Qualitative Risk Assessment of *Campylobacter jejuni* in Street Vended Poultry in Informal Settlements of Nairobi County

Beatrice J. Birgen[1]*, Lucy G. Njue[1], Dasel M. Kaindi[1], Fredrick O. Ogutu[2]

1Department of Food Science, Nutrition and Technology, University of Nairobi, P. O. Box 29053-00625 Nairobi, Kenya

2Food Technology Division, Kenya Industrial Research and Development Institute, P.O. Box 30650, GPO, Nairobi-Kenya

.

ABSTRACT

Aim: To determine the food safety risks of consumption of street-vended poultry products, to evaluate the determinants of microbial safety and the risk rank of these products.
Study design: A cross-sectional survey was done in the Korogocho and Kariobangi North slums among the consumers and vendors to assess their food safety knowledge and practices. Swab samples of the cooking equipment, utensils, and personnel, raw and cooked portions of poultry were collected for microbial quality evaluation. The most prevalent microorganism was assessed for its qualitative risk rank using the Risk Ranger software.
Place and duration of study: The study was carried out in the capital city of Kenya, Nairobi, from June 2018 to July 2018.
Methodology: A total of 15 vendors were exhaustively sampled and included in the study with the food safety and hygiene practices evaluated using a food safety checklist. The snowballing sampling technique was used to locate all the vendors. Samples of raw and cooked street vended poultry products were subjected to microbial analysis. All samples were collected in sterile polythene bags followed by transportation to the laboratory of the Department of Food Science and Technology of the University of Nairobi and microbial analysis.
Results: *Campylobacter jejuni* contamination, in both raw and cooked poultry products, was 8.95±0.94 $\log_{10}$ CFU g-1 and 4.66±2.67 $\log_{10}$ CFU g-1 respectively; the probability of contamination of raw street-vended poultry was found to be 48.96 %. The mean weekly intake of the poultry was reported 140.0 g per person. The probability of *campylobacter* infection in an individual consumer was found as 7.12 x 10-3 with the predicted illnesses among the population found as 1.11 x 106 cases. The qualitative risk estimate from the study was reported as 67, above the limit of 48 for medium risk.
Conclusion: The study concluded that *Campylobacter jejuni* posed high food safety risks as a resultant from the consumption of street-vended poultry.

Keywords: Campylobacter jejuni; Qualitative; Risk assessment; Street-vended; Poultry; Informal settlements

* E-mail address: birgenjeruto@gmail.com.

1. INTRODUCTION

Informal food vending either along the streets or market places contribute to the daily food intake of the urban and peri-urban poor [1]. The utilization of street foods is so high in developing countries especially in informal settlements [2]. The increasing popularity of street vended poultry is coupled with the increased intake of ready to eat poultry especially in urban areas [3]. This is because street-vended poultry is known to be affordable, accessible and ready-to-eat, thereby the high utilization in urban households. Street-vending in sub-Saharan African countries and other developing countries is informal with less regulation of the sector [4], thus the value and quality of food in this sector are usually not easily documented.

Despite the ever-increasing utilization of street-vended poultry products, safety concerns still linger over these foods. These foods are often sold in compromised hygienic conditions and are usually left open for display [5]. Microbial pathogens including but not limited to *Salmonella*, *Escherichia coli*, *Listeria monocytogenes*, *Staphylococcus aureus* and *Campylobacter* are prevalent in these products [6–9]. A study was done on street-vended chicken in Taiwan and the Philippines reported a salmonella contamination level of 7% and 8%, respectively [6]. Considering that poultry is a vehicle for various microorganisms, it's contamination with disease-causing microorganisms such as *Salmonella* and *Campylobacter* becomes a public health concern [8]. Factors that predispose these foods to contamination include personal and equipment hygiene, working environment and time and temperature abuse for the cooked food [10].

Campylobacter species including *C. jejuni* and *C. coli* are potent food pathogens found in poultry products and indeed several risk assessment reports have attributed chicken consumption to several campylobacter incidents [3,11]. The two microorganisms are part of a group of C*ampylobacter* species that causes campylobacteriosis which is a major foodborne infection from poultry products [12]. Campylobacteriosis is highly infectious and a leading cause of bacterial gastroenteritis [13]. The EU notification rate for campylobacteriosis in 2012 was found to be 55.49 per 100,000 population [14]. *C. jejuni* and *C. coli* account for almost 95% of the global incidences of campylobacteriosis [15]. Additionally, *C. jejuni* infection can also lead to auto-immune conditions of Guillain-Barré syndrome (GBS) and Miller Fisher syndrome [12]. Studies among under-five-year-old children showed that Campylobacter infection was as high as 17% [16]. This shows a threat to one of the most vulnerable groups.

