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Association between Household Livestock Ownership and Childhood Stunting in Bangladesh – A Spatial Analysis

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ABSTRACT

Livestock is an integrated part of agriculture, yet the relationship between household livestock ownership and child nutrition is a significant knowledge gap. The present study aimed to assess the association between household livestock ownership and childhood stunting and to explore the geospatial variations at district level in Bangladesh. A complete data of 19 295 children aged below 5 years were extracted from the latest Bangladesh Multiple Indicator Cluster Survey 2012–13. The tropical livestock unit (TLU) score calculated as a weighted value for each livestock and categorized as low, medium, and high using tertile. A hierarchical Bayesian spatial logistic model was used to assess the association between TLU and childhood stunting. Children from the household with high TLU were 10% less likely to be stunted (adjusted posterior odds ratio: 0.90, 95% credible interval: 0.84–0.97) after controlling for demographic, socioeconomic, morbidity, place of residence and spatial effects. There was also a substantial spatial variation in childhood stunting across districts in Bangladesh with the highest burden in the Northern and North-Eastern regions. The positive effect of household livestock ownership on reducing child stunting suggests that, in addition to nutritional intervention in Bangladesh, efforts to strengthen livestock production would be beneficial for improving child nutrition status. However, a small effect size may be owing to the lack of dietary diversity, livestock health and productivity data as well as the complexity of the relationship, requiring further study. Furthermore, a significant regional disparity in stunting highlighted the importance of spatial targeting during the design of interventions and implementation.

KEYWORDS: stunting, livestock, geospatial variation, Bangladesh

INTRODUCTION

Despite the reduction in recent years, stunting remains a major public health concern among under 5 years aged children in Bangladesh [1]. According to the recent estimates, more than one-third of children under 5 years are suffering from linear growth faltering [1]. Both the nutrition-specific and nutrition-sensitive approaches have taken to reduce the high prevalence of childhood stunting, but it remains challenging to achieve the target for the country [1, 2]. A recent study pointed out that Bangladesh is well behind the target of a 40%

reduction of stunting prevalence by 2025 set by the World Health Organization (WHO) [3]. The extent of stunting has a major impact since an adequate level of child nutrition is essential to the long-term development of a country. Therefore, appropriate need-based strategies focussing on individual and community priorities must be developed to accelerate the current pace of reducing childhood stunting in Bangladesh [4–6].

Agriculture is an important source of livelihood in developing countries like Bangladesh, influencing the nutritional status of the population [7, 8]. There are numerous ways in which agriculture is theorized to influence the nutrition status including reducing food insecurity, enhancing food purchasing power through income, increasing the availability of food for own consumption and improving the quality of foods and changes the social and health status [6]. Livestock is an integrated agricultural component which contributes to household productivity, income, consumption and food security [9]. According to the Food and Agriculture Organization (FAO) estimates, the consumption of per capita milk in developing countries has practically doubled over the last five decades, meat and egg consumption increased by a factor of three and fifth, respectively [10, 11]. Although livestock ownership might increase the risk of children being affected by environmental enteropathy which is associated with malabsorption of nutrients in the gut, it can contribute to dietary diversity and better nutrition for households who owned livestock [12, 13]. Earlier studies in the African region suggested that increasing livestock (such as cattle, sheep, pigs, goats, horses and poultry) ownership can significantly increase the consumption of animal-source foods (such as meat, milk and eggs) and improve nutrition outcomes [14, 15]. In realities, however, a very limited number of studies have conducted in Bangladesh to document the relationship between household-level livestock ownership and nutrition status.

According to the WHO international threshold, the under-5 stunting prevalence is very high in all districts of Bangladesh [16, 17], and it varies geographically (ranged 27.7–56.4%) [18, 19]. Moreover, it was found that livestock, which makes a major contribution to agriculture and its production, varies across geographic regions in the country [7]. For example, more than 80% of the households from the districts such as Thakurgaon, Panchagarh, Meherpur, Magura, Narail, Jhenaidah and Naogaon own any livestock, while it is below 30% in those from Dhaka and Munshiganj [17]. Therefore, special consideration of geospatial variation needs to be considered to assess the relationship between livestock ownership and childhood stunting. The Bangladesh Demographic and Health Survey (BDHS) and Multiple Indicator Cluster Survey (MICS) of Bangladesh routinely collect data on the health and nutrition of under-5 children [1, 17, 20]. These two surveys also collect household data on livestock ownership, though these data are used in constructing household wealth index as a binary indicator of any livestock ownership. One clear limitation of this binary indicator is it assumes all types of animals (such as cow, goat and poultry) have an equal contribution. To resolve this problem, Njuki *et al* [21] proposed an index, called the tropical livestock unit (TLU), which consists of combining the household's total livestock variables into a single variable by assigning a weight for each of the animals.

