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COMMUNITY KNOWLEDGE AND AWARENESS OF AFLATOXIN IN DIETARY STAPLES IN RURAL BUSIA COUNTY, KENYA: A MIXED METHODS STUDY

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ABSTRACT

Aflatoxins are an important food safety challenge globally and in Kenya. Understanding a community's knowledge, perception and practices is instrumental to improvement of aflatoxin control measures. Creating awareness on the causes of contamination and mitigation options could improve aflatoxin mitigation. This study aimed to map out dietary staples, establish drivers of food choices, describe knowledge and perceptions on aflatoxin and post-harvest grain management practices and use among the communities in Busia County in order to guide future evidence-based aflatoxin prevention and public health interventions. A household survey was conducted in 40 villages, and participants were selected using stratified systematic sampling in three sub-counties in rural Busia County. The survey was complemented and triangulated with a qualitative study component. Focus Group Discussions with sixty women and sixteen semi- structured interviews with nine men and seven women were conducted. Both descriptive and statistical analysis of data were performed. The results showed variability in household diversity scores and maize was observed as the community staple. While both younger and older participants were able to identify spoilt grains, they demonstrated limited knowledge and awareness of aflatoxin. Participants were not aware that seemingly clean grains could be colonized by aflatoxin as they only associated spoilage with discoloration and bitter taste of flour. Study participants were also not aware of the aflatoxin pathways to exposure as they used the spoilt grains in feeding chicken, making animal feed and local brew.
Appropriate disposal methods of aflatoxin contaminated food were not known. The knowledge gap was attributed to lack of awareness creation and sensitization by the relevant government ministries. For effective control and prevention of aflatoxin contamination, farmers and traders need to be aware of the causes of aflatoxin contamination of grains, available mitigation options and health risks attributable to aflatoxin exposure in order to self-regulate. Ministries of health and agriculture, through their public health officers, community health workers and agricultural extension officers respectively need to collaborate and spearhead awareness creation among communities and institute food surveillance systems in Busia County.

Key words: Aflatoxin, knowledge, perceptions, mixed methods, dietary staples, Busia County, Kenya

INTRODUCTION

Globally, over five billion people are chronically exposed to aflatoxin and approximately 36 million Disability-Adjusted Life Years (DALYs) are lost annually due to aflatoxin exposure [1,2,3]. Aflatoxins are a major public health and food safety concern worldwide and more so in sub-Saharan Africa [4]. In 2007, an aflatoxin sero-survey conducted in Kenya revealed that over three quarters of the population was exposed to aflatoxin and the exposure was prevalent across ages, gender, socio-economic status and region [5]. In this survey, all samples drawn from Busia had detectable levels of aflatoxin, an indication of chronic exposure. Laboratory results of samples tested in this current study showed incidence of aflatoxin in all dietary staples tested in the study area [6]. All maize, sorghum, groundnut, millet and cassava samples had detectable levels of aflatoxin with maize recording highest level (mean 100ppb; SD 252.9; range 1-1584ppb) while the least were observed in millet (range 0.5 to 12 ppb) and groundnuts (0.1 to 2.8ppb).

There have been recurrent aflatoxicosis outbreaks in some parts of Kenya with recent aflatoxin prevalence studies showing aflatoxin contamination of major grains in Kenya [7]. Reports of national grain reserves declared unsafe for human consumption have raised considerable attention towards mitigation of aflatoxin [8]. Aflatoxin mitigation requires effective pre- and post-harvest practices. Some of the post-harvest practices recommended include proper food drying, storage and preparation [9]. Many grains and tubers in Kenya are seasonal and require storage after harvest. Storage allows prolonged shelf life and minimizes food losses. Proper storage practices prevent cereal attack by rodents, insects and molds. Reducing moisture content in grains to equilibrium moisture content (EMC) controls fungal growth, seed germination and respiration [10,11]. Additionally, the level of aeration influences the growth of mold during storage therefore ideal storage facilities should ensure proper aeration for further drying. Heat and high humidity exacerbate the growth of aflatoxin – producing molds [9].