The risk posed by the contamination of *C. jejuni* in street vended poultry needs to be managed through guided policy action with a scientific justification of its course. However, quantitative risk assessment of *C. jejuni* in street-vended chicken in Nairobi County was difficult due to limited specific data on the food-borne illnesses associated with this microorganism in the country [17]. The numbers of cases of campylobacteriosis have increased in North America, Europe, and Australia. Although epidemiological data from Africa, Asia, and the Middle East are still incomplete, these data indicate that *Campylobacter* infection is endemic in these regions [52]. In as much as the qualitative risk assessment obtains a categorical or descriptive risk estimate rather than a numerical value as in the case of quantitative, the outcome is still valid for guided action [18]. In Europe, risk assessment has become a norm owing to availability of tools, reliable data, and experts; however, the converse is true in Kenya; making the present study to be of such a priority. This study used the qualitative risk assessment technique to rank the risk resultant from the contamination of the street vended poultry with *C. jejuni* in the informal settlements of Nairobi County; an area of study that poses serious public health concerns.

2. MATERIALS AND METHODS

2.1 Study Area

* E-mail address: birgenjeruto@gmail.com.

A cross-sectional study was conducted in the informal settlements; Korogocho (1.2504° S, 36.8909° E GPS coordinates) and Kariobangi North (1.2534° S, 36.88815° E GPS coordinates), Nairobi County (1.2921° S and 36.8219° E GPS coordinates), of Kenya. The 2009 national population census estimated the population of Nairobi County to be over three million, with over half of the population living in slums (Kenya National Bureau of Statistics, 2015). Street vended foods were collected in the following regions within Korogocho; Gitathuru, Nyayo, Kisumu Ndogo, Paradise and Kariobangi North.

2.2 Sampling and sample collection

Nairobi County was purposively selected for the study because of its populous nature. Korogocho and Kariobangi North areas were also purposively selected for the study as they are largely informal settlements with the population being those of low-income. A total of fifteen vendors were exhaustively sampled and included in the study with the food safety and hygiene practices evaluated using a food safety checklist. The snowballing sampling technique was used to locate all the vendors. Samples of raw and cooked street vended poultry products and surface swabs for display areas were subjected to microbial analysis. The respondents were purposely selected from the villages to include all the vendors selling the ready-to-eat (RTE) chicken meat products such as roasted chickens, braised chickens etc. All samples were collected in sterile polythene bags followed by transportation to the laboratory of the Department of Food Science and Technology of the University of Nairobi and microbial analysis done for *Escherichia coli*, *Salmonella*, *Staphylococcus aureus* and *Campylobacter jejuni*. The samples were stored at a temperature of 4 °C and analyzed within 2 hours of collection.

2.3 Microbial analysis

2.3.1 Determination of *Escherichia coli*

The determination and enumeration of *E. coli* was done as per ISO method 9308-1:2000

2.3.2 Determination of *Salmonella spp.*

The ISO method 6579 [19] was used to enumerate the *salmonella* species.

2.3.3 Determination of *Staphylococcus aureus*

EN ISO method ISO 6888-1:1998 [20] was used for the detection and enumeration of *Staphylococcus aureus.*

2.3.4 Determination of *Campylobacter jejuni*

The analysis was conducted according to ISO 10272-1:2017 [21] procedures which specify a horizontal method for the detection and enumeration of *Campylobacter* spp. *Campylobacter* spp. suspect colonies were identified by Gram stain, oxidase test, citrate test, phenylalanine test and catalase test.

2.4 Risk assessment tools

Data generated from secondary sources from published articles in renowned databases including Science Direct, Elsevier, Springer, Hindawi and reports by global bodies like FAO and WHO were used. The data was used to respond to a set of eleven questions posed by the risk ranger (Modelling software, Version 2) and risk rank obtained [[22]]. The risk estimate was generated in a risk ranger which represented the relative risk of campylobacteriosis due to consumption of street-vended poultry. The spreadsheet uses its in-built functions to convert qualitative responses into numerical values that it uses to generate a risk rank [[23]]. The risk estimate generated by the Risk Ranger is usually on a scale of 0-100.

