Recurrence of konzo in southern Tanzania: Rehabilitation and prevention using the wetting method

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Abstract

There have been four konzo outbreaks in Tanzania from 1985 to 2002/2003 with a total of 363 cases of konzo. Every outbreak of konzo resulted from large cyanogen intakes from bitter cassava during drought, which caused food shortages and led to people using short-cut methods of cassava processing. Rehabilitation of the 214 konzo subjects from the two most recent outbreaks of konzo in southern Tanzania was carried out by screening konzo subjects and included provision of crutches and wheelchairs. The wetting method was taught to 216 women activists from the konzo-prone villages, in the first large scale community based intervention to reduce cyanogen intake. Using cassava cyanide kits, the average total cyanide content was reduced by the wetting method about 4-fold, in agreement with previous studies. This model to help prevent konzo requires the widespread education of women activists to use the wetting method.

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1. Introduction

Cassava is an important staple crop in many parts of Africa due to its high yield and its tolerance to drought and disease. In Tanzania major cassava production areas include the Eastern, Southern, Western and Lake zones, see Fig. 1. It is used as a food insurance crop because it gives stable yields even in times of drought, alleviating food shortages during the hungry season of each year when food stocks are depleted. Cassava contributes between 9 and 60% of the total energy intake per day (Jonsson, 1986). Cassava contains the cyanogenic glucosides linamarin and a small amount of lotaustralin that are enzymatically broken down to cyanohydrins which are hydrolysed further to liberate hydrogen cyanide (HCN). Cassava roots and products from which cyanogens have not been effectively removed during processing are the source of dietary intake of linamarin and cyanohydrins, which are broken down in the gut to HCN (Mlingi, 1995).

Konzo is an upper motor neuron disease caused by dietary intake of large amounts of cyanogens from cassava. It is characterised by the abrupt onset of a varying degree of symmetrical, isolated and permanently but not progressive spastic paraparesis (Tylleskar et al., 1993). The disease has been reported in remote rural areas of Mozambique, Tanzania, Democratic Republic of Congo (DRC), Central African Republic and Cameroon. Outbreaks of konzo have been associated with high cyanide and low sulphur amino acid intake from a diet of insufficiently processed bitter cassava roots and lack of protein rich supplementary foods that supply the sulphur amino acids needed for cyanide detoxification (Cliff et al., 1985; Rosling, 1986).

Konzo epidemics such as recent outbreaks in DRC result from war, when people are forced from their homes and gardens and eat unprocessed bitter cassava. Konzo epidemics are also due to drought which causes crop failure, food shortages and adoption of short cut processing methods which inadequately remove cyanogens. Furthermore, during drought the cyanogen content of cassava roots is greatly increased (Bokanga et al., 1994) and cassava flour produced from these roots has greatly elevated cyanogen content (Cardoso et al., 2005). Endemic konzo has also been observed in poor rural communities (Howlett, 1994; Ernesto et al., 2002; Cliff et al., 2011).

The first konzo outbreak in Tanzania was reported in drought affected Tarime district in Mara region in the north in 1985 (Howlett et al., 1990, 1992). In the first investigation of this outbreak 39 cases (30 males and 9 females, aged 4–46 years) were diagnosed out of 50 cases that were clinically examined in the villages of Raranya, Nyambori and Nyambogo. Nineteen cases came from only six families and five from one family (Howlett et al., 1990). A further investigation in 1989 found 116 cases, and two deaths of verified cases were reported (Howlett et al., 1992). A second outbreak of konzo occurred in 1988 in Mtanda village, Masasi district in Mtwarra region in southern Tanzania, see Fig. 1, after reported frequent occurrences of acute intoxication after...
meals of cassava during a drought. Three konzo cases were reported with very high urinary thiocyanate and serum thiocyanate levels in one case (Mlingi et al., 1991).

The two most recent outbreaks of konzo occurred in 2001–2002 in Mbinga district, Ruvuma region with 24 konzo cases, and in Mtwara region in 2002–2003 with 214 konzo cases, see Fig. 1. These were the subject of two unpublished reports by the Ministry of Agriculture and Food Security (Assey and Mtunda, 2002) and the Ministry of Health (Tanzania Ministry of Health, 2003), respectively. In 2008–2009, we embarked on a program of physical rehabilitation of the konzo patients, based on a previous program in Mozambique by Mr. Domingos Nicala and Dr. Julie Cliff (Nicala, 2003). At the same time, we trained women activists from konzo-prone villages in use of the wetting method to reduce the cyanogen content of cassava flour.