This study hypothesized that higher TLU index value is associated with a lower prevalence of childhood stunting in Bangladesh. This present study also hypothesized that there is a substantial spatial variation in stunting prevalence across districts in Bangladesh. There is a lack of research in Bangladesh which explored the relationship between livestock ownership and stunting among under-5 children as well as district-level spatial variations. In looking at current research gaps, the present study aimed to assess the association between livestock ownership using the TLU index and stunting among under-5 children in Bangladesh, controlling for demographic socioeconomic, morbidity and place of residence factors. The study also aimed to explore the geospatial variations of stunting prevalence in Bangladesh for targeting intervention and policies to improve the health and nutrition of children geographically.

MATERIALS AND METHODS

Data source and participants

The data used for this study were extracted from the latest Bangladesh MICS 2012–13 survey [17].

The survey was designed to provide estimates for the prespecified indicators of children and women at the national level, for urban and rural areas, seven administrative divisions and 64 districts of the country. A map of the study area is provided in Supplementary Appendix Fig. 1. The survey was conducted using a two-stage stratified random sampling technique of households by considering each district as a stratum. In the first stage of sampling, 2760 enumeration areas (EAs) were randomly selected with probability proportional to stratum size, where an EA is typically a small village or part of a large village. In the second stage of sampling, a household listing was carried out, and a systematic sample of 20 households on average was drawn per EA. Finally, data from 51 895 households were collected with a response rate of 98.5%. A more detailed description can be found in the survey report [17]. Data of 20 903 under-5 aged children were extracted for this study. Among which 1608 samples were dropped owing to missing, incomplete or biologically implausible information and an analytical sample of 19 925 children was selected for final analysis.

MEASURES

Outcome

The primary outcome variable of the study was stunting of under-5 aged children. A child was defined as stunted if height-for-age *z*-score (HAZ) was below the median of the WHO reference population by more than 2 SDs [22]. HAZ values < -6 or $> +6$ were excluded as biologically implausible.

Tropical livestock unit

The TLU score calculated as a weighted value for each species to estimate the total value of their livestock holdings. The TLU weighting factors used were 0.50 for both cattle and buffalo, 0.10 for sheep and goats, 0.80 for horses, 0.01 for chickens, 0.03 for ducks, turkeys and geese, 0.02 for rabbits and 0.25 for pigs [21].

Control variables

The control variables considered for this study were the child's age (continuous), diarrhea episode in the last 2 weeks (yes/no), acute respiratory infections (ARI) status in the last 2 weeks (yes/no), maternal education (no education, primary, secondary and higher), place of residence (rural/urban), household wealth index (continuous) and cluster variation. The wealth index was calculated using principal components analysis of key socioeconomic variables: household dwelling quality and size, electricity access and ownership of various household assets (TV, radio, CD or DVD player, bicycle, mobile phone, plough, mattress, bed, sofa, table, solar panel, battery and bank account) [23]. The livestock variables were not considered in constructing the wealth index.

Statistical analysis

Descriptive statistics were used to explore the distribution of variables considered in this study. Moreover, a hierarchical spatial logistic model was used to assess the association between TLU and childhood stunting by considering spatial random effect. The spatial random effect helps to model dependence among neighbouring districts that are not explained by the model covariates. Let $y_{ij},\ i = 1, \ \ldots, \ n;\ j = 1, \ \ldots, \ d$ be the status of i^{th} children in the j^{th} district: 'stunted' (1) or 'not stunted' (0) follows

$$y_{ij} \sim \text{Bernoulli}(\pi_{ij}).$$

The binomial spatial regression model can be written as,

$$\log\left[\frac{\pi_{ij}}{1-\pi_{ij}}\right] = x_{ij}^{'}\beta + u_j + v_j$$

where $x_{ij}^{'}$ and β are the $p \times 1$ design vector and coefficient vector, respectively. The district-specific random effect can be decomposed into an unstructured random effect (v_j) and structured random effect (u_j). The combination $u_j + v_j$ allows considering the spatial dependence in the modelling process. Under the Bayesian framework, we consider a vague Gaussian prior for unknown random parameters, $\beta \sim \text{Normal}\ (0, 10^{-4})$. The non-spatial random effect v_j follows a normal distribution-where $\log(\tau_v) \sim \text{logGamma}(1,\ 10^{-2})$. The spatial random effect u_j follows an intrinsic conditional autoregressive distribution whose mean and precision (τ_u) depend on the structure as well as the size of the first-order neighbours of each district, where $\log(\tau_u) \sim \text{logGamma}(1, 10^{-2})$. The Deviance Information Criterion (DIC) are using to evaluate the performance of the full model versus the null model. The posterior distribution of model parameters is summarizing by using its median and 95% credible interval (CI). All analyses were performed using the statistical software package R (Version 3.6.0).