* E-mail address: birgenjeruto@gmail.com.

2.5 Data analysis

Genstat version 15 was used to analyse the microbial data. ANOVA was used to establish significant differences in the log counts of the microbial pathogens. The LSD was used to separate means that were significantly different. Descriptive statistics including mean and SD of the mean microbial contamination levels were also generated. The risk estimate was generated from the risk ranger [23]. The risk estimate generated was on a scale of 0-100.

3. RESULTS AND DISCUSSION

3.1 Hazard Identification

Campylobacter jejuni which was the most prevalent microorganism in both raw and cooked poultry products at 8.95±0.94 and 4.66±2.67 log CFU g^{-1} respectively; as compared to *Salmonella*, *E. coli* and *Staphylococcus* which had contamination levels of 6.42±1.64, 6.60±1.25 and 6.92±1.32 log CFU g^{-1} in raw poultry respectively and 2.22±1.88, 2.67±1.98 and 2.86±1.61 in cooked poultry respectively ($p<0.05$). These findings are different from those established in another study done on street-vended poultry in Egypt where *Staphylococcus aureus* was found to be the most prevalent food pathogen [3]. Cardinale et al. (2015) in his study on street vended poultry in Madagascar established that there was no contamination of the products with *C. jejuni* as proper heat treatment of the products addressed the problem.

Campylobacter jejuni is a gram-negative, non-spore forming and motile microorganism [12]. The microorganism also has flagella which it serves a role in its invasion [25]. The microorganisms account for about 90% of all human infections by *Campylobacter* sp. in human beings [26]. In recent times, the microorganism has been associated with enteritis and gastroenteritis in both the adult and paediatric patients [27]. About 30% of the cases of campylobacteriosis has been attributed to the consumption of poultry [28].

The microorganism induces food poisoning through intake of contaminated water or food [25]. *Campylobacter* isolation in patients suffering from diarrhoea in Kenya was reported as 12%, higher than for both *Salmonella* and *Shigella* [29.] Additionally, the prevalence of *Campylobacter spp.* in chicken in the informal settlements of Kenya was reported as 60-64% in the retail market. Mageto *et al.* (2018), reported that 32.5-76.5% of the *Campylobacter* isolates from chicken in Nairobi County were *C. jejuni*. Another study by Nguyen *et al.* (2016) reported that 61.3% of the *C. jejuni* isolates from chicken in Kenya showed multi-drug resistance.

3.2 Hazard Characterization

The clinical manifestation of the infection is gastroenteritis, meningitis and acute cholecystis [12]. The severity of the illness due to the infection by the microorganism was established as low as it was reported by Smith (1985) that the overall fatalities were 0.059 per 100,000 population. WHO (2018), reported that the illnesses would at times result in death thus rarely medical attention due to the diarrheal episodes. Other diseases that are resultant from campylobacter infection include Guillain-Barré syndrome (GBS) and Miller Fisher syndrome.

Gastroenteritis due to campylobacter infection is as usually occasioned by diarrhoea, malaise, fever and abdominal pain and sometimes vomiting, inflammation of the intestinal mucosa, presence of blood in faeces and disruption of the epithelial cells [25]. This study found that the incidence of foodborne illnesses with diarrheal symptoms was found to be 52.9%. A study done in informal settlements in Younde, Cameroon, found that 59.5% of the diarrheal cases there were attributed to infectious microorganisms like *C. jejuni [*34]. Deogratias *et al.* (2014) also reported a prevalence of 9.7% of campylobacter infection among under-five-year-old children in Tanzania with diarrheal infection. The global burden of campylobacteriosis in 2013 was reported as 7.5 million DALY [36].

* E-mail address: birgenjeruto@gmail.com.

The global data on GBS and Miller Fisher syndrome are so limited [36]. The GBS is characterized by sensory symptoms including sensation in the legs, rapidly progressive distal weakness, loss of vibration and proprioception and respiratory symptoms. WHO (2014), reported the disability weight of GBS at 0.445, lower than the one for gastroenteritis and enteritis. The illness, however, has a life-long disability.