There is need for improved knowledge among community members on causes of food contamination and the appropriate food management practices in order to mitigate contamination and minimize their exposure to food contaminants like aflatoxins and prevent food losses. Several studies have assessed prevalence of aflatoxin contamination of various grains in many parts of Kenya using quantitative methods [12,13,14]. Knowledge, values, attitudes, beliefs and traditions are predictors of dietary behavior yet there are limited studies if any, that have focused on level of knowledge and awareness of aflatoxin contamination among communities in counties like Busia that have not reported aflatoxicosis outbreaks yet rely on many aflatoxin prone food crops [15,16,17]. Gaining an in-depth understanding of specific post-harvest practices from a community perspective is vital to informing appropriate and culturally acceptable strategies that address the aflatoxin contamination and exposure. A systematic review of studies on potential mitigation measures of aflatoxin in maize used for animal feed preparation, in Kenya by Njugi *et al.* [18] concluded that there were lower levels of awareness among the groups who were always responsible for crop management and preparation [18].

The study objective was to map out dietary staples, establish drivers of food choices, describe knowledge and perceptions on aflatoxin and post-harvest grain management practices and use among the communities in Busia County in order to guide future evidence-based aflatoxin prevention and public health interventions. In addition, the study aimed to triangulate with quantitative findings in the current study and explain the recently observed extensive contamination of aflatoxin in dietary staples in Busia County.

MATERIALS AND METHODS

This was a mixed methods study in which consumption of dietary staples was determined using the dietary diversity tool which was administered at household level while Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs) were used to explore community's cultural beliefs, perceptions and post-harvest practices and use of grains prone to aflatoxin contamination. The qualitative data collection tools utilized open-ended questions and follow-up probes to evoke responses that are explanatory in nature. Face-to-face semi-structured interviews were used to enable flexible in-depth exploration of the research questions.

Study setting and Study design

This study was conducted in three sub counties of Busia county namely Nambale, Bunyala and Teso South. Busia County has three major ethnic groups namely, the bantu, the nilotes and the nilo hamities. The County has two ports of entry with Uganda, in Busia and Malaba towns. The primary economic activities in Busia County are cash crop and subsistence farming, fish farming, trade in farm produce and artisanship. Most people in the county earn their living from farming, producing maize, cassava, sugarcane, millet, sorghum and rearing livestock and poultry [19]. Busia county is a major trading location that accounts for substantive trade between Kenya and Uganda. The county is approximately 1,695 km^2, 924km^2 of which is arable land and 10% is covered by Lake Victoria.

Study procedure

A dietary diversity tool was administered at household level and a series of semi-structured interviews and focus group discussions conducted within the study areas based on credibility, dependability and confirmability dimensions to ensure robustness of the study.

Household sampling and Participant selection

Following a multi-stage sampling to identify study sub-counties referenced elsewhere, households were selected using stratified systematic sampling [6]. The total number of households required was then divided by the sample size to get a sampling interval. Respondents to the dietary diversity questions were persons responsible for household food preparation. Key Informant Interview respondents were purposively selected among opinion leaders that would help elicit more information about the community. Potential KII participants were from the village leadership, health and agricultural sectors, both governmental and non-governmental. Respondents were chosen based on their role in the community, knowledge about community life and willingness to

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participate in in-depth interviews. Focus group discussion participants were drawn from the six villages already sampled in the household survey. Community focal points in the respective villages assisted with participant mobilization using criteria developed by the study team. Eligible participants were women aged ≥18 years and residing in the villages.

Data collection

Data were collected in June, 2018. A dietary diversity tool comprising of 21 food groups was used to determine foods that are routinely consumed in study households. Semi structured interview technique was used for KIIs. Focus group discussions comprised of 9-12 adult women and lasted for between 1 - 2 hours. FGDs were held with groups of women categorized into: 1) women aged 18≤35 years, and 2) women aged ≥36 years. Each participant was allocated a numerical identifier. Focus group discussions were conducted in community venues most convenient to participants while KIIs were conducted at meeting places of the participants' choice that ensured privacy and confidentiality for participants and investigators. With the participant's permission, interviews and FGDs were audio-recorded. Both KIIs and FGDs were captured by Olympus voice recorder.

Each FGD was led by a trained moderator using a guide with open-ended questions and probes. Semi-structured interview guides were used for KII in order to allow for systematic exploration of several aspects of food safety. The scope of the FGD discussions spanned around aspects of the community's diets, including sources, storage and food preparation practices, food safety, knowledge and awareness of aflatoxin, decontamination of grains and alternative uses of contaminated grains. The audio recordings were complemented by field notes in which non-verbal cues were recorded. All the interviews and discussions were transcribed verbatim by a transcriber with reference to a standardized transitional transcription protocol [20]. The data analysis team systematically reviewed the transcripts against the audio files for accuracy and clarifications provided by transcriber. The study moderators also reviewed the audio recordings, the original transcripts and the English versions of scripts for consistency. Data was cleaned and deidentified before analysis.

