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Role, ownership and presence of domestic animals in peri-urban households of Kisumu, Kenya

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Summary

Low- and middle-income countries are experiencing rapid urban population growth, particularly in peri-urban informal settlements. In these urban areas, animal husbandry remains a valuable source of income and protein-rich foods but may also present a risk of zoonotic disease threat. To date, there have been studies that have assessed the prevalence and nature of animal ownership in these communities. This cross-sectional survey assessed the geographical, sociocultural and economic factors behind the presence, ownership and purpose of domestic animals in three informal peri-urban communities of Kisumu, Kenya. A majority (n = 587) of the study households exhibited domestic animal presence in the living space yet only 32% of households reported animal ownership (n = 252). The purposes of ownership included: for meat/eggs (55%); for income, sale or trade (43%); for milk production (31%); and as companions/pets (31%). Among households that owned animals, 76% reported that at least one animal slept in the house at night. In multivariate logistic regression, the following factors were significantly associated with household animal ownership: ownership of agricultural land (OR = 1.94, 95% CI = 1.12, 3.35), perceiving a strong community bond (OR = 2.28, 95% CI = 1.25, 4.16), and household membership in a community group (OR = 1.64, 95% CI = 1.04, 2.60). This research demonstrates the high prevalence of animal ownership in a low-income and high-density peri-urban neighbourhood of an African city, which may facilitate zoonotic disease transmission. Further research should assess if and to what extent animal ownership in such communities is associated with disease risk.

KEYWORDS

companion animals, livestock, one health, poultry, public health, zoonoses

1 | INTRODUCTION

Despite a general movement of people from rural to urban areas in low- and middle-income countries (LMIC), contact between humans, wildlife and domestic animals is increasing (Brown, 2004). Worldwide production of meat is expected to double by the year 2050, primarily in less developed countries, and milk production has increased over 49% between the years 1983 and 2013 (FAO, 2014, 2015). In LMIC, this increasing demand for animal food products has prompted a growing livestock-keeping sector in and around urban centres as a way to supplement income and diet (FAO, 2014; Herrero et al., 2013; Gallaher, Kerr, Njenga, Karanja, & WinklerPrins, 2013). Yet domestic animal contact and husbandry are driven by many geographical, sociocultural and economic factors (Ayenew, Wurzinger, Tegegne, & Zollitsch, 2011; Kagira & Kanyari, 2010a; Woldehanna & Zimicki, 2015). For example, property ownership, access to grazing land, local laws and community acceptance can all dictate what species are permitted and how a

household manages food, water and shelter for domestic animals (Kagira & Kanyari, 2010a; Lupala, 2002; Onim, 2007). The gender, age and marital status of household members can determine animal ownership or contact, type of animal owned, tasks related to care or processing, and decision-making abilities regarding sale and production (Herrero et al., 2013; Kimani et al., 2012; Njuki & Mburu, 2013; Woldehanna & Zimicki, 2015).

While animal husbandry provides households an opportunity to supplement income and available food, it can also pose a potential risk of zoonotic disease. Multiple studies have shown that improper animal husbandry practices expose livestock keepers, household members and communities to zoonotic disease threats (Grace, Monda, Karanja, Randolph, & Kang'ethe, 2012; Grace, Mutua et al., 2012; Kagira & Kanyari, 2010b; Opisa, Odiere, Jura, Karanja, & Mwinzi, 2012; Thumbi et al., 2015; Zambrano, Levy, Menezes, & Freeman, 2014). Differences in animal contact and husbandry responsibilities can result in unique zoonotic exposures for each household member or community resident. For example, milking animals, collecting eggs, feeding animals, cleaning animal waste areas, caring for sick animals and preparing animal products for household consumption or sale are often a woman's role in animal husbandry operations leading to multiple opportunities for direct transmission of zoonotic disease (Arora, Arango, Stefan, Chirinda, & Twyman, 2017; Paudel, ter Meulen, Wollny, Dahal, & Gauly, 2016; Quisumbing, Roy, Njuki, Tanvin, & Waithanji, 2013; Simiyu & Foeken, 2013). As women are also in charge of household meals and food preparation, members are then at risk of indirect transmission from contaminated water, food, utensils and hands. Similarly, men are often tasked with breeding, slaughtering, butchering, administering medicine to sick animals and marketing and selling animals and animal products (Arora et al., 2017; Miller, 2011; Quisumbing et al., 2013). This can put them at risk of direct transmission from animal contact, including inhalation of pathogens in tissue and viscera. Children often play in close proximity with companion or baby animals and exercise mouthing behaviours and poor hygiene, which can put them at an increased risk of zoonotic disease (Ngure et al., 2013; Pintar et al., 2015; Xue et al., 2010). In community settings, urban and peri-urban domestic animals often graze and roam openly creating a major source of waste pollution for soil, water and vegetation (Opisa et al., 2012).

Despite the zoonotic disease exposure threats with this rise in peri-urban agriculture and animal husbandry practices of LMIC, few studies have quantified the prevalence and role of domestic animals in households and living spaces of sub-Saharan Africa (SSA). Research is necessary to discover more about why domestic animals are present in urban and peri-urban households of Kenya and the role they play in order to determine the different zoonotic risks for household and community members. The goal of this study was to identify determinants for household ownership of domestic animals and distinguish the purpose, rewards and risks for the relationship peri-urban Kisumu, Kenya, residents have with these animals. Understanding the function of domestic animals in these communities can contribute to our understanding of zoonotic disease risk within households and communities and help guide effective public health interventions.

