Nonnative Cattle Ownership, Diet, and Child Height-for-Age: Evidence from the 2011 Uganda Demographic and Health Survey

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Abstract. In underresourced settings where domestic animals and children often cohabitate, there is limited evidence about the net impact of domestic animal ownership on child health. We analyzed the 2011 Uganda Demographic and Health Survey to determine whether household ownership of native cattle, goats, sheep, chickens, pigs, and nonnative cattle was associated with child height-for-age z-scores (HAZ), and to assess the influence of diet on this association in rural and urban environments. Using weighted multivariable linear regression, we found that nonnative cattle ownership was positively associated with HAZ in rural children 0 to < 2 years of age (+1.32 standard deviations [SD], 95% confidence interval [CI] = 0.2–2.5) and 2 to < 5 years of age (+0.58 SD, 95% CI = 0.003–1.2), and urban children 2 to < 5 years of age (+1.08 SD, 95% CI = 0.38–1.8). Sheep ownership was positively associated with HAZ in rural children 2 to < 5 years of age (+0.29 SD, 95% CI = 0.002–0.58) and goat ownership was positively associated with HAZ in rural children 0 to < 2 years of age (+0.27 SD, 95% CI = 0.003–0.55). We observed no other significant associations. Children who lived in households that owned nonnative cattle consumed dairy more frequently; however, the relationship between child HAZ and nonnative cattle ownership was not mediated by child dairy consumption. These findings suggest that domestic animal ownership may not be detrimental to child HAZ, and that nonnative cattle ownership is beneficial for child HAZ through pathways other than dairy consumption.

INTRODUCTION

Although the domestication of animals during the Neolithic Revolution is considered one of the most significant developments in human history,^{1,2} the relationship between human health and domestic animals is not fully understood. Domestic animals provide humans with an important source of food, income, labor, and energy,^{3–8} yet nearly two-thirds of human infectious diseases are contracted from animals.⁹ Infectious diarrhea, for example, may be passed from animals to humans in several ways. In industrialized countries, infectious diarrhea may be transmitted from animals to humans through the handling and consumption of domestic animal food products contaminated with enteric pathogens.¹⁰ In non-industrialized countries, where the majority of rural and urban households raise livestock,¹¹ a potential route for the transmission of infectious diarrhea from animals to humans is through contact with the feces of domestic animals.^{12,13} Infants and young children may be especially vulnerable to ingesting pathogens when playing in and around households contaminated with the feces of domestic animals.¹⁴

Until recently, there was little evidence on the relationship between the presence of domestic animals in the household and child health. The first systematic review on this topic found that the presence of food-producing domestic animals was associated with infectious diarrhea in children, especially through contact with water contaminated by the feces of these domestic animals.¹⁵ The majority of studies in this review used self-report of infectious diarrhea as the primary health outcome, which is subject to reporter and seasonality biases,^{16,17} lacks a standardized definition, and is a short-term health indicator. Long-term health impacts in children can be measured by child height-for-age,

which is an objective metric, and reflects multiple insults to child health, including recurring diarrhea and poor cumulative nutrition.¹⁸

Despite the growing body of literature that has used child height-for-age to evaluate the relationship between child health and the presence of domestic animals in the household,^{19–25} it remains unclear as to whether the potential long-term health risks of domestic animals ownership outweigh the potential health benefits. Recently, Mosites and others used data from the 2011 Uganda Demographic and Health Survey (UDHS) to show a positive association between height-for-age of children under 5 years of age and household livestock ownership (chickens, goats, native cattle, sheep) in rural Uganda.²¹ Our primary objective was to expand upon this work by evaluating the association between height-for-age of children under 5 years of age (0 to < 2 years of age and 2 to < 5 years of age) and household ownership of native cattle, nonnative cattle, goats, sheep, chickens, and pigs in rural and urban Uganda, and to evaluate the role of individual dietary intake of the child in these relationships. We hypothesized that child height-for-age was negatively associated with household domestic animal ownership as we suspected this increased child exposure to pathogens from domestic animal feces.