RESULTS

Of the 19 295 children, the prevalence of stunting was 42.8% (Table 1). The average age of the children was about 30.1 months with SD 17.3 months. Approximately 4.0% of children had an episode of diarrhea, and 3.4% had symptoms of ARI during the 2 weeks preceding the survey. Nearly one-fourth of the children of mothers had no education, while only 12.9% had secondary or higher education. Median household wealth score was −0.3569 with inter-quartile range 0.9819. Approximately 84.1% of the children were from the rural areas. Moreover, about 37.4% and 32.3% of children were from the household with low and high tropical livestock unit, respectively.

The Bayesian hierarchical spatial logistic regression analyses are presented in Table 2. The full model performed better according to the DIC value. After controlling for other factors (child age, diarrhoea episode and symptoms of ARI status during the 2 weeks preceding the survey, maternal education, place of residence and household wealth status), it was seen that children from the household with high TLU were 10% less likely to be stunted (odds ratio: 0.90, 95% CI: 0.84–0.97). Among the control variables, the odds of stunting was increased with increasing age, and higher among those who had symptoms of ARI. Also, the odds of being stunted decreased with increasing household wealth score and greater maternal education. An age-stratified analysis for children aged <6 months and ≥6 months showed that high TLU was significantly associated with reducing childhood stunting after controlling for other variables and spatial effects (Supplementary Table A1).

Table 1. Descriptive statistics of the selected variables

Characteristics	Statistics
Stunting, %	42.83
Child age (months) [Average (SD)]	30.05 (17.34)
Diarrhea, %	
No	95.98
Yes	4.02
ARI, %	
No	96.57
Yes	3.43
Maternal education, %	
No education	24.64
Primary	14.57
Secondary	49.62
Higher	11.16
Place of residence, %	
Rural	84.05
Urban	15.95
Wealth score, median (IQR)	−0.3569 (0.98199)
Tropical livestock units, %	
Low	37.36
Medium	30.30
High	32.34

IQR, inter-quartile range.

There was a statistically significant district-specific spatial variation in childhood stunting. In spatial variability, the proportion of the variance explained by the structured spatial random effect was roughly 22%, indicating that unstructured heterogeneity dominates the spatial variability. Figs 1 and 2 show the stunting risk maps for Bangladesh that arose from fitting the hierarchical spatial model with spatially non-structured and structured random effects to the data, respectively. It is apparent again that the Northern and North-Eastern districts of the country bear the greatest stunting burden. These maps also support the results of the spatial cluster analysis.

DISCUSSION

The present study contributes to our understanding of the relationship between livestock ownership and stunting among under-5 children as well as district-level spatial variation in stunting prevalence in

Table 2. Bayesian hierarchical spatial logistic model-based results of the association between household livestock ownership and stunting among children in Bangladesh

Model	Null model			Full model		
	$OR_{2.5\%}$	$OR_{50\%}$	$OR_{97.5\%}$	$OR_{2.5\%}$	$OR_{50\%}$	$OR_{97.5\%}$
Tropical livestock units (ref. Low)						
Medium				0.8831	0.9517	1.0254
High				0.8354	0.9006	0.9708
Child age in month				1.0139	1.0156	1.0175
Diarrhea (ref. No)						
Yes				0.8735	1.0182	1.1853
ARI (ref. No)						
Yes				1.0436	1.2278	1.4435
Maternal education (ref. No education)						
Primary				0.9091	1.0017	1.1036
Secondary				0.7466	0.8061	0.8701
Higher				0.4754	0.5437	0.6211
Place of residence (ref. Urban)						
Rural				0.9262	1.0154	1.1134
Wealth score				0.6895	0.7194	0.7502
Intercept	0.6747	0.7213	0.7706	0.4752	0.5418	0.6169
District (spatial)	0.003376	0.014929	0.078579	0.003647	0.016923	0.077760
District (non-spatial)	0.03649	0.059051	0.093782	0.034412	0.056402	0.092764
DIC		26074.78			25010.17	

OR, Posterior odds ratio.

