

## Microbial safety of Selected Food Borne Pathogens in Relation to Hygienic Practices in Industrial area, Nairobi Kenya

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### Abstract

Street food is valued for its importance in feeding urban population with cheap, accessible and nutritious foods. Street food can lead to food poisoning and illnesses resulting mainly from poor hygienic practices. There are limited studies on the hygienic practices and food safety for street food in Nairobi. This study was conducted to evaluate hygienic practices and relate it to microbial safety of street food in Nairobi Kenya. Twenty nine street foods vending stalls from five major roads namely; Enterprise, Lunga lunga, Ricky, Likoni and Nanyuki roads were evaluated. Seventy six percent of vendors did not hold food handlers medical certificate. A total of 88% of the sites were clean while 79% of the stalls were constructed by polythene bags and was spread in all location. Sixty six percent of vendors spread across all studied locations did not have protective clothing. Seventy nine percent of vendors had no training on food hygiene. Vendors in Lunga lunga road reported having received some training through an NGO and a women group. Majority of vendors used polythene bags for packaging take away rations. A total of 76% reported to not have received any customer complaints. Sixty nine percent of vendors dumped their wastes into Nairobi city council waste bins, while 79% used the Nairobi city council sanitary facilities. There ought to be adequate provision of water, sanitary facilities, waste collection services and training programs for the street food vendors to preempt any possibility of food poisoning outbreaks. These practices were observed in all locations where microbial counts were significantly different from each other suggesting that the practices could not be related with the counts.

**Key words:** street foods, food handling, virulence genes

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### Introduction

This study was conducted to evaluate the status of hygiene practices of street foods prepared on site and relate them to microbial contamination and pathogenicity of selected food borne pathogens in Industrial area, Nairobi. This would be used to advise on the appropriate measures which could be applied to avoid potential cases of food borne diseases. Nairobi is the capital of Kenya and the biggest city in East Africa with a population of 3.1 million residents (KNBS, 2010).

Street food is defined as food sold at various places with more access to consumers (FAO 2007).

The street food industry in Industrial area of Nairobi plays an important role in meeting the dietary needs of the Industry workers owing to its accessibility,

low cost and wide variety (Latham, 1997). (Mensah et al. 2002 and Dardano, 2003) note that a large proportion of ready to eat food is sold in the streets as the main food intake to consumers in the low socio-economic brackets. In Nigeria, substantial nutritional demands are met from street food in adolescent attending schools (Oguntona and Kanye, 1995) and urban market women (Oguntona and Tella, 1999). Involvement in street food is also a source of employment (Mwangi, 2002; Latham, 1997; Mensah et al. 2002; Muinde and Kuria, 2005). Street food has become common feature of urban life (Hilda, 2002). However, street food is prepared in unsanitary conditions employment (Mwangi, 2002; Muinde and Kuria, 2005; FAO, 1997) and can be a source of food contamination and food poisoning (WHO, 2011; Mensah et al. 2002; WHO, 2001). Food preparation surfaces and ready to eat foods can be reservoirs of microbial contamination (Christison, 2008; Ghosh et al.

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2007; Mankee et al. 2005). It has been established that ineffective personal hygiene can facilitate the transmission of pathogenic bacteria found in environment and on people's hands via food to humans (Tambekar et al. 2008; Mensah et al. 2002). Street food vendors are often unlicensed, untrained in food safety, hygiene and sanitation, and work under unsanitary conditions (FAO, 1997).

### Materials and Methods

A descriptive survey was conducted in Industrial area, Nairobi through structured questionnaires and observation as described by (Gay, 1982). Twenty nine sites were purposively selected to include vendors who prepare and sell food on site and formed the study area. The study sites involved included; 13 stalls from Enterprise road, 5 from Lunga lunga road, 6 from Ricky road, 3 from Likoni road and 2 from Nanyuki road. It covered areas on the stalls status, raw materials, food preparation work methodology, food handlers, utensils, sanitary facilities, customer complaints and pests. Qualitative data descriptive analysis from the hygiene questionnaire among the locations was carried out with SPSS version 17.

Fifty six samples from 7 food categories (FAO, 2011) were sampled from the selected stalls and analysed in a cross sectional study carried out between March and August year 2011. All food sampled were prepared, vended and consumed on site. The foods sampled were served within three hours of preparation.