MATERIALS AND METHODS

Tufts University Institutional Review Board declared this research exempt from review as it used deidentified data available to the public via the Demographic and Health Survey (DHS) website.

The UDHS data sample. Using a stratified two-stage sampling design, the UDHS successfully interviewed 9,033 Ugandan households and 7,878 mothers/caretakers of at least one child.²⁶ We refer to mothers/caretakers as simply “mothers” throughout this article. In a subsample of households selected for anthropometry, the UDHS measured the height of all children under 5 years of age from which they

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calculated height-for-age *z* scores (HAZ) according to the 2006 World Health Organization (WHO) reference standards.^{26,27} The UDHS program had extensive measures in place to ensure data quality throughout the data collection process. For example, interviewers were extensively trained in the classroom and in the field on how to administer the UDHS survey questionnaires in the local languages and how to weigh and measure children.²⁶ Fieldwork and data entry were supervised by trained members of the Uganda Bureau of Statistics.²⁶ Detailed descriptions of the DHS sampling strategy, survey construction, pretesting, and data collection are described on the DHS website.^{26,28}

The present study sample. Since we were interested in maternal information for our regression analyses, we restricted the sample to 2,214 children living with their mother at the time of the survey. Additionally, we excluded children with missing information on height and/or age ($N = 104$), and children with HAZ outside of ± 6 standard deviations ($N = 40$).

Variable definitions. The primary outcome variable of this study was HAZ on a continuous scale. The primary exposure variable of interest was household domestic animal ownership. We used binary indicators (yes/no) for household ownership of specific types of domestic animals including native cattle, nonnative cattle, horses/donkeys/mules, goats, sheep, chickens, and pigs. There was no official UDHS reference for the definition of nonnative cattle. According to the Food and Agriculture Organization of the United Nations, nonnative dairy cattle breeds in the region included Friesian, Holstein, Ayrshire, Jersey, Guernsey, and Sahiwal, and nonnative beef breeds included Hereford, Brahman, Sussex, Charolais, South Devon, Africander, and Simmental.²⁹

To account for dietary quality of children under 2 years of age, we constructed an indicator for infant and young child feeding practices (IYCF). Adequate IYCF was defined as having every appropriate feeding practice for the child's age, including exclusive breastfeeding until 6 months, early breastfeeding initiation within 1 hour of birth, continued breastfeeding at 1 year, timely complementary feeding at 6 to < 8 months, adequate dietary diversity from 6 to < 24 months, and minimum meal frequency at 6 to < 24 months.³⁰ We defined minimum meal frequency as the consumption of solid, semisolid, or soft foods twice per day for breastfed infants 6 to < 8 months of age, three times per day for breastfed children 9 to < 24 months of age, and four times per day for nonbreastfed children 6 to < 24 months of age.³⁰ Additionally, adequate dietary diversity was defined as having eaten four or more of the following food groups in the day before the survey: grains/roots/tubers, legumes/nuts, dairy, animal protein, eggs, vitamin A-containing fruits/vegetables, and other fruits/vegetables.³⁰ The UDHS survey protocol called for the collection of dietary intake information from mothers of children under 2 years of age. However, we found that the UDHS child data file had 577 children 2 to < 5 years of age with complete dietary recall information, which we used in these analyses.

We included maternal HAZ, years of schooling, and religion in our multivariable equations. The number of children under 5 years of age was used as a proxy for competition of children for maternal attention and household resources. We constructed household water, sanitation, and hygiene (WASH) variables from survey questions on drinking water source, water treatment, sanitation facilities, and hygiene

infrastructure. We classified household drinking water source and sanitation infrastructure following definitions used by WHO/United Nations International Children's Emergency Fund Joint Monitoring Programme for Water Supply and Sanitation.³¹ A binary (yes/no) variable was used to indicate the presence or absence of household water treatment. Finally, we created a multilevel hygiene variable based on the interviewer's observation of a household hand-washing station with water and cleansing agent.

