off their property. Descriptions of children practicing feces management specifically, often included them burying the feces where it lay in the yard rather than removing it. Participants referenced other animal owners in their community leaving waste in the same places. Some participants "throw it away in a bag at the

fields," (P16, semi-rural) adding environmental plastic pollution in addition to fecal contamination.

Animal waste management sometimes worked at the community scale rather than at the individual household level. A solid waste management system was in place in the study communities, with many participants referencing the garbage truck that went house-to-house collecting waste, including that from animals. Community-initiated environmental deposition of animal waste also occurred. Multiple animal owners in semi-rural Borbón reported their use of a communal trench or ditch to dispose animal feces in, utilized by other community members and cooperatively maintained to ensure that it flows. This system was celebrated by its users for its convenience and credited with the diversion of foul substances away from households. Even with so many users living near it, feeding it waste, and keeping it flowing with water and other tools, there was no mention of any foul odor being emitted from it. One participant described:

> I: Where do the animals defecate?
>
> P: The dogs, well, everywhere. It is just like that. That one is a bit cleaner, and she only does it in that corner… That you need to pick it up and take it to the trench to throw it there.
>
> I: To the trench…Do all of this fall in the trench too?
>
> P: Yes, but that stays up here, then the water comes and then it falls by that slit. When you clean the pig yard you throw water, so the feces fall to the bottom. You need to scratch a little, and then the water does the rest, and it falls. (P12, semi-rural)

Another semi-rural resident who utilizes the receptacle reported:

> I: Okay… So, when your pigs defecate there in the pigsty, umm, where do you eliminate those feces?
>
> P: Normally everything we clean up, ends up in the ditch.
>
> I: At the ditch?
>
> P: Yes, at the ditch. That's why we did it like that inside that edge of the ditch, so that everything that one cleans up ends up at the ditch, because the ditch it's being cleaned up

> constantly, it goes away. All the dirtiness goes, and you don't get any odor or anything nasty. (P13, semi-rural)

Participants were aware that this waste ditch "has a drain that flows to the estuary and the river," (P18, semi-rural) and that it "passes by Mr.(name's) place, a man who buys wood." (P12, semi-rural)

Different feces management methods were practiced with the feces of certain animals due to their smell. The trash was said to be taken by a garbage truck or trash cart, yet some animal owners still did not want the feces to be in such close proximity to them due to the odor and chose to toss it to nature. One participant expressed, "We would always throw the poop to the river, because when I throw it to the garbage it smells. The garbage truck comes at night, and I didn't want that smell in my kitchen, so, we use to throw it to the river." (P18, semi-rural) Pig feces had a notoriously unpleasant smell which drove pig owners to clean it frequently and often divert it far from their property, for example, piping it out into the environment or dumping it in the communal trench to flow down to the river. Some urban duck owners found the smell of duck feces to be far worse than other birds' feces and would manage it differently than their other birds' by picking it up and throwing it in the garbage rather than simply sweeping it.

The choice to leave an animal's feces in the environment was either unintentional or intentional. Animal owners that took no action in response to animal defecation sometimes reported that their animal, most often their cat, buried its own feces and therefore, it could not be seen to be removed. Another barrier to feces collection from the environment was rainy weather. A few participants who do regularly clean up after their animals, stated that rain prevented them from doing so in some scenarios. On the other hand, many participants could describe exactly where their cat or other free roaming animal defecated and chose to leave it where it laid. With

the practice of burying feces, it was most often simply covered with dirt where it stood, but feces were also removed from near the home and buried elsewhere in some instances, rather than relocating it to a trashcan. One participant describes this process:

> P: In the morning when she needs to go (pee /poop) she does it in the "patio" oftentimes she goes outside. When I notice that, I pick it up sometimes. When she does it at the "patio" I pick the shovel and I bury it. (P4, urban)

More specific components of feces management sometimes shared by participants included the use of certain instruments to avoid personal contact. Shovels, brooms and bags were the tools that participants reported using to collect and/or move their animals' feces, sometimes in tandem. For example, shovels were sometimes used to pick up feces and put them in a bag. Otherwise, feces were tossed from a shovel into the environment. Participants also frequently described they "picked up" animal feces without specifying how.

3.7 Animal Habitat Cleaning

Participants recognized the risk of contact with animal feces, especially those with small children at home, and generally cared to keep their living space sanitary. Whenever any type of animal defecated in the home, the area was disinfected with products such as chlorine and bleach, and local products such as Deja and Creso.