Referenced results are extracted from a study conducted concurrently. Microbial counts and molecular typing were carried out using standard microbiological methods as reported in (Gitahi et al. 2012)

### Results

**Hygienic and sanitary status of food stalls and its environs** Potential contaminants sources were evaluated in the study sites. The surrounding environment of the food vending facilities was assessed by observation for cobwebs, soot and dust.

All locations were exposed to at least one potential source of contaminants. Waste water drainage tunnels were 24 %, (7/29) in the proximity stalls to roads. Vehicles passed within ten metres in 27 %, (8/29) of the street food vending stalls. Six percent (2/29) of the sites were considered safe from contaminants (Table 1) at the time of assessment. Other potential sources of contaminants included dusty within five metres, and mud and sludge within two metres. High frequency of stalls (85 %) in Enterprise road had food preparation and serving areas with drainage tunnels and passing vehicles as potential contaminants. The potential contaminants included houseflies with the highest occurrence at 55 % (16/29) of all stalls and 77 % (10/13) of

stalls in Enterprise road and soot in 21 %, 6/29 of all stalls. Dust and cobwebs were among the least common sources of contaminants besides raw material peelings in one stall of Lunga lunga road (Table 1).

**Table 1. Potential contaminants sources in five roads in Industrial area, Nairobi**

	Enterprise n=13	Ricky n=6	Lunga lunga n=5	Likoni n=3	Nanyuki n=2
Dusty road within two metres	7 %	0 %	0 %	0 %	0 %
Drainage tunnel within five metres	11 %	0 %	30 %	33 %	0 %
Dust	7 %	7 %	10 %	33 %	0 %
Dusty road within five metres	3 %	0 %	0 %	0 %	0 %
Garbage site within fifteen meters	3 %	7 %	0 %	0 %	0 %
Mud and sludge within two meters	3 %	0 %	10 %	0 %	0 %
Vehicles passing within ten meters	11 %	17 %	0 %	33 %	50 %
None	3 %	9 %	0 %	0 %	0 %
House flies	33 %	14 %	30 %	0 %	25 %
Dust	0 %	7 %	0 %	0 %	0 %
Soot	7 %	21 %	0 %	0 %	25 %
Cobwebs	3 %	7 %	0 %	0 %	0 %
Open air no risk	7 %	7 %	10 %	3 %	0 %
Raw material peelings	0 %	0 %	10 %	0 %	0 %

**Cleanliness of vending stalls** Majority of sampled stalls were found to be clean. Highest levels of cleanliness were observed in Enterprise road, (85 %) 11/13. Likoni road had 100 % dirty stalls with dust, soot, cobwebs, houseflies and mud recorded at the time of assessment. Also, majority consisting of 83 % (24/29) of the stalls sampled were found to have clean equipment/utensils and vendors used soap in cleaning.

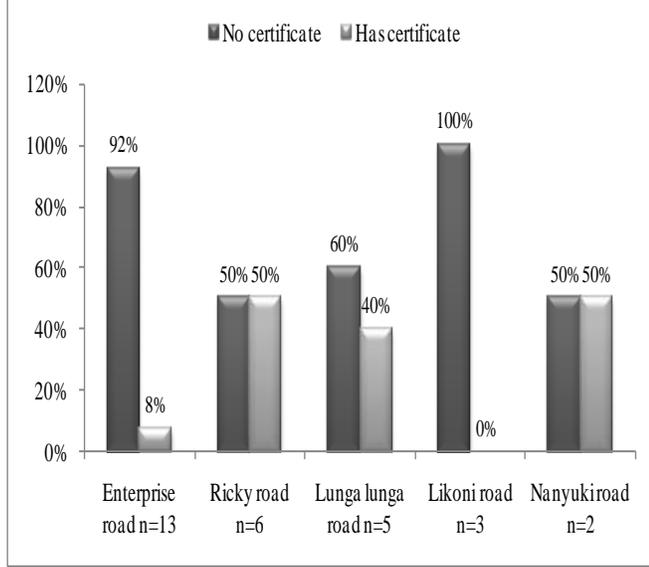
**Construction materials for the street food stalls** An array of materials were used to construct the make shift stalls. Majority of stalls in all locations were constructed using polythene bags, while hard board and iron sheet were less commonly used (Table 2). One vendor operated in open air in Likoni road.