Data analysis

Mixed methods analysis was used for purposes of triangulation and complementarity where results from qualitative analysis were used to interpret, to enhance or clarify findings in the quantitative data analysis. Key concepts were identified using content analysis from the research protocol and a conceptual framework to organize the data was developed (Fig 1).

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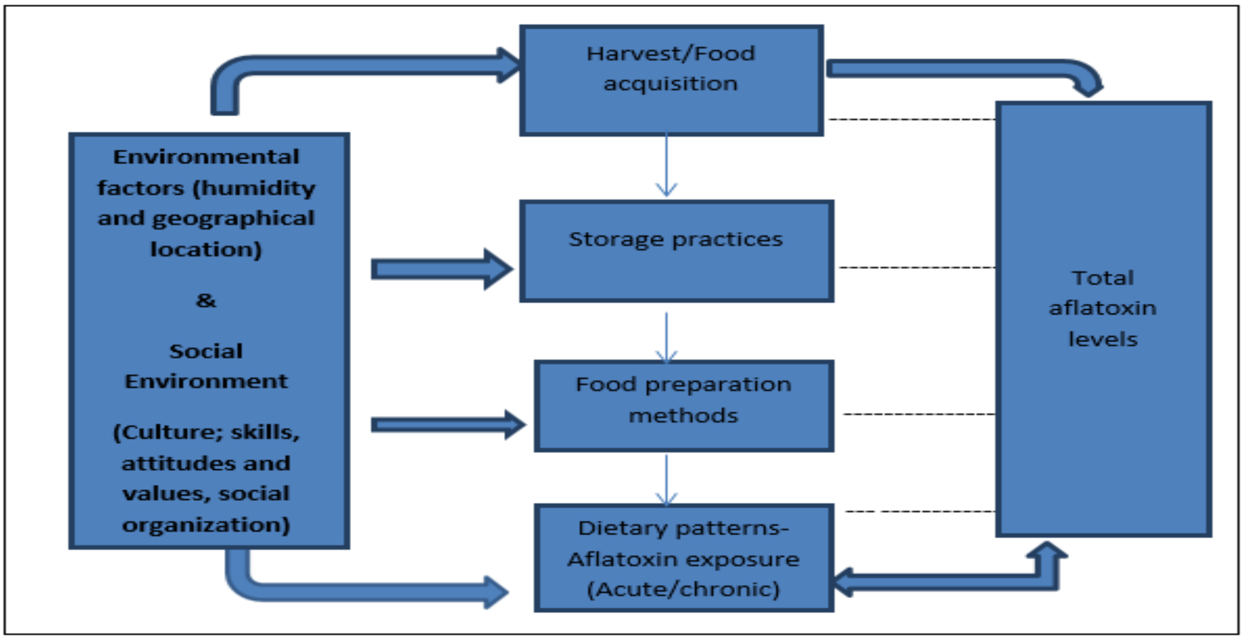

Figure 1: Conceptual framework of causal factors of aflatoxin contamination and human exposure
Source: Author

The analysis team reviewed, and coded transcripts then juxtaposed the codes against the domains incorporated in the interview protocol. An in-depth exploration and creation of additional categories to generate the code book, a summary encompassing all the concepts identified as primary and subsequent levels which were presented hierarchically. The experiences, perspectives and actions of participants were compared and contrasted by age and by location. A qualitative data management and analysis software (NVivo® Version 10, Burlington, M.A.) was used for coding and analysis. Triangulation strategy using two independent investigators (MO, AO) using the software to code the transcripts and inter-rater reliability done to compare the codes was used to ensure methodological rigor in the results [21,22]. The PI and one data analyst coded four interviews separately then interpreted the emerging key concepts and resolved any coding discrepancies. The inter-coder agreement was calculated and found a weighted Kappa coefficient that translated to an agreement of 77% of the data. To illustrate the findings, some verbatim quotes from the participants have been used. The results are reported by age sub-groups since there were some differences in some responses but with no regional differences. The quotes are labeled in terms of participants' specific age group affiliation (labelled either as $18 \leq 34$ *or* 35 and above) and their numerical identifier (P1, P2) shown as follows (P1, $18 \leq 34$; P2, 35 and above). An ellipsis (…) indicates omitted words or sentences. Findings are presented according to the analytical typologies.

