

Assessment of Cockroach Infestation Levels, Awareness and Control Practices of Vendors in Ready-To-Eat Food Premises in Kisumu City, Kisumu County, Kenya.

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ABSTRACT: In the urban areas of the world, cockroaches constitute a public health threat in the ready-to-eat (RTE) food premises because they spread diseases and contaminate food. Globally, food borne diseases transmitted by pests affect 600 million people annually with 48 million in the USA. Developing countries have more cases but are underreported due to poor diagnostic facilities. In Botswana, more than 40% of cockroach population is in urban areas due to inadequate waste disposal and poor housing. In Kenya cockroach infestation is a neglected public health issue. Cockroaches are of significant epidemiological significance yet levels not known in Kisumu City. Assessing the level of cockroaches' infestation, awareness and control practices helps in getting empirical data necessary for instituting effective control practices. Limited studies have been conducted on cockroach infestation levels in RTEs in Kisumu City yet the city leads in occurrences of gastroenteritis spread by cockroaches. The City has a high population living in poverty and dense housing favoring pests. Using a cross-sectional design, this study assessed the level of cockroach infestation, established the vendors' awareness and the control practices in the RTE food premises. Researcher administered structured questionnaires, observation tools and photography were used to collect data. Sticky traps were also installed overnight within the sampled premises. The study population consisted of 201 vendors of RTE premises. Some 145 respondents derived by Fisher's sample determination formula calculated at 50% picked by stratified random sampling proportionately from each of the 4 designated City's Public Health Zones were interviewed. Quantitative data was analysed through descriptive statistics and Chi-Square at a CL=0.05% and presented in frequency and percentages tables. Photography data was analyzed through pile sorting. Cockroach infestation in Kisumu City was high at a mean of 16.13 on Wang and Bennet scale. Many respondents 62(56.9%) were aware of cockroach infestation dynamics. Chemical control method was the most preferred for control of cockroach infestation in Kisumu City at 67(49.5%), followed by physical and biological methods of control at 45(33%) and 14(10.1%) respectively while cultural control methods least preferred at 9(6.4%) at $p=0.027$. As a recommendation, the Department of Public Health should ensure improved sanitation of the external environment and sensitize vendors on the public health impacts of cockroaches' infestation and advice on appropriate cockroach infestation control practices.

KEY WORDS: *Cockroach Infestation level, awareness on cockroaches' infestation, cockroaches control practices, ready-to-eat food premises.*

I. BACKGROUND INFORMATION

The second half of the twentieth century and the beginning of the twenty first century has witnessed important changes in ecology, climate and human behaviour that favour the development of urban pests (Bonney *et al.*, 2008). In 1950, only 29% of world population lived in urban areas in the developing countries but between 1960 and 1980, urban population in developing countries doubled and is expected to reach 56% by 2025 (Hedges, 1999). In contrast, the developed countries population proportion in urban areas was already at 72% in 1985 and is expected to hit 79% by 2025 with corresponding pests and vector-borne diseases increments as challenges (Knudsen and Sloof, 1992). Urban planners are therefore faced with monumental task due to the expansion of urban sprawls where the suburbs' of the cities are growing into natural habitats of ticks, rodents and other pests (WHO, 2008). Owing to population growth, poor levels of hygiene and increasing urban poverty in many developing countries, the urban environment is rapidly deteriorating (Knudsen *et al.*, 1992). Amongst the insect pests in urban environments, cockroaches are of significant public health importance (Bonney *et al.*, 2008).

Cockroaches' infestation is a neglected public health problem, yet the diseases caused or spread by cockroaches pose a serious risk to public health (Cloarec *et al.*, 1992). Cockroaches search for food in food preparation and storage areas as well as dirty drains, sewerages and rubbish bins thus play a role as vectors for pathogens that cause intestinal diseases such as dysentery, typhoid and cholera (Rivault *et al.*, 1992). Cockroach infestation levels are highly variable in size and spatial distribution and are characterized by a complex of interplay of many ecological and social factors and the influence of the other unsanitary factors related to water and harborage (Brenner and Markowitz, 2003). Urban health authorities in many countries are alarmed by the rise of vector-borne diseases as a result of increased presence of cockroaches and other pests due to overcrowding resulting from population growth and rural-to-urban migration (Knudsen and Slooff, 1992).

Globally, food borne diseases transmitted by pests affect over 600 million people. In the USA, these diseases affect over 48 million people per year with as many as 70 deaths. In developing countries fewer cases are accounted for due to poor reporting and lack of diagnostic facilities for the diseases (Brender *et al.*, 1997). In Africa, studies conducted in Botswana reveal that more than 40% of cockroach population is in urban areas due to inadequate solid waste disposal, accumulated wastes, poor housing and inadequate water supplies (Allotey *et al.*, 2006). In the developing countries cockroach infestation is a neglected public health issue partly because the related health burdens are largely unknown and focus has been on other diseases that portend obvious dangers to the populace (WHO, 2008). Despite the underreporting due lack of diagnostic facilities in many parts of the developing world, the increase in food-borne diseases, the emergence of new or newly recognized food-borne problems have been identified (Ventor, 2002). Another challenge in the developing countries is that a large number of outlets operate informally thus escaping scrutiny from public health authorities and this hamper proper documentation of accurate levels of cockroaches' infestation (Yasmeen, 1992).