3.3 Exposure Assessment

Contamination of the poultry occurs at any given stage of the process of preparation of the poultry. Contamination of the poultry parts occurs majorly during slaughter, with additional exposure as a result of the handling and preparation. The process of preparation of the street vended poultry in the informal settlements follows the schematic illustration shown in **Figure 1.** More than eight in every ten (87.5%) of the households in the informal settlements had the whole family as consumers of the street vended. Similar findings were reported in the informal settlements in India where both the adults and children were found to be consumers of street-vended [38]. The consumption of the street-vended chicken is either with or without further processing. Eight in every ten (82.8%) of these consumers had an intake of at least once a week. Namugumya and Muyanja (2011), also reported that poultry and meat products were one of the most frequent dishes of urban communities in Uganda. All the raw and cooked samples which were sampled were contaminated with *C. jejuni.* The microbial load of *C. jejuni* on the raw and cooked portion of chicken was reported as 8.95±0.94 and 4.66±2.67 log CFU in this study. Another study that evaluated the raw portions of chicken in Burma and Ngara that were reported by the vendors as the sources of the chicken found that they had a microbial load of >4 log CFU [16]. The high level of contamination in raw poultry was attributed to handling whereas undercooking was found to be responsible for the contamination in the cooked portions.

The informal settlements of the Nairobi County host majorly the low economic class. The informal settlements in Nairobi that would be of greatest interest including Kibera, Mukuru kwa Njenga, Mathare and Korogocho slums have an estimated population of 1.7 million people [40]. The low-income status of this area occasions the largest proportion of the residents to opt for the compromised quality of products. The study established that street food consumption in the area stood at 86%, which involved intake by the general household including children under the age of five years.

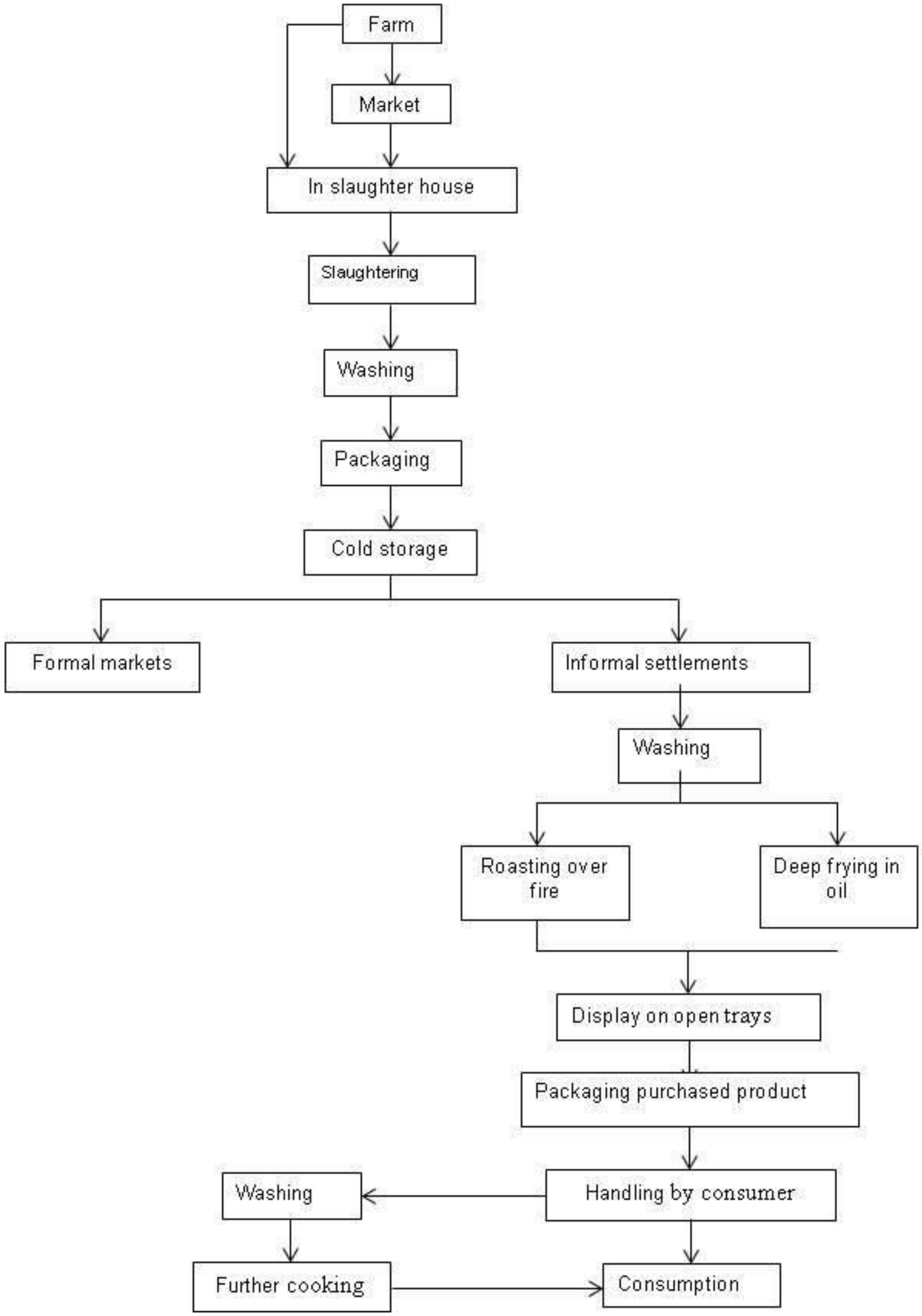
Through derivation from studies by Carron *et al.* (2018) and Mageto *et al.* (2018), the occurrence of *C. jejuni* in street vended raw poultry in the informal settlements was established as 48.96%. The high level of contamination in theses raw portions are due to poor food handling practices [41]. The raw portions of poultry are usually roasted or deep-fried before the sale. Proper heat treatment has been proven as an effective strategy in eliminating the microbial counts of *C. jejuni* to undetectable levels [42,43]. However, roasting as one of the fast heat techniques has been indicated as one of the improperly practised food preparation techniques that enhance food safety risks and heat resistance in microbes [43]. Karoki *et al.* (2018), in their study, showed that roasting would not reliably reduce the microbial counts in meat. Heating temperatures of ≥70 ^{o}C for about two minutes would reliably eliminate *C. jejuni*, though the preparation process of the meat even in households in the informal settlements is highly questionable due to the poor hygiene in the surrounding environment.