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RESULTS AND DISCUSSION

Findings are presented according to the three analytical typologies explored: (i) Community diets and food choices; (ii) knowledge, perceptions and awareness of aflatoxin; and (iii) Food safety and human health.

Study population and demographics
Of the 469 persons aged 20 to 93 years who participated in the household survey, almost all were female (98%) and over half were from Teso South sub-county. Less than 50% had attained primary level education. Six FGDs that involved 60 women from six villages and 16 KIIs with seven female and nine male informants drawn from agriculture and health sectors were also conducted. Over half (55%) of the FGD participants were aged ≥35 years. The focus group discussion sessions ranged between 80 and 240 minutes with a median of 145 minutes per session (Tables 1 and 2).

Community diets and determinants of food choice
Grains, pulses, fish, dark green leafy vegetables, vitamin A rich fruits, condiments and seasoning and beverages were observed as the foods that were eaten routinely in this community. All respondents to question one (n=440) reported consuming grains prone to aflatoxin contamination. Majority of the respondents (93%) also consumed white roots and tubers and pulses. The least consumed foods across all three sub-counties were nuts and seeds (49%). Low frequency of consumption of nuts and seeds was noted in this study. This observation is corroborated by findings by Ebere *et al.* [23] in their study conducted in Amagoro Western Kenya, one of our study sites. In their study, which also adopted a mixed methods approach, they noted that community members consumed nuts and seeds less frequently when compared to cereals and roots. This could be as a result of unaffordability of the nuts as reported in another study by Cyriac *et al.* [24] that sought to examine availability and affordability of nutritious foods in Western Kenya. These scholars noted that for market sourced foods, nuts and seeds included, a family spent most on a meal that was nutritious and least on a meal that satisfied only energy requirements [24]. It is, therefore, possible that families, due to their constrained economic capabilities opted not to purchase nuts and seeds. In the current study, the least consumption of tubers and nuts was observed among respondents from Budalang'i (Table 3).

Maize, sorghum and millet are consumed as either "Ugali" a stiff porridge or porridge. "Ugali" was perceived to be the most important food as all FGD participants from all three sub-counties reported, with vegetables and 'Omena'- dagaa as common accompaniments.

> *"…the food that we like most is ugali from cassava, small portion of maize, that is ugali from cassava that sorghum has been added and others add millet, that`s the food that people like so much. …, if they eat ugali they feel as if they have eaten" (P2,* 35 and above*).*

Grains, white roots and tubers and nuts and seeds are prone to aflatoxin contamination with relative severity [25]. Indeed, aflatoxin was detected in all maize, sorghum, millet,

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cassava and groundnuts samples and participants reported consuming them very frequently [6]. These findings are indicative of pervasive contamination of the county's dietary staples during the time of this study which indicates that residents of Busia County are chronically exposed to aflatoxin through their dietary staples and are predisposed to effects of chronic aflatoxin exposure. This could also be a possible explanation of the reported 100% exposure to aflatoxin in a sero-survey among humans from this region of Kenya in 2007 [5].

Households' food choices depended on mainly availability of food. There was consensus among respondents on periodic food shortages due to poor weather conditions and natural calamities like floods as is in the case of Bunyala sub-county as illustrated by these quotes.

> *"There are times when we have long spells of drought, we experience some shortages of some types of foods, so it does affect us" (KI 2).*

> *"Often when it floods in this area (Budalang'i sub-county), our foods are swept away in the shamba,…"(P7,* $18 \leq 34$ *).*

Nutritional education provided to mothers and caregivers at the pre-natal clinics to promote the child's healthy growth and development also influenced food choices. Infants and young children under two years of age diets were either modified or enriched family foods. Mothers from Bunyala reported preparing their infants' gruels using special flour mixtures to ensure better nutrition as reported by an FGD participant:

> *"when we go to the hospital, like we mothers who attend post-natal clinic we are advised to fry groundnuts and soya then dry them after which we mix with millet and a bit of rice, sorghum and cassava. …" (P4, 18 ≤ 34).*

This observation is similar to findings reported from studies conducted in Kitui, Vihiga, Isiolo, Marsabit and Turkana counties where porridge, milk, rice, potatoes and ugali formed the culturally core infant and young children's food and in Bukoba, in Tanzania where infants and young children's diets were also influenced by societal staple diets and agricultural activities [26,27].