Bangladesh. Results of this study demonstrated that household ownership of livestock was negatively associated with stunting among children meaning that greater livestock ownership reduced the likelihood of stunting after adjusting for other control variables and spatial effects. Also, a significant spatial variation of stunting across the country was found, although the non-spatial effect was more pronounced than the spatial effect. Districts from North and North-East parts of the country possessed a significantly higher risk of under-5 stunting.

Livestock, particularly in developing countries, is one of the most important parts of the agricultural economy. Livestock contributes many different ways to household livelihood, food security and nutrition—providing income, quality food, fuel, draught power, building materials and fertilizer [13, 24]. Many also argued that livestock ownership could be a useful wealth indicator between the poor and non-slightly better-off people and reduces nutrition deficiency through empowering women and improving crop yields [13, 21]. In Bangladesh, livestock is an integral part of farming systems and is a direct source of protein [25]. There might be a potential relationship between livestock ownership and child growth, yet information on this aspect is limited. The present study found a significant association between greater livestock ownership and lower risk of stunting among under-5 children. This finding is consistent with the findings of two recent studies conducted in African countries, which also found a moderate association between livestock ownership and lower risk of childhood stunting [12, 15]. As livestock ownership is quite high in Bangladesh [17], policymakers could take necessary initiatives to increase and promote livestock production for reducing the high prevalence of under-5 stunting in the country. However, a recent FAO report highlighted that livestock production has a significant influence on environmental problems, including global

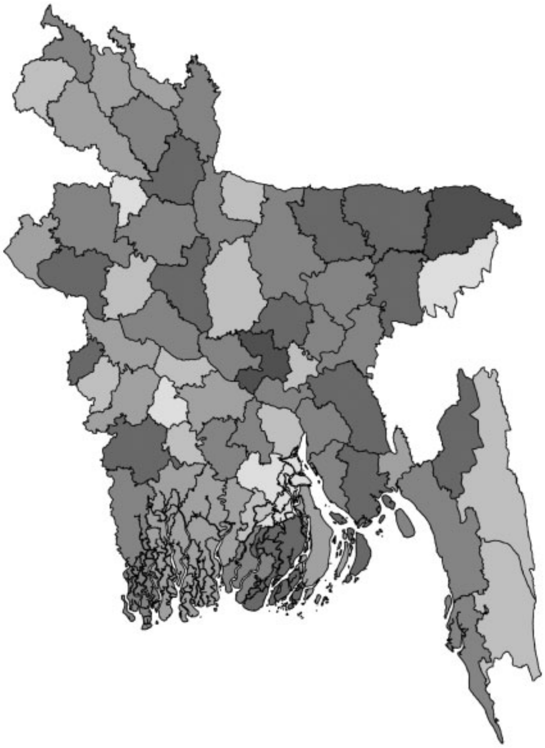

Fig. 1. Non-structured spatial effect over districts.

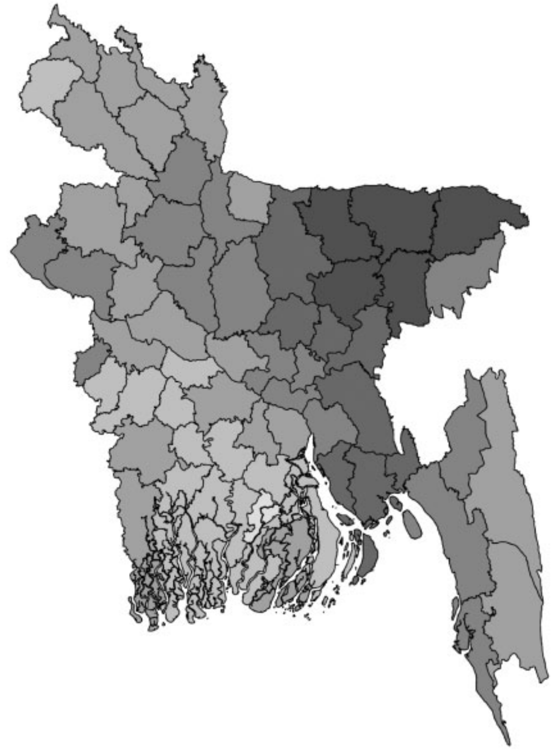

Fig. 2. Structured spatial effect over districts.

warming, air and water pollution, land degradation, deforestation and loss of biodiversity [26]. This highlighted the importance of balancing between livestock production and environmental change. In this regard, a recent study recommended that improving crop yielding through nutrient cycling, manure fertilizer and draft power could be an alternative [13]. Moreover, as livestock is the integral part of the agricultural production in Bangladesh, focussing on institutional reforms, improving livestock productivity and innovations could be effective solutions which enhance the interactions between agricultural production and the environment [27].

