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Research Article

Exposure of infants to fumonisins in maize-based complementary foods in rural Tanzania

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Feeding children with maize may expose them to fumonisins (FBs). This study assessed FB exposure for infants consuming maize in Tanzania by modeling maize consumption data (kg/kg body weight (bw)/day) with previously collected total FB contamination (μg/kg) patterns for sorted and unsorted maize harvested in 2005 and 2006. Consumption was estimated by twice conducting a 24 h dietary recall for 254 infants. The exposure assessment was performed with the @RISK analysis software. Of the infants, 89% consumed maize from 2.37 to 158 g/person/day (mean; 43 g/person/day ± 28). Based on the contamination for sorted maize; in 2005, the percentage of infants with FB exposures above the provisional maximum tolerable daily intake (PMTDI) of 2 μg/kg (bw) (26% (95% confidence interval (CI); 23 – 30)) was significantly higher than the level of 3% (90% CI; 2 – 12) in 2006. Pooling the datasets for sorted maize from the two seasons resulted in a seemingly more representative risk (10% (95% CI; 6 – 17)) of exceeding the PMTDI. However, infants who might have consumed unsorted maize would still be at a significantly higher risk (24% (95% CI; 15 – 34)) of exceeding the PMTDI. Sorting and other good maize management practices should be advocated to farmers in order to minimize FB exposure in rural areas.

Keywords: Exposure / Fumonisins / Maize-based complementary foods / Rural / Tanzania

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1 Introduction

Mothers in Tanzania, as in other African countries [1 – 3], use thin maize porridge as complementary food for their children. Complementary foods are the nonhuman-milk food-based sources of nutrients that are offered during the complementary feeding period [4]. Complementary feeding is the process starting when breast milk alone is no longer sufficient to meet the nutritional requirements of infants and therefore other foods and liquids are needed along with breast milk [4]. In addition to being bulky and containing low levels of bioavailable micronutrients (*e.g.* iron and zinc), maize-based complementary foods often contain considerable levels of fumonisins (FB) [5, 6]. FBs have relatively high prevalence in home grown maize in tropical and subtropical countries [7]. Dietary exposure to FBs has been linked to high incidences of oesophageal cancer observed in Transkei in South Africa [8, 9], North East Italy [10], China [11, 12] and Iran [13]. Studies in animals demonstrate that FB_1 causes liver cancer in male BD IX rats and female B6C3F1 mice and kidney cancer in male Fischer 344 rats [14]. Primarily, FB_1 inhibits the activity of ceramide synthase in the body resulting in accumulation of sphingoid bases and sphingoid base metabolites, thereby leading to the depletion of more complex sphingolipids [14]. The depletion of sphingolipids inhibits folate uptake leading to an intracellular deficiency in this vitamin [15]. Folate defi-

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Abbreviations: bw, body weight; **CI**, confidence interval; **FB,** fumonisin; **JECFA,** Joint FAO/WHO Expert Committee on Food Additives; **PMTDI,** provisional maximum tolerable daily intake ciency during the first trimester of pregnancy is associated with an increased risk of neural tube defects [15, 16].

Based on the available information, the International Agency for Research on Cancer (IARC) evaluated FB_1 as a group 2B carcinogen; possibly carcinogenic to humans [14]. The Joint FAO/WHO Expert Committee on Food additives (JECFA) recommended a provisional maximum tolerable daily intake (PMTDI) of 2 µg/kg body weight (bw)/day for FBs [17]. Other studies show that like other mycotoxins [17, 18], FB_1 can be immunosuppressive. Oswald *et al.* [19] reported that, compared to a control group, pigs that ingested 0.5 mg of FB_1/kg bw/day had significantly increased extra-intestinal pathogenic *Escherichia coli* colonization of the small and large intestines, a situation that is commonly observed in pigs when the immune system is compromised. In another study, Halloy *et al.* [20] observed that exposure of pigs to FB_1 and a bacterium, *Pasteurella multocida*, reduced the growth rate of the animals, and induced coughing and extended lesions of subacute interstitial pneumonia.