Impacts

- Domestic animals were present in over 70% of the participating household's outdoor living space (compound) yet only 32% of the households reported owning an animal
- Domestic animals owned by the households served primarily as a source of meat or eggs, income or milk production but also acted as companions and often slept inside the home illustrating multiple transmission opportunities for zoonoses
- Geographical, sociocultural and economic factors were significantly associated with household domestic animal ownership and the type of animal owned varied by male- v. female-headed households

2 | MATERIALS AND METHODS

2.1 | Study site

Comprising the third largest city of Kenya, Kisumu serves as the centre for commercial markets in the west (Habitat, 2005; Mireri, 2013). Despite Kenya's industrialism, most working citizens labour in informal or subsistence farming with agriculture the principal employment sector (IOM, 2015). Domestic animals remain important as almost 65% of Kenyan households own livestock or poultry (Grace, Monda et al., 2012; Grace, Mutua et al., 2012; Kagira & Kanyari, 2010a,b; Kenya National Bureau of Statistics, 2014; Mireri, 2013; Mireri, Atekyereza, Kyessi, & Mushi, 2007; Onim, 2007; Thumbi et al., 2015). This is mirrored within Kisumu where, despite the port access of Lake Victoria, almost 80% of the city is considered rural and approximately 50% of the residents are involved in urban agriculture and/or animal husbandry (KMC, 2004; Mireri et al., 2007).

Kisumu is home to many peri-urban informal settlements, where approximately 60% of the population reside (Habitat, 2005). Rural-urban migration has strained the city's already thin infrastructure and urban resources and the rural citizens who move to the peri-urban slum communities often remain impoverished and at a higher risk of morbidity and mortality (Habitat, 2005; IOM, 2015). This study on domestic animal ownership and presence was conducted across three peri-urban slum settlements of Kisumu—Nyalenda A, Nyalenda B and Kanyakwar (included the two subareas of Nyawita and Obunga).

2.2 | Study design and procedure

The study was a cross-sectional survey of 800 households across the three afore mentioned peri-urban slum settlements. Using a two-stage

cluster sampling design, households were randomly selected to participate in a larger research project to collect representative data on environmental conditions and child health. This study uses data collected under that survey concerning household demographics and animal ownership, presence, management and contact. For this analysis, animal contact was defined as: (i) having direct interaction with an animal, animal waste, animal tissue or animal products such as milk or eggs; and/or (ii) the sharing of the same physical environment such as within a home or yard/compound, or a public space.

The sampling was conducted in two stages. Firstly, a sample frame was established using a list of all active Community Health Volunteers (CHVs) for the three settlements with each CHV representing a cluster of approximately 100 households. CHVs are key to healthcare access in these communities and responsible for disease surveillance and reporting, updating medical registries for patients and families, advising on vaccinations and pregnancy care and providing health education and basic first aid to the household members in their area (Adam et al., 2014; Takasugi & Lee, 2012). From this list, 40 CHV clusters were selected using a random number generator. Secondly, from a list of households for each of the selected CHV clusters, 20 households were randomly selected for participation in the study.

Working with the CHV for the selected cluster, locally trained field staff from Great Lakes University Kisumu (GLUK) conducted hour-long household surveys in English, Kiswahili and Dholuo using handheld computer tablets configured with Qualtrics © 2015 software. Respondents were self-identified as the primary person in charge of water collection, hygiene and/or infant food preparation for the household. As per conventional practice, a household was defined as those who share the same kitchen area (Kenya, 2014; UNICEF, 2014).

The household survey contained questions related to geographical, sociocultural and economic factors, which were then analysed in this study for a significant association with domestic animal ownership at the household. All participants were asked whether the household owned animals but only those that said yes were asked (i) why the household owns animals; (ii) where the animals sleep; and (iii) which household member had the most contact with animal types. Species of animal owned by the household was determined by the answer given as to where different animal species slept. If the participant answered that an animal species slept inside the home, inside the compound, or outside the compound, it indicated that the household owned that animal species. In addition to self-reported animal ownership and purpose, an enumerator recorded observational data such as the presence of domestic animals by species in the compound where the household was based. Animals that wandered into the compound after the initial notation were not considered in the final tally. Observational data on domestic animals were applied to each survey household that belonged to the compound. The survey and observational data were analysed to describe the function of domestic animals in these peri-urban households and the geographical, sociocultural and economic factors that are significantly associated with their occurrence (Table 1). The survey was conducted during the dry season, between February and March 2015.

2.3 | Statistical modelling and analysis

Depending upon the dynamics of a community, animal husbandry, contact and ownership can vary upon whether the member is a male or female, whether they belong to a certain neighbourhood or social network, their financial status, their residence and their family structure (Grace, Monda et al., 2012; Grace, Mutua et al., 2012; Herrero et al., 2013; Ishagi, Ossiya, Aliguma, & Aisu, 2002; Ishani, Gathuru, & Lamba, 2002; Kimani et al., 2012; Njuki & Mburu, 2013; Woldehanna & Zimicki, 2015). For this study, potential factors associated with animal ownership were categorized to better address the questions of why domestic animals are at the households and the role they play to determine potential zoonotic transmission risks they may represent. The independent variables chosen were characterized as geographical, sociocultural and economic.

Livestock categories were cattle, horses, pigs, sheep or goats, and poultry categories were ducks and chickens. Pets or companion animals included cats or dogs. Household wealth terciles were calculated using a scale of household assets (*electricity*, *cooking fuel*, *household possessions*, *access to a bank account*, *number of people per sleeping room*, *access to improved water and access to improved sanitation*) and housing structure (*roof*, *wall and floor type*) based on the wealth index constructed in the Kenya Demographic and Household Survey (DHS) (Kenya National Bureau of Statistics, 2014). Households were then divided into wealth terciles categorized as rich, middle and poor based on the results of this scale. Using terciles instead of quintiles ensured larger proportions of the participating households fell into each category and that there were no unnecessary groupings (Khan, Hotchkiss, Berruti, & Hutchinson, 2006).