**Table 2. Construction materials used in the street food stalls from five selected locations in Industrial area, Nairobi**

	Enterprise n=13	Ricky n=6	Lunga lunga n=5	Likoni n=3	Nanyuki n=2
Polythene bags temporary roof	42 %	40 %	40 %	50 %	100 %
Polythene roof and wall	33 %	60 %	40 %	0 %	0 %

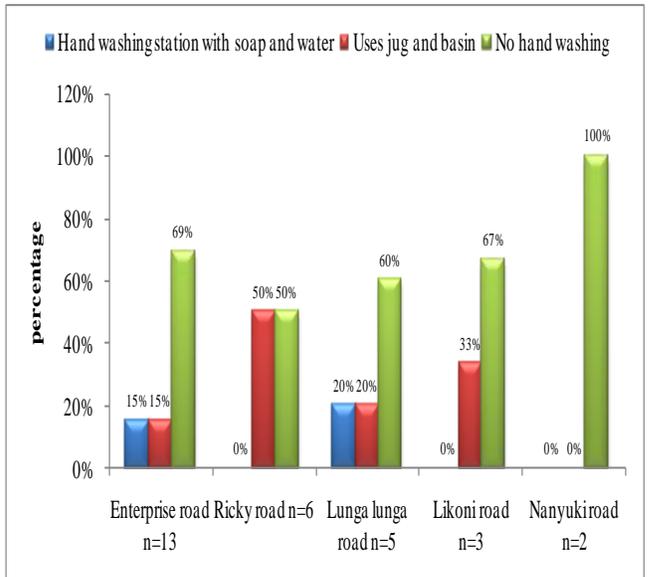
Hardboard wall and polythene roof	8 %	0 %	0 %	0 %	0 %
Iron sheet roof and polythene wall	8 %	0 %	0 %	0 %	0 %
Iron sheet roof and wall	8 %	0 %	20 %	0 %	0 %
Open air no roof or wall	0 %	0 %	0 %	50 %	0 %

**Food handlers/vendors practices** Possession of medical health certification by food handlers: Seventy six percent, (22/29) of vendors did not have a food handlers' medical certificate in all the locations. Majority of those without certificates consisted of 92 %, (12/13) of vendors from Enterprise road (Figure 1).



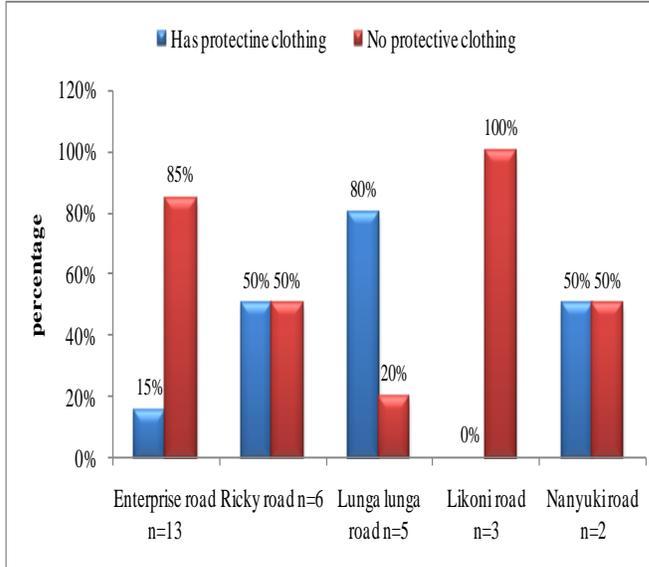
**Figure 1. The percentage of street food vendors with food handlers' medical certification in five roads of Industrial area, Nairobi**

**Hand washing** Majority (66 %) 19/29 of vendors from the sampled stalls did not facilitate washing hands of by customers. Among those who washed the customers' hands, 24 % (7/29) used a jug and a basin in hand washing while 10 % (3/29) had a hand wash station with water and soap. No hand washing was done in Nanyuki road (Figure 2). Vendors in all the locations reported that most of the customers preferred partial packaging of the foods with polythene bags or use of cutlery altogether. Also, Use polythene bags to package take away rations was spread in all locations, while use of personal containers and maize leaves was used in one stall.



**Figure 2: The percentage of hand washing by customers in street food stalls of Industrial area, Nairobi from five locations**

**Protective clothing** Thirty four percent (10/29) of the vendors used protective garment. However, only 10 % (3/29) had complete coats while 24 % (7/29) had half coats which could not offer protection. The lack of protective coat was noted in all the locations but high levels in Enterprise 85 % (11/13) and all 3 (100 %) stalls in Likoni roads (Figure 3).



