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FACTORS CONTIBUTING TO BACTERIAL DIVERSITY AND LOAD IN BULAWAYO RESTAURANTS, ZIMBABWE

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Abstract

An analysis of factors contributing to bacterial diversity and count was done on Bulawayo restaurants. Focus was on equipment, foods, personnel and working surfaces. Twenty five restaurants were selected using simple random sampling, 57 (n=57) food handlers and 25 (n=25) supervisors responded to questionnaires. MINITAB was used for data analysis, employing multiple regression and analysis of variance. Findings revealed that, males are better food handlers than females (t=-2.86) Facility, supervision, manager's experience medical checks ups, gender and inspection by Environmental Health Officers had a highly significant influence on laboratory overall results with a p value of 0.000 (p=0.01). Hypotheses 3, 4 and 5 were rejected at 0.01 level of significance. Food service personnel and the environment represent the main sources of contamination.

Key Words: Food handlers, Bacteria, Bacterial diversity, Supervision, Gender, Bacterial load

Introduction

Food poisoning

A major cause of infectious gastroenteritis (GE) throughout the world is contaminated food. As a way of monitoring compliancy with food laws and ensuring food safety, Environmental Health Officers (EHO) from the Municipality of Bulawayo perform monthly inspections on restaurants. From a sample of forty two restaurants inspected between September 2000 and October 2001, 40% were graded C which is unsatisfactory according to municipality policy. Among these 43.33% of the food handlers' hands and nail swabs had *Staphylococcus aureus* and were graded D. 40.09% of the swabs had at least two thirds coliforms. Though there were no records of food borne outbreaks in Bulawayo' s major hospitals at the time of the study, these statistics above present a health risk to the consumers. Food prepared in unsanitary conditions can lead to food poisoning (Borges *et al.*, 2011).

Therefore this study sought to:

a) Examine the trend in bacteria count on restaurant swabs.
b) Establish the possible factors contributing to bacterial diversity and load in restaurants in Bulawayo city by answering the following questions;
1. What conditions promote bacterial diversity and count in restaurants?
2. What bacteria are the most prevalent as reflected by the laboratory results?
3. To what degree do the bacteria exist?
4. To what extent do food handlers adopt

recommended behaviours reflect
ed in food inspectors' reports and manuals?

Literature Review

Toxigenic pathogens create food "poisoning" situations by producing an enterotoxin in the food (Behling et al., 2010), hence incubation times for onset of disease are often shorter than invasive pathogens. Examples of invasive and infectious food borne pathogens are described below.

Staphylococcal Food Poisoning

Staphylococcal Food poisoning is among the few causes of bacterial food poisoning that can be attributed to a food handler (Noah, 2005). Humans are natural carriers and spread staphylococci to other people and to food. *Staphylococcus aureus* spreads by direct contact, by skin fragments or through respiratory droplets produced when people cough or sneeze, (Montville & Mathews, 2008). Food preparation equipment such as meat grinders, knives, cutting blocks, storage utensils may also introduce *S. aureus* into food (Montville & Mathews, 2008).

Destruction of staphylococci can occur by normal cooking temperatures. According to Noah (2005) any staphylococci that survive because of inadequate heat penetration or more frequently, by post cooking contamination from a food handler will, if it is an enterotoxigenic strain and given the right conditions of warmth, moisture, pH and time produce toxin. The optimum temperature for growth and production of toxin is between 8 and 40^0C. Conditions often associated with outbreaks of staphylococcal illness are inadequate refrigeration, preparing food too far in advance, poor personal hygiene, inadequate cooking or heating of food, and prolonged use of warming plates when serving food.

Salmonella spp.

Salmonella spp. are invasive infectious pathogens. They are gram negative, rod shaped and usually motile. Food is the main source of infection by *Salmonella* spp. in humans (Malorny et al., 2008). There are different species hence most infection is caused by *Salmonella typhimurium* (Behling et al., 2010).

The infectious dose appears to be as low as 1 to 10 cells in some circumstances (D 'Auost,et al. 1985 in Behling *et al*., 2010) Salmonellosis is caused by the ingestion of contaminated food or water. Symptoms include abdominal pain, diarrhoea occasionally with mucus or blood, (Behling et al., 2010). Symptoms are often more severe in infants and adults over 60years of age.

The person is usually fully recovered within 48hrs. The foods associated with *Salmonella* food poisoning are foods of animal origin e.g. meat, poultry, eggs and dairy products. Major outbreaks have occurred with chocolate, milk powder, potato salad, egg salad, raw milk, mustard dressing, salad base, cheddar cheese, liver pate, aspic gaze, pasteurised milk, egg drink, cuttlefish, cooked eggs, fruit soup, mayonnaise, paprika chips, ice cream and alfalfa sprouts (D'Aoust et al.,1997 in Behling et al., 2010).