Food production capability which is dependent on access to productive land, financial capability for purchase of seed and hire of manpower and seasonality also influenced food choice. Dietary diversity was lowest in Budalang'i sub county. This could indicate limited crop production in Budalang'i or limited capacity to access varied foods. The more endowed a household was, the wider the food choices they had since they could purchase that which they had not cultivated.

Knowledge and awareness of aflatoxin

Most participants reported having knowledge of grain spoilage which they described as grains which were discolored or moldy and pest infested. The mold was locally referred to as "oluuku" in luhya, "pur" in dholuo and "Ausem"- Iteso. Residents attributed

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spoilage to poor storage practices and pest infestation. Most participants across the ages, identified storage of grains with high moisture levels as the main factor contributing to growth of molds on grains and spoilage. One participant said: *"If you put in the sacks when it`s still warm, it will create warmth and it causes moisture and presence of water will make it rot, because there is no place the air will escape" (P3,* 35 and above*).* Some participants also expressed concern about the groundnuts that are imported from Uganda and sold at the local market. *"Groundnuts from Uganda have caused a lot of problems. … they soak the groundnuts first to increase their weights before they bring to the market. When you buy them, you will notice that they have a yellow or green colour and they are not sweet" (*P8,35 and above).

However, when asked if they had heard of aflatoxin, almost all respondents across ages and across all study sites admitted to having limited knowledge and awareness of aflatoxins. The extent of awareness in the current study differed from that reported by Ndwiga and Marechera [16] in a study they conducted in Eastern Kenya, an area where aflatoxicosis is endemic. In their survey which targeted farmers randomly selected from four counties, they reported over 90% of participants having heard about aflatoxins [16]. However, these study findings corroborate those reported by Kang'ethe *et al.* [28] on the lower levels of knowledge about aflatoxin among women in Kenya and Malaysia [29,28]. Kang'ethe and Langa [29] compared the levels of knowledge between men and women in Eldoret, Machakos and Nyeri and found that only 40% of the women participants were knowledgeable while Sabran *et al.* [28] investigated determinants of adults' knowledge on fungal and aflatoxin contamination of diets. The later study observed positive and significant correlation between total score of knowledge on fungal and aflatoxin contamination. While these mentioned studies were surveys, the current study employed mixed methods.

One government officer, who seemed knowledgeable was also not certain whether aflatoxin was as a result of bacteria or fungal infection as he noted *"… first, for us the food that are easily… will I say that are attacked by the bacteria that causes aflatoxin, may be maize, maybe it is not well dried…. We have the ground nuts, if it is processed and not consumed at the right time and all that" (KI 4).* He attributed the lack of knowledge of aflatoxin by community members to the lack of sensitization through campaigns by the ministry and not having suffered from acute aflatoxicosis.

Local perceptions on grain contamination

That only discolored grains were spoilt. Limited knowledge of grain contamination by aflatoxin but high awareness of causes of grain spoilage was noted among participants. While study participants could visually identify spoilt grains, they were not aware that seemingly clean grains could be colonized by aflatoxin. Though the ministry of agriculture (MoA) officer knew that visual detection of aflatoxin was not possible, the study participants were not aware that seemingly clean grains would be aflatoxin contaminated. Participants associated spoilage with discoloration and bitter taste of flour contrary to findings reported by various investigators who have shown that aflatoxin detection was only possible by using laboratory methods [30]. While discoloration of grains would be an indicator of fungal growth, not all fungi produce toxins [11]. Conditions that affect toxin production have been reported to include fungal strains and the genera of fungi most implicated is *Aspergillus* [31]. Lack of knowledge of mycotoxin contamination has also been reported in parts of West Africa while existing knowledge gaps on causes of mycotoxins to health implications of exposure to mycotoxins in South Africa have been cited [32,33]. Adekoya *et al.* [32], in their study in Nigeria found that up to 98% of fermented food traders were unaware of mycotoxin contamination.

Participants attributed grain spoilage to lack of proper drying facilities, storage of grains while damp or storage of warm grains in air- tight containers. These findings are consistent with findings by Hell and Mutegi who also reported that the higher the moisture content in the grains the higher the chances of aflatoxin colonization [34].