Available data show presence of FBs in home grown maize in Tanzania. Doko *et al.* [21] reported FB levels up to 225 µg/kg in maize from Tanzania. Recently, Kimanya *et al.* [22, 23] reported that 52% of samples of maize which were collected from the 2005 harvest in four main maize producing regions of Tanzania, namely Tabora, Iringa, Ruvuma and Kilimanjaro, contained FBs at levels up to 11 048 µg/kg. According to the study, contamination was specifically high in samples from the Kilimanjaro region where 7 of 30 samples contained more than 4000 µg/kg; double the maximum level of FBs allowed in unprocessed maize for human consumption in the EU member states [24]. The same study also revealed that in contrast to people in the other regions, people in Kilimanjaro consume whole maize which may contain more FBs than dehulled maize. It has been reported that dehulling removes most of the toxins in the bran and germ fractions [25]. In a follow-up study of FBs in the 2006 home grown maize in Kilimanjaro, Kimanya [26] found FB levels up to 21 667 µg/kg in samples of freshly harvested maize collected before sorting and 1758 µg/kg in the same stocks of maize after they had been sorted and stored for 5 months. Consequently, adults and children in the rural areas of Kilimanjaro consuming maize as a staple food are at a risk of exposure to unacceptably high levels of FBs. Due to their relatively higher energy needs compared to adults, FB exposure in children consuming maize-based complementary foods would be higher than in adults [27]. The risk of exposure to unacceptable levels would be relatively higher in poverty stricken households who may consume unsorted maize. Jolly *et al.* [28] reported that more than 23% of the participants in a study of determinants of aflatoxin levels in maize consumed unsorted maize. It is imperative to quantify this exposure in order to provide a scientific basis for strategies to reduce FB contamination in maize and maize-based complementary foods. This study assessed the exposure to fumonsin in maize used as complementary foods in Tanzania by estimating maize meal consumption among infants in Rombo district of Kilimanjaro and combining the consumption data with the FB contamination data previously collected by Kimanya *et al.* [22, 23] for the 2005 and Kimanya [26] for the 2006 maize harvests.

2 Materials and methods

2.1 Study area

The study was conducted in Rombo district in Kilimanjaro region of Tanzania. In this district small-scale cultivation of maize, coffee, banana, potatoes, kidney beans, finger millet and cassava are the primary sources of food and income. The district was chosen for this study based on the outcome of a preliminary survey of FBs in maize in Tanzania which showed that maize from the district had higher total FBs ($FB_1 + FB_2$) contamination varying from 65 to 11 048 µg/kg compared to maize from the other surveyed districts which contained total FB levels ranging from 61 to 3560 µg/kg [22, 23].

2.2 Recruitment of infants

From July to September 2006, infants aged 6 months were progressively recruited from the register of births in seven reproductive child health clinics in Tarakea division of Rombo district. Infants of 6 months of age were identified using their registration number and date of birth. In Tanzania, all infants born in clinics are registered soon after birth. In case of home deliveries, registration is done on the day the child is taken to the clinic for immunization. On registration, each child is allocated a registration number and the child's particulars including date and place of birth recorded. According to the records of the Rombo district authorities, in the year 2002 the population for Tarakea division was 56 370 and children under 1 year of age were 4% of the population. Based on these data about 564 infants of 6 – 8 months of age would have been available for recruitment.

2.3 Complementary food survey

A food intake survey was conducted in September 2006 to estimate the quantity of maize consumed by the infants. Data collection took place about 3 months after the maize was harvested in the district. A 24 h dietary recall technique was used to estimate consumption of complementary food by the infants. Two visits at an interval of 1 – 2 weeks were made to the home of each of the infants. Information about type and quantity of food, ingredients or recipes (such as maize or mixed meal, water, oil, butter and others) used in the preparation of the maize-based complementary food and frequency of feeding for the food were collected using a questionnaire that was previously used by other researchers [1] for communities in Tanzania which have food consumption habits similar to the community we studied. Each mother was requested to show the quantity of food that the child consumed the previous day, during each feeding. The mother was requested to estimate the amount of prepared food given to the child by using water in the cup or bowl that is normally used in feeding the child. The water was transferred to a graduated feeding bottle and the quantity of water recorded as amount of food the child consumed during each feeding. No attempt was made to estimate any spilled food. Each ingredient used in preparation of the complementary food was directly estimated by using household measures such as a bowl, cup or spoon which is normally used in measuring the particular ingredient. The amount of maize flour (meal) used in the preparation of the complementary food was transferred to a khaki paper bag, sealed and then transported to the Tanzanian Food and Drugs Authority laboratory where its weight was measured and recorded. The food intake data were entered and processed in a Microsoft Access-based food intake database. With the software the amount of maize meal consumed by an infant *per* day was calculated. Based on amounts calculated for each of the two 24 h recalls, an average amount of maize meal consumed by each infant *per* day was derived. The average daily maize intake (kg/kg bw/day) for each infant was calculated by dividing the child's daily maize intake (kg/day) by his/her most recent bw, at the time of the complementary food survey, which was obtained from his/her monthly records of bw in his/her clinic card.