Clostridium botulinum

This is an anaerobic spore- forming rod that produces a potent neurotoxin. Food borne botulism is an intoxication involving the consumption of food containing botulinal toxin produced during the growth of these organisms in food, (Behling et al., 2010). Foodborne botulism is common in countries where economic conditions have contributed to an over reliance on home canning, bottling of foods. *C. botulinum* is widely found in low acid foods like honey and vegetables such as beans, peppers, carrots and tinned beef.

Clostridium perfringens

Another anaerobic spore forming bacteria known to cause food poisoning. According to the centre for Disease Control and Prevention (CDC) it ranks as the third most food borne bacteria common disease in the United States, (CDC 2004 in Behling et al., 2010). Hence it is sometimes called the food service germ because foods cooked and left for a long period at room

temperature have been associated with this illness. It is widely distributed in the environment and frequently occurs in the intestines of humans and many domestic animals. The spores persist in soil and areas subject to human or faecal pollution. *C. perfringens* is mesophilic with optimum growth temperature of 37 – 45°C. Its spores can survive normal cooking and pasteurisation temperatures after which they can germinate and multiply during slow cooking.

Streptococci

These are gram- positive spherical microorganisms that appear in chains or clusters. They are facultative anaerobes classified into groups A to O and the main pathogenic groups for humans are A, B, C, D and G. Groups A, B and G are commensals in humans. Group A streptococci are the most important humans pathogens. This group contains M-protein, which inhibits phagocytosis resulting in rheumatic fever and sceptic sore throat (Boyd, 1995). Carriers harbour the organism in the respiratory tract, skin or rectum.

Coliforms

Coliforms are enteric bacilli, which are fermentative inhabitants of the intestinal tract of humans and animals (Boyd, 1995). They are gram negative, non spore forming bacilli, for example *Escherichia coli, Klebsiela pneomoniae* and *Enterobacter aerogenes*. According to Feng et *a*l., (2002), detection of coliforms is used as an indicator of sanitary quality of water or as a general indicator of sanitary conditions in the food-processing environment. Faecal coliforms remain the standard indicator of choice for shellfish and shellfish harvest waters, and *E. coli* is used to indicate recent faecal contamination or unsanitary processing.

E.coli **0157:H7**

This pathogen and other enterohemorrhagic *E. coli* produce a toxin (s) after it implants in the colon and colonise it resulting in illness (Behling et al., 2010), hence it is a toxico-infectious agent. *E. coli* is a gram negative non-spore forming short rod-shaped bacterium capable of growth and gas production at 45°C. Some individuals can be infected but remain asymptomatic. Onset times can be 3 – 4 days and also 1 – 8 day incubation period is possible, (CDC 2004 in Behling *et al*., 2010). Human illness from *E. coli* 0157:H7 can result in non bloody diarrhoea and haemorrhagic colitis.

Controlling Bacteria in Food

HACCP – Hazard Analysis Critical Control Points

The traditional approach to controlling microbial safety of food is based largely on practical experience, education and training of personnel, inspection of production facilities and operations, and testing of the finished product (Micheele, 2003; Cenci-Goga et al., 2005). Relying on end product testing can present unexpected problems, hence the need for HACCP, which is a pro-active control programme for the food industry. HACCP is cost effective and offers a number of controls such as training, documentation responsibility and corrective action (Valder, 2009) also widely accepted as an extension of Good Manufacturing Practices (GMP).

HACCP is an approach to food safety that identifies where a likely health hazard may occur, then establishes and maintains safety measures to prevent the hazard from occurring (Mohamad et al., 2008). It is a quality management system that reduces the incidence of unsafe food reaching the consumer. It is a food safety program that also covers product quality. Pre-requisite programs (PRPs) are essential requirements for an effective HACCP program (Valder, 2009) Among other thingsPRPs address the environmental conditions in the food plant, for example, requirements for plant layout, hygienic design of equipment and control of operational procedures

The Food and Agriculture Organisation training manual of 1998 describes the purpose of HACCP as to prevent hazardsthat could introduce potentially dangerous food-borne illnesses in food by applying science-based controls that cover all aspects from raw resources through

preparation to final product. This differs from the traditional method of having industry and regulators perform random checks and sampling of manufacturing conditions and final products to ensure food safety.

The Food Safety Authority of Ireland (2009), considers the preventive approach of HACCP as not only to improve food safety management but also complements other quality management systems such as money saving, compliancy with the law, team work and efficiency amongst staff and ensures due diligence defence in court.

