



Microbiological hazard identification and exposure assessment of food prepared and served in rural households of Lungwena, Malawi

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ABSTRACT

The presence of food-borne pathogens, *Escherichia coli* O157:H7, *Staphylococcus aureus*, *Salmonella* species, *Campylobacter jejuni* and non-pathogenic *E. coli*, in 132 home cooked food samples consisting of maize flour porridge (MFP), ($n=41$), fish ($n=37$), vegetables ($n=28$), beans ($n=13$) and "Others" ($n=13$), collected from 6 villages in Lungwena, Malawi was investigated. It was found that 35% of the food samples were contaminated with one or more pathogens; with 48%, 8%, 61% and 23% of the food samples being found to harbour *E. coli*, pathogenic *E. coli* O157: H7, *S. aureus* and *Salmonella* species, respectively. *C. jejuni* was not detected in any food sample. Using a 95% level of significance, pathogen concentration among food categories demonstrated a statistical difference ($p=0.001$). Distribution of pathogens among villages was also found to be significant ($p=0.03$). MFP was the most contaminated food. Practices that promote the spread of the pathogens in the rural household kitchens were investigated. Food was thought to be contaminated as a result of poor food handling, preparation and storage practices.

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1. Introduction

The basic human requirement for the intake of food places every human being at risk of contracting infection by food-borne pathogens. This fact is true not only in developing countries but in many developed countries. Food experts and public health agencies have put emphasis on control of food-borne pathogens in industries during processing. Data from a number of studies for different countries indicate that many outbreaks originate in the home (Knabel, 1995; Scott, 1996; Beumer et al., 1998; Mead et al., 1999). Improper in-home food handling, preparation and consumption practices by consumers (FSAI, 1998; Bryan, 1988; Gorman et al., 2002), inadequate hygiene practices such as hand washing (Cogan et al., 2001), and use of unhygienic utensils and materials (Altekruse et al., 1995; Knabel, 1995; Beumer and Giffel, 1999), consumption of raw or unsafe food (CAST, 1994; Redmond and Griffiths, 2003), as well as cross-contamination via inanimate surfaces by raw food (Roberts, 1982; Ryan et al., 1996)

are some of the factors and practices that have been implicated in food-borne outbreaks in the home. The pathogens isolated most often in such outbreaks have been *Staphylococcus*, *Salmonella*, *Campylobacter*, *Escherichia coli*, *Clostridium perfringens* and *Vibrio cholerae*, (CHRP, 1998; Ekanem, 1998; Beumer and Giffel, 1999; Umoh and Odo, 1999; Mosupye and Von Holy, 2000).

In Malawi, little information exists regarding the incidence of food-borne illness due to food prepared in the home (D. Chilima, Lungwena Management Centre, personal communication), especially in rural areas where people traditionally live in mud houses. The control of diarrhoeal-related diseases through focussing only on the safe provision of water, has not had a sufficiently positive impact in such areas. In most cases, food is prepared under relatively unhygienic conditions and often not protected against environmental contamination. In addition, appropriate storage temperatures are difficult to maintain, as most households in rural areas do not own a refrigerator. In Lungwena, 99.3% of rural households do not own a refrigerator (Lungwena NUFU 2004 census: unpublished). Kitchens consist of a small mud or block structure with grass thatch and sometimes a small room or part of the inside corner of the house can be used as a kitchen. Domestic animals such as goats, sheep, calves and chickens may be housed in the kitchen at night. These animals together with the infestation of rats, cockroaches and

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flies have been implicated in contaminating food and water (Barrel and Rowland, 1979; Bryan et al., 1992).