Using STATA® Statistical Software, version 13 (Statacorp, 2013), descriptive statistics were employed to understand household and community demographics and animal ownership, presence, purpose and housing. Next, logistic regression models were constructed to identify possible significant factors of overall animal ownership and animal ownership by animal type. The outcome of interest was reported animal ownership at the household level. Independent variables with a p value ≤.15 in a bivariate logistic regression were included in a secondary multivariate logistic regression. This generous significance level was used to prevent the exclusion of potentially relevant explanatory variables in the multivariate model (Bursac, Gauss, Williams, & Hosmer, 2008). In addition, head of household sex was also included in the multivariate model of overall animal ownership due to the importance found between gender and animal ownership in other studies (Njuki & Mburu, 2013; Woldehanna & Zimicki, 2015). However, variables in the multivariate models were considered to be significant at a more traditional cut-off of p value ≤.05. The data set was weighted to account for the number of community clusters selected, replaced or active CHVs, the number of households listed on registry and the number of households selected. Data were assumed to be missing at random, and analysis was conducted only on available data.

TABLE 1 Variables used in analysis of domestic animal ownership, purpose and presence in Kisumu, Kenya, households and the geographical, sociocultural and economic factors associated with their occurrence

Category	Variable	Description
Animal ownership and contact	Animal ownership	Household reports animal ownership: yes/no
	Animal purpose[a]	1. Domestic Food Source (eggs, meat); 2. Companionship/Pet; 3. Domestic Milk Source; 4. Income through trade/sale; 5. Work/Labor; 6. Transportation; 7. Cultural Considerations (funeral, dowry, etc.)
	Cohabitation[a]	Animal species sleeps: 1. Inside the house; 2. Inside the compound; 3. Outside the compound; 4. None
	Animal type owned[a]	Animal species sleeps inside the house, inside the compound, or outside of the compound
	Livestock contact[a]	Household member with the most livestock contact: 1. Adult Female(s); 2. Adult Male(s); 3. Child or Children; 4. Other; 5. None
	Poultry contact[a]	Household member with the most poultry contact: 1. Adult Female(s); 2. Adult Male(s); 3. Child or Children; 4. Other; 5. None
	Companion contact[a]	Household member with the most companion animal contact: 1. Adult Female(s); 2. Adult Male(s); 3. Child or Children; 4. Other; 5. None
Geographical factors	Community	1. Kanyakwar; 2. Nyalenda A; 3. Nyalenda B
	Years at residence	Years the household has resided at the residence
	Ag land owned	Household owns agricultural land: yes/no
	Amount of Ag land	Number of agricultural hectares owned by household
Sociocultural factors	Head of household sex	Head of household: 1. Male; 2. Female
	No. of people	Number of adults plus number of children living at household
	Household community relationship	1. Weak/Very weak; 2. Neutral; 3. Strong/Very strong
	Community bond	1. Weak/Very weak; 2. Neutral; 3. Strong/Very strong
	Community group	Household belongs to a community group: yes/no
Economic factors	Food worry	Times the household worried about having enough food in the last month: 1. Never; 2. Rarely (once or twice in the past 4 weeks)/Sometimes (three to ten times in the past 4 weeks); 3. Often (more than ten times in the past 4 weeks)
	Wealth tercile	*Based on wealth asset index, housing materials, and access to improved water/sanitation*
	Own residence	Household owns land and/or house: yes/no
Observational data on animal presence	Animal presence	Domestic animal in the household's compound at the time of sampling: yes/no

[a]Questions only asked when household reported animal ownership (n = 252).

3 | RESULTS

3.1 | Household demographics and community characteristics

Household characteristics varied across the three communities (Table 2). The majority of household heads were male (n = 523; 68%), and the majority of survey respondents, or the person in charge of infant meals, water and/or hygiene, were female (n = 734; 92%). The head of the household either finished primary or secondary school for most households across all three communities with the main occupations being skilled manual work (33%) and sales and service (23%). Household size was mostly four or less (64%) and over 70% of homes had at least one child. Wealth varied across the three areas: Kanyakwar and Nyalenda B the largest proportion of households were in the poorest tercile (40% and 43%, respectively), whereas the largest proportion (46%) of households in Nyalenda A were in the wealthiest tercile.

3.2 | Household animal ownership, compound presence, purpose and cohabitation

Community and head of household gender differences in reported household animal ownership, observed presence of animals in the compound, type of animal owned, whether an animal slept in the home at night and the purpose of the domestic animals are demonstrated in Table 3. Of all households, 32% reported animal ownership. Animal husbandry was reported across all three communities, although Nyalenda B reported almost twice as much animal ownership (40%) compared to Nyalenda A and Kanyakwar (24% and 28%, respectively). A domestic animal was observed in over 70% of the household compounds, regardless of reported household animal ownership. Cohabitation with animals was common in households with reported animal ownership, and 76% of households with animals reported that at least one slept inside the house at night. The most common purpose for animal ownership was for consumption (meat or