CONCEPTUAL FRAMEWORK

Null Hypotheses

Following the literature review, it has been hypothesised that:

1. No bacteria will be established as preva

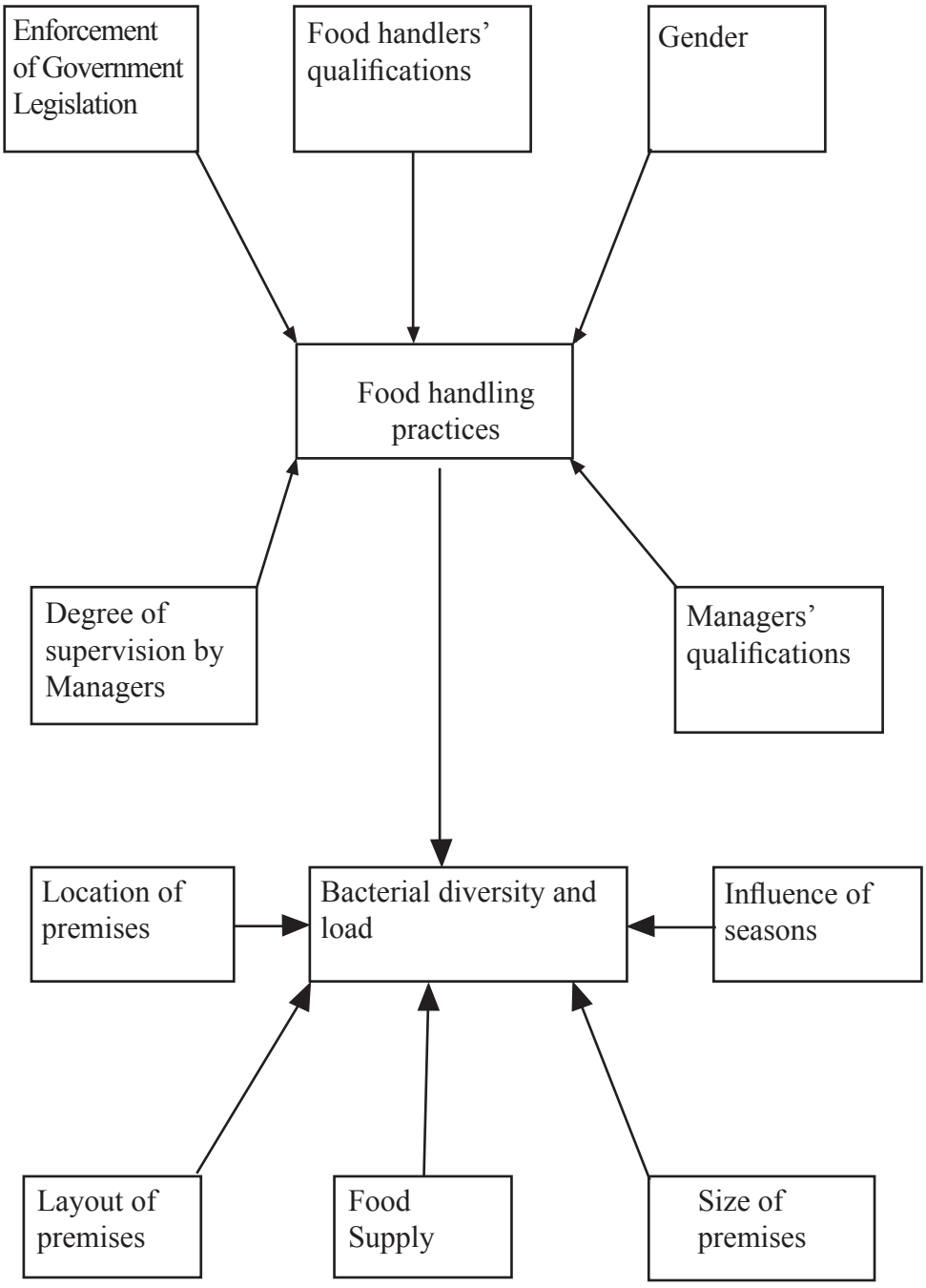

Figure 1

Block diagram for the conceptual frame work for the factors contributing to bacterial diversity and load.

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2. There will be no significant relationship between layout of premises and bacterial diversity and count.
3. There will be no significant influence of supervision to food handling practices.
4. There will be no significant difference in food handling practices between food handlers who hold pro fessional qualifications and those trained on the job.
5. Bacterial diversity and count will not be significantly influenced by hygienic practices.