Kisumu city in western Kenya has a large population of inhabitants and is a transit point in East Africa for trade, tourism and other cross-border activities (City Council of Kisumu, 2009). The densely packed housing, inadequate drinking-water supplies, garbage collection services the humid climate, high poverty index and surface-water drainage systems in Kisumu City combine to create favorable habitats for cockroaches (KNBS, 2013). In Kisumu City, food-borne diseases generalized as gastroenteritis appear as number three among the top ten diseases among the in-patients at 3,884 and number five for outpatients with 340 (KDHRM, 2002). This statistic motivates the choice of Kisumu. The study's target population was 201 adults operating the ready-to-eat food premises licensed vide County Government Single Business Permit within the City (City Council of Kisumu, 2015).

Most of the premises in the ready-to-eat food industry do not meet basic safety requirements against cockroaches' infestation due to large amounts of garbage accumulation in various points of the city that provides harbourage to insects and animal pests (FAO/WHO, 2005). Operators in the ready-to-eat food industry are responsible for safeguarding the public health of consumers by ensuring that consumers are safe from food-borne illnesses and any other associated adverse public health effects (CIEH, 1999). Food consumers in large cities of developing countries rely on ready-to-eat food outlets for their supplies and are exposed to significant dangers of contracting diseases, allergies and other medical conditions if cockroaches' infestation levels are not controlled (Yasmeen, 1992).

Studies have been conducted on infestation cockroach infestation levels in girl's dormitories and residential buildings (Gholam, 2013). However, corresponding studies have not been undertaken in the RTE food Premises and this necessitated this study. Several studies have established that high incidence of cockroach infestation occurs as a result of lack of knowledge on the factors encouraging cockroach infestation (Bradman *et al.* (2005), Wang *et al.* (2008) Bamigboye (2006) and Murphy *et al.* (2007). The earlier studies have also ascertained that the awareness levels were low on the involvement of rodent and cockroaches in transmission of life-threatening infections hence epidemiologically significant and could be responsible for increasing incidence of emerging infectious diseases (Hedges, 1999). These results called for an investigation into the awareness levels on cockroach infestation by the vendors in RTE food Premises in Kisumu City, Kisumu County.

The importance of infestation prevention through good hygiene, stock management and exclusion practices should be emphasized yet the actual control practices utilized by vendors of the ready-to-eat premises have not been established (Lee and Lee, 2000). Control practices employed in a place have a significant effect on the levels of cockroach infestation with evidence that where appropriate control practices are used as the interventions, the levels are much lower, yet studies have not been conducted in Kisumu City to reveal the practices. It therefore called for a research to ascertain the cockroach infestation control practices as used by vendors in the RTE food Premises.

II. STATEMENT OF THE PROBLEM

Cockroaches' infestation constitutes a major contributor to ill-health among the consumers of food in the ready-to-eat food premises, yet the infestation indicators are poorly studied. The quality and safety problems arising from cockroaches' infestation pose serious concern to public health and thus the need to institute safety limits in food and related industry coupled with an adequate capacity for Acts and Regulations for assurance and control. However, studies have not been conducted in Kisumu City to assess the infestation levels, the vendors in the ready-to-eat food premises awareness of cockroach infestation and the cockroach infestation control practices as currently used. The involvement of cockroaches in transmission of diseases cannot be understated for the fact that they also inhabit unhygienic places such as dumping sites, toilet premises and sewer lines which are highly contaminated with disease causing bacteria, fungal and viral pathogens as well as protozoa. Interventions need to be tailored to the baseline knowledge which is always unique to the target populations yet currently no clear data on cockroach infestation levels, vendors' awareness and control practices in Kisumu City, Kisumu County to define and understand the target population has been documented. Therefore, a properly formulated and executed cockroaches' infestation control policy that is evidence-based is needed in place the need for a study to determine specific areas for intervention. However, studies have not been conducted to establish the cockroach infestation levels in the ready-to-eat food premises, vendors' awareness and to ascertain control practices currently being used which forms our basis for this study.

III. GENERAL OBJECTIVE

To assess cockroaches' infestation levels, the vendors' awareness of cockroach infestation and the cockroach infestation control practices used by vendors in the ready-to-eat food premises in Kisumu City, Kisumu County.

Research Questions

- i. What is the cockroach infestation level in the ready-to-eat food premises in Kisumu City, Kisumu County?
- ii. What is the vendor's awareness on cockroaches' infestation in ready-to-eat food premises in Kisumu City, Kisumu County?
- iii. What are the cockroaches control practices being used by vendors in ready-to-eat food premises in Kisumu City, Kisumu County?

IV. EMPIRICAL LITERATURE

a. Level of Cockroaches' Infestation in Ready-to-Eat food Premises

The presence of even a cockroach is not to be overlooked as they can multiply and spread very fast (Gholam, 2013). The infestation levels seem to be higher in urban low-income places where there is poor disposal of waste, overcrowding and non-compliance to cockroaches' prevention practices (Wang and Bennet, 2009). Poor fecal and garbage disposal systems contribute to the proliferation of cockroaches (Cochran, 1983). Infestations are often the result of broken drains, building defects and areas that provide dark harbourages such as under stoves, behind refrigerators and near food and water (Rivault&Cloarec, 1997). Cockroaches can even be transferred between locations, for example by eggs or adults being within products purchased from infested shops (Wang, 2010).

Kisumu city in western Kenya has a large population of inhabitants and is a transit point in East Africa for trade, tourism and other cross-border activities (City Council of Kisumu, 2009). The densely packed housing, inadequate drinking-water supplies, garbage collection services the humid climate, high poverty index and surface-water drainage systems in Kisumu City combine to create favorable habitats for cockroach (KNBS, 2013). In Kisumu, most of the premises in the ready-to-eat food industry do not meet basic safety requirements against cockroaches' infestation due to large amounts of garbage accumulation in various points of the city that provides harbourage to insects and animal pests (FAO/WHO, 2005).