**Figure 3. The percentage of vendors wearing protective coats in the street food stalls of five roads in Industrial area, Nairobi**

Twenty four percent (7/29) of the vendors who had protective clothing washed their coats on a weekly basis, while 69 % washed the coats when visually dirty and 100 % in Enterprise road.

**Training of street food vendors on food hygiene and safety** Only 6/29 (21 %) have had training on food hygiene and food safety (Table 3). Another 7 % (2/29) relied on basic primary education, 2 vendors in Enterprise road had secondary school training while 2 vendors in Lunga lunga road had training from NGO and women groups.

**Table 3: Food hygiene training amongst street food vendors in five selected roads in Industrial area, Nairobi**

	Enterprise road n=13	Ricky road n=6	Lunga lunga road n=5	Likoni road n=3	Nanyuki road n=2
No training	77 %	100 %	40 %	100 %	100 %
Basic education in primary	7 %	0 %	20 %	0 %	0 %
Basin education in secondary	15 %	0 %	0 %	0 %	0 %
NGO and women groups	0 %	0 %	40 %	0 %	0 %

**Food handling practices before serving** Holding food after cooking and before serving: Majority consisting of 82 %, (23/28) of respondents let the food cool naturally while they wait for the customers. All vendors in Lunga lunga and Nanyuki road reported to let the food cool naturally. Others 8 % in Enterprise road and 17 % in Ricky road held their food on hot surface while some held the food warm (Table 4).

**Table 4. Method of food holding after cooking and prior to serving by street food vendors in five elected roads from Industrial area, Nairobi**

	Enterprise road n=13	Ricky road n=6	Lunga lunga road n=5	Likoni road n=3	Nanyuki road n=2
Left to cool naturally	92 %	50 %	100 %	67 %	100 %
Held on hot surface	8 %	17 %	0 %	0 %	0 %
Held warm	0 %	33 %	0 %	33 %	0 %

**Water quality and handling of raw materials** All the vendors do not treat or boil their drinking water. Majority 62 % (18/29) of vendors obtain their water from street water vendors and water kiosks 34 % (10/29) while a vendor in Enterprise road carries water from home. Some vendors in Enterprise road obtain water from both water kiosks and water vendors while all vendors in Likoni and Nanyuki roads obtain from water vendors (Table 5).

**Table 51. Sources of water for street food vendors from locations in Industrial area, Nairobi**

	Enterprise road n=13	Ricky road n=6	Lunga lunga road n=5	Likoni road n=3	Nanyuki road n=2
Water kiosk	54 %	40 %	20 %	0	0
Water vendors	54 %	60 %	80 %	100 %	100 %
Home	1	0	0	0	0

Majority 52 % (15/29) of the vendors obtained their raw materials from local groceries, followed by Wakulima market 38 % (11/29), local shops 31 % (9/29), local butcheries, Kia Michael market and raw food vendors/suppliers. Local sourcing was widely practiced (Table 6). Most vendors had multiple sources of food raw materials.

**Table 6. Sources of raw material for the street food vendors in five locations in Industrial area, Nairobi**

	Enterprise road n=13	Ricky road n=6	Lunga lunga road n=5	Likoni road n=3	Nanyuki road n=2
Wakulima	18 %	30 %	43 %	33 %	0 %
Raw food vendors	5 %	0 %	0 %	0 %	0 %
Local groceries grain vegetables vendors	36 %	20 %	43 %	33 %	25 %
Local butcheries	9 %	10 %	0 %	0 %	50 %
Kia Michael	9 %	20 %	0 %	0 %	0 %
Local shops	18 %	20 %	14 %	33 %	25 %
Some food precooked at home	5 %	0 %	0 %	0 %	0 %

**Pests** None of the respondents reported having encountered any pest or rodent. No control measure was noted to have been used because they encountered none.

