BMC Public Health

RESEARCH Open Access

Factors associated with caregivers' food safety knowledge, behavior, perception of food safety control, and the nutrition status of under-5 children in Nigeria

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Abstract

Background Household-level food safety practices may have a long-term outcome on the nutrition and health status of under-five children. This study explores the relationships between caregivers' self-reported food safety knowledge, behavior, perception of food safety control, and their young child's (< 5 years) nutrition status.

Methods In a cross-sectional study design, 664 caregivers from five Local Government Areas (LGAs) in Ibadan, Nigeria were surveyed using an interviewer-administered questionnaire on their food safety knowledge, behavior and perceived food safety control. Anthropometric measurements of the household's index child (aged 6–59 months) were also taken. Variables for food safety knowledge and behavior score were selected using principal component analyses. The nutritional status of the children (Z-scores for weight-for-height (WAZ), height-for-age (HAZ), and weight-for-age (WHZ)) were calculated. Description statistics were run on all variables and logistic regression models examined associations between the three food safety constructs and the children's nutritional status. Covariates such as LGAs, caregiver's age, household size, wealth index, child's gender, and age were adjusted.

Results High-level of food safety knowledge, behavior and lots of perceived control on food safety issues were reported by 77.7%, 76.7%, and 81.1% of the caregivers. Using WAZ, HAZ and WHZ that are ≤ -2, acute malnutrition (6.0%), chronic malnutrition (42.5%), and underweight (22.0%), respectively were prevalent among the children. Perceived food safety control was the only food safety construct associated with acute malnutrition. Wealth index, caregivers' age, number of under 5 at home, child age, and gender were associated with acute malnutrition. Caregiver's age, child's age, and gender were associated with chronic malnutrition. Furthermore, caregiver's age, education and child's age were associated with a child being underweight. The significance level was at $P < 0.05$.

Conclusion Factors associated with food safety and children's nutritional outcomes are multi-faceted in nature. Future studies should explore access to resources and other intermediate factors that may explain the linkage between childhood malnutrition and caregivers' food safety awareness, knowledge, and behavior. Public health and

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food safety initiatives to bridge the gap between perceived food safety control and actual food safety behavior/practices.

Keywords Food safety knowledge, Food safety behavior, Childhood malnutrition, Perception of food safety control

Introduction

Food safety is a significant global public health concern in foodborne illness outbreaks [1]. Despite the fact that unsafe foods contribute an estimated 600 million cases and 420,000 deaths of foodborne related diseases worldwide annually [2], foodborne diseases are preventable [3]. Understanding the factors influencing food safety behaviors and foodborne illness is crucial for global infection, illness, and death control, yet attention to food safety remains low, especially in developing countries [4] such as Nigeria.

Children under 5 years of age are highly susceptible to foodborne diseases due to their developing immune system, which is not yet matured to resist food-borne infections and toxins [5]. Roughly 30% of foodborne disease deaths are among children under 5 years old, making them a vulnerable group [2]. Children's nutrition and health outcomes may depend heavily on their caregivers' dietary practices, including food safety practices at home, which might be shaped by their caregivers' knowledge and other factors [6]. The United Nations Children's Fund (UNICEF) conceptual framework on child nutrition highlights the role of diets and care as immediate determinants of optimal nutrition among children, with food, practices, and service access as the underlying determinants [6]. Thus, good nutrition and health outcomes among children involve addressing both levels of determinant, ensuring that they have access to nutritious food and consume food that is safe and free from contaminants.

Previous studies from developing countries, including Nigeria, have examined children's nutrition outcomes in relation to their caregivers' dietary or feeding practices [7–10]. Similarly, previous food safety research has reported varying prevalence of food safety knowledge, attitude, self-efficacy, and practices/behaviors among caregivers [11–14]. Other authors also reported factors influencing safe food practices among caregivers using their hygienic practices and food storage [15, 16]. Consequently, understanding food safety knowledge and practical implementation among this age group through their caregivers is essential for maintaining nutrition, ensuring safe food access, and preventing foodborne diseases and adverse nutrition outcomes. However, studies investigating their impact on malnutrition and its connection with food-borne illness are limited. Thus, this study examines, (i) the level of food safety knowledge, behavior, and perceived food safety control of the primary caregiver in families, (ii) factors associated with caregivers' food safety knowledge, behavior, and perceived food safety control, (iii) the relationship between caregivers' food safety knowledge behavior, perceived food safety control, and the nutrition status of under-5 children in Nigeria.

Methods

Study sites

The study site was in Ibadan Metropolis in Oyo State, Nigeria, Fig. 1. Ibadan is Nigeria's third most populous city (over 6 million people in the metropolis) [17]. Ibadan Metropolis comprises five Local Government Areas (Ibadan North, Ibadan North-West (NW), Ibadan North-East (NE), Ibadan South-West (SW), and Ibadan South-East (SE)), which were all included in this study.