Gholam (2013) did an evaluation of sanitation in an IPM program for cockroach infestation in a girls' dormitory. The correlation coefficient between the sanitation rates and infestation rates showed that there was a significant positive relationship ($n=23$, Spearman correlation coefficient $r=0.445$, $p < 0.05$) between sanitation rate and intensity of infestation (according to the cockroach index) at the surveyed units (the girls' dormitory). The same result was achieved for the residential building ($n=11$, $r=0.636$, $p < 0.05$). Thus, poor sanitation was associated with the intensity of cockroach infestation at the residential building and girls' dormitory. The main sources of infestation include toilets, kitchen, rubbish containers and neighborhoods but the level of tolerance in a premise contributes significantly to the levels of infestation (Cochran, 1983).

The infestation levels seem to be higher in urban low income places where there is poor disposal of waste, overcrowding and non-compliance to cockroaches' prevention practices Wang and Bennet, 2009). Studies in Thailand have shown that cockroaches as the most common pest in urban are with highest densities in kitchens followed by bedrooms and lastly in the outside of the dwellings (Tawatsin *et al.*, 2001). Agrawal and Tilak (2006) reported more cockroach counts based on visual counts method compared to sticky trap method. However, the traps (baited with mouse pellets) were reported as a best way to determine cockroach infestation (Smith & Appel, 2008; Wang & Bennett, 2006).

b. Awareness of Cockroaches' Infestation by the Operators of the Ready-To-Eat Premises

Studies by Bradman *et al.* (2005), Wang *et al.* (2008) and Bamigboye (2006) established that disproportionately high incidence of pest infestation occurs, arising from poor hygiene and improper storage and disposal of waste as a result of lack of knowledge on the factors encouraging cockroach infestation. Murphy *et al.* (2007) established that the awareness levels were low on the involvement of rodent and cockroaches in transmission of life-threatening infections is epidemiologically significant and could be responsible for increasing incidence of emerging infectious diseases (Hedges, 1999). Findings show that there are many parasites of public health significance carried and harbored by cockroaches in Calabar (Tafteng *et al.*, 2005). Unfortunately, the people did not consider presence of cockroaches and parasitic infections as a serious problem, even though they did not like the sight of cockroaches (Schal, 1988). The isolation of these parasites from the cockroaches indicated that these pests could pose health problems to humans who may overlook their potential role in the spread of these parasites (Tafteng *et al.*, 2005).

Most people are unaware of cockroaches' ability to carry pathogens and that simple personal hygiene measures can help avoid contact with pests (Knudsen *et al.*, 1992). They are also unaware of safe pesticides usage in environmentally friendly ways (Webb *et al.*, 1999). Another study by Agbo and Akosu (2013) on cockroach and rodents' infestation in Benue State University students' hostel in Makurdi and their epidemiological implications found that overcrowding, and refuse accumulation provide suitable breeding grounds for cockroaches and rodents. It has been reported that because of the increasing environmental concerns and more regulatory restrictions on the use of insecticides, there will be an increased interest in environmentally acceptable concepts, including trapping, the latter not only for monitoring infestations, but also as an integral part of the cockroach management program (Hedges, 1999). The presence of cockroaches in large numbers in homes could serve as a source of these insects in vending sites by being transported on the utensils (Schal, 1988). At the vending sites, such populations could thrive due to the poor disposal of left-overs, lack of proper sanitation and ideal temperature conditions (Hedges, 1999). Cockroaches, rats, and mice are major problems in the urban built environment especially in multifamily dwellings where excessive moisture, extensive cracks and crevices, abundant food sources, overcrowded closets, and stacks of paper provide them nutrition and shelter (Bonney *et al.*, 2005).

According to Tafteng *et al.*, 2005 cockroach infestation levels is still poorly investigated in Africa, yet it poses serious public health outcomes. Studies have not been conducted to establish vendors of ready-to-eat food premises' awareness of cockroach infestation in Kisumu City, Kisumu County. This study therefore aimed at exposing the awareness levels of vendors in the ready-to-eat premises on factors of cockroach infestation to assist in developing awareness and educational programs to minimize cockroaches' infestation.

c. Cockroaches' Infestation Control Practices in the Ready –To-Eat Food Premises

The importance of infestation prevention through good hygiene, stock management and exclusion practices should be emphasized (Robinson, 1996a). It is not possible to completely eradicate cockroaches without cooperation of all affected players contributing sanitation efforts and communicating with authorities about new and recurring pest problems (Shahraki *et al.*, 2013). Sanitation is a key concept in relation to control of pests in urban environments and it has been noted that insanitary conditions results into proliferation of cockroaches (Rivault *et al.*, 1992).

The focus of IPM is to eliminate the source of pest problems – that is the conditions conducive to the establishment, survival and reproduction of pests (Wang and Bennet, 2009). In doing so, IPM controls cockroaches' infestations and cockroaches' access to people and their dwellings (Robinson, 1996a). Studies have shown that an IPM approach incorporating bait and other non-chemical methods can provide a high level of cockroach control (Wang and Bennett 2006). IPM relies on nonchemical approaches plus education and uses comprehensive information on the lifecycles of pests and their interactions with the environment to guide pest control is an alternative to conventional, chemical-based pest control (Schal, 1988). The concept underlying IPM is that pest populations can be controlled by removing their basic survival elements, such as air, moisture, food, and shelter, by blocking their access to apartments is also stated by Hedges, 1999.