The cooked samples of poultry had an average *C. jejuni* count of 4.66±2.67 log CFU which was above the infective dose for *c. jejuni*; The infective dose of *C. jejuni* has been indicated to be low, 2.7-2.9 log CFU [45]. The average weekly consumption sizes of poultry were found to be 140g per person. The intake levels found in this study were lower than those reported for both the children and adults who were reported to have consumption levels of 300g and 450 g respectively [38]. Further contamination of the cooked poultry products has been attributed to the poor post-processing handling that included contamination from the display

* E-mail address: birgenjeruto@gmail.com.

surfaces and hands. This study established that all the display surfaces of the vendors were contaminated with *C. jejuni* averaging at 6.84±0.71 log CFU. Three-quarters of the vendors (76.9%) did not cover their food on display. There were no systems for control against post-process contamination. In as much as 72.1% of the vendors had been oriented on food safety issues, none of them (0%) had any formal training or expertise in food handling. Food safety training improves the food safety of processed food [46].

* E-mail address: birgenjeruto@gmail.com.



* E-mail address: birgenjeruto@gmail.com.

Fig. 1. : Process of preparing street vended poultry in informal settlements. Sources [47, 48]

.

3.4 Risk Characterization

No study has established the quantitative estimate of the risk posed by consumption of street vended poultry in the informal settlements. There is also no documented information on the process controls of the preparation of street foods. The information from the three previous steps of qualitative risk assessment was combined in the Risk Ranger software for generation of a risk estimate. The probability of illness per day in a considered consumer was found as 7.12E-03. Another study that evaluated the risk of *Campylobacter infection* due to consumption of ham reported that the probability of illness in an individual was 2.20E12 [[49]]. Predicted illnesses in the population were found to be 1.11E06.

The risk estimate generated for the consumption of street-vended poultry in the informal areas was found to be 67. The level of risk posed is interpreted as to be a high risk, >48 [[22]]. The risk estimate is also higher than that posed by chicken consumed either in rural or urban china which was 52 and 49 respectively [[50]]. Another study in South Korea agreed that the outdoor eating of chicken and other poultry feeds poses additional risks than the indoor [[51]]. This calls for better controls to be put in place to manage the current risk. Proper cooking of the food and that which will reliably eliminate all hazards will reduce the risk posed in the consumption of street-vended poultry.

Table 1: Summary of Risk Ranger input data

Risk criteria	**General population**
Dose and severity	
Hazard severity	Mild hazard
Susceptibility	General, all members of the population
Probability of exposure	
Frequency of consumption	Weekly
Proportion consuming	Most (75%)
Size of population	1.7 million
Probability of consumption	
Probability of raw product contamination	48.96%

* E-mail address: birgenjeruto@gmail.com.