Study design and sampling

This cross-sectional study used a multi-stage sampling method (combining stratified, proportional, and convenient sampling techniques) to identify eligible participants. The sample size was estimated at 500 using the minimum sample size calculation for a cross-sectional study:

$$\frac{\mathrm{N} = \mathrm{Z}^2\mathrm{P}(1-\mathrm{P})}{d^2}$$

Where N is the sample size, Z is the statistic corresponding to the 95% level of confidence at 1.96, P=29.3% of households in Ibadan metropolis classified as food insecure in Nigeria [18], and d=degree of accuracy desired or maximum allowable margin of error, set at 5% (0.05). This was calculated at 318 plus 43% (n=182) for oversampling.

To arrive at the estimated sample size, the number of households that were recruited from each of the five LGAs was first estimated using a proportional sampling technique (i.e., proportion to population size approach) (Ibadan North=160, Ibadan NW=85, Ibadan NE=62, Ibadan SW=90, Ibadan SE=103). Second, a purposive random sampling technique was used to determine the wards (smaller geographical units within LGAs) from which the estimated number of households will be selected. This was calculated using 0.25% of the total wards in each LGA (adopted from Neuman 2014). Third, among the wards selected in each LGA, we estimated the number of households recruited in each ward. This was done by dividing the total number of households estimated for the LGA (in each ward) by the number of wards selected from the LGA. This means the same number of households were selected in all wards in a specific