> I: Okay, so when the cat does it here and you find the feces, how do you clean up?
>
> P: You have to pick them up with something, even if it's a plastic bag, I tie it up and put it on that side, on the trash, to clean it with chlorine, or wash it with "Deja". (P10, semi-rural)

Some participants describe daily household disinfecting for the sake of their family, regardless of the presence of animal feces in the house.

Animal habitats outside of the home that are defecated inside of, such as pigsties and chicken coops/hen houses, are washed out with water and often a chemical disinfectant, except for the bird habitats that are only reported to be swept, which was often related to the use of sawdust on the habitat floor and its incompatibility with water.

> I: What products do you use to clean?
>
> P: We use detergent and bleach to clean the pig pen, otherwise it stinks. We mix bleach and water in a recipient, and we brush the wood planks with a broom destined to clean that area, after that we wash it with water. (P18, semi-rural)

Outside the household, such as on the street in urban settings, water might have been thrown on the space to clean it. In semi-rural and rural communities, outdoor spaces were never cleaned or disinfected.

The cleaning of animal habitats, specifically where they defecate, varied in terms of frequency. Participants reported cleaning pigsties as frequently as every day, but the frequency could depend on factors such as the condition of the habitat in terms of feces amount and general disorderliness, the odor emitted from it, and the weather. Small chickens were cleaned up after less frequently than large chickens, who defecate more often and in larger quantities. Birds' habitats in general were cleaned with a range of frequencies, from every other day to every other week.

When cleaning products were used by animal owners to sanitize animals' spaces, they sometimes remained in the environment. Deja, Creso, chlorine, bleach and detergent were products that were applied to or became runoff into the environment in response to animal feces, with one participant specifying that the Creso they use runs down into a nearby lake.

I: Ok. Who keeps it clean? You were saying that you are in charge of the birds, and the hens. Who keeps clean the place where the birds stay?

P: My husband and my son clean the backyard. I can't bother them too much.

I: Ok. What about the farmyard where the pigs stay? The gentleman?

H: I am in charge of that every 8 days or every day.

I: How do you clean that?

H: I clean it with water, I disinfect with "Creso," and everything ends in the lake.

P: We throw everything down there. (P17, semi-rural)

4 Discussion

This study investigated animal husbandry practices in northwestern coastal Ecuador to understand how they contributed to environmental fecal contamination and could put community members, particularly children, at risk for enteric infections and possibly death. Furthermore, we sought to identify any variation in husbandry practices across the four eco-regions, namely urban, semi-rural, rural with road access (road communities), and rural without road access (river communities). A thematic analysis of 29 go-along in-depth interviews with animal owners across this urban-rural gradient revealed key behaviors that contribute to the contamination of their environment by their animals. The key components of animal management that have the greatest propensity to cause environmental fecal contamination are animal living conditions which determine animal defecation location, and the owner's animal feces management practices.

We found that certain animals were consistently provided with corralled living conditions, which is practiced in some countries but not others. Pigs, birds and other livestock were typically corralled by their owners in our sample, with their enclosures ranging in size from small coops or sties to large, fenced yards. This corralling is consistent with practices in European countries where pigs are regularly kept enclosed in pigsties with concrete or soil flooring.[31] However, enclosure of these livestock recorded in our study differs from other regional practices such as in Peru, Bangladesh and Ethiopia where pigs and poultry are typically free roaming throughout communities.[32–34]

Certain animals were consistently not corralled by the animal owners in this study, which are also consistently free roaming in other LMICs. We found that pets such as cats and dogs were most often free to roam throughout the owners' property and beyond, into the community and the

surrounding environment, which is consistent throughout many other LMICs. Data from the Philippines show an average of nearly 105 free-roaming dogs and 91 free-roaming cats per village with human population numbers falling between 4,000 and 200,000 that are comparable to those in our semi-rural and urban sites.[35] Other studies conducted in the early 2000s showed free-roaming dog populations per 100 humans as high as 19 in La Pampa, Argentina, 25 in Santa Cruz, Bolivia, 27 in Sorsogo Province, Philippines, 34 in Miacatlan, Mexico.[36–39]

