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Is Aflatoxin Contamination of Staple Children's Foods in Communities? An Underlying Factor in Child Stunting? A Question for Eastern Regions of Kenya.

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Abstract

Purpose: The purpose of the study was to examine if aflatoxin was related to child stunting in the study areas of two counties in Eastern Kenya. The objective of this study was to examine the relationship between aflatoxin and stunting in children 6 to 59 months. The study presents a question of aflatoxin as a contaminant of staple foods for children and therefore an "underlying factor" contributing to stunting outcome in children in affected study areas. A multi-stage field survey was carried out at county and household level.

Methodology: Data were collected at household level by research assistants using a smart phone which had geo-positioning that enabled data verification by supervisors. Food samples of local maize-flour and other cereals were collected and analyzed in the laboratory for aflatoxin contamination. Data was analyzed using SPSS Version 21. Analysis of factors that contribute to stunting raises an important question on the underlying possibility of aflatoxin.

Findings: Findings revealed a significant relationship was established between breastfeeding and stunting through ANOVA p/> 0.017 (t –value -2.810 and robust standard error of 0.5131 and coefficient value of -1.4411). Aflatoxin levels from samples of maize grain, flour mixes and animal feed collected was 17.8% of toxicity above national and regional safe margin of 10ppb.

Unique contributor to theory, policy and practice: Key interventions including farmer education and sensitization as well as use of aflasafe in the soil to reduce aflatoxin in the region are recommended.

Keywords: *Aflatoxin, Stunting, Education, Staple Foods.*

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INTRODUCTION AND BACKGROUND

It is estimated that 144 million of children below five years of age suffer from stunting globally. These estimates based on global overview (UNICEF/WHO/World Bank, 2020) also showed that decline in rate of child stunting is very low especially in the sub Saharan Africa region. The joint report UNICEF/WHO/World Bank (2020) showed that the sub Saharan Africa region had a burden of 34.5% of all 40% stunted children globally with a huge number (23.1%) of these stunted children living in the Eastern Africa region.

Further analysis of child stunting, an index of child growth and development was also considered a major concern and challenge based on data analysis by reviewers in many parts of the world. A meta analysis of child data using Demographic and Child Health surveys (DHS) covering ten countries from 2006-2016 by Akombi et al. (2017) revealed that child malnutrition (wasting, stunting and underweight) was highest in East Africa. Pooled estimated data from Burundi, Comoros, Ethiopia, Kenya, Malawi, Mozambique Rwanda, Uganda, Zimbabwe and Zambia) showed an aggregated stunting rate of 39% (95CI:33.6, 44.4).

Childhood stunting is linked to sub optimal capacity in growth and is manifested in intellectual and socio economic development challenges at individual and societal levels. A review of data from 16 countries (Smith and Haddad, 2015; for the years 1970 to 2012 showed that children who were stunted, underweight or wasted had lower work capacity and productivity even as adults in addition to potential chronic disease including diabetes and cancer in the future. This was also supported by others (World Bank, 2013). The socio economic impact was supported by another review (McGovern, et al. 2017) which published evidence that showed that child stunting was linked to poor economic outcomes. Causal factors linked to stunting include low rates of breast feeding, inadequate dietary intake both at maternal level and infancy stage, poor health and inadequate sanitation (Mzamara, et al. 2018; World Bank, 2013).

Aflatoxins are widely documented toxins that affect soil and staple foods (Monda et al. 2020). In addition to soil contamination, commonly contaminated staple foods include maize grain, groundnuts (peanuts); with animal feed becoming a subject of major concern to scientists in public health, food science, and food economists (Hoffman, et al. 2019, Okoth and Ohang, 2004; Kiarie, et al., 2016; Kilonzo, et al. 2014). Stunting and aflatoxin toxicity in diets of children has been widely documented. Data analysis have shown associations between child stunting and aflatoxin presence in the diets especially complementary diets given to children who are younger than five years of age (Kiarie, et al. 2016; Okoth and Ohang, 2004, Gong et al. 2003; Kamanya, et al. 2010). This study was done in counties that are geographically located in Eastern ecologic zone of Kenya. This is an area whose climate is damp and humid and one which has been identified as prone and conducive to aflatoxin in soils (Monda et al. 2020).If care is not taken in terms of storage, staple crops are compromised to aflatoxin because of moisture laden conditions (MoAFS, 2016).