2.4 Ethical considerations

The survey was conducted by trained nutritionists in collaboration with resident nurses. With the help of village executive officers, the interviewers conducted informal meetings with mothers of the eligible infants at the seven clinics in Tarakea division of Rombo district. During the meetings, the objective of the research, use of the results, benefits of the research to them and the procedure used to select them was explained and their formal consent sought. Mothers were also provided with written forms containing the same information. Each mother who consented to the study signed a form of consent prepared for that purpose. For the mothers who could not read and write, the resident nurse read the consent form and asked them for their verbal consent. For those mothers who gave their verbal consent, the local nurse wrote her/his name on the consent form and signed on it as a witness. The protocol for this study was reviewed and approved by the ethics committees of the National Institute of Medical Research in Tanzania and Ghent University in Belgium.

2.5 Probabilistic exposure assessment and risk characterization

The FB exposure (μg/kg bw/day) was modelled by multiplying maize meal consumption data (kg/kg bw/day) with total FBs ($FB_1 + FB_2$) contamination data (μg/kg). In order to evaluate different scenarios of exposure, different total FBs contamination patterns were used. These were:

(i) Total FBs contamination distribution as determined in samples of sorted maize that were drawn from the 2005 maize harvest in household storage facilities [22, 23]. FB content in 52% of the samples ranged from 65 to 11 048 μg/kg.

(ii) Total FB contamination distribution as determined in samples of sorted maize that was drawn from the 2006 maize harvest in household storage facilities [26]. FB content in 12% of the samples ranged from 24 to 1758 μg/kg.

(iii) Pooled total FB distributions as described in "(i)" and "(ii)" above.

(iv) Total FB contamination distribution as determined in samples of unsorted maize that were drawn from stocks of freshly harvested maize in 2006 [26]. FB content in 63% of the unsorted maize samples ranged from 94 to 21 667 μg/kg.

For all the scenarios, values of FB_1 or FB_2 below the LOD were replaced by the LOD value of 19.4 μg/kg divided by two [29, 30]. The probabilistic exposure assessment was performed with the @RISK analysis software; (@RISK 4.5.5 professional edition, Palisade, UK). The variability of the maize meal consumption and contamination values was described by a nonparametric, discrete uniform (RiskDunifrom) distribution ensuring that all values had same probability of occurrence. To characterize the uncertainty for the estimated values the food consumption and contamination distribution data were resampled (bootstrapped) for up to 500 times using the nonparametric approach. Then, second-order Monte Carlo simulation was performed for propagation of the variability and uncertainty for the values. The simulation had 500 iterations to account for the variability in the maize consumption and contamination data as the inner loop and 500 iterations to describe the outer loop for the confidence interval (CI) determination. In this case, 250 000 (500 × 500) iterations were carried out.

2.6 Statistical analysis of data

The statistical package used was Stata version 9 (Stata 9.0; Statacorp, Texas, USA). Data were transformed to normality using lnskew0 commands, in case of severe departure from normality. A standard *t*-test was used to compare means of continuous variables. The α error was set at 5% and all tests were two-sided. Microsoft Excel functions were used to determine probabilities of exposure and the 95% CI.