In this paper we bring together information on all konzo outbreaks in Tanzania, in particular the 2001–2003 konzo outbreaks and on the rehabilitation program carried out in 2008–2009. Also, we report on the training given to 216 women activists in the wetting method, which should help prevent konzo in the future.

2. Materials and methods

2.1. Location of konzo outbreaks and subsequent remedial action

In 2008–2009 a program to rehabilitate konzo subjects in the three districts of Mbinga, Mtwara rural and Newala was mounted, through collaboration between the Tanzania Food and Nutrition Centre (TFNC), Tanzania Red Cross Society (TRCS) with technical support from Australian National University and funding from AusAID. Three visits were made to the affected districts as follows: In August 2008 the 13 villages in Mtwara rural district were visited (Tatala and Ngude, 2008). In October 2008 visits were made to four villages and one additional village in Newala district and also a village (Mituka) in Mbinga district (Nkya and Ngude, 2008). In May/June 2009 visits were made to all the affected villages for rehabilitation of konzo subjects and for teaching of the wetting method to remove cyanide and help prevent future konzo outbreaks (Nkya et al., 2009).

Konzo subjects were visited in households, schools and village offices where they were examined by visiting qualified Medical Officers from TNFC and TRCS working in close collaboration with a District Health Officer, who helped mobilise village leaders and affected people. The subjects were examined for physical deformity, spastic gait and neurological signs of spastic paraparesis including increased knee jerk reflexes and ankle clonus. Screening identified those who could walk unaided, those with moderate deficits who needed support to walk, and those who needed wheelchairs. Past medical and dietary histories were also taken into account in order to rule out other causes of deformities such as polio.

2.2. Traditional methods of processing cassava roots

In Tanzania there are three traditional methods of processing cassava roots into cassava flour as follows:

1. Sundrying of peeled roots for some days until they are dry and brittle, followed by pounding and sieving which produces white flour that retains 25–33% of its original cyanogens (Mlingi et al., 1992; Cardoso et al., 2005).
2. Heap fermentation, which involves leaving a small heap of peeled roots in the shade for several days, followed by sundrying, pounding and sieving to produce flour with retention of 12–17% of total cyanide (Cardoso et al., 2005).
3. Soaking of peeled or unpeeled roots for 3–5 days submerged in water followed by sundrying, pounding and sieving. This is a very good method of removing cyanogens, but can only be used in places where there is plenty of water, such as in the wet tropics or near rivers or lakes.

In 2003 due to prolonged drought they did not harvest maize or millet and had to rely on cassava alone. Because of the famine short cut processing of cassava was used, which involved pounding peeled cassava in a mortar and then sundrying. This
pounding and sundrying was repeated several times and the flour used on the same or next day. This poorly processed cassava caused acute intoxication with vomiting, headaches and abdominal pains and konzo.

2.3. Wetting method for cassava flour, laminated posters and cyanide kits

The wetting method was discovered by Bradbury (2006), checked and extended by Cumbana et al. (2007) and demonstrated in the field in Mozambique in 2005 (Maquingue et al., 2005). The stepwise method is as follows:

1. Dry cassava flour is filled up to a mark inside a bowl.
2. Water is mixed in until the level of the wet flour comes up to the same mark.
3. The wet flour is spread out in a thin layer not more than 1 cm thick on a basket or tray and left in the shade for about 5 h or 2 h in the sun (Bradbury and Denton, 2010). The thin layer allows HCN gas to escape from the wet flour which must not dry out because this would stop the breakdown of linamarin by the enzyme linamarase.
4. The treated flour is used the same day to make stiff porridge following the traditional method.

The method was shown to groups of women activists in May–June 2009. The first demonstration was by Dr. Julie Cliff from Eduardo Mondlane University, Maputo, Mozambique, to TNFC and TRCS members, village leaders and women activists. Illustrated A4 posters, first produced in Portuguese by Dr. Dulce Nhassico in Mozambique, were modified and translated into Kiswahili and were given to activists. These laminated posters are available for free in 12 different languages from Dr. Bradbury, see http://online.anu.edu.au/BoZo/CCDN/.