TABLE 2 Household and community characteristics of peri-urban Kisumu, Kenya

Category	Kanyakwar *n* (%[a])	Nyalenda A *n* (%[a])	Nyalenda B *n* (%[a])	Total *n*
Total households	260	261	279	800
Gender of head of household[b]				
Male	180 (71)	162 (62)	181 (70)	523
Female	72 (29)	92 (38)	78 (30)	242
Education level for head of household				
Some primary	34 (13)	30 (11)	33 (11)	97
Finished primary	112 (44)	136 (52)	101 (37)	349
Finished secondary	92 (35)	79 (30)	94 (33)	265
Post-secondary	22 (9)	16 (6)	51 (18)	89
Occupation of head of household				
Not employed	19 (7)	23 (9)	22 (8)	64
Professional/technical/managerial or clerical	29 (12)	36 (13)	73 (26)	138
Sales and service	60 (23)	66 (25)	61 (21)	187
Skilled manual	109 (43)	82 (30)	71 (26)	262
Student or domestic service	6 (2)	7 (3)	3 (1)	16
Agriculture or fishing	1 (0.4)	5 (2)	8 (4)	14
Motorcycle/transport driver	36 (13)	42 (17)	41 (14)	119
Gender of respondent				
Male	24 (9)	17 (7)	25 (9)	66
Female	236 (91)	244 (93)	254 (91)	734
Number of people in household[c]				
1–4	166 (65)	181 (69)	166 (61)	513
5–8	92 (35)	72 (29)	107 (37)	271
9+	1 (0.2)	8 (3)	5 (2)	14
Children in the household				
None	76 (31)	71 (27)	60 (22)	207
At least one child	184 (69)	190 (73)	219 (78)	593
Wealth tercile[d]				
Poor	101 (40)	94 (37)	68 (23)	263
Middle	74 (28)	112 (43)	77 (31)	263
Rich	83 (33)	53 (20)	127 (46)	263

[a]Percentages based on weighted data.
[b]Reported head of household gender *n* = 765.
[c]Reported number of people in the household *n* = 798.
[d]Reported wealth terciles *n* = 789.
[e]Years at current residence *n* = 761.

eggs) (55%), followed by income, sale or trade (43%), and for milk production (31%) and as pets/companions (31%). Over half of the homes with reported animal ownership had chickens (61%) followed by cats (41%) and cattle (37%).

There were also distinct gender-based differences surrounding animal ownership and contact. Both male and female-headed households reported animal ownership (36% and 30% of the total participating households, respectively). Among the female-headed households that owned animals (*n* = 71), 69% reported the purpose was for meat/eggs while 44% had animals for income, trade or sale. Of the male-headed households with animal ownership (*n* = 169), 53% reported the animals were for meat/eggs and 45% said they were for income, trade or sale. Cattle, a more valuable form of livestock, were owned by almost half of the male-headed households (46%) with reported domestic animal ownership but only 19% of the female-headed households with reported animal ownership. Goats and sheep were mostly owned by male-headed households. Poultry were in female-headed houses at almost equal rates as male for chickens (56% and 60%, respectively); however, ducks were more common in female-headed households that owned animals.

TABLE 3 Animal ownership, presence and purpose in Kisumu, Kenya households

Category	By community				By reported head of household gender[a]	
	Total *n* (%[b])	Kanyakwar *n* (%[b])	Nyalenda A *n* (%[b])	Nyalenda B *n* (%[b])	Male-headed *n* (%[b])	Female-headed *n* (%[b])
Observed animal in compound						
No	206 (26)	69 (28)	77 (30)	60 (22)	132 (25)	65 (24)
Yes	587 (74)	191 (72)	184 (70)	212 (78)	386 (75)	175 (76)
Household animal ownership						
No	548 (69)	186 (72)	196 (76)	166 (60)	354 (64)	171 (70)
Yes	252 (32)	74 (28)	65 (24)	113 (40)	169 (36)	71 (30)
Type of animal owned[c]						
Cattle	94 (37)	27 (37)	20 (29)	47 (42)	74 (46)	13 (19)
Horse, donkey, mule	2 (1)	0 (0)	0 (0)	2 (2)	2 (2)	0 (0)
Goat	51 (20)	11 (15)	9 (13)	31 (29)	35 (26)	11 (19)
Sheep	31 (12)	12 (16)	4 (7)	15 (14)	26 (17)	2 (2)
Chicken	154 (61)	49 (66)	35 (54)	70 (61)	104 (60)	39 (56)
Pig	2 (1)	0 (0)	1 (1)	1 (1)	2 (1)	0 (0)
Duck	18 (7)	3 (4)	6 (9)	9 (7)	10 (5)	8 (13)
Dog	57 (23)	19 (26)	16 (22)	22 (19)	41 (22)	12 (15)
Cat	104 (41)	31 (40)	24 (37)	49 (43)	66 (39)	31 (44)
Animal ownership purpose[c]						
Meat/eggs	138 (55)	40 (54)	30 (45)	68 (61)	89 (53)	42 (69)
Milk production	79 (31)	23 (32)	22 (32)	34 (30)	61 (35)	14 (20)
Income, trade, or sale	108 (43)	30 (40)	25 (35)	53 (49)	76 (45)	27 (44)
Work	20 (8)	6 (9)	4 (7)	10 (10)	17 (12)	3 (4)
Transportation	1 (0.4)	0 (0)	0 (0)	1 (1)	1 (1)	0 (0)
Social currency	6 (2)	1 (1)	1 (2)	4 (3)	6 (4)	0 (0)
Pet	79 (31)	24 (31)	26 (41)	29 (25)	47 (26)	30 (36)
An animal sleeps in house[c]						
No	61 (24)	15 (21)	17 (25)	29 (28)	43 (28)	14 (24)
Yes	191 (76)	59 (79)	48 (75)	84 (72)	126 (72)	57 (76)
Type of animal sleeping in house[c]						
Cattle	5 (2)	0 (0)	0 (0)	5 (5)	4 (4)	1 (4)
Horse, donkey, mule	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Goat	4 (2)	1 (1)	0 (0)	3 (3)	2 (2)	2 (3)
Sheep	2 (1)	0 (0)	0 (0)	2 (1)	1 (1)	1 (1)
Chicken	117 (46)	37 (50)	28 (44)	52 (44)	78 (45)	33 (45)
Pig	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Duck	12 (5)	3 (4)	3 (5)	6 (4)	6 (3)	6 (10)
Dog	4 (2)	0 (0)	0 (0)	4 (3)	1 (1)	3 (6)
Cat	100 (40)	30 (39)	24 (37)	46 (40)	63 (36)	30 (41)

[a]Reported head of household gender $n = 765$.
[b]Percentages based on weighted data.
[c]Reported households with animal ownership $n = 252$.