Materials and Method

A combination of sampling, examination and descriptive longitudinal research design were used in this study since it measures changes over time. Pre-collected data was examined, entailing examination of the results of bacteriological analysis of swabs from food premises. This was done in order to gauge the type of hygienic standards applied during the handling, preparation and packaging of foods in the past.

Observation was used as a dominating method of data collection; questionnaires were used to obtain data from food handlers.This data was validated using experiments/ swab analysis of food samples, hands and environmental.

Procedures used

Sterile wood and cotton tip swabs were used to collect samples from kitchen surfaces as well as food handlers' hands and nails. At least six bottles containing tryptic soy broth (transporting media) were prepared for each food outlet to be visited, each bottle for a specific sample. The cotton tip of the swab was moistened in tryptic soy broth and approximately 100cm^2 of a visibly clean surface was swabbed and the swab was then ascetically placed back into broth. To kill any foreign bacteria from other sources apart from the swabbed ones, the brim of the bottle and swab end were flamed using a gas lamp and closed with a lid. The same technique was used for hands and nails as well as the interior and exterior of food surface. The bottle would then be labeled with the name of premises and area swabbed. Hand and nail swabs were taken after the food handlers washed their hands. Ready to eat food sampled included cold meats, sausages, pies, cheeses, bread, cakes, sandwiches and such-like foods. The samples were transported to the testing laboratory in a cooler box at a temperature not more than 7^{o}C. Each sample was homogenised and selective, differential and nutritive media was used to culture the organisms. Selective/ differential media included MacConkey and EMB agar, nutritive media included nutrient and blood agar. Selective media contain restrictive antimicrobial substances that allow the growth of a specific group of microorganisms while suppressing others (Greer et al., 2004). Differential media were used to differentiate closely related organisms or groups of organisms.

Observations were done over a period of five days during which the isolates were characterised and identified using colony mophorlogy, gram staining, cell mophorlogy and endospore formation. The isolated colonies were further subjected to biochemical tests basing on their different biochemical characteristics. Confirmation of the genus *Staphylococcus* was done using catalase, oxidase and the glucose fermentation test. *Staphylococcus aureus* was confirmed using the coagulase test. Biochemical tests performed to confirm coliforms and feacal coliforms include catalase and lactose/glucose fermentation oxidase and nitrate reduction. Brilliant Green Broth and Lauryl Tryptose were used to confirm coliforms and EC Broth with durham tube was used to confirm faecal coliforms as suggested by Ruhil et al, (2008). Confirmation of faecal streptococci was done using Ethyl Violet Azide Broth (EVAB) and Bile Aesculine Agar (BEA).

Raw scores of swabs taken from hands, nails and surface were computed and their means obtained over the five years. 'Other' refers to utensils that were swabbed but varied from one establishment to the other. The items were randomly picked while ready for use. Their scores were averaged and means obtained.

Results and Discussion

The main emphasis on the need for bacterial analysis was to gauge the type of hygienic standards applied during the handling and preparation and packaging of the foods. Contamination of foods by food handlers may occur at any point during the processing of the food at the food-preparation premises if proper handling practices are not followed.

On analysis, both the inner and the outer surfaces of these processed solid foods should ideally be devoid of bacteria, especially the faecal types of bacteria if proper handling practices have been followed. It therefore becomes necessary to bacteriologically analyse the inner and outer surfaces of food surfaces separately and then compare results before conclusions pertaining to the contamination level can be drawn. The following means were obtained using ANOVA.

Trend on analysis of swab

Table 1 shows the trend in bacterial count (means +/- SD) from 1997 to 2003.

Table 1
Trends in bacterial count (means ±SD) from 712 swabs taken between 1997 and 2003.

Year	Hands	Nails	Surface	Others	Overall
1997	2.60 ±1.35	2.08 ±1.08	2.80 ±1.00	3.32 ±0 .67	2.24 ± 0.52
1998	2.28± 1.21	1.64 ± 0.86	2.92 ±0.81	3.49 ± 0.55	2.24 ± 0.44
1999	2.64 ± 1.11	1.64 ±0.86	3.04 ±0.93	3.18 ± 0.71	2.58 ±0.71
2000-1	3.04 ±1.21	2.64 ± 1.50	3.08 ±0.95	3.19 ±0.72	3.00 ±-0.82
2003	2.16 +/- 0.80	2.36 ±1.04	2.52 ± 0.82	2.86 ±0.53	2.40 ±0.50
F	2.24	4.09	1.54	0.84	6.51
P	0.069	0.004	0.195	0.0474	0.000

Mean scores for hands nails surface and overall were generally low throughout the years, (Table 1). Overall results have a p value of 0.000 (F=6.51), which gives the impression that there is lack of commitment to personal and kitchen hygiene by food handlers.