Household wealth was estimated separately for rural and urban areas using asset indices appropriate to the setting. To calculate a weighted household asset index, we retained the first principal component produced by principal components analysis (PCA).³² Variables included in the PCA were household assets (e.g., radio, table, chair, sofa set, bed, cupboard, clock, watch, motorcycle/motor scooter, car/truck), electricity (urban only), quality of household building materials, agricultural land (rural only), and cooking fuel.^{33,34} Since we were interested in domestic animal ownership, we excluded these variables from the calculation of the indices. The asset index had a range of -4.7 to 4.9 in urban areas and -2.7 to 6.9 in rural areas.

The altitude of the sample cluster and administrative region were selected as geographic covariates; altitude was included because of its consistent association with growth delay.^{35,36} Ten Ugandan regions were classified into a western/non-western variable.

Statistical analyses. All calculations were performed using Stata[®] SE version 14.1 (StataCorp LP, College Station, TX). To mirror the UDHS complex sampling design, calculations were performed using Stata's SVY module. We stratified the analyses a priori by rural/urban residence and child age group (0 to < 2 years and 2 to < 5 years). Bivariate associations were evaluated using unweighted Student's *t* tests, Pearson's correlations, contingency tables, and analysis of variance. To obtain *P* values corrected for the complex survey design, linear and logistic regressions were performed using Stata SVY coding. Differences in medians were tested using weighted Somer's *D* adjusted for household clustering. Two-tailed *P* values less than 0.05 were deemed statistically significant.

Weighted multiple linear regression models were constructed using SVY:REG Stata coding to account for household clustering and stratification. Potential covariates for multivariable regressions were based on their demonstrated associations with child HAZ. First, household ownership for each type of animal was included in the model; households with horses/donkeys/mules were excluded from the analyses because none was recorded in urban areas and less than 0.1% were recorded in rural areas. To arrive at the final models, six categories of variables, which included WASH, child, maternal, household, geographic, and dietary characteristics, were tested as confounders of the relationship between child HAZ and domestic animal ownership using the 10% criterion of confounding.

RESULTS

Table 1 presents descriptive characteristics of children 0 to < 2 and 2 to < 5 years of age in rural and urban areas of Uganda. Stunting (HAZ < -2 standard deviations)²⁷ was more common in rural children compared with urban children,

TABLE 1
Sample characteristics

	Rural		Urban	
	0 to < 2 years	2 to < 5 years	0 to < 2 years	2 to < 5 years
	(N = 723)	(N = 918)	(N = 202)	(N = 227)
	Estimate	Estimate	Estimate	Estimate
	<i>n</i>	<i>n</i>	<i>n</i>	<i>n</i>
Child characteristics				
Mean HAZ	-1.0 (0.1)	-1.8 (0.1)	-0.8 (0.2)	-0.9 (0.1)
	723	918	202	227
Stunted (%)*	27.5	41.9	22.8	14.6
	723	918	202	227
Child nutrition				
Adequate infant and young child feeding practices (%)	10.8	No data	17.5	No data
	707		196	
Adequate dietary diversity (%)†	28.1	19.0	44.5	22.1
	548	488	142	85
Household characteristics				
Median asset score (25th–75th percentile)	-0.04 (-0.9 to 1.1)	-0.2 (-0.9 to 1.2)	0.4 (-1.1 to 1.7)	0.6 (-1.0 to 2.0)
	723	918	202	227
Animal ownership‡				
Native cattle (%)	25.0	27.1	20.0	16.1
	723	918	202	227
Nonnative cattle (%)	1.9	3.7	5.21	6.7
	723	918	202	227
Horses/donkeys/mules (%)	0.01	0.01	0.0	0.0
	723	918	202	227
Goats (%)	46.1	48.4	13.8	14.2
	723	918	202	227
Sheep (%)	10.2	11.7	2.8	3.9
	723	918	202	227
Chickens (%)	60.3	61.1	26.8	34.0
	723	918	202	227
Pigs (%)	19.5	20.0	8.0	8.2
	723	918	202	227

HAZ = height-for-age z score. Characteristics reported are survey corrected %, survey-corrected mean (standard error), or survey-corrected median (25th–75th percentile).