Effect of processing	The process usually (99% of cases) eliminates hazards
Possibility of recontamination	Yes- Major (50% frequency)
Post-process control	Not controlled-no systems, untrained staff (10-fold increase)
Increase to the infective dose	Slight (10 fold increase)
Further cooking before eating	Meal preparation usually eliminates (99%) hazards
Probability of illness per day in the considered consumer	7.12×10^{-3}
Predicted cases of illnesses in the population	1.11×10^{6}
Risk ranking (0-100)	67

4. CONCLUSION

In as much as the street vended poultry have a greater preference and affordability, the food safety risks of consuming the products are very high. The risk of campylobacteriosis due to intake of street vended poultry is very high among the dwellers of the informal settlements. Less surveillance and disregard of important food hygiene and preparation practices creates this gap that endangers the lives of the consumers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

AUTHORS' CONTRIBUTIONS

This work was done in collaboration among all the four authors. Author BJB designed the study, performed the analysis and wrote the first draft of the manuscript. Author LGN, DMK and FOO supervised the study and analyzed the data. All the authors managed the literature search writing of the final manuscript. All authors read and approved the final manuscript

REFERENCES

* E-mail address: birgenjeruto@gmail.com.

1. Oguttu JW. Participatory risk analysis of street vended chicken meat sold in the informal market of Pretoria, South Africa By. 2015 ;(April):1-254.
2. Climat R. Microbial safety aspects of street foods in Haiti. 2013.
3. Abd-El-Malek AM. Cooked poultry meat and products as a potential source of some food poisoning bacteria. IOSR J Environ Sci Toxicol Food Technol. 2017;11(06):23-29. doi:10.9790/2402-1106032329
4. Cardinale E, Abat C, Bénédicte C, Vincent P, Michel R, Muriel M. Salmonella and Campylobacter contamination of ready-to-eat street-vended pork meat dishes in Antananarivo, Madagascar: A risk for the consumers? Foodborne Pathog Dis. 2015;12(3):197-202. doi:10.1089/fpd.2014.1864
5. Tesfaye W, Bereda TW, Emerie YM, Reta MA, Asfaw HS. Microbiological Safety of Street Vended Foods in Jigjiga City , Eastern Ethiopia. (2).
6. Manguiat LS, Fang TJ. Microbiological quality of chicken- and pork-based street-vended foods from Taichung, Taiwan, and Laguna, Philippines. Food Microbiol. 2013;36(1):57-62. doi:10.1016/j.fm.2013.04.005
7. Food Standards Australia New Zealand. Scientific Assessment of the Public Health and Safety of Poultry Meat in Australia.; 2005.
8. Ologhobo AD, Omojola AB, Ofongo ST, Moiforay S, Jibir M. Safety of street vended meat products - chicken and beef suya. African J Biotechnol. 2010;9(26):4091-4095.
9. El-Shenawy M, El-Shenawy M, Mañes J, Soriano JM. Listeria spp. in Street-Vended Ready-to-Eat Foods . Interdiscip Perspect Infect Dis. 2011;2011:1-6. doi:10.1155/2011/968031
10. Rane S. Street Vended Food in Developing World : Hazard Analyses. 2011;51(1):100-106. doi:10.1007/s12088-011-0154-x
11. FAO, WHO. Risk Assessment of Campylobacter Spp . in Broiler Chickens and Vibrio Spp . in Seafood Report of a Joint FAO / WHO Expert.; 2002.
12. Kaakoush NO, Castaño-Rodríguez N, Mitchell HM, Man SM. Global epidemiology of campylobacter infection. Clin Microbiol Rev. 2015;28(3):687-720. doi:10.1128/CMR.00006-15
13. Marotta F, Garofolo G, Donato G Di, et al. Population diversity of campylobacter jejuni in poultry and its dynamic of contamination in chicken meat. Biomed Res Int. 2015;2015:1-10. doi:10.1155/2015/859845
14. EFSA. The European Union summary report on trends and sources of zoonoses, zoonotic agents and food-borne outbreaks in 2017. EFSA J. 2014;16(12). doi:10.2903/j.efsa.2018.5500
15. Mughal MH. Campylobacteriosis: A Global Threat. Biomed J Sci Tech Res. 2019;11(5):1-5. doi:10.26717/bjstr.2018.11.002165
16. WHO, FAO. FAO/WHO Guide for Application of Risk Analysis Principles and Procedures during Food Safety Emergencies. Rome, Italy: FAO and WHO; 2011.
17. FDA/CFSAN. DRAFT Qualitative Risk Assessment Risk of Activity / Food Combinations for Activities (Outside the Farm Definition) Conducted in a Facility Co-Located on a Farm. Washington D.C., USA; 2012.
18. ISO. Water Quality—Detection and Enumeration of Escherichia Coli and Coliform Bacteria. Vol 2000.; 2000.
19. ISO. ISO 6579. Microbiology of Food and Animal Feeding Stuffs. Horizontal Method for the Detection of Salmonella Spp. 4 Ed. 2002. The International Organization for Standardization, Amendment 1: 15 Jul. 2007. Vol 2002. Geneva, Switzerland: ISO; 2002.
20. ISO. Microbiology of Food and Animal Feeding Stuffs- Horinzotal Method for Enumeration of Coagulase Positive Staphylococci (Staphylococcus Aureus and Other Species). Vol 1999. 1st ed. Geneva, Switzerland: ISO; 1999. doi:10.1088/0957-4484/25/12/125707
21. ISO. Microbiology of Food Chain: Horizontal Method for Detection and Enumeration of Campylobacter Spp.; 2017.