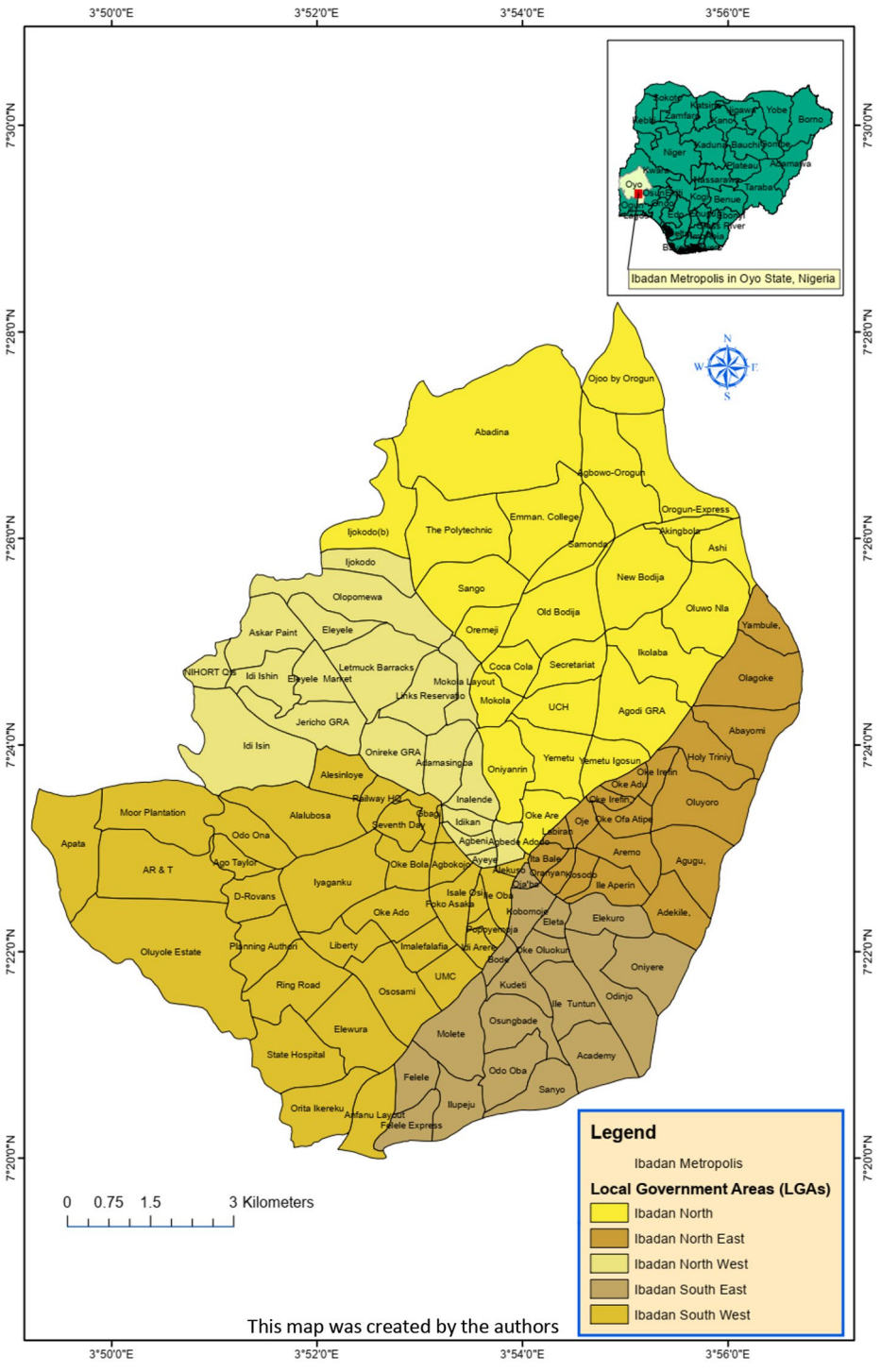

Fig. 1 A Map Showing the Study Site

LGA. Fourth, the settlements (smaller geographical unites with wards) from each ward were further selected by stratifying the numbers of preselected households to the population density (i.e., high, medium, and low) settlement. We then randomly selected the settlements within each type of settlement (i.e., high, medium, low).

Furthermore, we used a proportion to the number of settlement-type approaches to ensure the pre-estimated number of households from each type of settlement in a ward was represented. This means, that a high-density settlement will have the highest number of households, followed by medium and low. A sampling frame or a

listing of the settlement by wards in Ibadan Metropolis was obtained from the local immunization officers' office with the identified settlement. A list of eligible under five was obtained from the primary healthcare center serving the identified settlement. Lastly, the eligible participants in each settlement were identified with the help of primary healthcare workers using a convenience sampling method (using the list of eligible under-five children obtained from the primary healthcare center, serving the identified settlement).

The eligibility criteria include residing in one of the five LGAs, having at least 1 child who is between 6 and 59 months (<5 years) in the household, and the participant must be the primary caregiver of the index child (the youngest of the <5 children) in the household. The survey was conducted between November and December 2022. The final eligible participants were 664 caregivers from five distinct Local Government Areas (LGAs) in Ibadan, Nigeria. Written informed consent was obtained from all participants before engagement, and they were compensated in kind for their involvement. The approval for this study was obtained from the State Ministry of Health in the state of the study site (Oyo State) and from the University of Alaska-Fairbank Institutional Review Board using an expedited review process (Protocol #1897686-1).

Measures

The survey utilized was a validated multi-component questionnaire that assessed caregiver's food safety knowledge, behavior and perceived food safety control, the index child's nutritional status, and socio-demographics. An external expert in food safety reviewed the questionnaire, and their feedback was integrated to enhance the survey questions. The changes include adapting questions about demographics and household items were tailored to the local setting, sentences were reworded to limit predictable responses, and response options were adjusted accordingly, etc. A 3-person expert from the investigating team also checked the questions and responses for clarity in English and the local language, Yoruba (after being translated by a certified translator), to reshape and modify the survey questions. The final survey was programmed in English and Yoruba languages in REDCap. Data collection was conducted by twenty trained research assistants who worked in pairs and used the interviewer-administered approach to obtain responses to the survey questions. The research assistants also took the anthropometric measurements of the index child of the household using the standard procedure described below.

Socio-demographic information

Demographic and household characteristics survey questions were selected from the UNICEF Multiple Indicator Cluster Surveys [19]. Participants (all females) provided details on their socio-demographics, such as the child's gender, number of under 5 in the household, caregivers' highest education level, and age. According to the U.S. Agency for International Development (USAID) Demographic and Health Surveys standard, eleven questions about household assets assess the household wealth index [20]. The questions include seven dichotomous responses - "yes/no" on items like electric irons, fans, televisions, refrigerators, generating sets, cable TV, and electricity. The other four questions include ordered response questions on the types of residential buildings, the primary material of household walls, and floor and fuel used for cooking.

Food safety knowledge behavior and perceived control on food safety

The survey questions for food safety were selected and adapted from relevant previous surveys on food safety [21–25], to cover proper (i) food handling, (ii) handwashing, (iii) food storage, and (iv) household hygiene aspects of food safety. The survey questions for food safety knowledge have "yes", "no", or "I don't know" options, and food safety behavior has four Likert scale responses, including "every time", "most times", "sometimes", and "never". For the perception of food safety control, the participants responded to a question about how much control they think they have over the safety of the food they eat. The options provided include "no control", "not sure", "a little control", and "a lot of control".

Nutrition status of children under-5 using anthropometric measurements

Anthropometric measurements include height, weight, and mid-upper arm circumferences [26] to determine any nutrition-related risks affecting the child's health and well-being [27]. These measurements were taken by a trained research assistant using the standard procedure [28]. Measurements were standardized within the study site for inter and intra-observer variations, thus increasing reliability and minimizing common errors. The child's nutritional status was then calculated using Z-scores for weight-for-height (WAZ), height-for-age (HAZ), and weight-for-age (WHZ) using WHO Anthro software [29].