*HAZ < -2 standard deviations from World Health Organization reference standard.

†Measured on children ≥ 6 months of age.

‡Indicators of household possession (% owns).

and greatest among rural children 2 to < 5 years of age. In urban areas, the percentage of stunted children among those under 2 years of age was greater than among those 2 to < 5 years of age. Chickens, goats, pigs, and sheep were more commonly owned in rural households than urban households. However, the percentage of households that owned native cattle was similar in rural and urban areas, whereas few households owned nonnative cattle overall.

Rural areas. Results of the adjusted analyses of the relationship between child HAZ and household domestic animal ownership in rural areas are summarized in Figure 1. Nonnative cattle ownership was significantly associated with greater HAZ in children from both age groups. This association was strongest in households of children under 2 years of age. Additionally, goat ownership was associated with greater HAZ in children under 2 years of age and sheep ownership was associated with greater HAZ in children 2 to < 5 years of age. The addition of the covariates did not alter these associations according to our criteria for confounding.

Urban areas. Figure 2 shows the results from the adjusted analyses of the relationship between child HAZ and household domestic animal ownership in urban areas. Similar to the findings in rural areas, nonnative cattle ownership was associated with greater HAZ in children 2 to

< 5 years of age, but this association did not hold for children under 2 years of age in urban areas.

Characteristics of nonnative cattle owners. Since we found that child HAZ was independently associated with household nonnative cattle ownership, we further investigated the characteristics of households of nonnative cattle owners in comparison to households that did not own nonnative cattle.

Rural areas. Table 2 shows household and child characteristics in relation to nonnative cattle ownership in rural areas. Adequate dietary diversity of the child was reported more often in households that owned nonnative cattle. In particular, nonnative cattle ownership was associated with more frequent child consumption of eggs and dairy. Other notable differences were that households that owned nonnative cattle reported significantly greater asset index scores and better sanitation facilities.

Urban areas. Table 3 shows household and child characteristics in relation to household nonnative cattle ownership in urban areas. Households that owned nonnative cattle were more likely to own sheep, and households with children under 2 years of age were more likely to own goats. This group was also more likely to have taller mothers. There were no stunted children in any of the households that owned nonnative cattle.

FIGURE 1. Child height-for-age z-scores (HAZ) and household domestic animal ownership in rural areas. Box plots represent the relative sample size of households that owned each type of animal. ¹Adjusted for infant and young child feeding practices of children 0 to < 2 years of age, water, sanitation, and hygiene (WASH), child, maternal, household, and geographic characteristics.

Child dietary diversity in relation to nonnative cattle ownership. Rural areas. As seen in Table 4, the majority of children from rural households that owned nonnative cattle had adequate dietary diversity as measured in this study. Children from these households consumed eggs and dairy more frequently than children from households that did not own nonnative cattle.

Urban areas. As seen in Table 5, adequate dietary diversity was not related to nonnative cattle ownership in urban areas. As shown in Table 5, although mothers from urban households that owned nonnative cattle were more likely to report consumption of dairy by their children than mothers in households that did not own nonnative cattle (6 to < 24 months: 73% versus 55%, 2 to < 5 years: 53%

versus 35%), the difference did not reach statistical significance at the 0.05 level.

The role of child dairy consumption. Since nonnative cattle are purported to produce higher volumes of milk than native breeds,²⁸ and increased milk consumption is associated with improved child growth,³⁷ we considered the possibility that greater HAZ of children living in households that owned nonnative cattle was related to increased dairy consumption. We therefore tested the mediating effect of child dairy consumption on the association between child HAZ and household nonnative cattle ownership in the subset of children 6 to < 24 months of age, stratified by rural/urban residence. The analyses were restricted to this age range because dietary intake data were only available for this age group. We added

FIGURE 2. Child height-for-age z-scores (HAZ) and household domestic animal ownership in urban areas. Box plots represent the relative sample size of households that owned each type of animal. ¹Adjusted for infant and young child feeding practices of 0 to < 2 years of age, water, sanitation, and hygiene (WASH), child, maternal, household, and geographic characteristics.