Animals' living conditions determined where they defecated and therefore, the distribution of animal feces and fecal contamination across spaces, which is consistent with previous research. The smaller the spatial distribution of animal feces, the higher the concentration of fecal contamination within a space. For example, in our study pigs' feces were concentrated in pigsties, birds' feces in their coops or yard spaces. Defecation in enclosed spaces creates areas of high pathogen density which can be more harmful to the people who manage corralled animals. This was demonstrated by a study in Peru that measured far more Campylobacter infections in children of households with corralled chickens compared to free range.[40]

When animal feces are distributed across large areas, fecal contamination is less concentration, but more widespread, as supported by previous research. In this study, participant reported many different locations where animals would defecate, particularly from cats and dogs, which would disperse fecal pathogens throughout communities, both within and beyond the limits of animal husbandry operations. This broad dispersal of pathogens from animal feces is demonstrated by data from animal feces studies in other LMICs where indiscriminate defecation occurred throughout communities, including inside animal owners' homes, in town squares, in local watersheds and on the properties of people who did not own animals.[3,33,40] In Ethiopia, the presence of animal feces on peoples' properties was associated with detection of *E. coli* in

household water, food and soil near the household entrance.[41] A study in Kenya detected enteric pathogens in community soils and water sources as well as households, regardless of the presence of domestic animals and animal feces at the specific sampling location.[3] Corralled animal defecation and open animal defecation each pose their risks to humans, whether animal owners or not. Further studies of animal defecation behaviors in the context of their living conditions should be conducted to identify associated contamination risks as well as opportunities for risk reduction and innovation in this realm of animal husbandry.

We found that feces management practices were largely driven by feces location, particularly trending with distance from the home. Consistently, enclosed spaces near the household were cleared of feces while locations beyond the participants' and community members' property limits were left feces-ridden. Animals' ability to roam freely beyond property limits enables feces to go unmanaged as the owners either do not know where defecation takes place or do not care to remove it from communal or unused spaces. Cat and dog feces, for example, were deposited anywhere between the participants' homes or patios, and distant locations in the region such as hills and rivers, and participants rarely cleaned it up. This is consistent across communities where these free roaming animals are abundant and feces are ubiquitous throughout, such as in Kenya and Ethiopia.[3,31]

We found that the existence of waste management infrastructure does not necessarily lead to proper waste disposal, which aligns with previous research. While some of our participants referenced a waste management system in the form of house-to-house garbage collection, this choice to dispose of feces in other places could be a product of an inefficient or fragmented waste management system. The notion that waste management infrastructure shortfalls can give rise to improper waste management practices is supported by experiences of insufficient waste

collection coverage and irregularity in waste collection services that many LMICs experience.[42] Further investigation of the waste management resources in the study regions should be performed to identify related barriers to proper animal waste disposal and targets for system improvements to promote its utilization among communities and subsequently, the health of the environment.

The consistently high prevalence of animals throughout communities in LMICs has many implications for research and practice. Research has investigated how both free-roaming and enclosed animals might transmit pathogens. However, in our study, animal owners in practice are mostly aware of pathogen transmission from enclosed animals.

Studies of free roaming dog populations in LMICs are often conducted to inform interventions for rabies control and prevention.[34] Rabies interventions have been a public health initiative for decades as it's a recognized risk for humans and animals globally.[34] The extent to which free roaming animals impact other disease prevalence, particularly enteric infections, remains less understood and offers opportunities for future research. The investigation of dog, cat, and other community roaming animals in the context of enteric pathogen prevalence should be expanded to capture further implications of their presence for community health. Knowledge of standard animal living conditions in general helps identify targets for beneficial animal husbandry modifications.

We identified awareness of certain health implications of animal living conditions among the study sample, which are consistent with outcomes previously reported in literature. When participants chose to keep their chickens free in their yard out of a coop, it was to prevent "plague" spreading among them in an enclosed space. This choice is validated by the ongoing incidence of avian influenza in countries such as the United States among commercial poultry

operations and backyard flocks.[43] Some poultry owners in this study were aware of the risks associated with crowding their birds while others were not, or at least did not act on awareness by allowing their birds space to roam. Future research should query owners about their sources of information about animal living conditions to identify resources for other animal owners to access, as optimizing animal health is likely of interest to all animal owners. Furthermore, community assessments should be performed to identify context-specific ways to safely house animals that are feasible given the materials and space available.