Analytical plan

The wealth index was computed for each household from questions about household assets using the Nigeria equity tool (the tool was designed to provide relative wealth information by 'ranking' respondents within the national or urban population) [30]. For this study, each

item was first scored and summed based on the equity tool guideline in SAS software. The participants were then grouped into three groups based on quartiles of the study distribution (75th percentile as high, 25th percentile as low wealth index, and other as medium wealth index groups).

Two food safety constructs, denoted as "food safety knowledge" and "food safety behavior" scores, were first created by applying principal component analyses (PCA) to the questions that assessed food safety, knowledge, and behavior. This approach helped to reduce the question set's complexity, increasing interpretability while maximizing the variance in the data. A set of items with higher eigenvector values was selected for each construct, and this includes eight items for food safety knowledge (five for proper household hygiene, two for proper food handling, and one for handwashing) and six items (one for proper household hygiene, three for proper food handling, two for handwashing) for food safety behavior scores. These items were scored so that a higher score consistently reflects a high level of food safety knowledge and behavior. The internal reliability of these two constructs was then assessed with Cronbach's alpha. The reliability coefficients of 0.56 for food safety knowledge and 0.64 for food safety behavior indicate that the responses are moderately consistent between the included items.

Descriptive statistics were conducted for all variables of interest using frequencies for categorical variables and means and standard deviation for continuous variables. Bivariate analyses assessed the relationship between the food safety measures and children's nutritional status; Chi-Square test was used for food safety control and children's nutritional status while T-tests assessed children's nutritional status and food safety knowledge and behavior. Multivariate regression analyses were then conducted between the food safety knowledge and behavior scores (dependent variables) and the socio-demographic information of children and caregivers. We also examined the association between the perceived food safety control (dependent variable) and the socio-demographic information of children and caregivers with multinomial logistic regression analysis. The clustering effect of LGAs and covariates such as caregiver's age and highest education level, number of under-5 in the household, wealth index, child's gender, and age were adjusted in both regression analyses. Lastly, the associations between a child's nutritional status (dependent variable), food safety knowledge and behavior scores, and perceived food safety control were analyzed using multivariate logistic regression analyses. The clustering effect of LGAs and covariates were also adjusted in the multivariate logistic regression models. The statistical significance was set at $P<0.05$, and the analyses was conducted in SAS 9.4 [31].

Table 1 Children's Socio-demographic and Nutrition Status ($N=664$)

Variables	Mean ± SD	*n* (%)
Age (months)	29.9 ± 15.0	
Age group		
Infants (< = 24 months)		261 (39.3)
Young children > 24 months)		403 (60.7)
Gender (female)		292 (44.9)
Stunted (chronic malnutrition)		282 (42.5)
Wasted (acute malnutrition)		40 (6.0)
Underweight		146 (22.0)

Results

Children and caregivers' characteristics

The children had a mean age of 29.9±15.0 SD (in months). About 60.7% were between 24 and 59 months, and 44.9% were females. About 42.5% of the children had stunted growth (chronic malnutrition), 6% were wasted (acute malnutrition) and 22% were underweight (Table 1).

The caregivers had a mean age of 34.0±8.4 SD, and the mean number of children under 5 in the household was 1.4±0.7 SD. By wealth index group, 17.2% of the households were in the high wealth index, 57.8% in the medium wealth index, and 25% in the low wealth index. 64.5% of the caregivers completed secondary school, and 20.3% completed tertiary education. The food safety knowledge score ranged from 3 to 21, with a mean of 13.5±1.2 SD, and the food safety behavior score ranged from 4 to 14, with a mean of 17.5±3.1 SD. Based on the cutoff of >=25 percentile (14 for food safety knowledge and 16 for food behavior), 77.7% showed high food safety knowledge, and 76.7% showed high food safety behavior. 2.8% of participants expressed "no control" over perceived food safety, 16.2% "little control", and 81.1% "lot of control" (Table 2).