Of the households with reported animal ownership, primary contact fluctuated by household member and by animal type (Table 4). Adult females had more reported contact with poultry and companion animals. Adult males had slightly more contact with livestock than adult females. Children's animal contact was mostly with companion animals.

	Adult male	Adult female	Child	Other	None
Livestock	22.17%	20.14%	1.86%	5.04%	50.79%
Poultry	7.41%	58.85%	1.09%	2.48%	30.17%
Companion animal	7.36%	30.71%	9.18%	1.32%	51.44%

TABLE 4 Percentage of household member with the most contact by animal type in Kisumu, Kenya

3.3 | Factors of household animal ownership

Several significant explanatory variables related to geography, sociocultural factors and household income for animal ownership in the bivariate model were also significant in the multivariate model (Table 5). Households that reported owning agricultural land were almost twice as likely to own animals as compared to households that do not (aOR = 1.94, 95% CI = 1.12, 3.35). The more agricultural hectares that were owned, the more likely the household was to own animals. For example, households that own three or less agricultural hectares were over three times more likely to own animals than households that do not own agricultural land (aOR = 3.51, 95% CI = 1.55, 7.94) and households that own more than three agricultural hectares were almost eight times more likely to own animals compared to households without this land (aOR = 7.6, 95% CI = 1.65, 35.09) after adjusting for head of household gender, community, residence ownership, community bonds and group membership, and worry about having enough food to eat. Ownership of animals was slightly higher among households that owned their residence compared to households that rent (aOR = 0.37, 95% CI = 0.20, 0.66). Social networks had a positive association with animal ownership as households that perceived a strong/very strong community bond were more than twice as likely to own animals compared to those that felt their community bond was weak or very weak (aOR = 2.28, 95% CI = 1.25, 4.16). Finally, animal ownership occurred in households with membership in a community group more often than households without community group membership (aOR = 1.64, 95% CI = 1.04, 2.60).

The geographical, sociocultural and economic factors were also applied to household ownership by animal type (Table 6). Multivariate analysis showed that households were more likely to own livestock if the participant had lived at that residence for longer. Households were also almost three times as likely to own livestock if they owned agricultural land (aOR = 2.80, 95% CI = 1.10,7.12). The amount of agricultural land was also significant; as the size of land increased, the likelihood for household livestock ownership increased (aOR/CIs). Multivariate analysis of household poultry ownership and geographical, sociocultural and economic factors did not retain any significant relationships. However, among households with more than four occupants, there remained an association with household companion animal ownership.

4 | DISCUSSION

Urban animal husbandry is on the rise due to increasing populations and dietary trends towards more animal-based protein; SSA is expected to see significant growth in this sector (FAO, 2009; Grace, Monda et al., 2012; Grace, Mutua et al., 2012; Herrero et al., 2012, 2013). These factors coupled with the need for supplemental income will drive the ongoing animal husbandry practices of Kisumu, Kenya, and may lead to an increased risk of zoonotic disease (Kagira & Kanyari, 2010b). This study revealed geographical, sociocultural and economic factors associated with household animal ownership and the potential for zoonoses in peri-urban communities.

However, this study is not without limitations. Firstly, it is a cross-sectional survey with self-reported data and causal relationships could not be determined. And while a common measurement used to define a household is to count those that share the same kitchen, GLUK has found a more tailored approach works best for polygamous populations where a household is defined as those who share a meal prepared from the same pot or served at the same table. Additionally, the concept of ownership is difficult to measure when considering cultural norms and gender roles (Herrero et al., 2013; Njuki & Mburu, 2013; Onim, 2007). Future work in this area should consider using decision-making abilities in conjunction with ownership to determine who controls the asset.

Moreover, this research did not distinguish between different types of contact or ownership purpose for specific animal species. Additional research on domestic animal ownership in peri-urban communities should include these items. This survey also made no mention of the number of animals owned or if the animals reported as owned were housed at the peri-urban residence. The multivariate analysis by which ownership of agricultural land was significant for animal ownership suggests that at least some of the reported animal in this study may be held at property outside of the three communities. However, as almost three of four participating households had a domestic animal observed in their compound at the time of sampling, the risk of peri-urban zoonoses remains regardless if some animals are housed at rural property.

Despite these shortcomings and irrespective of ownership status, domestic animals are well established within these three communities (Kenya National Bureau of Statistics, 2014; KMC, 2004). We found that a majority of participating households had animals in their living spaces. Therefore, Kisumu residents experience the threat of zoonotic disease transmission as domestic animals are entrenched within their peri-urban landscape.