TABLE 2
Rural household and child characteristics in relation to nonnative cattle ownership

	Children		Children		Children	
	0 to < 2 years		2 to < 5 years		0 to < 5 years	
	Nonnative cattle owner		Nonnative cattle owner		Nonnative cattle owner	
	Yes (N = 14)	No (N = 709)	Yes (N = 28)	No (N = 890)	Yes (N = 42)	No (N = 1,599)
	Estimate	Estimate	Estimate	Estimate	Estimate	Estimate
	n	n	n	n	n	n
Child characteristics						
Mean HAZ	0.2 (0.6)*	-1.1 (0.1)	-1.2 (0.3)*	-1.9 (0.1)	-0.8 (0.30)*	-1.5 (0.05)
	14	709	28	890	42	1,599
Stunted (%)†	6.0	28.0	23.8	42.7	18.5*	36.0
	14	709	28	890	42	1,599
Other animal ownership‡						
Native cattle (%)	21.9	25.1	41.6	26.5	35.7	25.8
	14	709	28	890	42	1,599
Goats (%)	77.0*	46.0	60.8	48.0	65.7	46.8
	14	709	28	890	42	1,599
Sheep (%)	17.7	10.0	30.1*	11.0	26.4*	10.6
	14	709	28	890	42	1,599
Chickens (%)	75.1	60.0	66.0	60.9	68.7	60.5
	14	709	28	890	42	1,599
Pigs (%)	10.4	19.8	36.2	19.4	28.5	19.5
	14	709	28	890	42	1,599
Child nutrition						
Adequate infant and young child feeding practices (%)	0.0	11.0	No data	No data	0.0	11.0
	13	694			13	694
Adequate Dietary diversity (%)§	70.8**	27.2	64.1***	18.1	67.5***	22.9
	11	537	8	480	19	1,017
Household characteristics						
Median asset score (25th–75th percentile)	2.0	-0.2	2.4	-0.24	2.4	-0.2
	(0.4 to 3.9)*	(-0.9 to 1.1)	(0.3 to 3.2)***	(-1.0 to 1.1)	(0.26 to 3.2)***	(-0.9 to 1.1)
	14	709	28	890	42	1,599
Improved water (%)	62.6	70.5	60.5	67.9	61.1	69.1
	14	709	28	890	42	1,599
Improved sanitation (%)	40.9*	14.6	40.2*	16.1	40.4	15.4
	14	708	28	890	42	1,598
Handwashing station with soap and water (%)	6.4	6.2	12.9	7.4	10.9	6.9
	14	709	28	889	42	1,598

HAZ = height-for-age z score. Characteristics reported are survey-corrected %, survey-corrected mean (standard error), or survey-corrected median (25th–75th percentile). Bold text indicates a statistically significant difference between households that owned nonnative cattle and households that did not own nonnative cattle.

* $P < 0.05$.

** $P < 0.01$.

*** $P < 0.001$.

†HAZ < -2 standard deviations from World Health Organization reference standard.

‡Indicators of household possession (% owns).

§Measured on children ≥ 6 months of age.

a child dairy consumption variable to a weighted multivariable linear regression that modeled child HAZ against nonnative cattle ownership and all potential confounders other than dietary diversity. Child dairy consumption was defined with a yes/no binary variable to indicate whether the mother had reported the child's consumption of dairy products (milk, yogurt, cheese, infant formula) in the past 24 hours. The addition of child dairy consumption to the regression did not attenuate the relationship between child HAZ and nonnative cattle ownership, which suggests the lack of a mediating effect. It is possible that the lack of quantitative dairy intake data could have interfered with the ability to detect a relationship between child dairy consumption and child HAZ. Future studies should consider collecting quantitative dietary intake data to help resolve this research question. Likewise, further qualitative research on the question of intrahousehold dynamics in households that own nonnative cattle could elucidate how

these households manage the income generated by the sales of nonnative cattle milk.