Table 1 indicates that from 1997 – 2003 the mean score on hands has been ranging between 2.16 and 3.0 which is generally unsatisfactory according to Municipal standards since more score are in the region of 2. This implies that washing of hands has not been thorough or no bactericidal soap was used hence contaminated hands can transfer bacteria to food or utensils used for serving food thus rendering the food unsafe.

Trend on Nails

Nails have contributed significantly to the overall score, as the scores have been fluctuating between 1.6 and 2.6, which fall in the unsatisfactory range with the lowest score being more risky as they are potentially a health hazard. Nails and hands harbour pathogens like staphylococci which threaten human health (Noah, 2005). This calls for more attention to personal hygiene on the food handler.

Trend on others

The “others” are in the satisfactory range with F – ratio of 0.84 (p=0.474) which means utensils were satisfactorily taken care of since the p value in insignificant (p=0.5). Hence, cleaning of utensils was satisfactorily done.

Trend on Overall

The overall mean scores for this period were below satisfactory. Considering all the contributing scores, it can be noted that hands, nails and surface contributed significantly to the unsatisfactory overall results. This implies that for improvement, food handlers should pay more attention to personal and kitchen hygiene, which will in turn lower bacterial count and produce good results.

Trend of results across the years

The results show that, the mean scores have been fluctuating over the years and overall results are satisfactory. The mean scores for 1997 were unsatisfactory, dropped to far below satisfactory with some being potentially hazardous in 1998.

They rose to almost satisfactory in 1999, 2000-1, but show a significant fall in 2003. Hands and nails were below satisfactory for each year save for year 4 (2000/2001) with a mean of 3.04. The low overall scores obtained over the years resulted mainly from hands, nails and surface. Though the others were satisfactory their contribution in raising the score is significant.

Conditions promoting bacterial diversity and count

These were analysed at two levels that is, using restaurants and food handlers as units of analysis. Hence the twenty-five restaurants (n=25) were used as one unit of analysis while the fifty seven (n=57) food handlers formed the other unit.

Table 2 below shows results obtained using stepwise regression and regression analysis and taking the computed laboratory average (n=25) results as the dependent variable on 27 predictors.

Table 2

Relationship between food handlers knowledge and length of service to laboratory overall results, assessed using t-ratio. N=25

Variable	SD	P	t-ratio
Food handler's Knowledge (Q 7- 16)	0.233	0.005	3.10
Food handler's length of service (Q 5)	0.011	0.017	-2.58

R-Sq = 45.0%, R-Sq (adj) = 40.0%, F = 9.01, P=0.001
(Highly significant when p<0.01, Significant when p<0.05 Not significant when P>0.05)

The two factors account for 45.0% of the variance which was adjusted to 40% on regression. The above results show that food handler's knowledge is positively related to laboratory average results which means the more knowledgeable the food handler is, the better the laboratory results. On the other hand length of service is negatively related to results implying that the more the food handler becomes experienced the more they become careless, taking things for granted.

Taking the computed laboratory overall (n=25) results as the dependent variable, on 27 predictors the following results in table 3 were obtained;

Table 3

The relationship between supervision and layout of equipment to laboratory overall results, assessed using t-ratio. N= 25.

Variable	St.Dev	P	t-ratio
Supervision (Q 23)	0.07604	0.002	-3.45
Layout of equipment (Q 25)	0.3927	0.037	2.22

R-Sq = 39.37%, R-Sq (adj) = 33.9%, F = 7.14, P = 0.004
(Highly significant when p<0.01, Significant when p<0.05 Not significant when p>0.05)

The two factors account for 39.37% of the variance, which was adjusted to 33.9% on regression. Results show that the more often the supervision the lower the grade hence the negative relation. This implies that food handlers are always supervised in a situation where the supervisor has doubt on the quality of products. However the supervision is not effective since they are supervised by unqualified personnel hence the lower grades.

Layout of equipment is positively related to results which imply that the more organised the equipment the better and thorough is the cleaning. Hobbs and Roberts (1993) support logical layout of equipment to avoid cross contamination.

Taking food handlers as unit of analysis (n=57), table 4 below shows results obtained with laboratory overall as the dependent variable on 28 predictors.

Table 4

Association between laboratory overall results with facility, supervision, manager/supervisor's experience, medical check ups, food handler's gender and inspection by EHO using p value and t-ratio.