Culturally, Malawians in rural areas prefer eating food that has been prepared and served from their kitchen, as it is regarded to be warm and free from pathogens. Although this is believed to be so, Bryan et al. (1992) and Doyle et al. (2001) argue that such foods may not attain temperatures high enough to kill all pathogens. At times, leftover food that might have had been in contact with animals is eaten by children for breakfast without warming. The Lungwena catchment area is a predominant Moslem community and it has been speculated by Shojaei et al. (2005) that Moslems' hands can be contaminated by faecal matter, as they clean their "bottom" with water after using a toilet. The above prevailing conditions in Lungwena place members of the households at a high risk of acquiring food-borne infection. The occurrence of diarrhoeal diseases has been associated with malnutrition and poor water quality, with little association of food in general (Malawi College of Medicine (MCOM, 2000: unpublished). In addition, there is no documentation on the microbial status of both rural and urban home-prepared food. The present study therefore, attempts to identify potential microbiological hazards associated with common staple foods prepared and served in rural households in Lungwena, Malawi as well as documenting some of the practices that may promote contamination of so-called "warm and safe foods".

2. Materials and methods

2.1. Research area

Lungwena is a pilot project study area for Malawi College of Medicine where nutritional, water and sanitation studies have been conducted. The catchment's area consists of 26 villages (in 2 Traditional Authorities (TA) with a total population of 23,100; 5174 households spread within the coastal area of Lake Malawi as well as an upland area of Namizimu forest. In order to choose the target study area, a two-stage sampling procedure was used. Six villages (Milombwa, Chilonga, Mdala Makumba, Kwilasya, Chapola and Ntumbula) were sampled from both TAs according to the geographical layout of the area. Three villages were selected in the southern half of the area and another three villages from the northern half of the area. From each half area, one village was selected from in-land (dry land location) and two villages from the coastal areas (wet land location). A total of 350 households were randomly selected using statistical random numbers (using sampling frame from the Lungwena census survey of 2004).

2.2. Questionnaire

Data on food preparation, handling and storage practices were collected using structured questionnaires that had both observational and responsive questions. A structured English questionnaire translated into Yao was used to conform to the local language of the area. Equipment used for preparation of food, source of water for both utensil cleaning and cooking, utensil cleaning methods and hand washing were considered as food preparation and handling practices while storage of leftover food, storage length and holding of animals in food storage rooms were considered as food storage practices. The questionnaire was pre-tested in six households from the selected villages. Administration of questionnaires was done by three enumerators who had been trained for 3 days. Two hundred and eighty seven out of 350 randomly selected households were successfully interviewed. The other sixty three (63) households could either not be traced or had moved out of the village. Interviewees were mainly women (except in few households where women were not available) because in Malawi, preparation of food is mostly done by women.

2.3. Microbiological analysis

2.3.1. Sample collection and processing

A total of 132 food samples were collected from 132 households (22 households from each village) that were selected randomly from the 287 households. The samples consisted of Maize flour porridge (*nsima*), a traditional meal prepared by adding maize flour to boiling water until a thick dough like porridge is reached; fish, vegetables, beans and "Others" (e.g., corn flour, pawpaws, meat, cassava and mangoes). Samples were collected at lunch hour (during eating). Maize flour porridge samples were collected within 10–20 min after cooking. Sterile forceps and spoons were used to transfer the food from the eating plate to sampling containers. Vegetables, fish, beans and "Others" foods which were usually prepared before MFP were collected from the eating plate 1–3 h after preparation. A traditional ladle (*chipande*) that was used to serve the food onto a plate was used for this collection. Samples of between 150 and 200 g for each food category were collected into sterile bags. The bags with food samples were kept in a cooler box with ice packs maintained at 6–10 °C and transported to the laboratory and processed within 2–4 h. A 10 g amount of each sample was weighed into sterile stomacher bags (Stomacher 400, Seward Medicals; London, UK) and homogenised with 90 ml sterile Buffered Peptone Water (CM0509: Oxoid, Basingstoke, UK) containing 0.1% peptone+0.85% NaCl, for 2 min (Biolab, Midrand, South Africa). Serial dilutions of 10–1000 were prepared from the homogenate using Buffered Peptone Water.