DISCUSSION

Using the 2011 UDHS, we found that household ownership of nonnative cattle, goats, and sheep was positively associated with child HAZ, whereas household ownership of native cattle, chickens, and pigs was not associated with child HAZ. These relationships were independent of potential confounders such as household wealth and individual dietary intake of the child.

There is a growing evidence base demonstrating that household cow ownership is beneficial for child growth in eastern Africa.^{25,38,39} In particular, household dairy cow ownership has been reported as a positive predictor for child HAZ in coastal and rural areas of Kenya,^{4,40} rural Rwanda,⁴¹ and rural Uganda,²⁴ although the relationship held true in

TABLE 3
Urban household and child characteristics in relation to nonnative cattle ownership

	Children		Children		Children	
	0 to < 2 years		2 to < 5 years		0 to < 5 years	
	Nonnative cattle owner		Nonnative cattle owner		Nonnative cattle owner	
	Yes (N = 10)	No (N = 192)	Yes (N = 11)	No (N = 216)	Yes (N = 21)	No (N = 408)
	Estimate	Estimate	Estimate	Estimate	Estimate	Estimate
	n	n	n	n	n	n
Child characteristics						
Mean HAZ	−0.4 (0.2)	−0.8 (0.2)	−0.1 (0.6)	−1.0 (0.1)	−0.2 (0.4)	−0.9 (0.1)
	10	192	11	216	21	408
Stunted (%)†	0.0***	24.0	0.0	15.7	0.0	19.6
	10	192	11	216	21	408
Other animal ownership‡						
Native cattle (%)	32.1	19.4	34.2	14.8	33.4	17.0
	10	192	11	216	21	408
Goats (%)	62.1*	11.1	38.4	12.5	48.0	11.8
	10	192	11	216	21	408
Sheep (%)	36.0	1.0	24.7*	2.4	29.3*	1.7
	10	192	11	216	21	408
Chickens (%)	42.0	26.0	72.7	31.2	60.0	28.7
	10	192	11	216	21	408
Pigs (%)	9.7	7.9	7.4	8.3	8.3	8.1
	10	192	11	216	21	408
Child diet						
Adequate infant and young child feeding practices (%)	0.0	18.5	No data	No data	0.0	18.5
	6	186			6	186
Adequate Dietary diversity (%)§	44.3	44.5	4.4	23.9	23.7	36.3
	6	136	6	79	12	215
Household characteristics						
Median asset score (25th–75th percentile)	2.6 (2.2 to 2.6)	0.4 (−1.1 to 1.5)	2.6 (1.6 to 2.6)	0.5 (−1.0 to 1.8)	2.6 (1.6 to 2.6)	0.4 (−1.1 to 1.7)
	10	192	28	216	11	408
Improved water (%)	83.7	88.2	96.7	93.9	91.4	91.2
	10	192	11	216	21	408
Improved sanitation (%)	12.9	17.8	5.1	22.2	8.3	20.2
	10	192	11	216	21	408
Handwashing station with soap and water (%)	10.0	20.8	0.0	15.2	4.1	17.9
	10	192	11	216	21	408

HAZ = height-for-age z score. Characteristics reported are survey-corrected %, survey-corrected mean (standard error), or survey-corrected median (25th–75th percentile). Bold text indicates the detection of a statistically significant difference between households that owned nonnative cattle and households that did not own nonnative cattle.

* $P < 0.05$.

** $P < 0.01$.

*** $P < 0.001$.

†HAZ < −2 standard deviations from World Health Organization reference standard.

‡Indicators of household possession (% owns).