Baiting alone resulted in a more than 95 percent reduction of cockroaches in heavily infested houses by sealing cracks and crevices and by the careful placement of least toxic baits and gels (Schal, 1988). Maintenance, sanitation, education, and training are the cornerstones of IPM (Hedges, 1999). Insecticides are the major tool used by professionals and residents for German cockroach control (Koehler *et al.*, 1995). The advent of highly effective bait products in the early 1990s significantly reduced the overall cockroach infestations in the United States (Greene 1996, Gooch 1999, Hedges 1999). The control practices in place have a significant effect on the levels of cockroach infestation with suggestions that where appropriate control practices are used as the interventions, the levels are much lower (Bonney *et al.*, 2008).

Despite this evidence, studies have not been conducted in Kisumu City to reveal the cockroach control practices being currently utilized by vendors in RTE premises in Kisumu City. In addition to these, few systematic studies of IPM have been undertaken in the urban setting of which some have produced positive results, but others report limited success in the infested apartments (Wang and Bennett 2006, Wang 2010). This study was therefore undertaken to establish cockroach infestation control practices and to identify gaps in control practices being utilized to inform the development of best standards for cockroaches' management that beneficially reduce the levels of cockroach infestation.

d. Public Health Risks Associated With Cockroaches in Urban Areas

Cockroach infestation must be controlled to enable humans live disease free and economically productive lives (Tatfeng *et al.*, 2005). They consume and also contaminate food by transmitting yeasts such as *Candida spp.* and *Pichia spp.* from contaminated sources to food preparation and storage areas (Rivault *et al.*, 1992). They also cause allergies and even transmit pathogens such as *Bacillus spp.*, *Salmonella spp.*, *Enterobacter spp.*, *E Coli*, *Entamoeba histolytica* that cause gastro-intestinal diseases such as dysentery, diarrhoea and typhoid (Allotey *et al.*, 2006).

The risks also include physical contamination of food products by cockroaches' droppings, parts or other foreign bodies and the introduction of microorganisms (Gholam, 2013). Additional health consequences of rodent and cockroach infestation are the resultant increase in use of pesticides (Gholam, 2013). Frequent pesticide use results in environmental pollution and poor air quality within rooms (Wang, 2010). Empirical studies reported that high percentage of student resorting to insecticides to control infestation could cause accidental contamination of foods stuff inside students' rooms and increase indoor pesticide residue (Majekodumi *et al.*, 2002; Bamigboye, 2006; Wang *et al.*, 2008). Therefore the need for a study to determine the levels of infestation, the vendors awareness and the control practices as presently being used must be emphasized as a basis of "Information for Action" in reducing cockroach infestation and thereby averting the possible risks associated with cockroach infestation.

e. Conceptual Framework

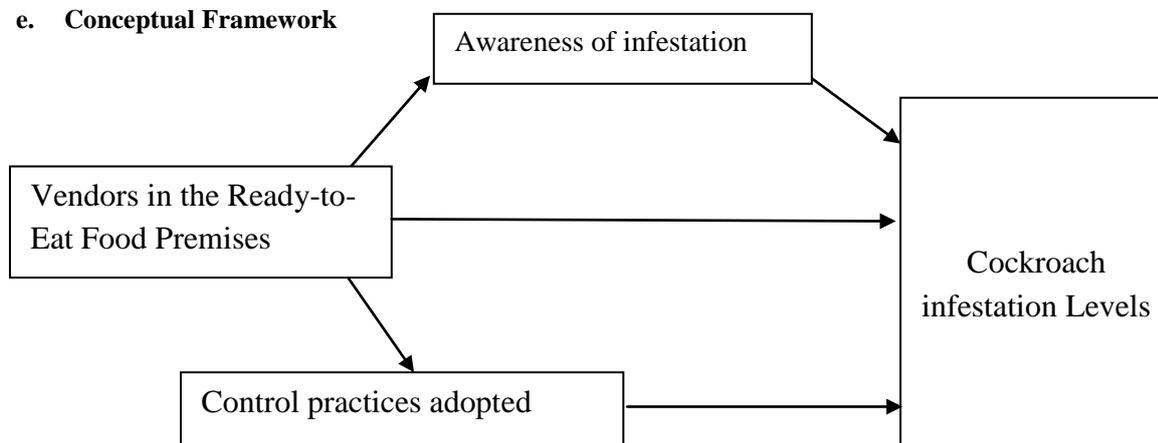


Figure 1: A Conceptual model. Source: Modified from John Hopkins Bloomberg School of Public Health Model, 2006

V. METHODOLOGY

This study was conducted in Kisumu City, Kisumu County. This is a port city situated within the Lake Victoria Basin (LVB) of Kenya. Kisumu City has a population of 409,928 persons, a population density of 828 per square km and a population growth rate of 2.8% per annum (KNBS, 2013). Kisumu city is located 10km south of the equator at longitude of 34° 45'E and latitude is 00° 03'S. The study adopted a cross-sectional design. The target population was 201 adults operating the ready-to-eat food premises within Kisumu City Kisumu County (City Council of Kisumu, 2015) Fisher's *et al* (1998) was used in sample size estimation while assuming

confidence level of 95% was assumed, the sample size was determined as 132 adults. To cater for sampling error and data inconsistencies as proposed by Niang *et al.*, 2006, 10% of 132 RTE food premises were added and so the adjusted sample size was 145 adults. Stratified random sampling was used to select the respondents. This study was limited to the list of ready-to-eat food premises licensed vide County Government Single Business Permit within the City. Respondents were limited to consenting operators only. Categorized hotels were omitted. Both primary and secondary data were collected. The study utilized both qualitative and quantitative data collection methods.