Bivariate analyses between perceived food safety control, food safety knowledge, behavior of caregivers and nutrition status of children

The analyses showed no significant difference for perceived food control nor food safety knowledge and food safety behavior scores among caregivers for stunting ($p=0.15$, $p=0.35$, and $p=0.65$), wasting ($p=0.14$, $p=0.10$ and 0.91) and underweight ($p=0.37$, $p=0.87$, and 0.53), respectively. However, the mean food safety knowledge score was higher among families with children who are not underweight and not experiencing stunting. In contrast, the mean food safety knowledge score was lower among families with children who were not experiencing wasting compared to those experiencing wasting. The mean food safety behavior score among families with children that were not experiencing stunting was also higher than for families whose children experienced

Table 2 Household and Caregivers' Socio-demographics, Food Safety Knowledge Behavior, and Perceived Food Safety Control (*N* = 664)

	Means ± SD	*n* (%)
Age (years)	34.0 ± 8.4	
Highest education		
No education		17 (2.6)
Primary school		84 (12.7)
Secondary school		428 (64.5)
Tertiary education		135 (20.3)
Number of under-5 in the household	1.4 ± 0.7	
Wealth index category		
Low		116 (25.0)
Medium		384 (57.8)
High		114 (17.2)
Perceived food safety control		
No control		18 (2.8)
Little control		106 (16.2)
Lot of control		531 (81.1)
Missing values		9
Food safety knowledge (high)		516 (77.7)
Food safety behavior (high)		509 (76.7)

stunting. However, the mean food safety behavior score was lower among families with children who were not experiencing wasting or being underweight compared to their counterparts (Table 3).

Socio-demographic factors associated with perceived food safety control, food safety knowledge, and behavior

Table 4 shows that among the predictors in the model, there was a significant overall effect of the caregiver's age ($p = 0.02$) and level of education ($p < 0.01$) on perceived food safety control. This finding indicated that a unit increase in caregivers' age was associated with a unit increase in the odds of having food safety control vs. no control (OR = 1.0, 95% Cl = 1.0-1.1). Furthermore, the odds of having food safety control vs. no control increased by 14.2 if the caregiver had at least secondary school education to no education (OR = 14.2, Cl = 1.9–13.7). The caregiver's level of education was significantly associated with the caregiver's food safety knowledge ($p = 0.01$) and no socio-demographic factors were associated with food safety behavior (Table 4).

Table 3 Bivariate analyses of Perceived Food Safety Control, Food Safety Knowledge and Behavior of caregivers and Nutrition Status of Children (*N* = 664)

	Stunted	Non-stunted	*P*-value	Wasted	Non-Wasted	*P*-value	Underweight	Not-underweight	*P*-value
				N (%)					
Perceived food safety control			0.15			0.14			0.37
No control	1.53	1.22		0.15	2.60		0.92	1.83	
Little control	7.94	8.24		0.31	15.88		3.05	13.13	
Lot of control	32.98	48.09		5.65	75.42		18.17	62.90	
Mean ± SD									
Food safety knowledge score	13.46 ± 1.21	13.54 ± 1.15	0.35	13.80 ± 0.08	13.49 ± 0.05	0.10	13.49 ± 0.09	13.51 ± 0.05	0.87
Food safety behavior score	17.43 ± 0.18	17.54 ± 0.16	0.65	17.55 ± 0.48	17.49 ± 0.12	0.91	17.64 ± 0.24	17.46 ± 0.14	0.53

Missing values = 9

Table 4 Socio-demographic factors associated with perceived food safety control, food safety knowledge, and behavior of caregivers (*N* = 664)

Variables	#Perceived food safety control OR (95% CI)	Overall effect *p*-value	Food safety knowledge β ± SE	Food safety behavior β ± SE
Wealth index		0.33		
High vs low	1.8 (0.2–18.2)		0.1 ± 0.2	0.6 ± 0.4
Medium vs low	1.1 (0.4–3.3)		-0.1 ± 0.1	0.1 ± 0.3
Caregivers' age	1.0 (1.0-1.1)*	**0.02**	0.1 ± 0.1	0.1 ± 0.1
Caregivers' highest education		**< 0.01**		
Primary school vs no education	4.3 (0.5–18.8)		0.6 ± 0.2**	-0.3 ± 0.8
Secondary school vs no education	14.2 (1.9–13.7.9)**		0.3 ± 0.1**	-0.1 ± 0.8
Tertiary school vs no education	2.7 (0.3–22.4)		0.5 ± 0.3	0.6 ± 0.9
Child's gender		0.77		
Male vs female	1.3 (0.4–3.6)		0.1 ± 0.1	-0.2 ± 0.2
Child's age group		0.59		
Young child vs infant	0.7 (0.2-2.0)		-0.1 ± 0.1	-0.1 ± 0.2
Number of under 5 in the household	1.0 (0.5–1.9)	0.38	-0.1 ± 0.1	-0.2 ± 0.2

#show the significance of "a lot of control" with "no control" as reference for perceived food safety control using multinomial logistic regression

*$p < 0.01$,**$p < 0.05$

Multivariate analyses of perceived food safety control, food safety knowledge, and behavior of caregivers, and nutritional status of children