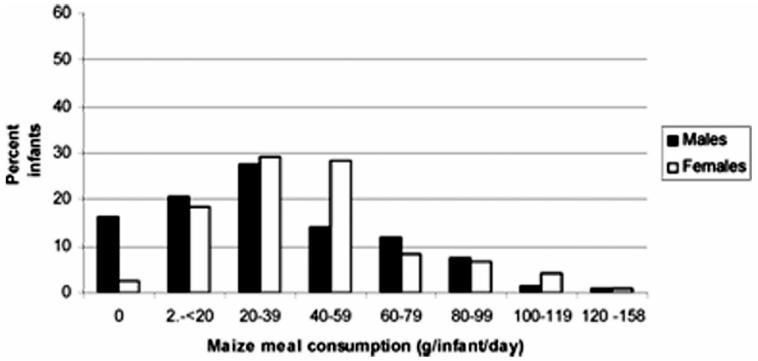

Figure 1. Distribution of infants consuming maize at different amounts *per* infant *per* day by sex.

3 Results

3.1 Study subjects and recruitment

According to records with health clinics in Rombo, 273 (48%) out of the expected 563 infants aged 6–8 months were available for enrolment. Food consumption data were obtained for 254 (93% of the 273 eligible) infants, 47% of whom were females. The mothers of three infants did not consent to participate in the study. The mothers of three other infants gave their formal consent but changed their minds afterwards, before the start of the food consumption survey. The homes of six other infants were located on the slopes of Mount Kilimanjaro which could not be easily reached. The mothers of seven infants were not found at home, despite having received information in advance on the planned visit.

3.2 Extent of use of maize as complementary food

Figure 1 shows the distribution of maize meal consumption by sex as generated by this study. Two hundred and fifty-four infants aged 6–8 months with average bws of 7.9 kg ± 1.04 participated in the food consumption survey. Eighty nine percent of the infants consumed maize meal during the survey period with an average *per* capita consumption level of 43 g/day ± 28 (range; 2.37–158 g/day). Of the infants who did not consume maize meal, 78% were males. The average *per* capita maize meal consumption among females (44 g/day ± 28) was not significantly higher than the *per* capita consumption of 35 g/day ± 35 among males ($p = 0.29$). Nine (4%) of the 254 infants consumed more than 100 g of maize meal *per* infant *per* day and one of the infants consumed as much as 158 g/day.

3.3 Probable fumonisin intake

Table 1 compares the probabilities of exceeding the PMTDI level of FBs and the mean FB exposures between two seasons of 2005 and 2006. It was estimated that in 2005, 26% (95% CI; 23–30) of the infants exceeded the PMTDI of 2 μg/kg bw/day set by the JECFA. A significantly lower percentage of 3% (95% CI; 2–12)] was estimated for the infants who consumed maize in 2006. The 50th percentile consumers of the 2005 maize were exposed to a FB level of 0.47 μg/kg bw/day) (95% CI; 0.41–0.54). FB exposure in the 50th percentile consumers of the 2006 maize was 0.10 μg/kg bw/day (95% CI; 0.09–0.23). At all the percentiles shown in Table 1, the FB exposure levels in 2006 were significantly lower than the exposure levels in 2005.

On the basis of the pooled contamination data for maize from the two seasons of 2005 and 2006, the probability of exceeding the PMTDI value was 10% and mean FB exposure in the 50th percentile consumers was 0.14 μg/kg bw/day (95% CI; 0.11–0.20). As shown in Table 1, the probability of exceeding the PMTDI as determined by using the pooled dataset (10%) was significantly lower than the probability (26%) of exceeding the tolerable level in 2005, but insignificantly higher than the probability (3%) of exceeding the tolerable level in 2006. At all percentiles shown, the FB exposure levels estimated by using the pooled dataset were significantly lower than the respective levels estimated by using the 2005 dataset. The comparison further shows that the FB exposure levels were considerably, but not significantly, higher than the respective levels estimated by using the 2006 contamination dataset.