2.3.2. Identification and enumeration

E. coli was enumerated by spread plating an aliquot of 1 ml onto 3M™ Petrifilms™ for *E. coli*/Coliform Colony Count (EC-plates) (3M Company, St. Paul, USA; Frampton and Restaino, 1993). The plated petrifilms were then incubated for 48 h at 37 °C (Nordic Committee on Food Analysis, 1993). Blue coloured colonies with gas entrapment on EC-plates were taken as presumptive *E. coli*. *E. coli* confirmation was done with the Indole test using Kovacs reagent (Merck, Midrand, South Africa). Identification of *E. coli* O157:H7 was done by streaking 100 µl of the serial diluted samples onto Cefixime Rhamnose Sorbitol MacConkey agar plates (CM1005; Oxoid) and incubated at 37 °C for 24 h. Straw-coloured colonies were identified and recorded as *E. coli* O157:H7 positive, (Chapman et al., 1994; Vernozy-Rozand, 1997). Presumptive colonies were pooled and subsequently subjected to a slide agglutination test using *E. coli* O157:H7 antisera (DR0620; Oxoid). For *S. aureus*, 1 ml of the serial dilution was spread-plated onto *Staphylococcus* Express Petrifilms (3M Company, St Paul, USA) and incubated at 37 °C for 24 h (Nordic Committee on Food Analysis, 1993). Colonies showing pink colour were identified and enumerated as *S. aureus*. Petrifilms with blue colonies were further incubated for 60 min and change of the colour to pink after overlaying the petrifilms with *Staphylococci* disks were also recorded as *S. aureus*. Confirmation was done by observing yellow colouration of colonies on mannitol salts agar after 24 h of incubation at 37 °C (Difco, 1998).

The presence of *Salmonella* spp. was determined by adding 1 ml of the diluted homogenate onto 10 ml of Selenite Cystine Broth (SCB base+0.4% Sodium Biselenite, CM0395; Oxoid) and incubated at 37 °C for 18 h. The broth was then sub-cultured onto *Salmonella-Shigella* agar plates (CM0099; Oxoid) for 24 h at 37 °C. Big colonies with a black centre were presumed to be *Salmonella* positive (Oxoid). Presumptive samples were exposed to biochemical tests by inoculating a colony into Kliger Iron agar (CM0033; Oxoid). These characteristic colonies were pooled and confirmed using a *Salmonella* latex agglutination test kit (FT0203; Oxoid). Identification of *C. jejuni* was done by inoculating an aliquot of 1 ml of the homogenate into 10 ml of Preston Enrichment (SR0117; Oxoid). The contents were incubated at 42 °C for 24 h (Scates et al., 2003). Two loopfuls of the broth were transferred to Blood agar (Columbia blood+Lysed Horse Blood, Merck, Midrand, South Africa),

wrapped in plastic pouches (AG0020C; Oxoid) and incubated at 42 °C for 4 days under micro-aerophilic conditions using an anaerobic jar (HP0031; Oxoid) containing CampGen sachets (CN0020C; Oxoid). Colonies appearing round to irregular with smooth edges were presumed positive (Lennette et al., 1985). A loopful of growth was placed in a drop of 3% hydrogen peroxide and appearance of bubbles was considered as positive for *Campylobacter*.

2.4. Statistical analysis

Data on the concentration of the food-borne pathogens was entered into Excel and transformed into log₁₀ Colony-Forming Units per gram (CFU/g) of food sample. Nonparametric statistical tests were conducted at the 95% level of significance using Minitab version 14 (Minitab Inc., 2004). Questionnaire variables were analysed using SPSS version 11.5.1 (SPSS Inc., 2002). Correlations between the occurrence of *E. coli* and the other studied pathogens were investigated by regression analysis.