Variable	St. Dev	P	t-ratio
Facility	0.03251	0.442	-0.77
Supervision	0.0399	0.000	-3.85
Manager/supervisor's experience	0.001495	0.000	-4.37
Medical check – ups	0.0625	0.003	3.33
Food handlers' gender	0.9544	0.006	-2.87
Inspection of premises by EHOs	0.4457	0.013	2.57

R-Sq=55.1%, R –Sq (adj) = 49.7, F= 10.22, P>0.000
(Highly significant when p<0.01, Significant when p <0.05 Not significant when P>0.05)

The above factors account for 55.1% of the variance, which was adjusted to 49.7% on regression. The above results (Table 4) show that facilities, supervision by managers, manager/ supervisors' experience, as well as food handlers' gender are negatively related to results implying that they have a negative association with lab overall results. The p-value for facilities is insignificant (0.442) implying that facilities do not influence lab, overall results. This means that even if necessary facilities are provided, their use and contribution to results depends on other factors like food handlers' knowledge and effective supervision. As with the restaurants the more the supervision the lower the grade implying that though supervisors have doubt in the quality of the product, they lack the necessary skills for effective supervision.

As previously observed, the more experienced the manager/ supervisor, the more careless they become. Most interestingly, gender is negatively related to results implying that the more females there are the lower the rating (y=a+bx) hence males are better food handlers than females.

On the other hand, medical checkups and inspection of premises by EHOs are positively related to results which means food handlers take inspection and medical results positively. Therefore, with more males, more checkups and regular inspection of premises from EHOs, good grades can be achieved.

Considering laboratory average (n=57) results as the dependent variable on the 28 predictors, the following observations were made. Table 5 shows the t-ratios of three variables.

Table 5

Relationship between food handler's knowledge, premises and food handler's gender with laboratory aveage, using t-ratio. N = 57

Variable	t-ratio
Food handler's knowledge	3.75
Premises average	-3.09
Food handler's gender	-2.38

The three factors account for 35.6% of the variance which was adjusted to 32.0 on regression. Since food handler's knowledge is positively related to results, it implies that the more knowledgeable the food handler is, the higher the grade becomes. On the other hand the bigger the premises, the lower the grade. This means that they tend to handle dirt more often or the less organised the equipment, the lower the grade implying that cleaning is not thorough. As reflected earlier, the more females there are, the lower the grade as evidenced by the negative relation. Descriptive statistics also showed that the more the customers served per day, the lower the lab ratings. Results revealed that, 61.54% of those premises serving at least 400 customers per day had a laboratory average of 3(C) which is unsatisfactory according to Municipality criteria. This implies that, in busy premises, workers become so occupied that they have no time to wash their hands and keep hygienic standards up. This calls upon the responsible authorities to engage cleaners in order to maintain acceptable hygienic standards and high turnover.

The most prevalent bacteria

Table 6 below shows the swabbing results of the 25 restaurants for the period 1997 to March 2003. These laboratory results reveal the most prevalent bacteria.

Table 6

The most prevalent bacteria taken from restaurants' swabbing results between 1997 and 2003. N = 25.

Type of bacteria	Number of swabs containing the bacteria						
	2003	2000-1	1999	1998	1997	Total	%existence
Coliform	114	64	85	73	69	405	56.88
Feacal coli	33	25	24	30	38	150	21.07
Feacal streps	24	12	13	10	11	70	9.83
Pathogens	10	15	17	18	27	87	12.22

Results in table 6 show that coliform has been dominant and the number of swabs containing this bacterium has been increasing. This implies a high degree of environmental contamination. Though not prevalent but dangerous, is the pathogen Staphylococcus aureus whose presence on swabs implies deficient personal hygiene. From the food samples analysed in February 2003, 50% had *Staphylococcus aureus and* 41.61% had coliforms. These indicate meagre personal and kitchen hygiene hence food becomes risky.

Degree of bacterial existence

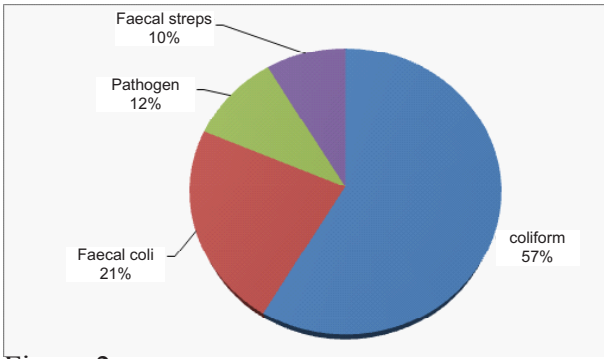

Figure 2

Degree of bacterial existence from 1997 to 2003, taken from swabbing results of 25 restaurants. N=25.