Table 2 shows the comparison of probabilities of exceeding the PMTDI and mean fumonsin exposures between infants who might have consumed the unsorted freshly harvested maize in 2006 and those who consumed the sorted and stored maize in the same year. It was estimated that 24% (95% CI; 15–34) of infants who might have consumed unsorted maize in 2006 were exposed to FB levels above the PMTDI level of 2 μg/kg bw/day. The probability (24%) of exceeding the PMTDI level of 2 μg/kg bw/day on consumption of unsorted maize in 2006 was significantly higher than the probability (3%; also shown in Table 1) of exceeding the tolerable level on consumption of sorted maize in the same year. The 90th percentile consumers of the unsorted freshly harvested maize were exposed to a total FB level of 8.87 μg/kg bw/day (95% CI; 3.95–17.74); an exposure level that is significantly higher than the value of 0.28 μg/kg bw/day (95% CI; 0.22–2.39) estimated for

Table 1. FB exposure at different percentiles, based on the contamination patterns for sorted maize from the 2005 and 2006 maize seasons

Season (Year)	Range contamination (μg/kg bw/day)	Probability of exceeding PMTDI (mean and 95% CI)	FB exposure (μg/kg bw/day) at different percentile consumers (mean and 95% CI)			
			50th Percentile	75th Percentile	90th Percentile	97th Percentile
2005	50–11 048[a)]	26^{A} (23–30)	0.47^{A} (0.41–0.54)	2.14^{A} (1.55–2.84)	9.09^{A} (6.56–14.20)	36.99^{A} (21.86–72.15)
2006	19–1758[b)]	3^{B} (2–12)	0.15^{B} (0.14–0.19)	0.24^{B} (0.23–0.66)	0.39^{B} (0.35–2.25)	2.06^{B} (1.03–8.31)
2005 and 2006	19–11 048[c)]	10^{B} (6–17)	0.14^{B} (0.11–0.20)	0.31^{B} (0.22–0.55)	1.89^{B} (0.55–5.86)	10.77^{B} (3.89–38.84)

Minimum contamination values were obtained by replacing contamination below LOD by LOD value of 19.4 mg/kg divided by 2 for each of FB B_1 and B_2; Values followed by the same superscript letter along the same column are not significantly different at 95% confidence limit.

a) Contamination data for sorted maize from 2005 season – scenario (1).
b) Contamination data for sorted maize from 2006 season – scenario (2).
c) Mixture of the contamination data for sorted maize from the 2005 and 2006 seasons – scenario (3).

Table 2. FB exposure at different percentiles, based on the contamination patterns for unsorted and sorted maize from the 2006 season

Range contamination (μg/kg bw/day)	Attribute (sorted/ unsorted)	Probability of exceeding PMTDI (mean and 90% CI)	FB exposure (μg/kg bw/day) at different percentile consumers (mean and 95% CI)			
			50th percentile	75th percentile	90th percentile	97th percentile
19–21 666[a)]	Unsorted	24^{A} (15–34)	0.17^{A} (0.12–0.21)	1.74^{A} (0.25–4.59)	8.87^{A} (3.95–17.74)	36.80^{A} (10.18–144.29)
19–1758[b)]	Sorted	3^{B} (1–12)	0.11^{B} (0.09–0.23)	0.17^{B} (0.14–0.80)	0.28^{B} (0.22–2.39)	1.99^{B} (0.32–12.54)

Minimum contamination values were obtained by replacing contamination below LOD by LOD value of 19.4 μg/kg divided by 2 for each of FB B_1 and B_2; Values followed by the same superscript letter along the same column are not significantly different at 95% confidence limit.

a) Contamination data for unsorted maize from the 2006 season – scenario (4).
b) Contamination data for sorted and stored maize from 2006 season – scenario (2).

infants who consumed the maize after had been sorted and stored for 5 months. The relationship between FB exposure for infants who consumed the unsorted maize in the year 2006 and their counterparts who consumed the same maize after it had been sorted is demonstrated in Fig. 2.

4 Discussion

This is the first study to show that infants consuming maize-based complementary foods in Tanzania are at a high risk of exposure to FB levels above the PMTDI of 2 μg/kg bw/day. It is also the first study to report quantity of maize in complementary food in Tanzania. The daily *per* capita intake of maize was high; 4% of the infants consumed maize at levels above 100 g of maize *per* person *per* day. The high daily *per* capita maize intake contributed in the high probability of exposures to FBs levels above the PMTDI value of 2 μg/kg bw/day. This high rate of maize intake is likely to decrease with age of the infants. Records of complementary food consumption in Tanzania indicate that from 9 to 10 months, the variety of foods fed to breastfeeding children expands. Although foods made from grains are still the most common foods some children start receiving other foods including fruits and vegetables, other milk products, meat, fish and poultry [31].