That additional drying and washing of grains decontaminates grains. When asked about what they did with the spoilt grains, all respondents from the younger age category reported to further sun-drying the grains while others reported mixing spoilt grains with seemingly good grains for improved palatability and minimize impact on health. Others reported washing the spoilt grain as a means of cleansing them and making them fit for human consumption. However, these respondents also noted that it was a challenging exercise since the discoloration was not completely eliminated as noted by one participant *"I washed it, people gave me advice to wash so that the colour can be removed, I tried but it became difficult, then I decide to get other maize and added to the discolored one then I milled"* (*P4,* $18 \leq 34$*).* Washing contaminated grains or solar drying have been demonstrated not to be efficacious in aflatoxin removal or decontamination because aflatoxins are very slightly soluble in water and melts at very high temperatures [35].

That there are alternative uses of spoilt grains. Community members demonstrated limited knowledge on the aflatoxin pathways to humans as they used spoilt grain in feeding chicken, making animal feed and local brew. This finding suggests that residents of Busia county might be exposed to aflatoxins either directly through consumption of contaminated grains or indirectly through animal products like eggs and milk. These findings are comparable to those from Nandi and Makueni counties [13]. Studies in Kenya's Eldoret, Machakos and Nyeri by Kang'ethe & Langa [18,29], reported contamination of animal feed and milk. Kang'ethe & Langa [29]also reported only 68% of the participants did not know how animals got aflatoxin and only 33% had heard of aflatoxin in milk. Alternative uses of contaminated grains predispose humans to further exposure to aflatoxin by ingestion of metabolites M_1 found in milk and eggs. Some participants reported *"…Selling to people who brew alcohol" (P7,* $18 \leq 34$*).* The local brew is locally known as "changaa" or "busaa". They believe that the most molded grain makes the finest brew. While these findings should be interpreted with caution, this lack of awareness could have contributed to the extensive aflatoxin exposure that was reported in the aflatoxin serology from Busia county in 2007, an indicator of chronic exposure in the region [5].

Notably, all the spoilt maize that was sold for pig food was milled at the common village mills raising risk for cross contamination. The lack of vigilance by the processors was also noted by one key informant who noted that *"Majority of the food* *processors in the County are not well capacity built and lack the appropriate equipment to test for Aflatoxin and therefore contamination here begins from the raw materials used throughout the processing line to the end product. In the processing line, hygiene is usually an issue, the machines are not well cleaned and this contributes to the end product contamination* (KI 5)

Food safety and human health

Food is considered safe if it does not cause harm to the consumer. Sub-standard food safety conditions were largely attributed to poor post-harvest food handling practices. Use of tarmac roads and sun drying directly on the ground and storage of food in poorly aerated containers were identified as poor practices. One key informant noted an increase in non-communicable diseases in the county and said *"diarrhea is one of the top five health problems in the county. I attribute this to poor food hygiene and safety conditions" (KI 7)* while another pointed out an increase in cancer cases *"we have noted an increase of cancer in the local population. We are seeing a lot of esophageal cancer cases... (KI 6).* Negative health events were also associated with the use of chemicals, both pesticides and herbicides on the farm and in food preservation. One participant observed *"Long time ago there used not to be diseases like cancer. Cancers are caused by the chemicals sprayed on the crops and used for preserving"* (P2, *35 and above).* Chronic aflatoxin exposure in humans has been linked to hepatocellular carcinoma [36,37]. In their assessment that sought to determine the global burden of hepatocellular carcinoma attributable to aflatoxin exposure, Liu *et al.* [36]found that about 25,200 to 155,000 of the 550,000 to 600,000 new hepatocellular carcinoma cases were found to be attributable to aflatoxin exposure.

Participants shared their treatment choices to health events following consumption of sub-standard food. While some sort medical attention, others resorted to self – medication; *"We just use flagyl* (P3, *18 ≤ 34)* or home-made remedies like herbs or just drinking salted water. Some believed that they had been bewitched so they opted for unconventional practices as one participant from Teso South noted "*You use a broom to hit your stomach and it cools*" (P9, *18 ≤ 34).* Aflatoxicosis has currently no cure thus culturally acceptable and inexpensive aflatoxin reduction interventions are recommended.

Aflatoxin ingestion has been associated with decreased micronutrient levels in children and can impair child growth [38]. Aflatoxin exposure has also been found to be significantly correlated with wasting in children under three years of age [39] and to stunting [40]. One key informant reported that *"…stunting rate is at 19.8% in Busia county, … like last year December we had very many cases of wasted children… then you find most of them are malnourished"* (KI 3). Chronic aflatoxin exposure in humans has been linked to hepatocellular carcinoma [36], impaired immunity (Jiang 2005) and stunted growth among children [40].