3. Results

3.1. Incidence of food-borne pathogens in food samples

Sample analysis indicated the presence of one or more of the food-borne pathogens in each food sample, except for *Campylobacter jejuni* which was not detected in any food sample. Table 1 shows the incidence of *E. coli*, *E. coli* O157:H7, *S. aureus* and *Salmonella* spp. *E. coli* was detected in 48% of the food samples, with the highest incidence in the “Other” food category, (62%). *E. coli* O157: H7 was detected in 8% of the food samples, with the highest incidence of 15% observed in both beans and the “Other”. *Salmonella* spp. was isolated in 23% of the food samples while *S. aureus* was isolated in 61% of the food samples. The highest incidence of *S. aureus* (75%) was seen in vegetables while the highest incidence of *Salmonella* spp. (31%) was observed in the “Other” food category. Simple regression analysis found positive correlation between the presence of *E. coli* and *S. aureus* ($p < 0.05$).

3.2. Bacterial counts

Logarithmic mean ranges and medians of bacterial counts for the food categories are shown in Table 2. Pathogen levels in all samples ranged from 2.00–6.54 log₁₀ CFU/g with a median of 4.02 log₁₀ CFU/g, while *E. coli* concentration ranged from 2.00–6.07 log₁₀ CFU/g, with a mean of 3.91 log₁₀ CFU/g. *Salmonella* spp. ranged in numbers from 3.02–4.83 log₁₀ CFU/g with a mean of 3.70 log₁₀ CFU/g. *S. aureus* presented the highest bacterial counts with a range of 3.00–6.54 log₁₀ CFU/g and a mean of 4.00 log₁₀ CFU/g. The “Other” food category recorded the highest mean concentration pathogen of 4.20 log₁₀ CFU/g, with a range falling between 3.04 and 5.33 log₁₀ CFU/g. The lowest mean concentration was recorded in the MFP category. Statistical

Table 2

Mean concentration ranges of *E. coli*, *S. aureus* and *Salmonella* in various cooked foods

Food category	Range of microbial counts (log ₁₀ CFU/g)			
	<i>E. coli</i>	<i>S. aureus</i>	<i>Salmonella</i>	Mean
MFP	2.00–6.07 (3.49) ^a	3.00–5.48 (3.75) ^a	3.02–4.10 (3.45) ^a	3.60
Fish	3.04–5.48 (4.01) ^a	3.18–6.54 (3.90) ^a	3.12–4.78 (3.36) ^a	3.80
Vegetables	3.00–5.33 (3.60) ^a	3.00–5.33 (4.04) ^a	3.36–4.00 (3.64) ^a	3.80
Beans	3.00–5.80 (3.49) ^a	2.40–5.45 (4.36) ^a	4.56 ^b	4.10
Others	3.48–5.33 (4.95) ^a	3.10–4.26 (4.03) ^a	3.04–4.83 (3.71) ^a	4.20
Mean	3.91	4.00	3.70	3.90

^aMedian concentration for the food category.

^bOnly one sample of beans was positive.

analysis demonstrated a significant difference in pathogen concentration among food categories ($p = 0.001$).

3.3. Distribution of food-borne pathogens in villages

The percentage distribution of pathogens between the villages is shown in Fig. 1. Four villages i.e., Chapola, Chilonga, Milombwa and Ntumbula were located in the wet-lands while Kwilasya and Mdala Makumba were located in dry land. The highest (31%) and lowest (5%) incidence of *E. coli* was observed in Chapola and Mdala Makumba, respectively. The highest (40%) incidence of *E. coli* O157:H7 was observed in Kwilasya, with none being detected in Ntumbula and Mdala Makumba. *S. aureus* and *Salmonella* spp. incidence of 34% and 29%, respectively, were highest in Chapola and Kwilasya. Generally, Chapola and Kwilasya recorded the highest pathogen incidence (both with an average of 27%). There was a significant difference ($p = 0.03$) in pathogen incidence among villages. However, there was no significant difference ($p = 0.26$) in pathogen incidence between dry and wet land locations.