This study highlighted that geospatial disparity alters the prevalence of stunting in Bangladesh. Studies [18, 19, 28] conducted in similar setting also found the geospatial variations in the prevalence of childhood malnutrition across the country. It is unarguably true that domains with a high prevalence of under-5 stunting halt the national-level progress of reducing stunting. Therefore, geospatial analysis can make it possible to analyze the variations precisely so that policymakers can design effective public health intervention, treatment and prevention strategies for the under-5 stunting hotspots [19, 28]. Current spatial analysis revealed that districts such as Habiganj, Netrakon, Gaibandh, Khagrachari, Sunamganj, Sirajganj and Rajshahi pose a high risk of stunting, while districts such as Habiganj, Netrakon, Sunamganj and Kishoregonj attribute significant spatial variations than other districts. Therefore, effective childhood stunting prevention and control interventions need to be taken place for these geographically depressed districts to avert the burden of stunting in Bangladesh. As spatial variation is likely to be associated with the local spatial variation, the focus should be given at promoting health education and disease prevention at the community level, and scaling-up interventions such increasing livestock production through better utilization of available resources (i.e. capital, land and labour) [29–31]. As livestock ownership is very common in Bangladesh and almost two-thirds of the households own any livestock, increasing livestock production could be the finest solution as it promotes both the nutrition-specific and nutrition-sensitive approaches to accelerate progress toward improved nutrition and reduce health disparities [17].

This study has several strengths. First, a large survey data representative nationally and sub-nationally (for urban and rural areas, 7 divisions and 64 districts) representative was used in this study, which had high average response rates (98.5%). Second, high-quality survey interviews reduced the potential interview bias while multilayer monitoring system such as regular field visits by the survey team, re-interviews of respondents and spot-checking the completed questionnaire by quality control teams ensured high data quality. Third, the use of Bayesian geospatial modelling, which took into account both the spatial and non-spatial variations of stunting prevalence across areas. Fourth, this study carried out the age- and group stratified analysis carefully. Finally, this study provides evidence of the association between household-level livestock ownership and childhood stunting alongside the identification of geospatial hotspots. In addition, this study has a few limitations. First, investigating the causation from the cross-sectional study design is challenging, which suggests further research in a longitudinal setting to better understand the relationship. Second, variables such as livestock management capabilities, crop loss in the preceding year, and medical issues were not considered in this study, which could influence the association of livestock ownership and stunting. Third, livestock can help to reduce stunting by provisioning animal-source foods and reducing macro and micronutrient deficiencies. However, this survey did not collect data on child food consumption that suggest further research. Livestock can be associated with increased stunting through infectious diseases, as sick animals can spread zoonoses and increase contamination. However, higher ownership of livestock at the household-level may relate to higher wealth status and better access to improved water-sanitation and health care services, resulting in enhancing the environment and reducing the impact of infectious diseases. Although the present study has adjusted data on retrospectively reported child morbidity (diarrhea and ARI), it has not assessed all possible pathways and suggests further research.

From a policy perspective, our findings suggest that efforts to strengthen livestock production (as a part of multi-sectorial approaches) will be beneficial to reduce childhood stunting. A remarkable disparity of stunting across the country also suggests considering geographical targeting. It is undoubtedly true that exploring geographical variations helps to reduce geographical inequalities by implementing geographically targeted interventions. Therefore, collective multi-sectoral approaches both from the government and development organizations need to be taken to reduce the high burden of childhood stunting in Bangladesh. A recent study [13] highlighted that a theoretical framework identifying the links between livestock ownership and stunting needs to be developed carefully to ensure translating livestock ownership into actual nutritional benefits for children.

CONCLUSION

Our study has demonstrated that livestock ownership is significantly related to a lower risk of stunting among children in Bangladesh. As an agro-based country, livestock, especially in rural areas, are omnipresent in Bangladesh and contribute to the economic development of the family in many ways. But understanding household livestock ownership and child health status are quite complex due to its world-wide discordance suggest further investigation into this relation. Also, large scale community-based integrated program, including agricultural production, child feeding, water and sanitation and disease prevention are required to optimize the benefit. Furthermore, geographical targeting is also required during program implementation owing to the substantial geospatial variations across the country. Therefore, the present study can help policymakers set a base for policy implication and future research.

SUPPLEMENTARY DATA

Supplementary data are available at *Journal of Tropical Pediatrics* online.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ETHICAL STANDARDS DISCLOSURE

MICS data are public access data and were made available upon request. While conducting the survey, informed consent was obtained from the respondents prior to the interview. Ethical clearance to conduct the MICS was approved by the Government of Bangladesh.

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