We determined that different animal feces management practices have different implications for environmental fecal contamination. Animal feces was either left where it was excreted or collected. When feces were removed from their original site, participants either disposed of it properly (e.g., trash or septic tank) or simply relocated it to a site in the environment (e.g., ditch, field or river). Among the three most frequent methods, throwing feces into the trash is what we consider to be a non-contaminating method practiced by individual animal owners, while throwing it into the environment and taking no action at all are what we consider to be contaminating methods. The decision to dispose of feces in empty lots or fields rather than the trash is frequently made and detrimental to the environment yet not justified in the interviews. It likely stems from a cultural or community norm, similar to, but less blatant than the use of a communal waste ditch in Borbón, that is collectively kept flowing down to a water reservoir. This high prevalence of waste disposal in the environment within communities is consistent with practices commonly reported in literature. Observational studies in Latin American, Asian and Africa, countries report that 25%-32% of feces were improperly disposed of in bushes, open fields, or rivers.[44–46] These same studies observed 12%-42% of individuals leave the feces where it was deposited.[44–47] We consider the burying of animal feces to be a potentially

environmentally contaminating management method whether the owner buries it, or the animal buries its own feces. This practice was also observed in studies in Africa and Latin America.[46–48] Disposal in sewers and septic tanks is thought to not contribute to contamination as well as the mopping of animal feces, mainly from birds, with use of a disinfectant. Two feces management methods require more information about the process for us to determine if they contaminate the environment. These are the burning of feces and using feces as fertilizer. Studies have demonstrated the risks associated with improper employment of animal feces as fertilizer, such as salmonella transmission, though proper conversion of feces to utilizable fertilizer is possible and safe.[49,50]

Improper, contaminating animal feces disposal practices were far more common than safe animal feces disposal among the study sample. 75% of urban animal owners, 33% of semi-rural animal owners, 80% of rural road animal owners and 50% of rural river animal owners practice at least one non-contaminating feces management method while 100% of urban, semi-rural and rural river owners and 80% of rural road owners use at least one contaminating method. One rural road community member uses only non-contaminating feces management methods while none of the members of other eco-regions do so. 25% of urban owners, 53% of semi-rural owners and 50% of rural river owners, 11 people total, use only contaminating methods, while no rural road community members do so. Disposal of feces in the environment, including burying feces, was practiced by participants in every eco-region, making it difficult to associate this decision with any type of community with any region's unique social norms and waste management systems. The striking proportion of participants practicing unsafe animal waste management also calls for community-wide education campaigns which have been effective in improving waste management and environmental health in other LMICs.[51]

We now know a variety of household and community level behaviors that feed into the poor quality of animal feces management, which inform many of the gaps identified by Penakalapati et al. (2017) in their adapted socio-ecological model (Figure 2). Specifically, at the household level, animal housing and containment, or the lack thereof, have major implications for the spread of fecal contamination in communities. Participants express understanding of practices to prevent contamination of their own home, illustrated by immediate cleaning of in-home feces and use of disinfectants. There is a clear focus on preventing household contamination, while understanding of environmental contamination risks and prevention may not be understood as well. Animal feces storage and management take a variety of forms and more often serve to exacerbate environmental fecal contamination by animals. At the community/public level, community water sources and fields are viewed as acceptable waste receptacles. Animal feces management in public settings is lacking, as feces is often left where it drops, unless it impacts other individuals by being on their property, where social pressure plays a role in mitigating environmental fecal contamination.

4.1 Strengths and Limitations

Limitations of this study include the uneven distribution of participants between the four eco-regions with a range of 4- to 15-person subsamples. With 4 to 6 individuals representing urban and rural regions, it is difficult to identify eco-region-specific animal husbandry characteristics. The relative variety of feces management practices per eco-region is likely due to the sample size rather than community norms. Past husbandry practices that were discussed in interviews such as when a currently owned animal was younger, or with animals that have died, were not included in analysis. This resulted in the exclusion of behavior data such as kitten litter box management and indoor puppy potty training. It also excludes factors related to animals that

are no longer present but would have added to some individuals' husbandry practice data. Another limitation was engendered by lack of specificity during interviewing. When describing feces management, sometimes participants simply say, "throw away," which can mean throw in the trash or throw in the environment. There are notable strengths to this study as well. The employment of verbatim transcripts strengthens the validity of the data with theoretical validity being strengthened by the sample size.[52] The achievement of code and meaning saturation ensured that all data collected through interviews was captured to develop the key themes.[53]