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The Kenya Demographic and Health Surveys (KDHS) data is prepared and presented by the Kenya Bureau, Housing and Statistics (KNBS) normally every five years. The data is presented to guide policy and important programmatic actions. For over 20 years, national prevalence of stunting in children below five years ranged between 26% and 33%. In the Eastern region of Kenya the average prevalence was 30.1% and 41.9%. during the same period. This shows that the stunting rate in the study area was higher than the national average. Government departments, multi-lateral, bilateral agencies, NGOs and communities have shown higher levels than as shown in Fig 1 (KDHS, 1989, 1993, 1998, 2003, 2008/9 and 2014). This study therefore poses a question if aflatoxin could be could be an underlying factor in stunting among children below five years of age in the study area and other regions where stunting is deemed problematic in the welfare of young children. The objective of the study presented in this paper was to examine the prevalence of stunting in the study areas of Meru and Tharaka Nithi counties and also examine if there was any relationship between aflatoxin levels in staple foods used to feed young children and child stunting.

MATERIALS AND METHODS

The study adopted a two-stage cluster sampling strategy used by the Kenya National Bureau of Statistics (KNBS, 2017). Materials and methods described in this paper cover one of four objectives of a lager study that was done in the study area. Data presented is only on child stunting, food consumption by the children in the study and information on aflatoxin contamination of foods eaten by the children at household level. Households were selected on a systematic random sample with an eligibility criteria of presence of a child 6 to 59 months of age. Questionnaires were developed and validated by panels of technical experts. Reliability of the questionnaires was determined through a pilot study with results analysed and statistically validated through Cronbach Alpha (0.90) precision test. Data was collected at household level by trained research assistants who used KOBO tool in smart phones with geo-position capacity. Parameters of two counties were homogenious especially because aflatoxin levels and child stunting prevalence is the same. Data was transmitted electronically to a supervisor who validated each entry before transmission to the data analysis system that used SPSS software.

Height or length of children was measured to the nearest 0.1cm using OXFAM/UNICEF measuring length boards. Children 6 to 24 months were measured while lying in a flat position on the length board while the older children 25 to 60 months were measured in an upright standing position using a height board. The age of children was reported by the mother or primary caretakers and validated through the records from their Maternal and Child Health (MCH) cards. Height for age in z scores (HAZ) were taken to determine stunting levels as per WHO (2006) standards with cut offs < -1 to>/ 2 z scores (mildly stunted); <-2 to > -2zscores (moderately stunted) and <-3zscores (severely stunted) from the reference median and +3 z scores as overweight /obese. The gender of the child was recorded. Child feeding details based on the food consumption by food groups and were recorded. Food consumption for each child was based on frequency of

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consumption by food groups (dairy products and other animal proteins; fruits and vegetable; roots and tubers; legumes and nuts ; and starchy foods mainly maize flour and sweetened foods).

To determine levels of aflatoxin, cereal grains samples (mainly as maize and sorghum) and samples from flour used for preparing children's food and also animal feed samples were collected using dry specimen containers as per Kenya Bureau of Standards (KEBS) recommendations and transported to Dakwa Agencies for analysis at University of Nairobi laboratory. The samples were analyzed using Veratox direct competitive Elisa procedure (Neogen, 2017). The methodology allowed the technician to obtain concentrations in parts per billion (ppb). Using this procedure, free aflatoxin in the samples and controls were able to compete with enzyme-labeled aflatoxin (conjugate) for the antibody binding sites. Measurement was for total aflatoxin (AFBI, AFB2, AFGI, AFG2) and was measured in parts per billion (ppb).

RESULTS

Stunting

The prevalence of child stunting was 30.2% (moderate and severe levels) as per WHO (2006) criteria on child stunting (Table 1). Stunting was significantly dependent on gender (Table 2). More male children were stunted compared to the female gender. Analysis showed a significant difference in the gender at Pearson Chi-square of 8.10 at p value of 0.44 ($p<0.05$). Further analysis of the data on the gender variable did not show any significant differences in stunting based on two genders t=1.1494, p value =0.251. Differences were observed between the two study counties. Children from households in Meru county had higher but not significant prevalence of stunting than Tharaka Nithi county.