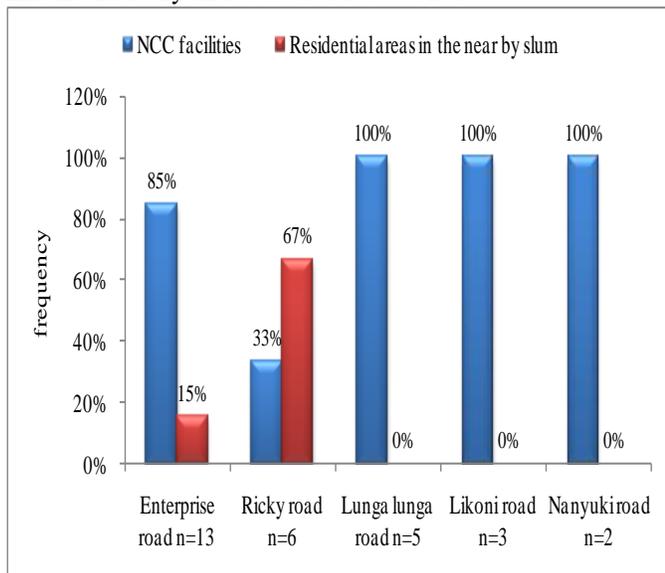
**Customer complaints** Only 21 % (6/29) of vendors had received customer complaints (Table 7) including; food quality consistency, flavour, taste and texture in Enterprise road, Ricky and Nanyuki roads and poor ration mixture in Lunga lunga.

**Table 7. Customer complains in street food stalls from five locations in Industrial area, Nairobi**

	Enterprise road n=13	Ricky road n=6	Lunga lunga road n=5	Likoni road n=3	Nanyuki road n=2
Food quality consistency					
flavour taste and texture	31 %	17 %	0 %	0 %	50 %
Ration mixing	0 %	0 %	20 %	0 %	0 %

	None	69 %	83 %	80 %	100 %	50 %
<b>Waste disposal</b>	Seventy two percent (21/29) of vendors dump wastes from their stalls into Nairobi city council waste bins. Only 31 % (9/29) sell the vegetable wastes. A vendor in Likoni road drains the waste water into the drainage nearby (Table 8).					
	Enterprise road n=13	Ricky road n=6	Lunga lung road n=5	Likoni road n=3	Nanyuki road n=2	
NCC bins	85 %	67 %	60 %	33 %	100 %	
Sell vegetable wastes		50 %	80 %	33 %	0 %	
Wash water to drain	0 %	0 %	0	33 %	0 %	

**Access to sanitary facilities** Seventy nine percent, (23/29) vendors use the Nairobi City Council (NCC) sanitary facilities (toilets) while 21 % (6/29) use sanitary facilities in the nearby slums (Figure 4). All vendors in Lunga lung, Likoni and Nanyuki roads used NCC toilets.



**Figure 4. Sanitary facilities used by street food vendors in five locations in Industrial area, Nairobi**

### Discussion

Studies have indicated that ready to eat foods and food preparation surfaces may be reservoirs for microbial contamination (Mankee et al. 2005; Ghosh et al. 2007; Christison et al. 2008). Street foods can also be sources of enteropathogens (Mensah et al. 2002). Food borne

microorganisms cause disease through infection or intoxication.

Majority of street food vending stalls (22/29) were clean at the time of the survey signifying an effort by the vendors to keep their area of work clean. This was despite some stalls being exposed to potential contaminants and houseflies in all the locations except Likoni road stalls. The presence of houseflies implies probable lack of adequate sanitation. This agreed with (Muinde and Kuria (2005) who found houseflies in most of the street food stalls in Nairobi. Muganga, 2001 noted house flies in 54.8 % of the vending stalls. This implies that food contamination is most likely to occur despite efforts to keep the stalls clean. In a study conducted in Ghana by Annan-Prah et al (2011), food items were sold in the open-air which was dusty, near drainage gutters and some near garbage bins. Muinde and Kuria, (2005) reported about 85 % of the vendors prepared their foods in unhygienic conditions given that garbage and dirty waste were close to the vending stalls. In some of the stalls vehicles passed by within ten meters while 97.6 % stalls were situated where vehicles passed within 20 meters radius. The maintenance of clean stalls is made difficult by the nature of construction material given the fact that most stalls where constructed using polythene bags. This was also observed in a study carried out by Muinde and Kuria (2005) where most of the stalls in Nairobi (23/29) were made of polythene bags and wood, which are difficult to clean and sanitize. In the present study equipment was clean and that majority of the vendors cleaned the utensils after every meal using soap during cleaning. These practices were observed in all locations where microbial counts were significantly different from each other suggesting that the practices could not be related with the counts.

