Impact of mycotoxins on child growth in sub-Saharan Africa

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<table>
<thead>
<tr>
<th><strong>Mycotoxin</strong></th>
<th><strong>Fungi</strong></th>
<th><strong>Crops</strong></th>
<th><strong>Health impact</strong></th>
</tr>
</thead>
</table>
| Aflatoxin    | *Aspergillus flavus*  
* A. parasiticus | Maize, peanuts etc  
Warm, humid climate  
Increases during storage | Acute toxicity  
Liver carcinogen  
Stunting |
| Fumonisins   | *Fusarium verticillioides* etc | Maize  
Mainly field contamination | Neural tube defects  
Animal carcinogen  
Animal growth loss  
Stunting? |
| Deoxynivalenol | *Fusarium graminearum* | Maize, wheat etc  
Warm or temperate climates | Non-fatal GI disease  
Animal growth loss |
Biomarkers to measure exposure

Aflatoxin albumin adducts in blood (ELISA)

Urinary fumonisin B1 (stable isotope dilution assay by LC/MS)

AF-alb versus dietary aflatoxin intake


Urinary FB1 versus dietary intake

Our recent studies have focused on The Gambia in West Africa and Tanzania in East Africa with exposure also measured in some neighbouring countries (Senegal & Guinea/Kenya & Uganda)
Our data give a snapshot in time for exposure in each study.

Exposure may vary geographically within a country or in different years.
In 2004 there was an outbreak of high aflatoxin contamination in Kenya.

In this region in 2004 there was an outbreak of aflatoxicosis that involved many deaths.
It is common to see variation in different regions of the same country. This could be due to socio-economic conditions, farming practice or local climate.
Variation in exposure of 3 mycotoxins in Tanzanian children

AF-alb Geometric mean (pg/mg alb)

Urinary FB1 Geometric mean (pg/ml)

Urinary DON Geometric mean (ng/ml)

Nyabula
Kikelelwa
Kigwa

baseline 6 months 12 months
Exposure to Aflatoxin Associated with Impaired Growth

Reduced height increase in Beninese children with higher aflatoxin exposure

<table>
<thead>
<tr>
<th>Aflatoxin Exposure Group&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Mean AF-alb over 8 months Height increase (cm)</th>
<th>Unadjusted</th>
<th>Adjusted&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>lower quartile</td>
<td></td>
<td>4.9 (4.5,5.3)&lt;sup&gt;*,c&lt;/sup&gt;</td>
<td>5.9 (5.2,6.6)</td>
</tr>
<tr>
<td>mid-lower quartile</td>
<td></td>
<td>4.4 (4.1,4.7)&lt;sup&gt;**&lt;/sup&gt;</td>
<td>5.3 (4.8,5.9)</td>
</tr>
<tr>
<td>mid-upper quartile</td>
<td></td>
<td>4.1 (3.8,4.5)&lt;sup&gt;**&lt;/sup&gt;</td>
<td>4.8 (4.4,5.2)</td>
</tr>
<tr>
<td>upper quartile</td>
<td></td>
<td>4.1 (3.8,4.5)&lt;sup&gt;**&lt;/sup&gt;</td>
<td>4.2 (3.9,4.6)</td>
</tr>
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</table>

<sup>a</sup>The quartiles are <23.3, 23.3-53.0, 53.0-101.5, >101.5 pg/mg.

<sup>b</sup>Adjusted for age, height, weaning status, mothers SES and village.

<sup>c</sup>Data labelled * are significantly different to **.

Tanzania study

There were non-significant negative associations between AF-alb and LAZ scores at 12 months.

There were significant negative associations between urinary fumonisin and LAZ scores.

There was a mean difference of 1.8 cm less growth in children in the highest UFB1 quartile compared to the lowest.

Possible mechanisms for aflatoxin impaired growth

- Intestinal epithelium damage contributes to environmental enteropathy
- Immune suppression increases number of infections (e.g., diarrhoea that reduces nutrient uptake)
- Liver toxicity reduces IGF protein levels in circulation
- DNA methylation changes in genes affecting growth
Community hand sorting of peanuts to reduce aflatoxin in food

**Recruitment**
25 women recruited from 5 villages (5 from each village)

**Questionnaires**
Teaching
With the aid of pictures

**Sample Collection**
- ‘baseline’ N=5
- ‘clean’, N=25
- ‘mouldy’, N=25
- ‘roasted’, N=5

**Lab Analysis**

**Nuts supplied by us – Procured from market**

**Provided with shells on – weight decreases once shells removed**

**Hand-sorting by participants**

**Sorted Mouldy Nuts**

**Weigh the shelled nuts and dispatch 0.5 Kg to each participant**

**Roasting included**

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Sorted Mouldy Nuts

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Roasting included

Community hand sorting of peanuts to reduce aflatoxin in food
Calculation of aflatoxin B$_1$ reduction based on measured AFB$_1$ levels after sorting into ‘mouldy’ and ‘clean’ groundnuts

<table>
<thead>
<tr>
<th>Weight of ‘baseline’ shelled nuts (g)</th>
<th>Weight of ‘mouldy’ nuts removed (g)</th>
<th>AFB$_1$ amount in ‘mouldy’ nuts (µg)</th>
<th>AFB$_1$ in remaining ‘clean’ nuts (µg)</th>
<th>Reduction in AFB$_1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>79,388</td>
<td>1,533</td>
<td>905.5</td>
<td>29.9</td>
<td>96.7%</td>
</tr>
</tbody>
</table>
Evaluation of intervention effectiveness

Finding: the intervention reduced FB1 intake and urinary FB1 biomarker level
Research gaps to address

• Evaluation of excretion of fumonisin and DON biomarkers in different age groups
• Understand contribution of aflatoxin to endemic enteropathy
• Explore the effects of dual or multiple exposures on growth
• Assess effectiveness of community interventions
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