The study reveals that the extent and risk of exceeding the PMTDI varies from season to season according to seasonal changes in FB contamination of maize. The mean exposure level in 2006 was 21% of the exposure in 2005, corresponding well with the difference in contamination pattern between the two seasons. Mean FBs contamination in the maize from the 2006 season was 26% of the FBs contamination in maize from the 2005 season [22, 23, 26]. In Kimanya *et al*. [22] the higher contamination in 2005 was attributed to the drought that was experienced in Tanzania in that year. Drought stressed crops are more susceptible to fungal growth and subsequent FB contamination compared to healthy crops [7, 18]. This difference in exposure resulting from seasonal variation in contamination justifies the need for using FB contamination data from more than one season in FB exposure assessments. Thus, the mean exposure of 0.14 μg/kg bw/day and probability of exceeding the PMTDI of 10% as determined by using the pooled contamination datasets for the 2005 and 2006 maize may be considered more representative exposure levels for infants in this community. It should be realized, though, that in some seasons the FB intake level and the probability to exceed the

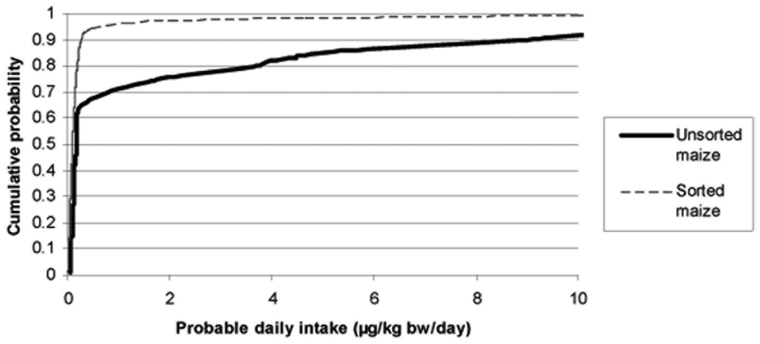

Figure 2. Relationship between probable daily fumonisin intake (PDI) for infants who might have consumed unsorted maize in 2006 and those who consumed sorted maize from the same year.

PMTDI value might be higher than the respective levels estimated by this study.

An exposure assessment conducted by Shephard *et al.* [27] for FBs in rural areas of the former Transkei region of South Africa found a relatively higher risk of exposure to the toxins compared to the risk determined by this study. The researchers reported that the mean exposure levels for all the age groups they studied were above the PMTDI and that, children (1–9 years) had the highest exposure. The observation that the children in Transkei had the highest exposure to FBs was attributed to high maize consumption by the children relative to their small body size. The mean daily maize consumption in the 1–9 year old children studied by Shephard *et al.* [27] was 12.4 g/kg bw which is higher than the mean maize meal consumption of 4.9 g/kg bw/day in the 6–8 month old infants who participated in this study. Consequently the mean exposure level for the children in the Transkei exceeded the PMTDI value of 2 μg/kg bw/day whereas the mean exposure level determined by this study was lower than one half of the PMTDI value.

In contrast to the findings by this study and the study by Shephard *et al.* [27], exposure assessments conducted in other countries such as Iran [32], Denmark [33], the USA [34] and The Netherlands [35] found minimal risk to the general population. The high FB exposure in Africa arises from the high maize meal consumption on this continent compared to western countries and Iran. The average *per* capita maize consumption in Western Europe is 0.13 g/kg bw/day [27] and in Iran, 0.05 g/kg bw/day [32] (both cases based on the bw of 70 kg for an adult man). These maize consumption levels are very low compared to the above-discussed consumption levels of 12.4 g/kg bw/day in Transkei, South Africa and 4.9 g/kg bw/day in Rombo, Tanzania.