In terms of medical certificates, only 24 % (7/29) vendors had food handlers' medical certificate. This was lower than levels noted in the streets of Accra Ghana (40 %) by Ackah et al. (2011). Annan-prah et al. (2011) observed that 45 % of street food vendors in Cape coast Ghana were not certified medically to handle food. As highlighted in the standard newspaper, Kenya of September 13 2011, there is a need to ensure food handlers are immunized or treated against typhoid and other food borne illnesses. There is a gap to ensure only medically fit food vendors handle ready to eat foods. The highest percentage of vendors without food handlers medical certificate were in Enterprise road where microbial counts were lower than other locations with relative higher vendor with the certificates (Gitahi et al. 2012) suggesting this could not be determinant in microbial counts of the street food.

The equipment could be contaminated during the drying step where the vendors overturned the utensils on a basin and on a make shift rack uncovered and could not protect the utensils from possible contamination from the environment.

Only 34 %, 10/29 of the vendors provide equipment for hand washing. Some use a jug and a basin to aid in hand

washing, while others had a hand wash station with water and soap. This differs from a study by Muganga (2001) where it was revealed that 50 % of vendors had hand washing vessels. It has been established that ineffective personal hygiene can facilitate the transmission of these pathogenic bacteria found in environment and on people's hands through food to humans (Tambekar *et al.* 2008; Mensah *et al.* 2002). Atbara city, Nahr Elneel, Sudan where 98% of the respondents agreed the hand must be washed before eating meal (Abdalla *et al.* 2009). Consumers were reported to prefer using cutlery instead of finger food eating. This could eliminate contamination during eating since there is no contact between unwashed hands and the food. This disparity in hand washing practices indicated no relationship to microbial counts reported by Gitahi *et al.* 2012.

Sixty six percent (66 %), (19/29) of the vendors did not have protective clothing and could not protect the foods they handle from any contamination from their bodies and clothing. The wearing of protective coats by personnel was 50 % in Ricky road and 15 % in Enterprise road. Majority of the food vendors in Enterprise road, 92 % did not have protective coats while prominent contaminants were dust, houseflies, and vehicles passing by.

Muinde and Kuria (2005) also reported that 81.3 % of the vendors did not use aprons.

There was a lack of training; 79 % (23/29) of the vendors were not trained suggesting lack of control in food protection from contaminants. This was also as noted in India by Tambekar *et al.* (2011) where food vendors were unaware of food regulations and were untrained on food hygiene. Despite the variation in the use of personal protective clothing and lack of food safety and hygiene training, the microbial counts in the study locations were not significantly different suggesting microbial counts were not determined by these two parameters.

Majority of the vendors 79 % (23/29) left the food cool naturally which could lead to multiplication of microorganisms present in the food at the time of storage. However, this food was always served within 3 hours of cooking and mostly when hot. Two food categories: vegetables and meat (fish) had unacceptable levels of *Staphylococcus aureus* possibly emanating from post cooking handling in fish while the vegetables were primarily salads (uncooked). Eighty seven per cent (26/29) of the vendors use polythene bags to wrap take away rations. Muganga (2001) in contrast reported that printed papers were the major packaging media in street foods in Nairobi. This could have resulted from the revolution into use of plastics recently to replace most other packaging material. Annan-prah *et al.* (2011) also had observed that 6 % of street food vendors in Cape coast Ghana use newsprints, and 20 % polythene bags to package food. The increase in the usage of polythene bags in Nairobi suggest measures are required to ensure these packaging forms are free of any potential food contaminant.

All vendors have not received any customer complaints related to food safety while some 21 % (6/29) stated to have received complaints on the texture and consistency of the foods. Three per cent of vendors have received complains on the varying quantities of the rations/menus. Annan-prah *et al.* (2011) observed that only 4 % of street food clients in Cape coast Ghana were concerned with hygienic considerations of street food. This could be the case in Kenya where street food customers may have not reported food borne disease.

Majority of the vendors obtained water from water vendors (62 %; 18/29) and water kiosks (34 %; 10/29) indicating dependence on water supply the vendors have no control over. This agreed to a study by Muganga in 2001 where majority of vendors obtained water from kiosks, suggesting more people engage in water vending business in the streets. Muinde and Kuria (2005) observed that water was ferried from homes of the street food vendors because no potable water was available at their areas of operation. However, this water may not be enough for dish washing and food preparation.