For stunting, the multivariate logistic regression analysis showed a significant overall effect on the caregiver's age, child's gender and age group. The results indicated that the odds of stunting increased as the caregiver's age increases (OR=1.0, 95% Cl=1.0-1.1) and for a child at least two years vs. under 2 years old (OR=2.7, 95% Cl=2.0-3.9. However, it decreased for a male vs. female child (OR=0.6, 95% Cl=0.5–0.9). For wasting, there were significant overall effects on the caregiver's perceived food safety control ($p=0.03$) but no significant difference by the levels of perceived food safety control. Moreover, the caregiver's age (OR=1.1, 95% Cl=1.0-1.1), the number of children under 5 in the household (OR=2.3, 95% Cl=1.2-5.0), child's gender (OR=0.4, 95% Cl=0.2–0.9), and age group (OR=2.3, 95% Cl=1.1–4.8) were all associated with wasting. Furthermore, the results showed an unexpected finding that households with high and medium wealth indexes have higher odds of having a child experiencing wasting than the low wealth index household (OR=11.7, 95% Cl=2.3–58.8 and OR=3.1, 95% Cl=1.4–7.2, respectively). Overall, wealth index was significantly associated with wasting at $p=0.02$ but not with stunting or underweight.

Furthermore, the odds of being underweight increase as the caregiver's age increases (OR=1.1, 95% Cl=1.0-1.1) and for a child at least two years vs. under 2 years old (OR=1.7, 95% Cl=1.1–2.5). Also, there was a significant association with the caregivers' education ($p<0.05$) (Table 5).

Discussion

This study examined factors associated with caregivers' knowledge, behavior, and perceived control of food safety. Additionally, we examined the associations between caregivers' knowledge, behavior, and perceived control of food safety and the nutrition status of children aged six months to five years. Most caregivers have a high level of food safety knowledge, practice proper food handling and household hygiene behaviors, and have a high level of perceived control over their food safety. While caregivers with higher perceived control of food safety were less likely to have children with wasting, findings did not show any other relationship between caregiver knowledge, behavior, and perceived control of food safety and other anthropometric measures.

This study's findings on high food safety knowledge and behavior among caregivers align with those of a cross-sectional study among caregivers in urban areas in Vietnam [12]. Moreover, our findings on high food safety knowledge and perceived food safety control among the surveyed caregivers in this current study align with those of caregivers of children of six to twenty-three months in Uganda [11]. This earlier study identified adequate food safety knowledge (74.1%), positive attitudes (68.1%), and high food safety self-efficacy among the surveyed caregivers. This self-efficacy, comparable to our study, assesses an individual's confidence in their capability to handle

Table 5 Multivariate Analyses of Perceived Food Safety Control, Food Safety Knowledge, and Behavior and Nutritional Status of Children ($N=664$)

	Stunting		Wasting		Underweight	
Variables	**OR (95% Cl)**	**Overall effect *p*-value**	**OR (95% Cl)**	**Overall effect *p*-value**	**OR (95% Cl)**	**Overall effect *p*-value**
Perceived food safety control		0.29		**0.03**		0.14
Little control vs no control	1.7 (0.5-5.0)		4.6 (0.3–75.4)		2.8 (0.8–9.2)	
Lot of control vs no control	2.1 (0.7–5.9)		1.1(0.1–7.6)		1.7 (0.6–5.2)	
Food safety knowledge	1.0 (0.9–1.2)	0.87	0.7 (0.4–1.2)	0.23	1.0 (0.8–1.2)	0.85
Food safety behavior	1.0 (0.9–1.1)	0.85	1.1 (0.9–1.2)	0.38	1.0 (0.9-1.0)	0.38
Wealth index		0.31		**0.002**		0.09
High vs low	1.4 (0.7–2.5)		11.7 (2.3–58.8)**		2.2 (1.1–4.5)	
Medium vs low	1.3 (0.9–2.1)		3.1 (1.4–7.2)**		1.3 (1.0-2.3)	
Caregivers' age	1.1 (1.0-1.1)	**<0.05**	1.1 (1.0-1.1)	**0.01**	1.1 (1.1–1.1)	**0.02**
Caregivers' highest education		0.11		0.37		**<0.05**
Primary vs no education	0.9 (0.3-3.0)		1.4 (0.1–14.0)		0.4 (0.1–1.8)	
Secondary vs no education	1.3 (0.4–4.2)		2.9 (0.2–31.2)		0.8 (0.6–3.9)	
Tertiary vs no education	2.1 (0.6–7.2)		1.7 (0.2–18.9)		1.0 (0.2–5.3)	
Child's gender		**0.01**		**0.02**		0.08
Male vs female	0.6 (0.5–0.9)*		0.4 (0.2–0.9)*		0.7 (0.5–1.1)	
Child's age group		**<0.001**		**0.02**		**0.01**
Young child vs infants	2.7 (1.9–3.9)**		2.3 (1.1–4.8)*		1.7 (1.1–2.5)*	
Number of under 5 in the household	1.2 (0.9–1.6)	0.21	2.3 (1.1-5.0)	**0.04**	1.3 (0.9–2.3)	0.24

*$p<0.05$, $p<0.001$

various aspects of food safety, such as proper handling, storage, and food preparation. The earlier study's finding on self-efficacy is similar to our results, which revealed that many caregivers are perceived to have lots of control over food safety issues.