Table 1. shows stunting prevalence as determined by two sample means

Gender	Observation	Mean	Std. Error	Std. Dev.	95% Conf. Interval	
					Lower	Upper
Female	228	-0.957	0.232	3.498	-1.914	-0.500
Male	269	-0.602	0.204	3.353	-1.204	-0.199
Combined total	497	-0.765	0.153	3.421	-1.066	-0.463
Difference in mean		-0.355	0.309		-0.962	0.252

t-value = -1.1494; p-value = 0.251
The two means by gender did not however show significant difference in stunting based on two sample t=tests (t=-1.1494; p-value= 0.251 , p<0.05)

Data analysed showed stunting differences based on gender (Table 2). However the was no significance difference determined on basis of gender.

Table 2. Frequency of children stunting gender and county of study

Cross-section table showing stunting categories by gender			
	Gender		
Stunting (LFA) classification	Female	Male	Total
Normal (-2 < z < 2)	145	152	297
Moderate (-3< z < -2)	22	50	72
Severe (z < -3	38	40	78
Obese (z>3)	23	27	50
Total	228	269	497

Pearson Chi-square=8.10; p-value =0.044
Results indicate the stunting is dependent on gender (p<0.05)
Distribution by gender of children revealed higher stunting in the male child compared to female gender. Further analysis showed this difference was significant at Pearson Chi-squire = 8.10 and p value of 0.044 (p<0.05)

Child feeding

A majority of children consumed foods grown and processed in the community. Protein foods including dairy foods were consumed majority of children from both counties. In Meru county the proportion was 63% while in Tharaka Nithi a smaller proportion (37%) was reported. Half of the children in each county were reported to consume starchy foods comprising cereal grain flour mixtures of which maize was most common followed by sorghum flour mixtures. Legumes comprising varieties of beans also formed a significant proportion (58%) of foods for children in Tharaka Nithi and 42% in Meru county.

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Table 3. Children feeding by food groups taken in the last 24 hours

	County				
	Meru		**Tharaka Nithi**		**Total**
	Number of households	**Percentage**	**Number of households**	**Percentage**	
Fruits	185	59%	130	41%	315
Dairy	218	63%	127	37%	345
Legumes	22	42%	30	58%	52
Starch	213	50%	212	50%	425
Protein	135	61%	85	39%	220

Most Aflatoxin contamination of foods are freely available at community level. Samples of flour mixtures and grain grown and processed in the study areas of Tharaka Nithi and Meru counties had 17 % of aflatoxin contamination at levels above national legal mandate of 20ppb. Differences in levels of toxicity was observed between the two counties where samples from Tharaka Nithi exhibited 20% levels of contamination and Meru had 13% toxicity level. However these differences were not significantly different. Qualitative questions on feeding practices revealed that majority of households consume food from their farms. Any excess stock is sold at community local markets. This is the food fed to young children and all other members of the family including breast feeding mothers. Therefore any member of the household is highly exposed to aflatoxin contaminated food.

Aflatoxin levels in food samples collected at household level

The analysis using Kenya Bureau of Standards (KEBS) safety limits indicates that overall 17% of the tested foodstuffs had contamination beyond the safety level (Table 4). Of the foodstuffs tested from Meru, 13% were contaminated above the limit and of the foodstuffs tested from Tharaka-Nithi, 20% were contaminated above the limit. In spite of this the aflatoxin levels and county are independent. Please see the Table below.

Table 4. Aflatoxin levels in samples measured

	Aflatoxin safety levels according to KEBS standards					
County	SAFE	%	NOT SAFE	%	TOTAL	%
MERU	85	86.7%	13	13.3%	98	42.8%
THARAKA-NITHI	105	80.2%	26	19.8%	131	57.2%
TOTAL	190	83.0%	39	17.8%	229	100.0%

chi-square =1.72, p-value=0.190

This implies that at 5% level, the aflatoxin levels between the two counties are not statistically different

Regression analysis was done to determine relationship between aflatoxin and prevalence of child stunting and other key variables in child feeding. Breast feeding was found to have a significant effect on stunting based on the height for age and length for age in z-scores criteria for stunting used in this study.

Table 5. Data on the table shows the way the relationship between aflatoxin contamination and prevalence of child stunting was determined .

In running this regression, a control for demographic variables of interest was made. Further, the standard errors had to be corrected to account the clustering of the data. From the results below, only breast feeding had a significant effect on stunting as measured by length for age z-scores.