Nevertheless, there are some important limitations. These study findings are not generalizable to other counties in Kenya. However, they are indicators of the general levels of awareness of food safety situation and specifically of aflatoxin in the county.

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In addition, there might be some implicit and unarticulated knowledge, beliefs and practices that are not reflected in these results.

CONCLUSION

Food safety is a necessary condition to attainment of food security. The importance of dietary staples such as maize and sorghum flours commonly used in diets of both young children and adults in the study areas cannot be gainsaid. However, their nutritional value can be compromised by aflatoxin colonization and contamination. It is now evident that maize, sorghum and cassava are the main dietary staples in this community. Findings revealed limited awareness among community members on aflatoxin contamination of food and the various pathways for human exposure to aflatoxin. It was also apparent that appropriate disposal methods of aflatoxin contaminated food were not known as contaminated food was being fed to domestic poultry and animals. This being a community that practices subsistence farming, consumption of unmonitored food is in no doubt. There is need to contain levels of aflatoxin within in maximum tolerable levels. While it is not feasible to monitor all household foods, it is possible to educate the household members on proper food handling practices that help mitigate aflatoxin contamination. It is, therefore, imperative to create awareness among farmers and retailers on pre- and post-harvest handling practices and causes of aflatoxin occurrence and health implications, with the objective of encouraging voluntary compliance to public health regulations and improved food handling practices. Farmers have to be educated on how to identify visibly damaged and moldy grains, shown how to successfully determine fully dried grains and how to store the grains. Education on proper disposal or alternative use of contaminated grains would also be needed in order to protect residents from being exposed to this carcinogenic toxin. The government should use these findings to guide risk communication on aflatoxin contamination, exposure and associated health risks. This would require public health officers and agricultural extension workers to provide the information at both farm and market levels.

DECLARATIONS

Ethics approval and consent to participate

Ethical approval for this study protocol (KNH_UON ERC protocol # P720/11/2015) was obtained from the Kenyatta National Hospital-University of Nairobi Ethical Review Committee (Ref: KNH-ERC/A/114). In addition, a research permit was obtained from the National Commission of Science Technology and Innovation (NACOSTI) # NACOSTI/P/17/23914/20543 to conduct research in Busia County. Consent was obtained from FGD participants at the time of the group discussion while Key informants provided consent days before the interview. Written consent was obtained in Swahili. For illiterate participants, consent was given by use of a thumbprint and the witness verified with his or her signature.

Consent for publication

Not applicable

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Availability for data and materials
The dataset used during the current study is available from the corresponding author on request.

Competing interests
The authors declare no potential conflict of interest with respect to the research.

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Authors' contributions
AOA conceived and designed the study, collected data, analyzed data, interpreted the results and authored the manuscript. FMT designed and interpreted the results. SO performed the laboratory tests on food samples and interpreted the results. All authors read and approved the final manuscript.

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Table 1: Demographic characteristics of study participants by sub-county, Busia County, 2018

Characteristics		**Budalang'i n (%)**	**Nambale n (%)**	**Teso-South n (%)**	**Total N (%)**
		108	136	225	469
Sex	Female	101(93.5)	134(98.5)	222(98.7)	457(97.4)
	Male	7(6.5)	2(1.5)	3(1.3)	12(2.6)
Age	Median	50.5	40	42	43
	Range	[21, 90]	[20, 85]	[20, 93]	[20, 93]
Ethnicity	Bantu	105(97.2)	114(83.8)	36(16)	255(54.4)
	Nilotes	3(2.8)	4(2.9)	36(16)	43(9.2)
	Nilo-Hamites	0(0)	18(13.2)	153(68)	171(36.5)
Education Level*	Pre-primary	73(67.6)	74(54.4)	140(62.2)	287(61.2)
	Primary	21(19.4)	44(32.4)	62(27.6)	127(27.1)
	Secondary	4(3.7)	13(9.6)	19(8.4)	36(7.7)
	College and above	1(0.9)	4(2.9)	2(0.9)	7(1.5)
	Refused	9(8.3)	1(0.7)	2(0.9)	12(2.6)
Household Members	Median	5	6	6	6
	Range	[1, 10]	[2, 13]	[1, 13]	[1, 13]