Caregivers' age and educational background were significantly associated with how they perceived their control of food safety issues. Older caregivers are more likely to perceive that they have a high level of control over their food safety than younger caregivers. This may be attributed to accumulating knowledge and familiarity with cultural practices emphasizing food safety measures among older caregivers. This may contribute to a greater sense of confidence and perceived control over food safety practices among older adults than younger caregivers. Furthermore, the positive association of education with perceived food safety control is not surprising since education often contributes to confidence in handling such matters. While no socio-demographic factors were associated with food safety behavior in our current study, caregiver's education was significantly association with their food safety knowledge. Higher educational levels have been previously correlated with a greater food safety knowledge and practice [12]. Recognizing these associations, it is vital to address how to effectively reach mothers/caregivers with lower education backgrounds and young caregivers, providing them with formal or informal education initiatives focused on enhancing their knowledge and practices related to food safety. Additionally, while some caregivers may have knowledge and awareness of food safety principles, they may encounter challenges or barriers in translating this knowledge into consistent and effective practices. Hence, comprehensive interventions incorporating multiple components such as investment in infrastructure, policies, etc. are necessary to overcome various barriers hindering adequate food safety practices among caregivers of children under five.

This study fills a critical knowledge gap as there is a dearth of studies that examined the association between caregiver's food safety practices and the nutrition outcomes of their children. An overall association was observed between perceived food safety control and children's nutritional status. However, it is interesting to find that there was no significant difference in nutritional outcomes based on the level of perceived control. This may be because caregivers may feel confident in their ability to control food safety; their behaviors and practices may not necessarily reflect this confidence, leading to inconsistencies between perceived control and actual outcomes. Moreover, nutrition outcomes are multifactorial [6] and may be influenced by factors beyond food safety alone, including dietary diversity, access to healthcare, socio-economic status, and genetic and other external factors beyond caregivers' control, such as environmental hygiene, access to clean water, and sanitation facilities. The influence of perceived food safety control, food safety behavior and practice on nutrition outcomes may be diluted by these factors, thereby overshadowing their impacts.

Nevertheless, the absence of a direct association between caregivers' knowledge, behavior and children's nutritional status does not negate the positive indicators observed in our bivariate analyses. The bivariate analyses showed a statistically insignificant but higher mean score for caregivers' food safety knowledge and behavior for the children who are not experiencing stunting or underweight compared to those facing such nutritional challenges. A similar notable trend emerges for caregivers with a strong perception of food safety control, as most of them have children not experiencing stunting, wasting or being underweight. Although this does not indicate better child nutrition outcomes among caregivers with positive or adequate food safety knowledge, behavior and perceived food safety control, they do suggest a potentially favorable trend worth further exploration and consideration in future research and interventions.

Moreover, we found that certain characteristics of caregivers, children, and households were associated with the children's nutritional status. These encompassed the age of caregivers, the gender and age group of children for stunting, the household wealth index and size, the age group and gender of children, and the age of caregivers for wasting. Additionally, caregiver age, education level, and the age group of children were found to be associated with underweight status. The caregiver's age seems to be a significant factor affecting all three dimensions of children's nutrition outcomes. However, there is a slight increase in the odds of worst nutrition outcomes (OR 1.1) as the caregiver's age increases. Interestingly, this finding contrasts with previous studies in Egypt that found the odds of stunting decrease with the mother's age among preschool children aged 2–5 [32]. Another recent study among children between 6 months and 5 years in Zimbabwe [32] also reported a significant lower risk of stunting for caregiver < 18 and 36 years compare to > 45 years. This discrepancy in findings could be due to differences in sample characteristics and contexts. In some contexts, older caregivers may have more experience or access to resources, while in others, younger caregivers may be more adept at adopting new nutrition and health recommendations. A significant overall association between the education of caregivers and underweight underscore the crucial role of caregiver knowledge and literacy in shaping the nutritional status of children [7, 33].

The children's age group emerges as another significant factor across all three nutrition outcomes, with older children exhibiting a higher risk of malnutrition than younger children. This finding is consistent with a

previous analysis of the Demographic and Health Surveys across 31 countries in sub-Saharan Africa [34] and a recent systematic review on adverse nutrition outcomes among children in sub-Saharan Africa [35]. Both studies revealed that younger children face a lower risk of adverse nutrition outcomes than older children [34, 35]. Growth distortion may start early but becomes more apparent as children grow older. Thus, it is imperative to mitigate the risk of malnutrition and support optimal growth and development throughout childhood.