In Kisumu and throughout Kenya, animals are permitted to graze openly as long as property is not damaged (Habitat, 2005; KMC, 2004). However, this practice can lead to a public health risk. Unsafe handling and disposal of animal waste put residents at risk for zoonotic disease, regardless of household ownership as domestic animals can generate waste that pollutes shared community space (World Health Organization, 2012). Animal waste can contaminate public

TABLE 5 Regression output for factors of household animal ownership in Kisumu, Kenya

	Unadj. bivariate regression			Adj. multivariate regression		
Variable	**OR (95% CI)**	***SE***	***p* Value**	**aOR (95% CI)**	***SE***	***p* Value**
Head of household	0.75 (0.45–1.25)	0.19	0.27[a]			
Male	–	–	–	–	–	–
Female	0.75 (0.45–1.25)	0.19	0.27	0.70 (0.39–1.26)	0.20	0.23
Community	1.00 (1.00–1.01)	0.00	0.02*			
Kanyakwar	–	–	–	–	–	–
Nyalenda A	0.84 (0.48–1.50)	0.23	0.53	0.87 (0.54–1.42)	0.21	0.58
Nyalenda B	1.71 (1.0–2.87)	0.44	0.04*	1.40 (0.88–2.21)	0.32	0.15
Years at current residence	1.50 (1.03–2.18)	0.28	0.03*			
>1 year	–	–	–	–	–	–
1–5 years	1.10 (0.78–1.56)	0.19	0.58	1.18 (0.71–1.97)	0.30	0.52
≤6 years	2.08 (1.09–3.96)	0.66	0.03*	1.51 (0.72–3.17)	0.55	0.27
Own agricultural land	2.92 (2.05–4.15)	0.51	0.00*			
No	–	–	–	–	–	–
Yes	2.92 (2.05–4.15)	0.51	0.00*	1.94 (1.12–3.35)	0.53	0.02**
# of agricultural hectares	1.30 (1.18–1.45)	0.07	0.00*			
None	–	–	–	–	–	–
≤3	7.41 (3.53–15.57)	2.71	0.00*	3.51 (1.55–7.94)	1.41	0.00**
>3	19.07 (4.49–81.09)	13.62	0.00*	7.60 (1.65–35.09)	5.74	0.01**
Unsure	2.42 (1.73–3.38)	0.40	0.00*	1	(omitted)	
Own residence	0.27 (0.19–0.39)	0.05	0.00*			
No	–	–	–	–	–	–
Yes	0.27 (0.19–0.39)	0.05	0.00*	0.37 (0.20–0.66)	0.11	0.00**
Community bond	1.54 (1.13–2.09)	0.23	0.01*			
Weak/Very weak	–	–	–	–	–	–
Neutral	1.13 (0.72–1.77)	0.25	0.60	1.38 (0.80–2.37)	0.37	0.24
Strong/Very strong	2.26 (1.29–3.95)	0.62	0.01*	2.28 (1.25–4.16)	0.68	0.01**
Household relationship to community	1.21 (0.91–1.61)	0.17	0.19			
Weak/Very weak	–	–	–	–	–	–
Neutral	0.87 (0.46–1.66)	0.28	0.67	–	–	–
Strong/Very strong	1.35 (0.74–2.45)	0.40	0.32	–	–	–
Household membership in community group	1.92 (1.23–2.98)	0.42	0.01*			
No	–	–	–	–	–	–
Yes	1.92 (1.23–2.98)	0.42	0.01*	1.64 (1.04–2.60)	0.37	0.03**
Number of people in household	1.06 (0.78–1.45)	0.16	0.69			
1–4	–	–	–	–	–	–
5–8	1.12 (0.79–1.59)	0.19	0.52	–	–	–
9+	0.69 (0.15–3.27)	0.53	0.64	–	–	–
Wealth tercile	0.96 (0.76–1.19)	0.10	0.68			
Poor	–	–	–	–	–	–
Middle	0.97 (0.59–1.59)	0.24	0.90	–	–	–
Rich	0.91 (0.59–1.42)	0.20	0.68	–	–	–

(Continues)

TABLE 5 (Continued)

Variable	Unadj. bivariate regression			Adj. multivariate regression		
	OR (95% CI)	*SE*	*p* Value	aOR (95% CI)	*SE*	*p* Value
Household worry about having enough food	1.09 (0.92–1.30)	0.09	0.32			
Never	–	–	–	–	–	–
Rarely	0.74 (0.51–1.08)	0.14	0.12*	0.73 (0.46–1.16)	0.17	0.18
Sometimes/Often	1.20 (0.85–1.69)	0.20	0.30	1.04 (0.59–1.83)	0.29	0.89

*Significant at $p \leq .15$ in the bivariate analysis.
**Significant at $p \leq .05$.
[a]Not significant at $p \leq .15$ in the bivariate analysis but a priori.

locations or local water sources used for recreation or drinking by rainfall, soil movement and waste disposal and management practices of farmers. For example, research on urban Kenyan dairy farms found *Cryptosporidium* in environmental samples from the farms themselves but also at neighbouring households that did not own cows (Grace, Monda et al., 2012; Grace, Mutua et al., 2012).

In addition, some livestock keepers and households utilize manure as garden compost or biomass fuel. In Kisumu, Kagira and Kanyari found that 62% of livestock keepers disposed of animal waste by creating hills of the manure near animal housing, 50% dumped animal waste in community areas next to roads or in open fields, and 24% used the waste as crop fertilizer (Kagira & Kanyari, 2010b). At the time of sampling, some of the presented study households were burning large piles of dried manure at their home as a smoke repellent for ticks, mosquitoes and other biting flies (personal communication, 20 February 2015).