The total cyanide content in cassava flour before and after the wetting treatment was measured using simple picrate kits, obtained from Dr. Bradbury (Egan amd Majengo.}

3. Results

There was an outbreak of konzo during drought in 2001–2002 in Mbinga district, Ruvuma region. A medical team found 24 cases of konzo of whom 12 were children below 18 years (Assey and Mtunda, 2002). In August 2003 there was a much larger outbreak in Mtwarra region, population 1.25 million. Investigation by a medical team from the Ministry of Health and WHO reported 214 konzo cases in 13 villages of Mtwarra rural district and four villages of Newala district. Nearly all affected patients were from poor families (Tanzania Ministry of Health, 2003). The results of these investigations into konzo outbreaks in 2001–2003 and the number of cases found at follow up in 2008–2009 are given in Tables 1–3. Table 1 refers to the major outbreak in 13 villages of Mtwarra rural district of Mtwarra region, Table 2 to Newala district of Mtwarra region and Table 3 to Mkuka village in Mbinga district of Ruvuma region. A total of 238 cases were reported in 2001–2003. Four additional cases with onset in those years were found in 2008–2009 (see Tables 2 and 3). Table 4 gives a summary of the numbers of konzo cases found in Tanzania which equals 363 (Cliff, 2010) in Table 5 is given the age and sex of konzo cases from the Tarime district outbreak in 1989 (Howlett et al., 1992) and from the Mbinga district outbreak in 2001–2002 (Assey and Mtunda, 2002).

### Tables 1–3 show the number of crutches and wheelchairs distributed in each district. All konzo subjects who needed them in Newala and Mbinga districts were supplied with crutches (Tables 2 and 3) but only 35 pairs of crutches were available for 110 subjects in Mtwara rural district (Table 1). With wheelchairs, 13 were needed (Tables 1–3) and only 2 were distributed in Mtwara rural and Newala districts.

#### Table 1

Konzo cases in 13 villages in Mtwarra rural district in 2002–2003, August 2008 and rehabilitation needs.

<table>
<thead>
<tr>
<th>Time visited</th>
<th>Subjects with konzo</th>
<th>Rehabilitation aids needed and provided&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Crutches (one piece)</th>
<th>Wheel chairs</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002–2003</td>
<td>195&lt;sup&gt;b&lt;/sup&gt;</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>August 2008</td>
<td>116</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>May/June 2009</td>
<td>–</td>
<td>110 (35)</td>
<td>5 (1)</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> The 13 villages are Mgombani, Njengwa, Nyundo, Naucheche, Niyumba, Nitekela, Napaunga, Ntimbwimbwi, Nkurumango, Kiromba, Ntujengwa, Chiwilo and Majengo.

<sup>b</sup> Aids needed; those provided shown in brackets.

#### Table 2


<table>
<thead>
<tr>
<th>Time visited</th>
<th>Subjects with konzo</th>
<th>Rehabilitation aids needed and provided&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Crutches (one piece)</th>
<th>Wheel chairs</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002–2003</td>
<td>19&lt;sup&gt;c&lt;/sup&gt;</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>October 2008</td>
<td>20&lt;sup&gt;d&lt;/sup&gt;</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>May/June 2009</td>
<td>8 (8)</td>
<td>–</td>
<td>3 (1)</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> Villages with konzo cases were Lengo, Songambele, Ngulu and Mkunjo in 2002–2003 and on screening in October 2008 one additional village (Mdamba) was visited.

<sup>b</sup> Aids needed; those provided shown in brackets.

<sup>c</sup> 10 females and 9 males.

<sup>d</sup> 18 konzo subjects from the 4 original villages plus two extra subjects from Mdamba.

#### Table 3

Konzo cases in Mkuka village, Mbinga district in 2001–2002, October 2008 and rehabilitation aids.

<table>
<thead>
<tr>
<th>Time visited</th>
<th>Subjects with konzo</th>
<th>Rehabilitation aids needed and provided&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Crutches (one piece)</th>
<th>Wheel chairs</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001–2002</td>
<td>24&lt;sup&gt;e&lt;/sup&gt;</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>October 2008</td>
<td>26&lt;sup&gt;f&lt;/sup&gt;</td>
<td>–</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>May/June 2009</td>
<td>14 (14)</td>
<td>3 (0)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> Rehabilitation aids needed, those provided shown in brackets.

<sup>b</sup> Six females and 6 males aged 4–17 y; 11 females and 1 male aged 18 + y.

<sup>c</sup> Two additional subjects in 2008.