	Number of	**obs = 184**		
	F(8, 11)	**16.7**		
Analysis of variance results	**Prob > F**	**0.000**		
	R-squared	**0.0715**		
	Root MSE	**3.1221**		
	Coefficient	**Robust std. error**	**t-value**	**p-value**
AFX	-0.0077	0.0116	-0.660	0.521
GENDER	0.2652	0.2216	1.200	0.256
H_GENDER	0.1048	1.0208	0.100	0.920
H_AGE	0.0097	0.0209	0.470	0.650
M_STATUS	-0.0413	0.2794	-0.150	0.885
EDN	-0.1365	0.2462	-0.550	0.590
EMP	0.2078	0.1900	1.090	0.297
BREAST	-1.4411	0.5131	-2.810	0.017
Constant	-1.6274	1.6723	-0.970	0.351

NB: Standard errors adjusted for 12clusters in CLUSTER hence use robust S.E

Dependent variable is length for age z-scores (LFA)

Key:

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AFX = Concentration of aflatoxin in household foods

GENDER = Gender of child

H_GENDER = Gender of household head

H_AGE = Age of household head

M_STATUS =marital status of household head

EDN = Level of education of household head

EMP = Employment status of household head

BREAST = Whether a child is breast feeding or not

Discussion

This study found high level of stunting (30.2%) combined results of the two counties which is consistent with national and regional data from Kenya demographic and health surveys (KDHS 1989 to 2014) as shown in the reviewed literature for this study. These results also follow the trend of pooled data and analysis by scholars (Akombi et al. 2017) and global and regional estimates by international agencies (UNICEF/WHO/World Bank group 2020). Stunting in children is a major challenge towards their physical growth, their psychosocial development and future impacts on health and economic wellbeing. The study found high aflatoxin (17 ppb) contamination of complementary food eaten by children in the study area. Animal feeds were found to be equally infested by total aflatoxins. This finding is important because a majority of children were fed on protein group of food (61%) in Meru and 31% in Tharaka Nithi. Dairy products were also commonly given to children (63% in Meru) and 37% in Tharaka Nithi. A study by Kilino et al (2016) revealed very high level of aflatoxin in milk sold in Kenya urban areas.

Relationships between aflatoxin and sunting in young children has been appearing in studies for sometime. Okoth and Ohanga (2004) conducted a study in Western part of Kenya which showed that children who consumed diets that had high levels of aflatoxin did not grow to the normal trajectory based on growth standards. Kamanya et al. (2010) reported that in their study in Tanzania, children who consumed diets contaminated by aflatoxin were found to be impaired in terms of growth based on height for age. Hoffman et al. (2019) established that children who consumed primarily maize diets that had aflatoxin suffered from growth impairment. Others (Kiarie et al. 2016, Gong et al (2003) presented similar results in Kenya, Benin and Togo.

Over 30 years ago (UNICEF 1990) UNICEF developed a conception framework that has been a guiding tool for interventions to curb problems of malnutrition in young children. This framework was based on layers of causes of malnutrition. Some were dubbed “basis”; “underlying” and immediate. Programmes for addressing malnutrition by multi-agency partnership have been done at community, institutional and at household levels. Some of these programmes have also been categorized as “specific” and others “sensitive”. In all these efforts children’s prevalence of stunting in particular have changed minimally. Trends of stunting in Kenya show 35% in 1989; and by the year 2014 the only small drop revealed a prevalence of 26% in 2014 (KDHS 2008/9; KDHS2014) at national level. It is on the basis of these reports that this paper asks " Are there other underlying issues that contribute to child stunting?" For over three decades stunting rates have remained extremely high with about 1 in 3 children found to be stunted. Should aflatoxin contamination of soils, staple foods not be an important underlying factor in causal of child stunting?"

Figure 1

Trend compares national average stunting for rural and urban households and the Eastern Kenya geographic zone (Eastern Province). The region has exhibited high rates of stunting compared to national average rates.

Trend of Child Stunting in Kenya 1989 to 2014 KDHS (1993, 1998, 2003, 2008/9, 2914). Kenya Demographic Surveys, Kenya National Bureau of Statistics. Republic of Kenya, Nairobi.