The study used: Questionnaires, Observation Checklists, Photography and cockroach Sticky Traps and data abstraction from secondary sources. Content validity was determined by evaluating test items against the test specifications, drawn up through a thorough examination of the subject domain so as to ensure that it covers a representative sample of the items to be measured. The sampling tools were pre-tested in a pilot study on 10 respondents who were drawn from the study area but not included in the study sample to ensure accuracy of the instruments, clarity of words and questions and to detect and correct any biasness. Necessary changes were made in the sampling tools before final administration. The questionnaire gave an $r = 0.7$ which was reasonably reliable. Statistical Packages for Social Science (SPSS) version 22 program was used to analyse the quantitative data. Photography data was analyzed through pile sorting. The study observed the ethical considerations, Informed consent of all the study respondents was sought and obtained before their participation in the study. To help ensure anonymity, the respondent's names were not captured. The respondents were informed that participation in the study was voluntary.

VI. RESULTS

a. Demographic Information

The respondents were able to state their designation, majority were managers at 83(61.5%) while a minority at 52(38.5%) were owners. This presented a balanced view on infestation levels, awareness and control practices in ready-to-eat food premises in Kisumu City, Kisumu County. The respondents were able to state their sex, majority at 82(60.6%) were female and least respondents 53(39.4%) were male. Being that the respondents were picked randomly, this meant that the ready-to-eat premises are largely dominated by female operators. Using Chi-Square, the researcher also established that sex of the owner or the manager was important in explaining whether a premise would be infested with cockroaches or not, $p=0.001$, C.L. = 0.05, $df=1$.

The respondents were able to provide their ages, many the respondents at 62(45.9%) were between 25-29 years, 32(23.9%) respondents were of ages between 30-34 and 35-39 years whereas the least respondents at 9(6.4%) and another 32(23.9%) aged 40 and above by using descriptive statistics. The age variation was important in the study in that it gave an impartial view in relation to the modern and traditional pest control methods. The researcher established that the age of the manager or owner was important in explaining whether a premise would be infested with cockroaches or not, $p=0.003$, $df=3$, C.L. = 0.05. The respondents were able to record their level of education, most of them at 53(39.4%) had only primary level of education while the minority at 41(30.3%) each were post-primary level of education possessing secondary and tertiary college level of education. These results indicated that all the respondents had the basic education and were able to clearly comprehend the question, process them and give valid responses. The researcher established that the level of education of the manager or owner was important in explaining whether a premise would be infested with cockroaches or not at $p=0.006$, $df=2$, C.L= 0.05. The respondents stated their work experience, majority at 92(67.9%) had worked for years in the hotelier industry while 43(32.1%) had worked just 12 months and below. This indicated that the respondents had a good feel of what goes on in relation to cockroach infestation and control, they gave rich insights that enabled the researcher to answer the research questions. Using Chi-Square it was found out that work experience of the manager or the owner was important in explaining whether a premise would be cockroach infested with cockroaches or not $p=0.031$, $df=1$, C.L=0.05.

Table 1: Demographic information of the respondents

Variable	Categories	Frequency and proportion
Designation of interviewee	Owner	52(38.5%)
	Manager	83(61.5%)
Gender	Male	53(39.4%)
	Female	82(60.6%)
Age	25-29	62(45.9%)

	30-34	32(23.9%)
	35-39	9(6.4%)
	40 and above	32(23.9%)
Level of education	Primary	53(39.4%)
	Secondary	41(30.3%)
	College	41(30.3%)
Work experience	<-12-Months	43(32.1%)
	>12 Months	92(67.9%)

b. Level of Cockroaches Infestation in Ready-To-Eat Food Premises

The respondents were asked questions on several aspects of cockroach infestation to determine the level of cockroach infestation in the ready-to-eat food premises. Sticky traps were placed overnight in the premises for five consecutive days and number of cockroaches sticking on it recorded; the averages were then worked out per zone and interpreted using the Wang and Bennett (2006) scale. The results are as shown in Table 2. Using descriptive statistics it was observed that majority at 127(94.0%) had seen them in their premises while 8(6.0%) respondents said they had not seen them. This meant that cockroaches are fairly common in the ready to eat food premises in Kisumu. Respondents were able to indicate whether they are able to see cockroach feces and the quantities, majority at 77(56.9%) while a minority of the respondents at 58(43.1%) had not seen the feces in their premises. This confirmed that there was high cockroach infestation in ready to eat food premises in Kisumu City with 77(56.88%) of the facilities being infested at various levels of infestation. It was established that the Eastern zone had the highest mean at 27.1(Very High), the Western zone premise had a mean of 21.32(High), the northern premises gave a mean of 8.17(High) with the Southern zone having the least mean of 7.94(Moderate). The overall mean was 16.13 interpreted as High, this mean that the cockroach infestation in Kisumu city was noted as high.

Table 2: Level of infestation Indicators and infestation levels

Variable	Category	Frequency and proportion
Spotted a cockroach in premise	Yes	127(94.0%)
	No	8(6%)
Cockroach feces spotted	Yes	77(56.9%)
	No	58(43.1%)
Variable	Category	Mean and Rating
Zone	East	27.1 (Very High)
	Southern	7.94 (Moderate)
	Northern	8.17 (High)
	Western	21.32 (High)

c. Awareness of cockroach infestation signs by vendors in the ready-to-eat food premises

The respondents were asked whether they were aware of any cockroach infestation signs; the locations where cockroaches were spotted, damages caused, and awareness of possible outcomes of infestation and the results were shown in Table 3

Table 3: Awareness of Cockroaches Infestations Signs, Locations, damages related to cockroach infestation and Awareness of possible infestation outcomes