Water in all the stalls is not boiled before serving for drinking suggesting the need for assurance that the water must be safe for human consumption from the source if the water is not obtained from treated sources of the city council. Some vendors (31 %) did not wash their raw food before cooking. These results agree with those of Muinde and Kuria (2005) who found that vendors did not wash fresh foods properly. Pathogens may enter the food system during preparation, cooking, packaging or marketing (Barro *et al.* 2007). Vendors obtained their raw materials from multiple sources indicating the need for a wider approach in addressing the safety of street food. There ought to be traceability measures in the pursuit to ensure safe street food in Nairobi city of Kenya.

Majority (69 %) of vendors dump their waste into Nairobi City Council waste bins. Some vendors (21 %) sell the vegetable wastes while 33 % of vendors in Likoni road drain the waste water into the drainage nearby. These disposal methods do not pose a threat in contamination of street food prepared and consumed on site. Muinde and Kuria (2005) reported that 92.5 % of street food vendors in which Nairobi did not have garbage receptacles; hence they disposed their garbage near the stalls. This suggests waste bins may have been introduced in which Nairobi city after the study by Muinde and Kuria (2005).

A total of 79 % (23/29) vendors sampled use the NCC sanitary facilities while 21 % use the nearby slums which indicate the need to improve access of these facilities in the streets where the food vending business is prevalent. The NCC has created access for this. There however need to be awareness creation for people to use more of the existing facilities.

## Conclusion

The findings of this study reveal areas of improvement which could be implemented towards attaining safe street food.

Majority 76 % of vending stalls were seen to be clean which indicates an effort by the vendors to keep their premises clean. However, there is a need to ensure the stalls are properly located to prevent the food contamination from the potential contaminants. Construction materials should be designed for easier cleaning. Seventy six per cent of vendors did not hold food handlers' medical certificate. It is recommended that medical screening be carried as a requirement as any carrier of a food pathogen can contaminate food.

Only 34 % of the vendors hand washes their customers. Most customers were reported to prefer polythene bags and cutlery instead of washing hands. Stalls owners and the food handlers should be trained to embrace a hand washing culture to avoid any food contamination. This should augment already existing media advertisements to embrace hand washing. Emphasis should be moved from school children alone to the whole population.

Only 34 % vendors wore protective clothing and majority could not protect the food from contamination emanating from their bodies. The wearing of protective clothing will need to be enforced to ensure potential of food contamination is reduced.

There were no customer complaints regarding food safety signifying a higher level of satisfaction by consumers on the services obtained from these stalls or ignorance altogether. It could also mean under reporting of the complaints.

Training on food hygiene and food safety was lacking in 79 % of the vendors. All vendors were women and consideration can be enhanced by food hygiene training programs that can be correlated to women participation in the society.

A total of 79 % vendors could let the food cool naturally and if the food is not purchased and served when hot, there is potential microbial multiplication if contamination occurs. A total of 90 % vendors use polythene bags to wrap/pack take away rations. The high frequency of usage of polythene bags to package food will require these material evaluated for potential source of contamination.

Seventy nine percent; (79 %), (23/29) of the vendors used NCC sanitary facilities. The high level of dependence of NCC facilities indicates a need to harmonize and provide services at close proximity to the food vendors and their clients.

The water is not boiled before serving to customers. Since some (7 %) of this water is not obtained from treated sources of the NCC, then it should be evaluated as a potential source of food contamination. The water can also be contaminated during vending and could be evaluated.

The outcome of this study can serve as a baseline data for management and improvement of the street food safety based on these areas.

From the referenced study (Gitahi et al., 2012), the vegetable foods the highest total viable counts at  $4.71 \pm 0.3 \log_{10}$  cfu/g, highest total coliforms counts at  $4.48 \log_{10}$  cfu/g and highest *Staphylococcus aureus* at  $4.03 \log_{10}$  cfu/g. All vegetables were served raw. They were not heat treated and were held at ambient temperature between preparation and service.