Degree of bacterial existence from 1997 to 2003

From a total of 712 swabs, 57% had coliform, 21% faecal coli, 12% *Staphylococcus aureus* and 10% faecal streptococci (Table 6). Though swabs contaminated with staphylococci are few, only swabs from hands and nails are tested for the bacteria, which accounts for 35% of the total hands/ nails swabs. This implies that food may also be contaminated since most of the handling is done by naked hands.

The pattern of existence in relation to seasons

Using one way analysis of variance to examine the pattern of existence, the following means in table 7 were obtained over the five-year period.

The means in season one that is, summer are chiefly unsatisfactory with hands and nails contributing more to the unsatisfactory overall results. In the same manner season 2 (autumn), has unsatisfactory means save for the 'others' leading to unsatisfactory overall result. This trend tends to continue over the next two seasons, that is winter and spring where hands, nails and surface continue to maintain low means resulting in unsatisfactory overall results.

Table 7
Seasonal occurrence of bacteria represented by mean scores.

Season	Mean Scores					
	N	Hands	Nails	Surface	Others	Overall
1	25	2.48	1.88	2.96	3.1	2.4
2	29	1.96	2.2	2.55	3.1	2.3
3	35	2.28	2.06	2.82	3.18	2.4
4	36	2.77	2.11	3.1	3.35	2.72

Generally hands, nails and surface continue to score low throughout the year hence contribute more to the overall results which are generally unsatisfactory. This follows that, the pathogens *Staphylococcus aureus* and coliforn dominate throughout the year. The former leaves in the comfort of food handler's hands and nails and the later habitating on hands, nails and surface. It therefore remains the food handlers' responsibility to practice personal and kitchen hygiene in order to minimise/ reduce bacterial count in food samples and swabs and thus raise the overall score.

Adoption of recommended behaviours by food handlers

From the trend of results taken over the five years, one can conclude that, the recommended behaviours are not adopted as expected because the results continue to fluctuate. The EHOs recommended that, food handlers should use bactericidal soap for washing hands and utensils. In addition, a brush for scrubbing nails should be used. They are also encouraged to wash their hands after using the toilet. If these recommendations were taken seriously then this should reflect in the results. The soap if used would kill the bacteria and reduce their numbers in the samples. Studies by Rebellato *et al*., (2012) suggested that recommended behaviours were adopted and maintained for at least one month following an examination. This means that people relax with time such that on the next visit, results will not reflect any improvement.

Discussion

Demographic data

Investigation revealed that there are more males than females in the food handling and supervisory classes. Their age groups range from about nineteen to above thirty-five though the majority are in the 19-30 years category. Boutrif (1995) revealed that women pursue better general hygiene practices than man. Contrary to this report, statistics in this research revealed that males are better food handlers than females (with a t-ratio of -2.87). Hence as illustrated on the framework, gender has a direct effect on food handling practices.

Academic and Professional Qualifications of Food Handlers

Statistics showed that a majority of the food handlers lack the necessary qualifications. Cates et al*.,* (2009) in Rebellato, *et al.*, (2012) suggested that educated and certified food handlers will use knowledge of food safety in food preparation settings. The same studies indicated that the presence of a certified kitchen manager is protective for most types of food critical food safety violations. In the same vein, The Bureau of Labour Statistics, Occupational outlook handbook (2010) advocated for the education of managers so that they can be effective leaders and enhance high levels of sanitation.

Lack of qualifications implies lack of knowledge hence accounts for the low ratings in bacteriogical results of swabs and food samples. The hypothesis, which says, there will be no significant difference in food handling practices between food handlers who hold professional qualifications and those trained on the job, is rejected at 0.01 level of significance since p for knowledge is 0.005 ($p<0.01$). Knowledge of the food handler has emerged as one of the factors leading to positive results ($t=3.75$). Marriot and Gravani (2006), advocated for the education of the food handler in order to produce food that is safe to the consumer. Therefore food handlers'

qualifications affect food handling practices as indicated on the framework. The higher the level, the better their personal hygiene and handling practices.

Environmental Conditions

The data revealed that overall results have generally been unsatisfactory and this emanated from low ratings on hands, nails and surface. The low ratings were due to the presence of staphylococci on hands and nails as well as coliform on hands, nails, surface and utensils. This implies lack of personal and kitchen hygiene with p value for hands as 0.069, nails 0.004, surface 0.195 others 0.014 leading to poor overall results with f-value of 6.51, and p=0.000, which is highly significant. Noah (2005) pointed out that food handlers' resident bacteria may be passed on to food or equipment via the hands. Adherence to good personal hygiene and to hygienic food handling practices is essential if microbial contamination is to be prevented. Therefore the hypothesis that says, bacterial diversity and count will not be influenced by hygienic practices is rejected at 0.01 level of significance basing on the p value of overall laboratory results ($p<0.01$).