Moreover, targeted interventions are needed to address the specific nutrition needs of older children, including promoting healthy feeding practices tailored to older children and enhancing caregivers' education on age-appropriated nutrition. Regarding children's gender, our finding aligns with the finding of the Zimbabwe study, which reported lower odds of stunting among male compared to female children [36]. However, it contrasts the study's findings that used Demographic and Health Surveys (DHS) across 31 countries and the systematic review [34, 35]. These discrepancies in findings regarding children's gender and its association with malnutrition may stem from variations in sample demographics, cultural norms, and healthcare access across different regions. Additionally, the statistical techniques used could contribute to divergent results between studies. Further research incorporating more considerable and diverse populations and standardized methodologies is essential to elucidate the complex relationship between children's gender and malnutrition risk.

Households with a larger number of children under five were associated with wasting (acute malnutrition) in the surveyed households, similar to a previous systematic review [34]. Moreover, other studies have consistently highlighted the association of siblings with adverse nutrition outcomes and developmental delays [37–39], considering factors such as the number of under five children [37], the number of siblings [39], gender and the age difference among siblings [40]. The presence of multiple siblings within this age bracket could exacerbate competition for limited resources, such as food and attention from caregivers, thereby increasing the risk of malnutrition among children in such households. Thus, strategies to address malnutrition include targeted nutritional support programs that address the specific needs of larger households, such as access to nutritious foods, educational resources on optimal feeding practices, and support for caregivers in managing the nutritional needs of multiple children.

This study indicated that households with high and medium wealth indexes were surprisingly more likely to have a child experiencing wasting than households with a low wealth index. While this contradicts previous findings in other countries [41], this result aligns with the outcomes of another study across multiple countries in sub-Saharan Africa, which found that households across various wealth indexes (poor, medium and wealthier) had the same odds of experiencing adverse nutrition outcomes compared to the wealthiest households [34]. This surprising finding may be explained by the concept of positive deviance, where specific individuals have uncommon practices that enable them to achieve better outcomes despite facing barriers like those of other studies. Again, wasting is a complex issue influenced by dietary choices, awareness, cultural factors, and social and environmental factors extending beyond mere economic disparities. This highlights the necessity for comprehensive and targeted approaches to improve nutrition and child health, regardless of the families' socioeconomic status.

This study has a few limitations. First, given that it was a cross-sectional study, we cannot make any causal conclusions or determine the direction of mechanisms between food safety and nutritional status. Second, our assessment of food safety constructs was self-reported, subject to recall bias and social desirability biases. However, the findings could be generalized in geographical location with similar demographics.

Conclusion

The study reflects the complex nature of food safety challenges encompassing caregivers' self-reported food safety knowledge, behavior, perception of food safety control and their impact on children's nutritional outcomes. Moreover, future studies should investigate access to resources and other factors that may explain the relationship between the child's nutritional status and caregivers' perception of food safety control, knowledge, and behavior.

The study highlights the need for public health and food safety initiatives to bridge the gap between perceived food safety control and actual food safety behavior/practices. These initiatives may include educational programs, awareness campaigns, social and food safety-related behavior change communication, and interventions addressing barriers to adequate resources, encouraging individuals to translate perceived control into consistent, safe food practices. Additionally, comprehensive interventions are needed to address the complex interplay of factors contributing to adverse nutrition outcomes among children under five. This approach should ensure that all households have equitable access to resources and support, regardless of their socioeconomic status or family structure.

Acknowledgements

We acknowledge all the research assistance that supported the data collection, residents of the community where the data were collected.

Author contributions
A.T.A., F.S., O.A., N.T., A.A.A., B.O., and A.A. conceptualized and got funding for the project. A.T.A., F.S., O.A., N.T., A.A.A., B.O., A.A and B.B. were involved with the data collected. A.T.A. conducted the analysis. A.T.A. and D.L. wrote the main manuscript text and Tables 1, 2, 3, 4 and 5, and A.A.A. prepared Fig. 1. All authors reviewed the manuscript.

Funding
This study was supported by the USAID Feed the Future Food Safety Innovation Lab.

Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
Ethical clearance was granted by Alaska-Fairbank Institutional Review Board using an expedited review process (Protocol #1897686-1).

Consent for publication
All authors consent to submit and publish the manuscript.

Competing interests
The authors declare no competing interests.
Written informed consent was obtained from all participants before engagement, and they were compensated for their time.

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Received: 3 June 2024 / Accepted: 24 September 2024
Published online: 14 October 2024

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