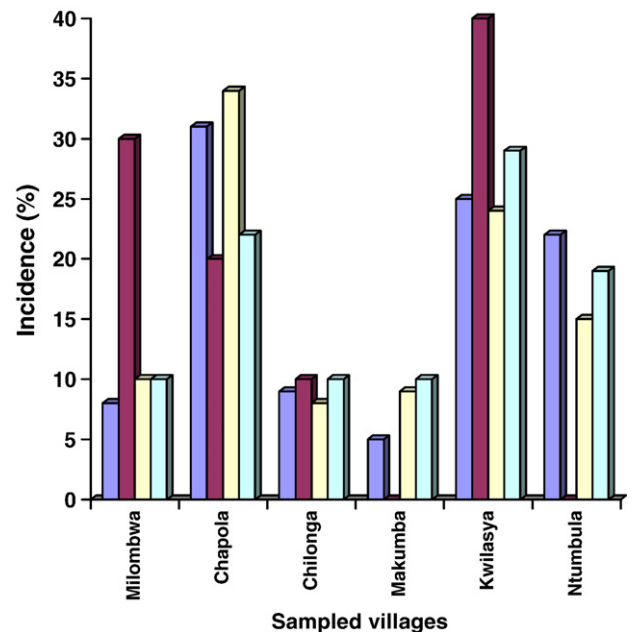


Fig. 1. Distribution (%) of predominant positive samples identified from each village. Bar 1, 2, 3 and 4 for each village represents *E. coli*, O157:H7, *Staphylococcus aureus* and *Salmonella* species., respectively.

Table 1

Incidence of food-borne pathogens in various cooked foods in Malawi

Pathogen	Food categories					
	MFP (n=41)	Fish (n=37)	Vegetables (n=28)	Beans (n=13)	Others ^a (n=13)	Total (n=132)
<i>E. coli</i>	17 (41%)	18 (49%)	15 (54%)	6 (46%)	8 (62%)	64 (48%)
<i>E. coli</i> O157:H7	Nd ^b	2 (5%)	4 (14%)	2 (15%)	2 (15%)	10 (8%)
<i>Salmonella</i> spp.	9 (22%)	11 (30%)	5 (18%)	1 (8%)	4 (31%)	30 (23%)
<i>S. aureus</i>	26 (63%)	19 (51%)	21 (75%)	9 (69%)	5 (38%)	80 (61%)
<i>C. jejuni</i>	Nd ^b	Nd ^b	Nd ^b	Nd ^b	Nd ^b	Nd ^b
Mean (percent)	42	38	40	33	37	35

^aOthers consisted of corn flour, pawpaw, meat, cassava and mangoes.

^bNd; Not detected.

3.4. Food handling, preparation and storage practices

3.4.1. Food handling and preparation

Results on equipment used for food preparation revealed that 44% of the respondents used winnowing basket and knives, 42% used plastic/metal basins and knives while 11% and 7%, respectively, used local chopping boards and knives and "Others" (hands and knives or hand only) (Table 3). Responses on utensil cleaning methods revealed that 72% of the respondents used cold water, 13% cleaned with hot water and a few respondents (7% and 6%, respectively) only wiped the plates with a piece of cloth and "Others" methods (sun drying and no cleaning). Most respondents reported to use borehole water for utensil washing (94%) and cooking of food (84%). Interestingly, hand washing before food preparation was reported by 98% of the respondents and a reasonable proportion of the respondents (59%) indicated that they had washed their hands after using the toilet when preparing food.