Variable	Category	Frequency and proportion
Awareness of infestation signs	Yes	102(75.2%)
	No	33(24.8%)
Spots in the premises were seen	Kitchen	19(14.0%)
	Corners	18(13.0%)
	All over	63(47.0%)
	Food store	5(4.0%)
	Eating area	23(17.0%)
	N/A	7(5.0%)
Damages related to cockroach Infestation	No damage	8(6.0%)
	Small damage	60(44.4%)

Awareness of possible outcomes of infestation	Large damage	67(49.6%)
	Yes	108(80.0%)
	No	27(20.0%)
Nature of outcomes	Reduced Clientele	32(23.7%)
	Disease outbreak	55(40.7%)
	Compromised aesthetics	20(14.8%)
	Poor hygiene indicator	28(20.7%)

The respondents stated whether they were aware of any cockroach infestation signs, majority of them at 102(75.2%) said that they were aware with only 33(24.8%) of the respondents saying that they were not aware. The awareness on the infestation signs is a plus towards controlling cockroach infestation in the ready to eat food premises. The respondents were able to indicate the locations of the premise in which they mostly saw the cockroaches, majority at 63(47.0%) saw them during the day, 23(17.0%) mostly saw the cockroaches in the feeding area, 19(14.0%) saw them in the kitchen mostly, 18(13.0%) saw the cockroaches mostly in the corners of the premise while a minority of the respondents at 5 (4.0%) saw the cockroaches mostly in the food store while 7(5%) did not respond to the question because it was not applicable to them. These result is an indication that most of the ready to eat food premises are likely to be infested since cockroaches are seen everywhere.

Table 4: Observation Checklist Results-Premise Cleanliness, Presence and Proportion of Roaches, Presence of Feces and Amount of Feces Observed.

Variable	Category	Frequency	Proportion
Premise storage areas clean	Yes	99	73.3%
	No	36	26.7%
Roaches Present	Yes	87	64.4%
	No	48	35.6%
Roaches present in entire kitchen	Yes	48	35.6%
	No	87	64.4%
Feces present	Yes	77	57.0%
	No	58	43.0%
A lot of feces present	Yes	37	27.4%
	No	98	72.6%
A little feces present	Yes	40	29.6%
	No	95	70.4%
Valid		135	100.0%
Missing		0	
Total		135	

The observation checklist indicated that majority of the premises at 87(64.4%) did have roaches. Cockroaches were spotted in the entire kitchens for 48(35.6%) premises. Additionally, the checklist showed that their storage areas of most premises at 99(73.3%) were clean whereas those of 36(26.7%) premises were observed not to be clean. Respondents were able to indicate whether they are able to see cockroach feces and the quantities, majority at 77(57.0%), among these 40(29.6%) were able to see a little amount of feces while 37(27.4%) a lot of feces. This study confirmed that there was high cockroach infestation in ready to eat food premises in Kisumu City with 77 (57.0%) of the ready-to-eat premises being infested as indicated by presence of the feces.

Awareness of factors that aggravate the presence of cockroach in the premise

Respondents were able to indicate whether they were aware of the factors that aggravated the presence of cockroaches in their premises, majority at 77(56.9%) were aware and the least at 58(43.1%) not aware. Among those who were aware, some 21(27.2%) indicated that the existence of cracks on the walls and floors aggravated infestations, another 12(15.6%) mentioned food spillages in the premises as a contributing factor with yet others indicating state of drainages, food storage systems, garbage emptying frequency and control practices at 14(18.15%), 3(3.9%), 9(11.7%) and 18(23.4%), respectively. This meant that the respondents were in a position control cockroach infestation in the ready to eat food premises but were seemingly not doing much since the earlier findings pointed to the fact that the cockroach infestation was high. The respondents explained that the

factors that aggravated cockroach infestation were darkness, filthiness, careless dumping of wastes, decomposing food stuff and untimely cleaning of utensils.

Table 5: Awareness of factors aggravating cockroach infestation in Ready-to-Eat Food Premises

Variable	Category	Frequency and proportion
Aware of factors aggravating infestation	Yes	77(56.9%)
	No	58(43.1%)
List of factors aggravating infestation	cracks on the wall/ floors	21(27.2%)
	Food spillage	12(15.6%)
	State of drainages	14(18.1%)
	Food storage systems	3(3.9%)
	Garbage emptying frequency	9(11.7%)
	Cockroaches control practices	18(23.4%)

d. Cockroaches Control Practices Adopted in Ready-to-eat Food Premises in Kisumu City

Table 6: Control practices, preferences and experts involvement in infestation control by vendors in the Ready-to-eat premises

Variable	Category	Frequency and proportion
Ever used cockroach control mechanism	Yes	97(71.6%)
	No	38(28.4%)
Ever involved experts in controlling cockroaches	Yes	21(15.6%)
	No	114(84.4%)
Control methods in use	Biological	14(10.1%)
	Chemical	67(49.5%)
	Physical	45(33%)
	Cultural	9(6.4%)
Preferred method	Biological	4(2.8%)
	Chemical	109(80.7%)
	Physical	22(16.5%)
	Cultural	0(0.00%)

The respondents were able to state whether they have tried mechanisms to control cockroaches in their premises, majority at 97(71.6%) said yes, whereas the least at 38(28.4%) said no, this meant that awareness on cockroach control practices among the respondents may have been translated into control practices.