Aside from faecal contamination of food and water sources or direct transmission of zoonoses through contact, animal presence in the community can also contribute to the spread of vector-borne disease and soil-transmitted helminths. Domestic animals, waste and feed can attract rodents, other vectors and scavenging wildlife (Fournier, Young, Rajić, Greig, & LeJeune, 2015; Mackenstedt, Jenkins, & Romig, 2015). Previous research in Kisumu found that more than one-third of school children within the informal settlements of this study area had at least one soil-transmitted helminth, several of which were zoonotic (Odiere et al., 2011). Additionally, while looking at zoonotic endoparasites of cattle within Kisumu communities, Kanyari, Kagira and Mhoma found that most cattle were infected with two to three parasites at a time (Kanyari, Kagira, & Mhoma, 2010).

Within marginalized communities such as the peri-urban settlements of Kisumu, informal markets move animal products between neighbouring households, bypassing the larger, regulated formal market (Grace, Randolph, Olawoye, Dipelou, & Kang'ethe, 2008; Grace, Monda et al., 2012; Grace, Mutua et al., 2012; Herrero et al., 2013). In this study, social networks proved important factors for household animal ownership. These networks may create a customer base for buying and trading in animals and animal products while allowing households to practice husbandry without fear of retribution or complaints. However, while having the opportunity to barter and sell to neighbours can create an accessible market for small-scale animal husbandry, it presents a public health challenge as these products are not regulated for safety. Research in central Kenya found *Brucella abortus* and *Escherichia coli O157:H7* in unpasteurized milk products of informal markets (Arimi, Koroti, Kang'ethe, Omore, & McDermott, 2005).

In this study, animal ownership was reported most often as a source of meat and eggs and to function as an income asset. This is supported by Kagira and Kanyari who found the same results for Kisumu livestock keepers (Kagira & Kanyari, 2010a). Many study households with animal ownership also stated they had them as companions/pets and many had cats (41%). Companion animals have been bred over centuries to desire close contact with humans posing a risk for zoonotic disease transmission.

Of serious concern regarding household zoonotic risk are animals being kept inside the home at night. In this study, most households that own animals allowed at least one to sleep inside. The threat of theft or predation encourages cohabitation with animals (Onim, 2007). However, housing animals inside increases the risk of food and water contamination from animal contact, soiled hands or containers, or other vectors they may encourage such as flies and rodents (Millar et al., 2002). In Cameroon, indoor chickens were linked to *Campylobacter* exposures (Koulla-Shiro, Loe, & Ekoe, 1995). In south-west Kenya, waste from domestic chickens with close proximity to households was positive for *Cryptococcus* (Kemoi, Okemo, & Bii, 2013). Keeping animals inside the home can also encourage ingestion of animal waste by small children (Marquis et al., 1990).

In many developing countries, the type of animal owned by each gender is associated with the value of the animal (Herrero et al., 2013; Njuki & Mburu, 2013). Male family members tend to own larger and more valuable animals like cattle, goats and sheep (Grace, Monda et al., 2012; Grace, Mutua et al., 2012; Herrero et al., 2013). Previous work in peri-urban communities of Kisumu found more livestock ownership by males and more poultry ownership by females, a finding mirrored by the current study (Kagira & Kanyari, 2010a; Onim, 2007).

The differences in animal species ownership have implications for zoonotic disease exposures for household members. The type of animal that a member has contact with, and the type of contact, could lead to different exposure risks for different household members (Kagira & Kanyari, 2010b; Woldehanna & Zimicki, 2015). The

TABLE 6 Regression output for significant factors of Kisumu, Kenya, household animal ownership by animal type

	Unadj. bivariate regression			Adj. multivariate regression		
Variable	**OR (95% CI)**	***SE***	***p* Value**	**aOR (95% CI)**	***SE***	***p* Value**
Household owns livestock						
Head of household	0.41 (0.17–0.98)	0.18	0.04**			
Male	–	–	–	–	–	–
Female	0.41 (0.17–0.98)	0.18	0.04**	0.43 (0.17–1.12)	0.20	0.09
Years at current residence	0.50 (0.32–0.76)	0.10	0.00**			
>1 year	–	–	–	–	–	–
1–5 years	0.64 (0.26–1.55)	0.28	0.31	0.29 (0.08–0.96)	0.17	0.04**
≤6 years	0.27 (0.12–0.63)	0.11	0.00**	0.17 (0.05–0.55)	0.10	0.01**
Own agricultural land	4.03 (2.20–7.36)	1.20	0.00**			
No	–	–	–	–	–	–
Yes	4.03 (2.20–7.36)	1.20	0.00**	2.80 (1.10–7.12)	1.29	0.03**
# of agricultural hectares	1.44 (1.12–1.84)	0.17	0.01**			
None	–	–	–	–	–	–
≤ 3	3.58 (1.61–7.94)	1.41	0.00**	1.57 (0.74–3.33)	0.58	0.24
>3	15.44 (1.82–131.19)	16.3	0.01**	38.15 (3.90–373.3)	42.95	0.00**
Unsure	3.53 (1.68–7.42)	1.29	0.00**	1	(omitted)	
Household relationship to community	0.75 (0.56–1.00)	0.11	0.05**			
Weak/Very weak	–	–	–	–	–	–
Neutral	0.39 (0.19–0.82)	0.14	0.01**	0.52 (0.21–1.29)	0.23	0.15
Strong/Very strong	0.47 (0.25–0.87)	0.14	0.02**	0.53 (0.22–1.30)	0.23	0.16
Wealth tercile	1.29 (1.00–1.66)	0.16	0.05**			
Poor	–	–	–	–	–	–
Middle	0.75 (0.43–1.31)	0.21	0.30	0.66 (0.34–1.28)	0.22	0.21
Rich	1.61 (0.98–2.65))	0.40	0.06*	1.72 (0.85–3.47)	0.59	0.13
Household owns poultry						
Household relationship to community	0.72 (0.49–1.05)	0.14	0.09*			
Weak/Very weak	–	–	–	–	–	–
Neutral	0.94 (0.42–2.10)	0.37	0.87	0.97 (0.42–2.23)	0.40	0.95
Strong/Very strong	0.56 (0.25–1.23)	0.22	0.14*	0.60 (0.27–1.30)	0.23	0.19
Number of people in household	1.63 (0.92–2.90)	0.46	0.09*			
1–4	–	–	–	–	–	–
5–8	1.57 (0.86–2.85)	0.46	0.14*	1.48 (0.86–2.52)	0.39	0.15
9+	6.30 (0.56–70.58)	7.51	0.13*	6.28 (0.53–75.01)	7.69	0.14
Household owns companion animals						
Years at current residence	1.51 (0.86–2.69)	0.43	0.15*			
>1 year	–	–	–	–	–	–
1–5 years	0.50 (0.19–1.31)	0.24	0.15*	0.53 (0.21–1.33)	0.24	0.17
≤6 years	1.63 (0.51–5.20)	0.93	0.40	1.68 (0.44–6.43)	1.11	0.44
Own residence	0.52 (0.26–1.05)	0.18	0.07*			
No	–	–	–	–	–	–
Yes	0.52 (0.26–1.05)	0.18	0.07*	0.88 (0.33–2.35)	0.43	0.80