3.4.2. Food storage

Most of the respondents (79%) indicated that they stored leftover food for consumption. Storage length ranged from 1 day to more than 2 days, with 69% of the respondents storing their food for 1 day, while 21% and 12%, respectively, stored their leftover food for 2 days and more than 2 days (Table 3). The length of storage was reported to be dependent upon type of food, with beans, fish and meat being stored for more than 1 day. Respondents also reported storing leftover food when they did not have adequate food to last them to the next

Table 3
Food handling, preparation and storage practices and pathogen incidence in 287 households in Malawi

Practices	Frequency of responses	Incidence of all pathogens
	(n=287)	(n=132)
<i>Food preparation equipment</i>		
Local chopping board and knife	33 (11)	12 (9)
Winnowing basket and knife	126 (44)	77 (58)
Plastic basin and knife	121 (42)	34 (26)
"Others"	7 (0)	9 (7)
<i>Hand washing practices</i>		
Before food preparation	280 (98) ¹	130 (98)
After toilet use	68 (59) ¹	42 (32)
<i>Utensil cleaning method</i>		
Cold water	208 (72)	98 (74)
Hot water	37 (13)	30 (22)
Wiping only	19 (7)	2 (0)
"Others"	17 (6)	2 (0)
<i>Source of water for cleaning utensils</i>		
Protected well	1 (0)*	2 (0)
Unprotected well	12 (4)	11 (8)
Borehole	270 (94)	109 (83)
Lake/river	4 (0)*	10 (7)
<i>Sources of water for cooking</i>		
Protected well	4 (0)*	6 (5)
Unprotected well	28 (10)	4 (0)
Borehole	241 (84)	119 (90)
Lake/river	14 (5)	3 (0)
<i>Food storage</i>		
Storing of cooked food	226 (79) ¹	113 (86)
1 day storage	192 (67)	89 (67)
2 days storage	60 (21)	25 (19)
More than 2 days	35 (12)	18 (14)
Animal keeping in food room	102 (36) ¹	22 (17)

*Percentage less than 3.

(¹) Percentages.

¹Yes responses.

harvesting season. A total of 102 out of 287 of the respondents housed animals such as goats, sheep in the same room where all household foods, including leftovers were kept. The presence of both *E. coli* and *S. aureus* in food categories were associated with the keeping of animals in kitchens where food was prepared.

4. Discussion

The study has demonstrated contamination of the food categories by either one or a combination of pathogens (data not presented). Foods prepared and served in Lungwena were observed to have features of street-vended food (served by dirty utensils, exposed to dirty water) that were studied in Africa by Mosupye and Von Holy (1999), Umoh and Udoba (1999), Ekanem (1998), Kubheka et al. (2001) and in Brazil by Hanashiro et al. (2005). In general, the study found MFP to be the most contaminated food category (42%). Contamination of such foods, popularly known as *sadza* in Zimbabwe, has also been reported by Nyatoti et al. (1997). This food category is the most common food that is served in Lungwena households. MFP, just like fermented sorghum porridge studied by Mosupye and Von Holy (1999), is usually prepared at a temperature high enough to kill pathogens. During the study, it was observed that members of the households were eating MFP that was served in a communal plate. Before eating, all members washed their hands from one bowl (communal washing plate) and the dirty water was not changed in between hand washing. Such practices could be the source of the pathogens. When MFP was processed in the laboratory, it was also observed that the food matrix contained raw flour. This raw flour could have acquired pathogens from improper handling. Bacteria could then have been transferred and multiplied in the food during cooling.

C. jejuni was not detected in any food sample. It has been significantly associated with the consumption or handling of raw or uncooked poultry, meats, raw milk and surface water (Ono and Yamamoto, 1999; Humphreys, 2001; Atanassova et al., 2001a). In this study all the samples analysed were different from the associated foods (apart from one meat sample). Previous studies on street-vended as well as home-prepared foods have recorded less than 2% or no incidence of *C. jejuni* (Allmann et al., 1995; Mosupye and Von Holy, 1999; McMahon and Wilson, 2001). Their findings are similar to the results of our study. The sampled food would unlikely be contaminated with *Campylobacter* unless it had acquired the organisms during preparation. *C. jejuni* does not grow in the food as such or in food environment (Cardinale et al., 2005). It is a fastidious organism and particularly sensitive to drying (Griffiths and Park, 1990). Therefore, the kitchen environment could be unfavourable to its persistence and growth. Much as the *Campylobacter* spp. was not isolated, the results should be treated with caution. *Campylobacter* can be difficult to isolate due to its fastidious growth requirements. In addition, it is usually found in small numbers in food samples and hence *Campylobacter* could have hidden within the food matrix and been discarded with residues following inefficient homogenisation. Therefore, the number reported in this study may be an underestimation of the true incidence.