There was a significant relationship between trial of mechanisms to control cockroaches and the level of infestation of cockroaches in the ready-to-eat premises in Kisumu City, $p=0.001$, $df=1$, $C.L=0.05$. This meant that the application or non-application of mechanisms to control cockroaches was important in explaining the level of cockroach infestation. The respondents were able to mention the control mechanisms that they use including burning the cockroaches with hot water, cleaning/sweeping dirty surfaces, spraying/application of chemicals, proper food handling, rearranging the premise, Physical killing, proper handling of food wastes, use of traps and keeping cats. Respondents indicated whether they have sought expert advice on how to deal with cockroaches, majority at 114(84.4%) had not sought expert advice only a minority of the respondents at 21(15.6%) had sought advice expert. The respondents who had sought expert advice were concerned with the most effective and less costly cockroach control method that they could adopt. The respondents who had not sought expert advice on cockroach control explained that they lack the consultation fee, some are not aware of the availability of the experts. Respondents were able to state the most preferred method of controlling cockroaches, majority at 109(80.7%) preferred chemical, minority at 22(16.5%) preferred physical and least respondents at 4(2.8%) preferred biological.

This showed that chemical method is the most popular cockroach control method in ready to eat food premises in Kisumu City. The least preferred cockroach control method was biological. There was a significant relationship between the most preferred method of controlling cockroaches and the level of cockroach

infestation in ready-to-eat premises in Kisumu City, $p=0.027$, $df=1$, $C.L.=0.05$. This meant that the most preferred method of controlling cockroaches is important in explaining whether a premise would be infested with cockroaches or not.

Perceived effectiveness of cockroach control practices

On the biological cockroach control methods, majority at 121(89.9%) did not use it hence not applicable, 9(6.4%) of the respondents said it was very effective with 5(3.7%) respondents saying it was less effective. The chemical methods were not used by a majority of the respondents at 73(54.1%), 57(42.2%) respondents said it was very effective with only 10(7.3%) respondents saying it is less effective. Majority of respondents at 126(93.6%) did not use the cultural methods system, 5(3.7%) respondents said it was very effective while 4(2.8%) respondents opined that it was less effective.

A majority of the respondents at 95(70.6%) did not apply the physical control, 25(18.3%) respondents said that it was very effective with 20(14.7%) saying it is less effective. An inferential analysis by Chi-Square established that there is a significant relationship between the level of effectiveness of cockroach control practices and the level of cockroach infestation in the ready to eat food premises $p=0.041$, $df=1$, $C.L.=0.05$. This meant that the effectiveness or ineffectiveness of cockroach control practices is important in explaining the level of cockroach manifestation in the ready-to-eat food premises in Kisumu City.

The respondents were able state how often they used each of the cockroach control practices, it was established that chemical control was the most frequently used by majority of the respondents at 31(22.9%). The least applied cockroach control practice was the cultural method with 126(93.6%) premises, Biological method were not used by 121(89.9%), physical method was not applied by 90(67%) while chemical was not applied by the least number at 68(50.5%). This showed that the chemical method was the most popular cockroach control method with the least popular being the cultural control method. It was established by Chi-Square that there was a significant relationship between how often a cockroach control practice was used and the level of cockroach manifestation in the ready-to-eat food premises ($p=0.019$, $df=1$, $C.L.=0.05$). This meant that how often a cockroach control practice is used is important in explaining the level of cockroach infestation.

Table 7: Perceived effectiveness of cockroach control practices

Variable	Category	Frequency and proportion
Perceived effectiveness		
Biological	Very effective	9(6.4%)
	Less effective	5(3.7%)
	N/A	121(89.9%)
Chemical	Very effective	57(42.2%)
	Less effective	10(7.3%)
	N/A	68(50.5%)
Physical	Very effective	25(18.3%)
	Less effective	20(14.7%)
	N/A	90(67.0%)
Cultural	Very effective	4(2.8%)
	Less effective	5(3.7%)
	N/A	126(93.6%)
Frequency of application		
Biological	Frequency	5(3.7%)
	Rarely	9(6.4%)
	N/A	121(89.9%)
Chemical	Frequency	31(22.9%)
	Rarely	36(26.6%)
	N/A	68(50.5%)
Physical	Frequency	30(22.0%)
	Rarely	15(11.0%)
	N/A	90(67.0%)
Cultural	Frequency	9(6.4%)
	Rarely	0(0.0%)
	N/A	126(93.6%)

VII. DISCUSSIONS

a. Levels of cockroach's infestation in ready-to-eat food premises in Kisumu City.

The infestation levels as manifested by the zones corroborate a study by Agbo and Akosu (2013) on cockroach and rodents' infestation in Benue State University students' hostel in Makurdi and their epidemiological implications found that overcrowding and refuse accumulation provide conducive breeding grounds for cockroaches and rodents. This is more so because the most densely populated and overcrowded Eastern zone reported the highest infestation levels with the least being Southern zone which has a comparatively lower population density and better environmental care in terms of garbage collection and related activities.

It was observed that the cockroach infestation was very high in the Eastern zone, this converges with the findings of Gholam (2013) that the correlation coefficient between the sanitation rates and infestation rates had significant positive relationship ($n=23$, Spearman correlation coefficient $r=0.445$, $p<0.05$) between sanitation rate and intensity of infestation to mean that the cleaner sections were less likely to be infested as manifested in premises in the Southern zone.

The results for higher levels of infestation in the feeding areas than the kitchen however contradict studies in Thailand have shown that cockroaches as the most common pest in urban are with highest densities in kitchens followed by bedrooms and lastly in the outside of the dwellings (Tawatsin *et al.*, 2001). The higher levels in the Eastern zone seems to be aggravated by the existing poor sanitation poor access to safe water, low education levels are poor hygiene practices and waste disposal practices and they are similar to findings in a study done in Tafteng *et al.*, 2015 in Nigeria.