4.2 Next Steps

Descriptions of personal animal husbandry behavior gathered throughout this study help to clarify the ongoing contribution of fecal contamination by domesticated animals in different eco-regions in northwestern coastal Ecuador. Diving deeper into the community norms that facilitate and perpetuate this contamination via focus group discussions would contribute to the understanding of the issue as well as provide a space to discuss acceptable mitigation efforts and their barriers and facilitators. Additionally, this qualitative analysis of interviews with animal owners provides insight into behaviors that have the potential to cause widespread contamination of the environment, but the extent to which they do is unknown. The incorporation of quantitative methods such as environmental and fecal sampling should be employed to quantify the environmental fecal contamination exacerbated by animal owners in these eco-regions and produce statistics regarding risk of exposure and the like, to spur behavior change.

5 Conclusion

Animal fecal contamination of the environment puts individuals at risk of exposure to agents that cause diarrheal illness, environmental enteric dysfunction, and more that burden

population worldwide, and in low-and-middle-income countries especially, where clean water, proper sanitation and good hygiene is suboptimal. Identifying the practices that cause environmental contamination the first step in behavior change interventions to improve the quality of the community environment, reducing pathogen exposure and related morbidity and mortality.

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6 Appendix

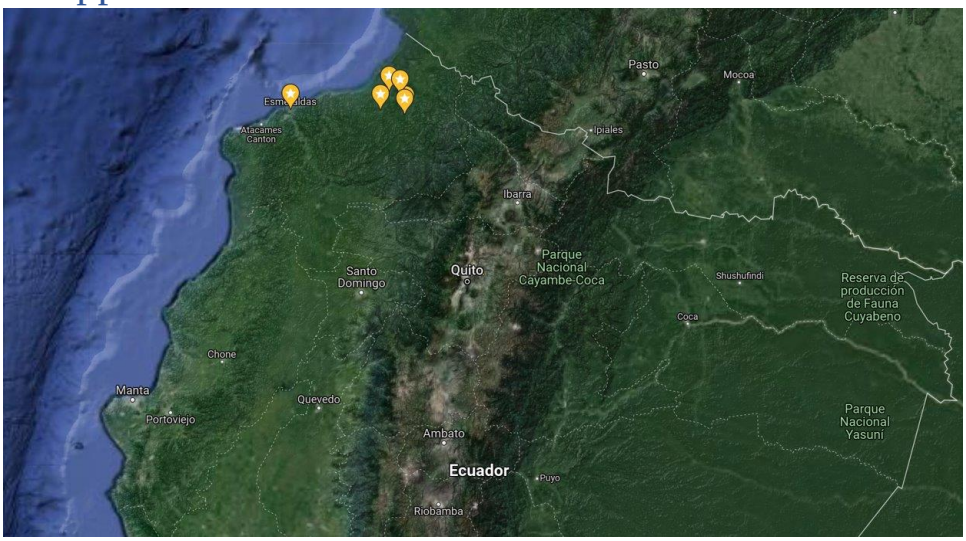

Figure 3. Map of study sites, zoomed out

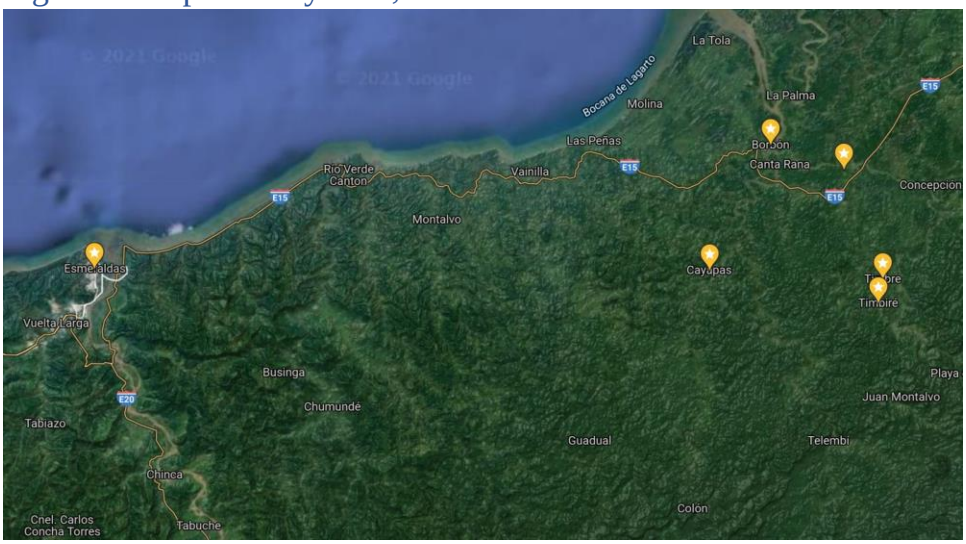

Figure 4. Map of study sites, zoomed in

Tables

Table 1: Participant Demographics

#	Eco-Region	Neighborhood	Age	Education	Ethnicity
1	Urban	Tiwinza	62	0	Afro-Ecuadorian
2	Urban	Tiwinza	72	0	Afro-Ecuadorian
3	Urban	Tiwinza	40	5	Afro-Ecuadorian
4	Urban	15 de Marzo	45	9	Afro-Ecuadorian
5	Semi-Rural	Torres Gemelas	42	7	Mestizo