#### Table 4

Summary of konzo cases in Tanzania.

<table>
<thead>
<tr>
<th>Date</th>
<th>District and region</th>
<th>Number of cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td>Tarime, Mara</td>
<td>36</td>
</tr>
<tr>
<td>1989&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Tarime, Mara</td>
<td>118</td>
</tr>
<tr>
<td>1988</td>
<td>Masasi, Mtwarra</td>
<td>3</td>
</tr>
<tr>
<td>2001–2002</td>
<td>Mbinga, Ruvuma</td>
<td>24</td>
</tr>
<tr>
<td>2002–2003</td>
<td>Mtwarra rural, Mtwarra</td>
<td>195</td>
</tr>
<tr>
<td>2002–2003</td>
<td>Newala, Mtwarra</td>
<td>19</td>
</tr>
<tr>
<td>2008–2009&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Mbinga, Mtwarra rural and Newala</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>363</td>
</tr>
</tbody>
</table>

<sup>a</sup> Further investigation. Included deaths of 2 verified cases.

<sup>b</sup> On rehabilitation of 2001–2003 konzo subjects in 2008–2009, 2 additional cases were found in each of Mdamba village, Newala district (Table 2) and Mbinga district (Table 3).

#### Table 5

Age and sex of konzo subjects from Tarime and Mbinga districts.

<table>
<thead>
<tr>
<th>District &amp; year</th>
<th>Age range, y</th>
<th>Numbers of konzo cases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>Male</td>
</tr>
<tr>
<td>Mbinga 2001–2</td>
<td>4–17</td>
<td>6</td>
</tr>
<tr>
<td>Mbinga 2001–2</td>
<td>18+</td>
<td>11</td>
</tr>
<tr>
<td>Tarime 1989</td>
<td>2–17</td>
<td>25</td>
</tr>
<tr>
<td>Tarime 1989</td>
<td>18+</td>
<td>10</td>
</tr>
</tbody>
</table>

These tables provide detailed information about konzo cases in various regions of Tanzania, including the number of cases, age range, and rehabilitation needs.
There were 14 training sessions of women activists from the villages to use the wetting method, that involved 96 activists from Mtwara rural district, 60 from Newala district and 60 from Mbenga district. Laminated posters in Kiswahili were distributed to women activists, but unfortunately there were insufficient posters for all participants, due to a misunderstanding in Canberra of the exact date of the visits. In six of the demonstration workshops in Mtwara rural and Newala districts the total cyanide content of cassava flour was measured at the beginning and end of the 5 h wetting period using the cyanide kit for cassava flour (Bradbury et al., 1999). The average total cyanide content of the 6 flour samples fell from 61 (22) ppm to 18 (5) ppm after the treatment, where the numbers in brackets are standard deviations. The average retention of cyanide is 27%, which falls within the 3–6-fold reduction in total cyanide found previously (Bradbury, 2006; Cumbana et al., 2007).

4. Discussion

Every outbreak of konzo in Tanzania including the 2002–2003 episodes has resulted from large cyanogen intakes from cassava during drought, which caused crop failure, food shortage and use of short-cut methods of processing cassava. Also during drought, it has been shown by Bokanga et al. (1994) that the water-stressed cassava plant produces greatly increased amounts of linamarin and cassava flour made from these roots contain much larger amounts of cyanogens than normal (Cardoso et al., 2005).

Another factor that contributes to high cyanogen intake is the introduction from elsewhere of bitter cassava varieties that have high yields and disease resistance. This occurred in the Tarime district in 1979–1980 (Howlett et al., 1992) and in Mbenga district 5–6 years before the 2001–2002 outbreak, where the bitter cassava cvs Gomani and Tupuka originated from Malawi (Assey and Munday, 2002). Similarly in Mozambique, konzo and severe episodes of acute intoxication occurred during drought, because of the introduction of bitter cassava into new areas without the teaching of processing methods (Cliff, 1994). In development of new cassava varieties by plant breeders it is important for National Agricultural Research Institutes (NARI’s) and ITA to have low total cyanide content as one of their breeding objectives, which should be made easier because of the availability of pircate kits to determine total cyanide content, see http://online.anu.edu.au/BoZo/CCDN/. However, in Malawi one of two cassava clones recently approved and released officially (CH92/082) is rated as bitter (Benussi et al., 2010). Furthermore, it is wrong to promote cassava without a warning statement that it contains poisonous cyanogens (Madamombe, 2006).