The highest incidence of *E. coli* was demonstrated in the "Other" food category (62%). This category consisted of meat, maize flour, cassava, rice and mangoes. All the foods in this category (except maize flour which was the main ingredient of the MFP) were reported not to be frequently consumed in the households. The maize flour was the most contaminated commodity in this category. In their study of pathogenic *E. coli* in traditional African weaning food, Nyatoti et al. (1997) found *E. coli* in 36% of the food samples used for weaning foods, most of which are prepared from maize flour. Kunene et al. (1999) found an *E. coli* incidence of 53% with a range of 3.20–5.02 log₁₀ CFU/g in sorghum flour and fermented sorghum porridge, commodities that have similar characteristics to maize flour. Home-made street-vended

foods have also been reported to contain *E. coli* incidence of between 7 and 32% (Black et al., 1982; Bryan et al., 1992; Simango et al., 1992; Ekanem, 1998; Umoh and Odoaba, 1999; Cardinale et al., 2005; Hanashiro et al., 2005). There was a high overall incidence of *E. coli* O157: H7 in this study (8% of the samples), with the highest incidence in beans (15%). Previous studies carried out in Zimbabwe have reported finding pathogenic *E. coli* (EPEC) in 16% of all food samples (Simango et al., 1992) while Nyatoti et al. (1997) detected pathogenic strains of *E. coli* in 15% of their food samples and 7% in beans. In our study, it was found that animals were sleeping in the same rooms where food was prepared. Apart from these animals being so close to food in the homes, they were also left to graze around without restrictions. As observed in Kwilasya, animals drunk from open water sources where people also drew their water for drinking and cooking. It was not uncommon to observe animal houses in close proximity to the dwelling houses. Such practices may be contributing to the high incidence of both non-pathogenic and pathogenic *E. coli*. High concentration of *E. coli* correlated with the presence of *E. coli* O157: H7.

Most of the food samples (61%) in the study were contaminated with *S. aureus*. The highest incidence was found in vegetables (75%). Previous studies on home-made street-vended vegetables have reported incidences ranging from 2.5 to 25%, with concentrations of 3–6 log₁₀ CFU/g (Umoh and Odoaba, 1999; Fang et al., 2003; Sandel and McKillip, 2004), which are lower than those found in the present study. It should be noted that the street-vended foods in the previous studies were for commercial purposes and, in order to attract customers extra care might have been observed by the vendors during preparation. These studies were also conducted in urban areas. The presence of *S. aureus* in food is associated with contamination that has been directly introduced into the food by food handlers through coughing and sneezing as well as storage of food at high temperature (Jay, 1996; Kaneko et al., 1999; Sandel and McKillip, 2004). In this study, it was observed that most food was prepared on fire that was made with semi-dried fuel wood. This results in the production of smoke particles which could induce sneezing, leading to contamination of the food. Food was prepared in advance and stored at room temperature for 1–3 h before consumption and this practice could have allowed the pathogens to grow to large numbers. *S. aureus* produces pre-formed toxins that can cause food intoxication (Atanassova et al., 2001b), especially when its population exceeds “10⁵ CFU/g with a temperature of greater than 15 °C at pH>4.6”, (Rørvik and Granum, 1999). The high number of pathogens and the ambient food storage temperature reported in some households may be a contributing factor with regards to Staphylococcal food intoxication.