It was clearly shown in this study that infants who might be complemented with unsorted maize would be at a significantly higher risk of exceeding the PMTDI level of 2 μg/kg bw/day compared to their counterparts complemented with sorted maize. Thus, sorting of maize as practiced by the farmers themselves had a significant reduction in FB exposure to the infant. This is an important observation because in parts of Africa, a considerable proportion of farmers do not sort maize to remove the mouldy or damaged kernels or cobs before storage and consumption. More than 23% of participants in a study of determinants of aflatoxin levels in Ghanaians admitted the consumption of unsorted maize [28]. However, the efficacy of sorting is dependent on the extent of the initial contamination [36]. This is evidenced by the observation that the occurrence of total FBs contamination in sorted maize from the 2005 harvest was remarkably higher than that of total FBs contamination in the sorted maize from the 2006 harvest. In 2005, 40% of the sorted maize contained total FBs at levels from 65 to 11 048 μg/kg (median; 523 μg/kg) whereas in 2006 only 12% of the sorted maize contained FBs at relatively lower levels ranging from 24 to 1758 μg/kg (median; 105 μg/kg). This observation suggests that sorting as a practice to minimize FB contamination in maize should be combined with other good maize management practices for its effectiveness in reduction of FB exposure to be realized.

It is worth to note that FB exposure data generated by this and other [25, 33] studies that used contamination data for unmilled maize might have been overestimated. This is because in the course of milling, maize undergoes a dehulling step that is known to reduce FB contamination in the consumed fraction; the flour [25, 37, 38]. Therefore, use of contamination data determined in ready-to-cook maize flour or ready-to-eat complementary food would generate better estimate of the FBs exposure in this community. However, despite the shortcoming, the results of this exposure assessment should be taken as a strong evidence for the need for conducting a more comprehensive exposure assessment for FBs in ready-to-cook or ready-to-eat maize-based complementary foods in Tanzania.

It is well documented [28, 33–35] that the risk of exceeding tolerable limits for contaminants can be minimized by reducing level of consumption of the food in question or limiting the level of the contaminant in the food or limiting both the consumption and contamination. Assessing FB exposure in maize from the USA, Humphreys *et al.* [34] found that, in order to avoid the risk of high FB exposure, limiting maize intake would be more practical than limiting the level of FBs in maize. The low economic power of the people in rural Tanzania does not permit advocacy for reduction of maize consumption as a strategy to minimize

FB exposure in the general population. However, this could be a possible option for reduction of FB exposure in children in this community. Use could be made of the existing child nutrition programs in Tanzania which promote adoption of mixed cereal formulations for complementary foods [4], to advocate for gradual substitution of less contaminated grains such as finger millet and sorghums [39] for the maize ingredient in complementary foods. This can be done by sensitising nutrition program officers in Tanzania on the FB health risks associated with consumption of maize in complementary foods and advice them to include a FB reduction component in the nutrition programs. Additionally, further research is needed to study the extent of substituting other grains for maize in the cereal complementary foods in order to ensure reduction of FB exposure without compromising the nutritional quality of the foods.

Another option for minimizing FB exposure in rural communities relying on maize as staple is reduction of the toxins in the food. This can be achieved through training of farmers on good agricultural and management practices for reduction of FBs in maize. Enforcement of a maximum limit of FBs in maize is another strategy to minimize FB contamination in maize which, however, is more protective for children and other people in urban centres compared to those in rural areas. In rural places, farming is for subsistence and people are food insecure; conditions that make the enforcement of regulations impractical.

Based on the pooled contamination data for maize from the two seasons of 2005 and 2006, one out of ten infants consuming maize-based complementary foods in Rombo exceeds the PMTDI level of 2 μg/kg bw/day set by JECFA for FBs. According to the risk magnitude scales recommended by Calman and Royton [40], the risk is very high. Policy makers need to understand the implication of this magnitude of risk in child and public health in general and take urgent and appropriate measures to minimize FB exposure among infants and the general public to levels as low as practically possible. Indeed, the control measures should be able to minimize FBs exposure, not only for those above, but also for those below, the PMTDI value of 2 μg/kg. The group below the PMTDI level constitutes infants exposed to chronic levels of FBs. These low level exposures have serious health implications, particularly because FBs have been associated with oesophageal and liver cancers in humans [14].

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The authors have declared no conflict of interest.

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