In Table 5 there is a comparison of the age and sex of konzo cases in Mbenga district in 2001–2002 with the Earlier Tarime outbreak of 1985, further investigated in 1989 (Howlett et al., 1992). Crippling by konzo does not occur below the age of 2 year, but occurs particularly with children and women of child bearing age (Howlett et al., 1992). In Mbings there were equal numbers of boys and girls, but at age 18 + year there was a preponderance of females, whereas in Tarime there were nearly three times as many boys as girls and equal numbers of adult males and females (Table 5). The konzo outbreaks in Mtwara rural district gave a ratio of females to males of 1.44 (Table 1) and in Newala district there were 10 females and 9 males (Table 2). The ratio of females to males in Tarime was 0.43, in Mbenga was 2.4 (Table 5) and a recent study in DRC gave 3.3. (Diaosula Ngudi et al., 2011). This high variability, also noted by Howlett (1994), was thought to be due to local unknown factors.

A comparison has been made between the range of disabilities found in 1989 in Tarime and our results in Tables 1–3. The percentage of konzo subjects that required one or two sticks was 28% (Howlett et al., 1992) and crutches in this paper was much greater at 40–56%. The percentage that could not walk and needed a wheelchair was 5% (Howlett et al., 1992) and in this paper was 3–25%. In general our data showed a higher rate of disability than that of Howlett et al. (1992), which may be due to the patient selection process being naturally biased towards konzo subjects with disability. There was a shortfall of crutches in Mtwara rural district and wheel chairs were also in short supply (Tables 1–3). The shortage was due to logistical problems in transporting them from Dar es Salaam to these remote rural areas. To overcome these problems, rehabilitation of konzo subjects should be integrated into national and local rehabilitation programs.

The geographical spread of konzo has increased in Tanzania, where it was initially observed in 1985–1988 in the north, but more recently (2001–2003) has occurred in the south with twice the number of cases (Table 4). An increased geographical spread has also occurred in Mozambique (Cliff et al., 2011) and in DRC due to civil war (Chabwine, 2009). This increased geographical spread of konzo is likely to continue, with more frequent incidences of drought due to climate change and increasing use of cassava particularly in new areas, to cope with increasing population pressure (Nhassico et al., 2008).

The wetting method used to reduce the cyanogen content of cassava flour was taught to 216 women activists from the konzo-prone villages in the three districts. The illustrated, laminated posters in Kiswahili provided a lasting teaching material available to the women. This has been the first large scale community based intervention to prevent future outbreaks of konzo by limiting the intake of cyanogens from cassava flour through a simple processing technique. By using pircate cyanide kits it was found that the wetting method reduced the total cyanide content of cassava flour about 4-fold. The wetting method is easy to use, requires no extra equipment and the thick porridge (ugali) tastes better. No extra water is used overall if the wet flour is processed for 5 h in the shade, but if processed for 2 h in the sun extra water is needed.

In the DRC the wetting method is used by rural women if they are unsure of whether or not the cassava flour has high cyanide content (Bradbury et al., 2011). In Mozambique during drought when cassava plants produce bitter roots we have observed that women processors turn from sundrying to the more work intensive heat fermentation, in order to reduce the cyanogen content of their flour by 50% (Ernesto et al., 2002), but this reduction is still insufficient to prevent konzo (Cardoso et al., 2005). It is particularly in this drought situation that the wetting method would be most useful because it reduces the cyanogen content 3–6-fold, which should be sufficient to prevent konzo. However the application of the wetting method requires widespread focused education of women cassava processors and the provision of appropriate teaching material.

5. Conclusions

All four Tanzanian outbreaks have been associated with cyanogen intake from bitter cassava amongst poor rural people during drought, when food shortages have led to short-cut methods of processing cassava. Rehabilitation of konzo subjects in 2008–2009 was incomplete due to a shortfall of rehabilitation aids caused by logistic problems. Such rehabilitation should continue after epidemics, integrated into national and local programs. A wetting method to reduce the cyanogen content of cassava flour was taught to 216 women activists in the konzo-prone villages. This is the first large scale community based intervention to help prevent future konzo epidemics in Tanzania. This model requires widespread focused education of women activists and could be
followed in other countries of Africa which suffer from the scourge of konzo.

Conflict of Interest

The authors declare that there are no conflicts of interest.

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