6	Semi-Rural	Lumber	35	10	Mestizo
7	Semi-Rural	Borbon	18	11	Afro-Ecuadorian
8	Semi-Rural	Nuevo Amonecer	32	10	Mestizo
9	Semi-Rural	La Tola	22	12	Afro-Ecuadorian
10	Semi-Rural	Lechugol	18	8	Mestizo
11	Semi-Rural	Lechugol	41	10	Afro-Ecuadorian
12	Semi-Rural	Lechugol	21	8	Afro-Ecuadorian
13	Semi-Rural	Puerta de Dios	52	4	Afro-Ecuadorian
14	Semi-Rural	Borbon	29	12	Afro-Ecuadorian
15	Semi-Rural	Lumber	35	7	Afro-Ecuadorian
16	Semi-Rural	Lumber	35	6	Mestizo
17	Semi-Rural	La Cayapa	19	11	Mestizo
18	Semi-Rural	La Cayapa	73	0	Mestizo
19	Semi-Rural	La Cayapa	38	2	Mestizo
20	Rural Road	25 de Mayo	41	9	Afro-Ecuadorian
21	Rural Road	Maldonado	26	10	Afro-Ecuadorian
22	Rural Road	Maldonado	40	6	Afro-Ecuadorian
23	Rural Road	Timbire	55	3	Mestizo
24	Rural Road	Timbire	50	9	Afro-Ecuadorian
25	Rural Road	Timbire	63	6	Afro-Ecuadorian
26	Rural River	Zancudo	57	1	Afro-Ecuadorian
27	Rural River	Zancudo	33	3	Afro-Ecuadorian
28	Rural River	Colon de Onzole	63	3	Afro-Ecuadorian
29	Rural River	Colon de Onzole	43	4	Afro-Ecuadorian

Table 2: Participant Animal Ownership

#	E-R	chicken	creole	duck	turkey	guinea pig	dog	pig	cow	donkey	sheep	cat	parrot	turtle	pigeon	Chachalaca	T
1	U		2	1			4										7
2	U	10										1					11
3	U			1		1						1					3
4	U	3	4	4		1					1			3			16
5	S-R						2	1				1					4
6	S-R		10									3				1	14
7	S-R	3					2					1					6
8	S-R		28	21			3					1					53
9	S-R					1	1					2					4
10	S-R		20									2	1				23
11	S-R	1	9					3				1					14
12	S-R						1	2				1					4
13	S-R		4				1	1									6
14	S-R						2					1	1				4
15	S-R		15	4			2	1				1					23
16	S-R	9	60	5	1		3	4				1				1	84
17	S-R						1	1				1					3
18	S-R		3				1					2					6
19	S-R						1					1	1				3
20	R-R	200					2	1				1					204
21	R-R						2	1				3					6
22	R-R		15	2			2					2					21
23	R-R		30				2	2							1		35
24	R-R		20	2			4	4		2		1					33
25	R-R		12									1					13
26	R-r		10						4			1					15
27	R-r			2			1					1					4
28	R-r		20	5			3					1	1				30
29	R-r		15	30			1	1									47
T		226	277	77	1	1	39	26	4	2	1	32	4	3	1	2	696

E-R= eco-region; U= urban; S-R= semi-rural, R-R= rural road, R-r= rural river; T= total