The condition of the infrastructure is another effective factor in determining levels of infestations as older buildings with more crevices and cracks register more infestation than new ones and studies have revealed a correlation between the age of a building and infestation levels of cockroaches as witnessed by Shahraki *et al.*, 2013. Both of these findings suggest a similar pattern to the one observed in results from this study and as such add substance to the viability.

Results from observation checklists indicated that cockroaches could be seen in the day in most ready to eat food premises. These results converge with Swadner (1995) assertion that cockroaches are nocturnal and are rarely seen during the day unless populations are very high thus a sign of high levels of infestation.

The respondents said that cockroach feces are usually visible in the premises. These again were signs of infestation as stated by Rivault & Cloarec (1997) who noted that visibility of cockroach faeces and foul smell in the environment from faeces is a sign of heavy cockroaches' infestation.

b. Awareness on cockroach infestation by vendors of ready-to-eat food premises in Kisumu City.

Results indicate that vendors are fairly aware of the cockroach infestation factors. This meant that the respondents were in a position control cockroach infestation in the ready to eat food premises but were seemingly not doing much since the earlier findings pointed to the fact that the cockroach infestation was high. This finding contradicts observation Robinson, 1996a that awareness of the infestation factors translates into efforts that substantially reduce the cockroach infestation levels.

The results explained that the factors that aggravated cockroach infestation were darkness, filthiness, careless dumping of wastes, decomposing food stuff and untimely cleaning of utensils. These outcomes converge with earlier studies by Hedges, 1999 which posted similar results.

It was also established that vendors in the ready to eat food premises were aware of cockroach control mechanism and that 77(56.9%) were involved in cockroach control this was in line with Ruben (2013) assertions that pest management requires participation of the hotel management and staff not just the pest control contractors. He notes that when functioning well, the hotel management and the workforce communicate regularly and have clear responsibilities of monitoring and controlling the pests' infestation in their premises.

It was also established that vendors were aware that the cockroach infestation could have adverse effects of which 55(40.7%) emphasizing that cockroach infestation may result into an increase in enteric diseases transmission; this corroborates the findings of Murphy *et al.* (2007) that the involvement of rodent and cockroaches in transmission of life-threatening infections is epidemiologically significant and could be responsible for increasing incidence of emerging infectious diseases.

Fewer respondents indicated that infestation of a premise by cockroaches would lead to a decline in clientele with others positing that the presence of cockroaches is an indicator of poor hygiene status of the premises. These findings support earlier studies by CIEH, (2009) which revealed that consequences of high levels of cockroaches' infestation in the ready-to-eat food premises may include prosecutions by environmental health departments, stopped production and the adverse publicity thus resulting in direct economic losses.

c. Cockroaches control practices in ready-to-eat food premises in Kisumu City.

The use of physical killing, proper handling of food wastes, use of traps and keeping cats converges with Rivault *et al* (1992) who postulated that sanitation is a key concept in relation to control of pests in urban environments and it has been noted that insanitary conditions results into proliferation of cockroaches.

Many 114(84.4%) had not sought expert advice on cockroach control with most of them saying that they have the basic knowledge on cockroach infestation and control. These findings are supported by Webb *et al* (1999) assertion that managers of the ready-to-eat food premises are unaware of safe pesticides usage in environmentally friendly ways.

This showed that chemical method is the most popular cockroach control method in ready to eat food premises in Kisumu City while the least preferred cockroach control method was biological. This finding concur with observations by Gooch, 1999 that chemical control is the most effective cockroach infestation control mechanism against German cockroach is the chemical.

VIII. CONCLUSIONS

There was a high mean level of cockroaches' infestation in the ready to eat food premises in Kisumu City as reflected on the Wang and Bennet Scale. The study revealed that the vendors are quite aware of cockroach infestation signs, factors aggravating infestation and possible control practices; this puts them at an advantaged position in fighting cockroach infestation the ready to eat food premises in Kisumu City. Four most common cockroach control methods used in controlling cockroach infestation were chemical, physical, biological and cultural. The most effective and preferred cockroach infestations control was chemical method while the least preferred control method is the cultural.

IX. RECOMMENDATIONS

There is need to improve the sanitation of the external environment through effective garbage collection and clearance and drainage systems to reduce possibilities of infestation and or re-infestation by both the ready-to-eat premises management teams and City's Public Health Department.

Regular sensitization sessions for the ready-to-eat food premises vendors on the possible adverse public health outcomes of cockroaches' infestation as well as cockroach control mechanisms and what works best at different levels of manifestation by Public Health Department. Capacity building for the vendors on knowledge of cockroaches, their biology, ecology and associated potential public health outcomes is fundamental since it contributes to prevention of infestations by aiding identification as well as shaping attitudes and practices of the workforce in the industry. The need for continuous monitoring of cockroaches with traps on a regular basis to avert infestation and or re-infestation must be underscored in the premises.

A properly formulated and executed cockroach's infestation policy is an investment in the future of this City to mitigate the consequences of disease burdens which may result from the cockroaches' infestation Addressing the infestation factors calls for innovative strategies coupled with executive commitment. The IPM should be widely adopted in ready-to-premises in Kisumu City incorporating bait and other non-chemical methods to provide a high level of cockroach control.

X. RECOMMENDATIONS FROM THE STUDY FOR FURTHER RESEARCH

A study should therefore be done on the various characteristics that result in the differential cockroach infestation in the ready to eat food premises in Kisumu City. Similar studies should be conducted in other urban Cities to compare the outcomes in terms of infestation levels, awareness levels and the control practices to provide deeper understanding of the cockroach infestation dynamics.

In addition to this study, it would be important to conduct a broader study on other pests' infestation levels, awareness and control practices of vendor in all the food and allied industries in Kisumu City since pests do not exist as very isolated entities.

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