* E-mail address: birgenjeruto@gmail.com.

22. FAO. Application of risk assessment in the fish industry.
23. Ross T, Sumner J. A simple , spreadsheet-based , food safety risk assessment tool. Int J Food Microbiol 77. 2002;77:39-53.
24. Cardinale E, Abat C, Benedicte C, Vincent P, Michel R, Muriel M. Salmonella and Campylobacter Contamination of Ready-to-Eat Street-Vended Pork Meat Dishes in Antananarivo, Madagascar: A Risk for the Consumers? Food borne Pathog Dis. 2015;12(3):197-202. doi:10.1089/fpd.2014.1864
25. Quetz da JS, Lima IFN, Havt A, et al. Campylobacter jejuni infection and virulence-associated genes in children with moderate to severe diarrhoea admitted to emergency rooms in northeastern Brazil. J Med Microbiol. 2012;61(4):507-513. doi:10.1099/jmm.0.040600-0
26. James C, Daramola B, Reyers F, Purnell G, Turner R, James SJ. Qualitative Risk Assessment to Support a Policy Decision on Partially - Eviscerated (Effilé) Poultry Production.; 2014.
27. Facciolà A, Riso R, Avventuroso E, Visalli G, Delia SA, Laganà P. Campylobacter: from microbiology to prevention. J Prev Med Hyg. 2017;58(2):E79-E92.
28. Chlebicz A, Śliżewska K. Campylobacteriosis, Salmonellosis, Yersiniosis, and Listeriosis as zoonotic foodborne diseases: A review. Int J Environ Res Public Health. 2018;15(5):863. doi:10.3390/ijerph15050863
29. Carron M, Chang YM, Momanyi K, et al. Campylobacter, a zoonotic pathogen of global importance: Prevalence and risk factors in the fast-evolving chicken meat system of Nairobi, Kenya. PLoS Negl Trop Dis. 2018;12(8):1-18. doi:10.1371/journal.pntd.0006658
30. Mageto L, Ombui JN, Mutua FK. Prevalence and risk factors for Campylobacter infection of chicken in peri-urban areas of Nairobi, Kenya. J Dairy, Vet Anim Res. 2018;7(1):22-27. doi:10.15406/jdvar.2018.07.00184
31. Nguyen TNM, Hotzel H, Njeru J, et al. Antimicrobial resistance of Campylobacter isolates from small scale and backyard chicken in Kenya. Gut Pathog. 2016;8(1):1-9. doi:10.1186/s13099-016-0121-5
32. Smith GS. Fatalities Associated With Campylobacter jejuni Infections. JAMA J Am Med Assoc. 1985;253(19):2873. doi:10.1001/jama.1985.03350430085033
33. WHO. Campylobacter.
34. Deogratias AP, Mushi MF, Paterno L, et al. Prevalence and determinants of Campylobacter infection among under five children with acute watery diarrhea in Mwanza, North Tanzania. Arch Public Heal. 2014;72(1):1-6. doi:10.1186/2049-3258-72-17
35. WHO, OIE, FAO, Universiteit Utretcht. The Global View of Campylobacteriosis: Report of an Expert Consultation, Utrecht, Netherlands, 9-11 July 2012. Utretch, Netherlands; 2013. doi:ISBN 978 92 4 156460 1
36. WHO. WHO estimates of the global burden of diseases. Who. 2014;46(3):1-15. doi:10.1016/j.fm.2014.07.009
37. Selvan P, Preethi NS. Exposure assessment of Bacillus cereus in street vended chicken biryani – a deli food of South India. Int J Curr Microbiol Appl Sci. 2018;7(12):2894-2899.
38. Namugumya BS, Muyanja C. Contribution of street foods to the dietary needs of street food vendors in Kampala , Jinja and Masaka districts , Uganda. Public Health Nutr. 2011;15(8):1503-1511. doi:10.1017/S1368980011002710
39. Odhiambo WA, Kebira AN, Nyerere A. Prevalence of Campylobacter jejuni and other bacterial pathogens in selected foods and drinks served in fast food kiosks in Ngara and Burma markets in Nairobi. Int Acad J Heal Med Nurs. 2017;1(1):32-57.
40. Mutisya E, Yarime M. Understanding the grassroots dynamics of slums in Nairobi: The dilemma of Kibera informal settlements. Int Trans J Eng Manag Appl Sci Technol. 2011;2(2):197-213.
41. Alimi BA. Risk factors in street food practices in developing countries: A review. Food Sci Hum Wellness. 2016;5(3):141-148. doi:10.1016/j.fshw.2016.05.001