** Level of education completed by the respondent*

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Table 2: Demographics of the Focus Group Discussion participants and Key Informants /respondents in Busia County

Sub-County	Sub-location	Village	Age-group	No. of participants
Budalang'i	Magombe East	Buyuku Idokho	18 ≤ 34	8
Budalang'i	Magombe East	Khuriaka	35 and above	12
Nambale	Buyofu	Buyofu A	18 ≤ 34	10
Nambale	Buyofu	Elwanikha A	35 and above	11
Teso South	Amukura	Alelesi	35 and above	10
Teso South	Okiludu	Okiludu	18 ≤ 34	9
Total				**60**
Key Informant	**Sector**	**Designation**	**Gender**	
KI 1	Health	Community Health Volunteer	Female	
KI 2	Health	Community Health Unit Chair	Male	
KI 3	NGO - FHI360	County Nutrition Coordinator	Female	
KI 4	Ministry of Agriculture	County Agri-Nutrition Coordinator	Male	
KI 5	Agriculture	Food technologist	Female	
KI 6	Health	Director of Health	Female	
KI 7	Health	Public Health Officer	Male	
KI 8	Community	Village elder – Nambale	Male	
KI 9	Community	Village elder - Nambale	Male	
KI 10	Community	Village elder - Budalang'i	Male	
KI 11	Community	Village elder - Budalang'i	Male	
KI 12	Community	Village elder – Teso South	Male	
KI 13	Community	Village elder – Teso South	Male	
KI 14	Community	Women group leader - Nambale	Female	
KI 15	Community	Women group leader - Budalang'i	Female	
KI 16	Community	Women group leader – Teso South	Female	

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Table 3: Household dietary diversity in Busia County, Kenya

Food group	Nambale Households % (n)	Budalang'i Households % (n)	Teso-South Households % (n)	Total Households % (n)
Food Group1 (Food from Grains)	100 (n=122)	100 (n=104)	100 (n=214)	100 (n=440)
Food Group2 (White Roots, Tubers & plantains)	93 (n=122)	81 (n=104)	97 (n=214)	92 (n=440)
Food Group3 Pulses	95 (n=122)	83 (n=104)	98 (n=214)	93 (n=440)
Food Group4 Nuts & Seeds	46 (n=122)	23 (n=104)	63 (n=210)	49 (n=436)
Food Group5 Milk & Milk Products	89 (n=122)	62 (n=104)	96 (n=214)	86 (n=440)
Food Group6 Organ Meat	57 (n=122)	30 (n=104)	74 (n=214)	59 (n=440)
Food Group7 Meat and Poultry	93 (n=121)	74 (n=104)	95 (n=213)	89 (n=438)
Food Group8 Fish & Seafood	93 (n=122)	83 (n=104)	99 (n=212)	93 (n=438)
Food Group9 Eggs	90 (n=122)	65 (n=104)	94 (n=212)	86 (n=438)
Food Group10 Dark green Leafy Vegetables	99 (n=122)	88 (n=104)	99 (n=212)	96 (n=438)
Food Group11 Vitamin-A rich veges/roots/tubers	92 (n=122)	73 (n=104)	96 (n=212)	89 (n=438)
Food Group12 Vitamin-A rich fruits	97 (n=122)	89 (n=104)	100 (n=211)	97 (n=437)
Food Group13 Other veges	98 (n=122)	93 (n=104)	100 (n=211)	98 (n=437)
Food Group14 Other fruits	84 (n=122)	71 (n=104)	91 (n=211)	84 (n=437)
Food Group15 Insects and other small protein foods	70 (n=122)	33 (n=103)	74 (n=210)	63 (n=435)
Food Group16 Other Oils & Fats	83 (n=120)	71 (n=80)	77 (n=206)	77 (n=406)
Food Group17 Savoury & Fried Snacks	92 (n=122)	59 (n=83)	93 (n=209)	86 (n=414
Food Group18 Sweets	59 (n=122)	18 (n=83)	74 (n=209)	58 (n=414)
Food Group19 Sugar-Sweetened Beverages	86 (n=122)	41 (n=83)	90 (n=209)	79 (n=414)
Food Group20 Condiments & Seasonings	100 (n=122)	95 (n=83)	100 (n=207)	99 (n=412)
Food Group21 Other Beverages & Foods	98 (n=122)	95 (n=83)	99 (n=204)	98 (n=409)

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