(Continues)

TABLE 6 (Continued)

	Unadj. bivariate regression			Adj. multivariate regression		
Variable	**OR (95% CI)**	***SE***	***p* Value**	**aOR (95% CI)**	***SE***	***p* Value**
Number of people in household	0.66 (0.33–1.35)	0.23	0.25			
1–4	–	–	–	–	–	–
5–8	0.55 (0.27–1.12)	0.19	0.10*	0.52 (0.27–1.00)	0.17	0.05**
9+	6.33 (0.51–79.18)	7.89	0.15*	1	(empty)	

*Significant at $p \leq .15$ in the bivariate analysis.
**Significant at $p \leq .05$.

current research in Kisumu found household members have unique roles regarding animal contact. This finding is reinforced by multiple other studies looking at animal contact and household members (Herrero et al., 2013; Kagira & Kanyari, 2010b; Kimani et al., 2012; Njuki & Mburu, 2013; Osbjer et al., 2015; Woldehanna & Zimicki, 2015). For example, research on the daily activities of dairy keepers in Nairobi found that although the cattle were most often owned by men, women had more contact with the animals throughout the day from cleaning udders, milking, preparing milk for sale, delivering/selling milk products, cleaning cattle sheds and feeding and watering cattle. Men were engaged in the treatment of sick animals (Grace et al., 2008; Kang'ethe et al., 2012).

But animal contact and husbandry practices may also be occurring with persons not considered household members as evidenced in the results of this study. In Kisumu, previous work shows that livestock keepers hire workers to assist with animal husbandry and one study found that 76% of dairy cattle labour was done by hired outside workers (Kagira & Kanyari, 2010a; Onim, 2007). These workers have direct contact with their employer's animals and can transmit zoonotic pathogens to their own family members via hands, clothing, shoes, food and water, or by person-to-person spread regardless if their household owns animals themselves.

Animal ownership at the household level was associated with several geographical, sociocultural and economic factors. In terms of geographical factors, the community in which the household resides and whether the household owned agricultural property with both significantly associated with domestic animal ownership. As mentioned before, household animal ownership has been tied to community acceptance and access to grazing lands. Households that own agricultural property were also more likely to report domestic animal ownership.

Sociocultural factors that were associated with reported animal ownership also support the idea that community acceptance and local laws influence husbandry practices since households perceiving a strong/very strong community bond and membership in a community group were significantly related to domestic animal ownership. This may mean that they feel supported in the endeavour or they have a market for animal products. Membership in the community group could also allow them to utilize small loans or other avenues to purchase livestock or poultry.

And for economic factors, this research did not find an association between household animal ownership and household wealth. This is supported by previous work that finds that although an estimated one billion people depend on livestock for income and food, one-third of whom are the urban poor, animal husbandry is popular across all wealth groups (Grace et al., 2008; Grace, Monda et al., 2012; Grace, Mutua et al., 2012; Onim, 2007; Thumbi et al., 2015; Thys, Oueadraogo, Speybroeck, & Geerts, 2005). The one selected economic variable that was significantly associated with household animal ownership was whether the participating resident owned their residence. This may be because the independence afforded by property ownership allows the household to decide whether to keep domestic animals as opposed to getting permission from a landlord.

This study demonstrates that animal husbandry is occurring in peri-urban communities of Kisumu, Kenya, as an important source of revenue and protein-rich foods. Livestock and poultry present opportunities for community members, but they, along with companion animals, pose a significant health risk when not handled properly. The types of animals owned and the difference in contact by household members demonstrate a need for better research into husbandry practices and the roles of animals. As zoonotic disease risk extends beyond households with animal ownership, education and the promotion of preventative behaviours to reduce exposure risk should be considered for all members of these communities. As shown in this study, animal ownership is tied to community bonds and group membership. Community outreach would be a key area for promoting safe animal husbandry and contact. Learning more about the dynamic bond between humans and animals in Kisumu can help guide One Health interventions and policy aimed at creating a healthier environment for all.

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ETHICS STATEMENT

Approval for this study was granted through the ethics committees of the London School of Hygiene and Tropical Medicine (LSHTM) [Ref No. 8482] and Great Lakes University Kisumu (GLUK) [Ref No. GREC/167/36/2014].

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