* E-mail address: birgenjeruto@gmail.com.

42. Josefsen MH, Löfström C, Hansen TB, Christensen LS, Olsen JE, Hoorfar J. Rapid quantification of viable Campylobacter bacteria on chicken carcasses, using real-time pcr and propidium monoazide treatment, as a tool for quantitative risk assessment. Appl Environ Microbiol. 2010;76(15):5097-5104. doi:10.1128/AEM.00411-10
43. de Jong AEI, van Asselt ED, Zwietering MH, Nauta MJ, de Jonge R. Extreme heat resistance of food borne pathogens Campylobacter jejuni, Escherichia coli , and Salmonella typhimurium on chicken breast fillet during cooking. Int J Microbiol. 2012;2012:1-10. doi:10.1155/2012/196841
44. Karoki WH, Karanja DN, Bebora LC, Njagi LW. Isolation, characterization, and quantification of bacteria from African sausages sold in Nairobi County, Kenya. Int J Food Sci. 2018;2018:1-9. doi:10.1155/2018/3861265
45. Epps SVR, Harvey RB, Hume ME, Phillips TD, Anderson RC, Nisbet DJ. Foodborne Campylobacter: Infections, metabolism, pathogenesis and reservoirs. Int J Environ Res Public Health. 2013;10(12):6292-6304. doi:10.3390/ijerph10126292
46. Adesokan HK, Akinseye VO, Adesokan GA. Food safety training is associated with improved knowledge and behaviours among foodservice establishments workers. Int J Food Sci. 2015;2015:1-8. doi:10.1155/2015/328761
47. Muth MK, Beach RH, Karns SA, Taylor JL, Viator CL. Poultry Slaughter and Processing Sector Facility-Level Model.; 2006.
48. Carron M, Alarcon P, Karani M, et al. The broiler meat system in Nairobi, Kenya: Using a value chain framework to understand animal and product flows, governance and sanitary risks. Prev Vet Med. 2017;147:90-99. doi:10.1016/j.prevetmed.2017.08.013
49. Lee J, Ha J, Kim S, Lee H, Lee S, Yoon Y. Quantitative microbial risk assessment for Staphylococcus aureus in natural and processed cheese in Korea. Korean J Food Sci An Vol. 2015;35(5):674-682. doi:10.3168/jds.2015-9611
50. Wang J, Guo YC, Li N. Prevalence and risk assessment of Campylobacter jejuni in chicken in China. Biomed Environ Sci. 2013;26(4):243-248. doi:10.3967/0895-3988.2013.04.002
51. Jeong J, Lee J, Lee H, et al. Quantitative microbial risk assessment for Campylobacter foodborne illness in raw Beef offal consumption in South Korea. J Food Prot. 2017;80(4):609-618. doi:10.4315/0362-028x.jfp-16-159
52. Kaakoush, N. O., Castaño-Rodríguez, N., Mitchell, H. M., & Man, S. M. (2015). Global epidemiology of Campylobacter infection. *Clinical microbiology reviews*, *28*(3), 687-720.

* E-mail address: birgenjeruto@gmail.com.