§Measured on children ≥ 6 months of age.

rural Kenya only under the condition that the household members consumed the milk of dairy cows.⁴⁰

Given that nonnative cattle tend to produce large volumes of milk, and cow's milk has nutrients necessary for healthy child growth, including protein, calcium, and insulin-like growth factor-I,^{42,43} we tested the hypothesis that child dairy consumption was a mediator of this relationship. Our data showed no evidence to support this hypothesis, even though child dairy consumption was greatest in households that owned nonnative cattle.

There are several potential explanations for these results. One explanation is that households that owned nonnative cattle had an extra source of income from the sales of nonnative cattle milk. Additional income generated by milk sales could have been used to purchase nutrient dense foods that tend to be more expensive, such as eggs and pasteurized milk. Another explanation is that households that owned nonnative cattle were inherently different from households that owned local breeds of domestic animals. For example, households that owned nonnative cattle may have been

wealthier and more willing to take on risk since nonnative cattle are often expensive to maintain because of their inability to survive harsh climates, and susceptibility to local diseases such as trypanosomiasis.^{44–46} In this way, household ownership of nonnative cattle may have acted as a proxy for household socioeconomic status, which suggests that these households had greater access to resources such as health care, education, and high-quality foods. In fact, we found that rural households that owned nonnative cattle had the highest asset index scores, greatest percentage of child dietary diversity including egg and dairy consumption, and better household sanitation. Mothers from urban households that owned nonnative cattle were least likely to be stunted. These households were most likely to own a greater diversity of animal species, such as goats and sheep.

Despite our hypothesis, the present study found no evidence for an association between child HAZ and household ownership of native cattle, pigs, or chickens. We were surprised that we did not find a relationship between household chicken ownership and child HAZ, since chickens

TABLE 4
Child dietary diversity in relation to nonnative cattle ownership in rural areas

	Children		Children		Children	
	6 to < 24 months		2 to < 5 years		6 months to < 5 years	
	Nonnative cattle owner		Nonnative cattle owner		Nonnative cattle owner	
	Yes (N = 11)	No (N = 542)	Yes (N = 28)	No (N = 890)	Yes (N = 39)	No (N = 1,432)
	%	%	%	%	%	%
	n	n	n	n	n	n
Adequate dietary diversity (%)	70.8*	27.2	64.1***	18.1	67.5***	22.9
	11	537	8	480	19	1,017
Dairy (%)	80.2**	24.6	79.2**	17.8	79.7**	21.4
	11	539	8	482	19	1,021
Meat (%)	7.7	29.0	0.0	21.4	4.0	25.5
	11	540	8	482	19	1,022
Eggs (%)	43.2***	5.6	43.2***	3.4	43.2***	4.6
	11	540	8	482	19	1,022
Legumes and nuts (%)	72.5	56	64.1	42.6	68.4	49.7
	11	540	8	482	19	1,022
Grains (%)	72.0	81.4	64.1	64.4	68.0	73.4
	11	540	8	482	19	1,022
Vitamin A-containing fruits and vegetables (%)	42.0	20.4	33.6	13.3	37.9	17.1
	11	540	8	481	19	1,021
Other fruits and vegetables (%)	56.3	47.9	33.6	36.9	45.2	42.7
	11	538	8	481	19	1,019

Characteristics reported are survey-corrected %. Bold text indicates the detection of a statistically significant difference between households that owned nonnative cattle and households that did not own nonnative cattle.

* $P < 0.05$,
 ** $P < 0.01$,
 *** $P < 0.001$.

tend to roam freely and defecate within the living quarters. We suspected that children from households that owned chickens ate more eggs, and this may have neutralized the risk posed by environmental contamination from chicken feces. In exploratory analyses, we found that household chicken ownership was not associated with

child egg consumption within the past 24 hours. We tested whether the effect of household chicken ownership on child HAZ was different depending on child egg consumption, but we found no significant effect modification. Future research should explore whether the lack of effect of household domestic animal ownership (local cattle, chickens, pigs)

TABLE 5
Child dietary diversity in relation to nonnative cattle ownership in urban areas