Statistics showed that coliform has been predominant since 1997. From the data presented, it accounted for 57% of the contamination on swabs, with faecal coli contributing 21%, staphylococci 12% and faecal streptococci. 10%. This rejects the hypothesis that says, no bacteria will be established as prevalent since coliform is predominant. The presence of coliform implies a high level of environmental contamination. Hence hygienic standards of surfaces and equipment are highly questionable. Faecal coliform and faecal streptococci indicate faecal contamination. According to studies by Özlem and Feryal (2005), the presence of faecal coliforms and faecal streptococci in the kitchen implies low levels of hygienic standards and ineffective use of disinfectants. Results presented in this study have shown that facilities are negatively related to results, which implies that even with the necessary provisions (disinfectants included) their use may be questionable. On the other hand it can also be argued that though disinfectants were provided, they were not the recommended bactericidal soaps hence would not be effective even when used. Therefore there is a need to educate the food handlers on the importance of using disinfectants.

Results also showed that 56% of the premises have waste disposal areas that are potentially a healthy hazard, characterised by uncovered bins, with some inside the kitchen, thus attracting flies and cockroaches. Some had poor drainage systems inside or just around the kitchen, which is a source of contamination. Descriptive statistics showed that 61.54% of the premises, with a turnover of at least 400, had unsatisfactory grades. This implies that, the more the turnover, the busier the premises, hence less attention is paid to hygiene, resulting in the low grades. Twelve percent (12%) of the premises, with dining or services areas between 150 and 250m^2 had satisfactory results, implying that the size of kitchen/ dining area should be proportional with the scale of operation. It was also discovered that 64% of the premises had pests (cockroaches and flies) in the kitchen, dining / service area or both. Pests are vehicles for microorganisms hence their presence continue to lower the levels of hygiene, hence bacteria become abundant. Anon (2004), in Marriot and Gravani (2006), indicated that a link exists between pest exclusion and food safety and security since pest management technicians monitor the interior and exterior of food facilities for abnormal conditions that may jeopardise food safety. Therefore to lower bacteria and improve laboratory grading, the environment in which food is prepared should be kept clean and free of pests. It follows that, location, and size of premises have a direct effect on bacterial diversity and count. In this respect, the hypothesis that says, there will be no significant relationship between layout of premises to bacterial diversity and count is rejected at 0.05 level of significance basing on the p value of 0.37, ($p<0.05$)

Effect of Level of Supervision

Though managers and supervisors monitor progress through supervision, statistics showed that supervision is negatively related to results ($t=-3.85$) and a p value of 0.000 when

N=57, p=0.002 when N=25. In both cases supervision has a highly significant influence on food handling practices. Thus, the hypothesis that says, there will be no significant influence on food handling practices is rejected at the level of significance of 0.01, since p<0.01. Those supervisors, who supervise their employees, do not yield the required expectations. This could be because their supervision lacks vision or that they impose their suggestions on subordinates without involving them in training. Hence subordinates would not tolerate supervision and would not take orders leading to a general trend of unsatisfactory results. It is therefore suggested that food handlers should be seen and felt as active members of the system and hence be involved in solving the problem through training.

EHOs inspection has been viewed positively since it is positively related to results (t-ratio 2.57). This means that the food industry respects inspection and takes advice positively. However the general trend shows that results have been unsatisfactory though premises were inspected. Inspection of food premises should be regularly done and more visits can be made if there is reason to suspect that the premises or practices are unhygienic. Therefore more visits and laboratory examinations of swabs and samples throughout the year would ensure that people do not relax. It has also been discovered (through ANOVA) that, the difference in seasonal mean scores on laboratory results is insignificant. Hence there is no reason to assume that one season is better than the other in terms of bacterial type and abundance, contrary to Noah's (2005) opinion that bacterial food poisoning is common in summer than in winter.

Conclusion

It has been discovered through this study that, factors contributing to bacterial diversity and loadcan be grouped into two, that is, food handling practices and environment in which the food is prepared. These two factors have different root causes as shown in the discussion. These root causes can be controlled by engaging food handlers in training on pre-requisite programmes as well as by adopting the HACCP system. Investigations did not have convincing evidence to show that seasons have influence on bacterial diversity and count.In this study, there was insufficient evidence to establish food supply as a possible contributing factor to bacterial diversity and count.

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