In this study, a *Salmonella* incidence of 23% was recorded, with fish having the highest incidence (8%). A study by Cardinale et al. (2005) reported a *Salmonella* incidence of 20% in restaurant foods, while an incidence of 2% has been reported in fish by Leite et al. (2000) and FAO and WHO (2002). Fish was caught from a nearby lake (Lake Malawi), whose waters have also been found to contain *Salmonella* spp. (unpublished report). In some households, the fish was observed to be improperly prepared (quick roasting was done during eating) and hence pathogens that are located inside the raw flesh may not be completely killed despite the fact that *Salmonella* is sensitive to heat (Guthrie, 1991). Poultry and its products have also been implicated in the spread of *Salmonella* (Bryan and Doyle, 1995; Humphrey, 2000; Poppe, 2000). Therefore, chickens that were observed in some households, as well as the improper cooking of the fish that might have had been contaminated by the lake water, could be factors leading to a high incidence of *Salmonella* in these products.

Domestic practices of food handling and preparation are one of the numbers of reasons that explain the increasing incidence of gastrointestinal infection associated with domestic environments (Scott et al., 1982; Daniels, 1998; Beumer and Kusumaningram, 2003). The

study has demonstrated that the incidence of pathogens was correspondingly high in households where poor food practices were promoted (Table 3). Most of the households indicated that they cleaned their utensils before serving the food. Water used for cleaning utensils was drawn from boreholes (94%), sources which are normally regarded as safe. Previous studies conducted in the area have found that borehole water gets contaminated in the household during storage (Lungwena NUFU 2004 census: unpublished; Osmundsen, 2005). The Lungwena census also reported that Kwilasya and Chapola villages drew their water from shallow wells. Use of contaminated water has been associated with cross-contamination in home-made food (Simango et al., 1992; Mosupy and Von Holy 2000). Pathogens can be transferred to food from utensils that are not properly cleaned with contaminated water (Williamson et al., 1992; Lee et al., 2006). Therefore, the water might have contaminated the utensils during cleaning and then cross-contaminated the food, as revealed by a high incidence of pathogens in the two villages (Fig. 1). Although no studies have been conducted on the microbiological quality of winnowing baskets, pathogens can easily attach themselves onto the weaves, making them difficult to remove during cleaning. Therefore, these pathogens could have been transferred to the food in the same manner as the transfer of pathogens by chopping boards was observed by De Boer and Hahne (1990), Scott and Bloomfield (1990) and Humphrey et al. (1994). Our study also observed that hand washing was mostly done without using any sanitizers. This could have promoted transfer of the pathogens from the hand to the food. Cogan et al. (2001) argue that mechanical removal of pathogens with soap and water alone is not the most effective method for achieving hygiene, but that this should be supplemented with the use of an effective disinfectant.

In conclusion, this study found that home-made food in Lungwena is contaminated with food pathogens. MFP, which is the main food that Lungwena households depend on for daily meals, is the most contaminated foodstuff. Although food is cooked (boiled) at a temperature high enough to inactivate pathogens, post-contamination and cross-contamination that is being promoted by unhygienic food handling, and incorrect storage practices are causing this “safely prepared food” to be unsafe. One of the high risks in domestic kitchens is storage of leftover food (Beumer and Kusumaningram, 2003) and this study has revealed that 79% of the households stored leftover food for consumption for more than 2 days. It is very unlikely that all the respondents warmed the leftover food before consumption. The storage of leftover food at room temperature by most households, preparation of foods such as vegetables, beans and fish well in advance, as well as keeping animals in the same room where leftover food was stored, is sufficient directly to associate such practices to contamination of the food as reported by previous investigators (Roberts, 1982; Ryan et al., 1996; Brinkman et al., 1999). The occurrence of these pathogens calls for concerted efforts by the Ministry of Health, Environmental Health Officers and Surveillance Health Assistants in developing food safety education campaigns. Control measures for the diarrhoeal diseases occurring in the area should not only target water sources.

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