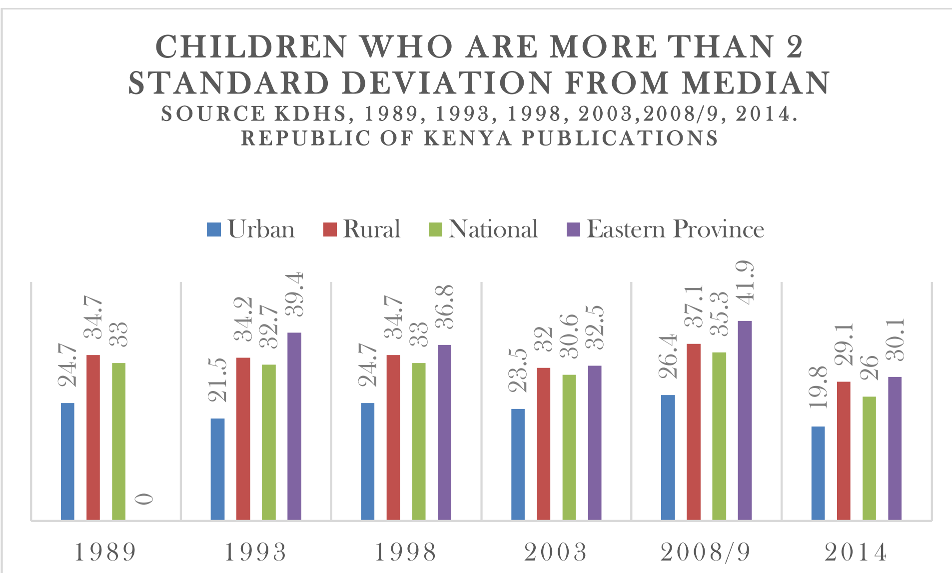

Figure 2. Theoretical Framework for the child Stunting objective in this study

This figure depicts the study's theoretical linkages between the study variable aflatoxin at different points of food value chain and the outcome which the child's nutritional status (stunting in the study).

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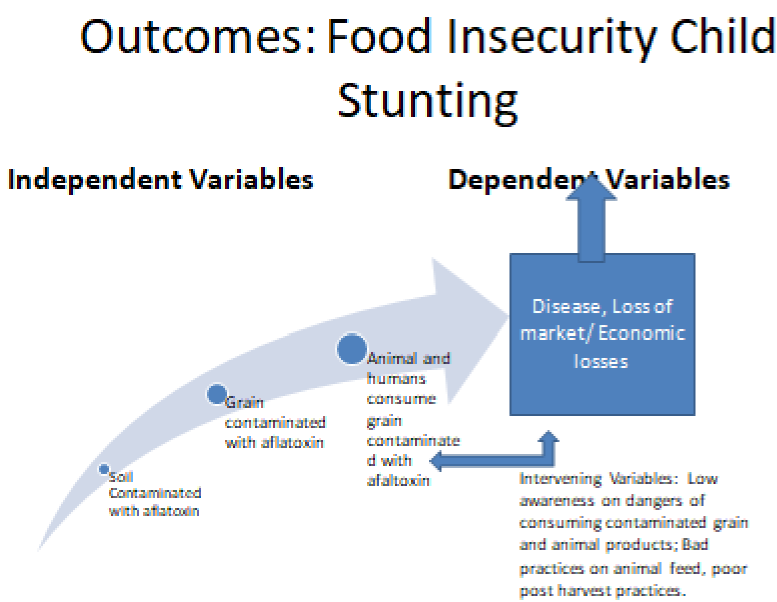

Conclusion

This study emphasizes the need to be extremely cautious on aflatoxin contamination in children's food. An additional but equally important factor is the findings of high aflatoxin levels in soil (Mondo et a. 2020) where staple foods are grown. These reports show that children are growing up in a highly toxic environment which has implications on their health and development. Communities should be sensitized and given appropriate practical experiences to safeguard their health through health education and extension agriculture services. Both Ministries of Health and Agriculture should put adequate resources to eliminate aflatoxin in the soil and grain in affected communities.

Recommendations

Recommendations from this study provide opportunities for actors at different levels in Kenya and study area to prioritize issues that lead to reduction of stunting in children below five years of age. These actors include the national and county governments. Resources that are put in place to improve nutritional status of children are managed by communities on contamination of food particularly maize/corn with aflatoxin. Communities require knowledge on health dangers of aflatoxin especially young children. Communities need to be informed that aflatoxin infested grain should not be fed to domestic animals (cows/goats) or chickens because the toxins get into milk or eggs and that consumption of these products affects humans along the food chain. At the level of health facilities health workers should educate mothers on issues of growth monitoring so that stunting in children can be reduced early by promoting good nutritional practices in feeding young children. The national governments should promote detoxification of soils to remove all aflatoxin from crops.

Conflict of Interest: The researchers have no conflict of interest in any aspect of the research taken and associated publication.

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