	Children		Children		Children	
	6 to < 24 months		2 to < 5 years		6 months to < 5 years	
	Nonnative cattle owner		Nonnative cattle owner		Nonnative cattle owner	
	Yes (N = 6)	No (N = 137)	Yes (N = 11)	No (N = 216)	Yes (N = 17)	No (N = 353)
	%	%	%	%	%	%
	n	n	n	n	n	n
Adequate dietary diversity (%)	44.3	44.5	4.4	23.9	23.7	36.3
	6	136	6	79	12	215
Dairy (%)	73.2	55.4	53.2	35.5	62.9	47.4
	6	137	6	79	12	216
Meat (%)	44.3	50.9	4.4	17.9	23.7	37.5
	6	137	6	79	12	216
Eggs (%)	0.0	19.6	0.0	10.1	0.0	15.8
	6	137	6	79	12	216
Legumes and nuts (%)	48.0	54.3	7.9	34.2	27.3	46.3
	6	136	6	79	12	215
Grains (%)	48.0	82.5	7.9*	49.9	27.3*	69.5
	6	137	6	79	12	216
Vitamin A-containing fruits and vegetables (%)	23.1	24.8	0.0	7.7	11.2	18.0
	6	137	6	79	12	216
Other fruits and vegetables (%)	27.9	58.2	4.4*	40.7	15.8*	51.2
	6	137	6	79	12	216

Characteristics reported are survey-corrected %. Bold text indicates the detection of a statistically significant difference between households that owned nonnative cattle and households that did not own nonnative cattle.

* $P < 0.05$,
 ** $P < 0.01$,
 *** $P < 0.001$.

on child HAZ is because the benefits of ownership are negated by exposure to household contamination.

Prior studies have reported conflicting results on these relationships. For example, Ethiopia's 2015 Feed the Future survey found that children living in households that owned poultry had greater HAZ than children from households that did not own poultry.⁴⁷ However, other studies have found that children had low HAZ if the poultry or other domestic animals were kept in the household overnight.^{47,48} Child exposure to animal fecal contamination within the living environment has been reported in studies from Zimbabwe,¹³ Peru,⁴⁹ and Bangladesh.^{12,50} Since information on animal corralling was not collected as part of the 2011 UDHS, we were unable to examine these relationships in more detail.

One of the greatest limitations of the present study is its inability to specify where the livestock were kept, so we were unable to comment on the level of environmental contamination in the study households. It is possible that urban families kept their livestock in rural areas far away from the household, which would have several implications for the children living in these households. First, this practice would limit the child's access to nutrient-dense animal source foods produced by the livestock. On the other hand, keeping animals away from the household would prevent child exposure to animal fecal contamination. More studies are needed to examine the spatial relationship between families and their livestock, and how these relationships may influence the child's diet and exposure to household-level contamination.

Other limitations of the study are that the study was cross-sectional. Given the possibility of bias of sensitive interview subjects such as socioeconomic status, there may have been potential misclassification of information on livestock ownership, which could have resulted in an underestimate of the relationships examined in this study. Dietary intake information was based on a nonquantitative 24-hour recall reported by mothers and may not have been reflective of the child's usual intake. It is possible that misclassification of dietary intake could have resulted in residual confounding. The sample size of households that owned nonnative cattle was small, and may explain why some comparisons did not reach statistical significance at the 0.05 level. These results were consistent with a 2008 livestock census that found over a quarter of Ugandan households owned native cattle, but only 10% of these households kept nonnative breeds such as black and white Holstein Friesian.⁵¹

There are several strengths of this study. The 2011 UDHS was one of few DHS data sets from Africa to collect information on dietary intake of the child, which allowed us to examine the role of diet in the relationship between nonnative cattle ownership and child HAZ. We found a consistent positive association between nonnative cattle ownership and child HAZ in multiple subgroups of the national data set, which suggests that this relationship is not a statistical artefact.

In conclusion, our study found that nonnative cattle ownership is positively associated with child HAZ through a mechanism other than child dairy consumption. We did not find evidence for an association between child HAZ and household ownership of domestic animals such as native cattle, pigs, and chickens.

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