Vegetables from Ricky road were sourced from Wakulima market and local groceries and had the highest *Staphylococcus aureus* counts of  $4.69 \pm 0.05 \log_{10}$  cfu/g. There was significantly similar ( $p < 0.05$ ) counts ( $\log_{10}$  cfu/g) of *Staphylococcus aureus* in vegetables from Nanyuki road (4.45), Ricky road (4.60) and Likoni (4.51). Enterprise road and Likoni road whose raw material vegetables were obtained from local groceries and Wakulima market had significantly similar counts ( $p < 0.05$ ) of *Staphylococcus aureus* in vegetables suggesting contamination may have originated from the raw materials. Total coliform counts from vegetables in Likoni and Lunga Lunga road were significantly similar ( $p < 0.05$ ). Fifty percent of vegetables in Lunga Lunga road and Likoni road had been obtained from Wakulima market and local groceries each. Sixty percent of raw materials used for preparation of street foods were from Wakulima market while 40 % were from local groceries. Fifty percent of raw materials for preparation of street foods in Nanyuki road were sourced from local groceries and all had significantly similar contamination levels of coliforms counts in vegetables ( $p < 0.05$ ). These suggest coliforms could have emanated from several sources as reported including the raw materials or wash water. All vendors in these locations obtained water from vendors and could have resulted in the difference in microbial counts.

*Enterococci* counts in vegetables were highest in Nanyuki road with  $3.44 \log_{10}$  cfu/g. All vegetables were obtained from local groceries. Vendors in this location were not trained on food safety and hygiene, 50 % of the vendors had no food handlers' medical certificate and protective coat and no hand washing was of clients. There were 77 % of the stalls with houseflies as a potential source of contamination. In the same location, 69 % of the vendors did not hand wash their customers, 92 % did not have food handlers' medical certificate. This indicates a potential sanitation problem despite the fact that 85 % of stalls accessed were clean. Also 85 % of the vendors in this location used Nairobi City Council waste bins to dispose of their wastes. In meat based street foods, *Staphylococcus aureus* and coliforms contamination in the meats were significantly different ( $p < 0.05$ ) in all the locations. These were sourced from Kia Michael meat market and local butcheries for all the street food vendors. Counts of *Staphylococcus aureus* could have resulted from post cooking handling of the foods. Meats in Nanyuki road had unacceptable counts of

coliforms of 4.10 log<sub>10</sub> cfu/g; levels above the limits of 4.00 log<sub>10</sub> cfu/g (KEBS, 2003). It was noted in Nanyuki road that 50 % vendors had no food handlers' medical certificate and protective coat and additionally no food hygiene training and no hand washing of clients.

The presence of unacceptable levels of coliforms in meat (fish) from Nanyuki road may suggest inadequate handling during the display of fish before sale by the vendors. In this location 50 % of stalls were dusty and had houseflies suggesting inadequate sanitation.

In the legume based street foods, *Enterococci* species counts were lowest in legumes (2.04 ±0.06 log<sub>10</sub> cfu/g). Coliform counts were 2.33 log<sub>10</sub> cfu/g and 3.37 log<sub>10</sub> cfu/g for *Staphylococcus aureus*. All legumes met microbial safety standards (KEBS, 2003; Gilbert et al. 2000).

Microbial counts in starchy roots based street foods were 2.42 log<sub>10</sub> cfu/g for coliform and 2.44 log<sub>10</sub> cfu/g for *Enterococci*. No microorganisms were detected in starchy roots from Ricky and Lunga lunga. The absence was expected from the fact that these foods are extensively boiled on site and peeled before serving.

Microbial counts in cereal were within the standards or limits for acceptable street foods (KEBS, 2003; Gilbert et al. 2000).

In the mixed dishes, *Escherichia coli* were qualitatively detected from only one sample. These foods are extensively boiled. This may be why microbial count was low at 2.70-2.90 log<sub>10</sub> cfu/g for coliforms and 3.30 - 3.34 log<sub>10</sub> cfu/g for *Staphylococcus aureus*.

The beverage had the lowest total viable counts at 3.19 ± 0.2 log<sub>10</sub> cfu/g. Coliforms, *Staphylococcus aureus* and *Enterococci* species were not detected in the beverage foods. This was expected since these foods were heated to boiling during cooking and were subsequently served hot.

Strains of *Escherichia coli* detected in vegetables from Lunga lunga and Likoni road and mixed dish (githeri from Likoni road) were confirmed to be different through Rep PCR analysis against reference strains previously reported to contain virulence genes *stx2*, *stx1* and *eae* by Kohler et al. (2008).

*Staphylococcus aureus* isolated from street food do not possess enterotoxigenic genes that code for production of (se) staphylococcal enterotoxin genes *d* and *g* (Gitahi et al. 2012)

Studies are also required to establish the safety of water used in the street food preparation and the efficacy of the hygienic practices in the street food stalls of Nairobi, Kenya.

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