

# Microbial Contamination of House Hold Refrigerators in Calabar Metropolis-Nigeria

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**Abstract** *Background:* Microorganisms are ubiquitous in nature, its presence in a particular location and condition suitable for its multiplication dictate its pathogenicity or otherwise. *Objective:* To investigate the microbiological load and the potential risk of refrigerated food and water exposed to in Calabar metropolis. *Design:* Sterile swab sticks moistened with peptone water were used to swab the refrigerator parts of interest. The swabs were aseptically transferred to appropriate culture media and the cultures incubated at 37°C for 24 hours. *Setting:* The base, shelves and inner sides of 50 randomly selected household refrigerators in Calabar Metropolis were examined for microbial pathogens presence to determine their possible role as infection reservoir. *Subject:* Bacterial and fungal isolates were identified morphologically, physiological, and biochemically while parasites were detected by direct microscopy. *Result:* In all, 100% of refrigerators sampled showed bacterial contamination, 32% showed fungal contamination, while 8% had parasitic organisms. *Genera* of bacteria isolated in descending order of frequency were: *Staphylococcus aureus* 27.3%, *Escherichia coli* 20.2%, *Shigella* spp 13.0%, *Pseudomonas aeruginosa* 11.9%, *Aeromonas hydrophilia* 8.3%, *Salmonella typhi* 5.9%, *Klebsiella pneumonia* 5%, *Streptococcus pyogenes* 4.7%, and *Proteus mirabilis* 2.3%. Fungal organisms isolated were *Candida albicans* 54%, *Penicillium* spp 43.2% and *Aspergillus flavus* 2.7% while the parasites detected were *Entamoeba histolytica/dispar* 50% and *Ascaris lumbricoides* 50%. *Conclusion:* The presence of these organisms, including potential foodborne pathogens, in domestic refrigerators portends serious health implications. The need to maintain appropriate food storage and refrigerator management, and proper hand hygiene is recommended.

**Keywords:** microbial, pathogens, refrigerators, Calabar metropolis

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## 1. Introduction

Microorganisms are ubiquitous occurring nearly everywhere in nature. They occur most abundantly in the presence of nutrients, moisture and temperature suitable for their growth and multiplication [1].

Since the conditions that favour the growth and multiplication of most microorganisms are also favourable to man, it is inevitable that we live among thousands of microorganisms. They are found in the air we breathe, the food we eat and on our body surfaces and other close environments. The presence of microorganisms in a location has various effects that could either be beneficial or harmful and human beings have various ways of resisting invasion by potentially harmful ones

Domestic refrigerator also known as 'Household Refrigerator' is a low temperature appliance used in homes for the preservation and storage of food products [2]. Refrigeration is one of the most widely practiced methods of controlling microbial growth on perishable products [3] of which temperature specification of four to five (4-5°C) degree Celsius is considered desirable [4].

Refrigeration is employed to control the rate of certain chemical and enzymatic reactions as well as the rate of growth of food microorganisms [5]; food spoilage slows down as molecular motion slows, which retards growth of bacteria that cause food to spoil.

However, studies have shown that perishable food will deteriorate even at refrigerator temperature due to spoilage because of microorganism, enzymes and oxidation [6]. The type of container or wrapping material they are stored in and duration of storage are also important factors that influence the type of microbial growth, toxicity and spoilage of food during refrigerated storage [7]. Although low temperature retards spoilage, but even a sub-freezing temperature of about 7°C does not prevent multiplication of all microorganisms, refrigerated foods are therefore subjected to spoilage by molds, yeasts and bacteria [8]. In the presence of nutrients, moisture and favorable temperatures, they tend to grow increasingly and rapidly leading to food and water borne illnesses [9]. Bacteria from unwashed raw foods, leaking packages, unclean container surfaces introduced into refrigerators can directly contaminate other stored foods and persist on the interior surfaces. This in turn creates the risk of indirect long term contamination during subsequent food preparation

[10]. The internal surface within the domestic refrigerators usually creates an unfavorable environment for many pathogenic bacteria but most of them are capable of growing and surviving at low and cold temperature. If refrigerators are not properly maintained, it becomes a breeding ground for such bacteria [11].

Many diseases are caused by microorganisms such as bacteria, viruses and parasitic infestations arising out of food spoiled due to prolonged storage of perishable and semi perishable food items, like *Staphylococcus* bacteria which produces toxin as by-product of growth and multiplication and cause food intoxication [12]. More so, bacteria such as *Listeria monocytogens*, *Escherichia coli*, *Salmonella* spp, *Campylobacter jejuni*, *Clostridium botulinum*, *Yersinia enterocolitica* and parasites such as *Cryptosporidium parvum* and *Giardia lamblia* have been implicated in food and water borne illness [13]. The global incidence of food borne diseases is difficult to estimate, but it has been reported that in 2005 alone, 1.8 million people died from diarrheic diseases [14]. Research indicates that domestic refrigerators are three times more frequently involved in initiating food borne illness than commercial refrigerators [15] and perhaps as many as 50% of household food borne illness can be attributed to an inappropriate food storage and refrigerator management [16]. It was reported that food borne illness in African region recorded a dramatic rise in 2008; Anthrax in Zimbabwe, typhoid fever in Uganda, chemical poisoning due to consumption of seed beans and maize in Nigeria and Kenya, cholera from several countries example Mozambique, Nigeria, Congo, Zambia, DRC, Kenya, Tanzania, South Africa, Zimbabwe, pesticide poisoning from cabbage and other vegetables in Senegal, fish in Mauritius, mushroom poisoning in Algeria, botulism and hepatitis A in Uganda; Gala night dinner [17].

The most common problem in Nigeria is keeping food in the danger zone of 4°C to 60°C. This is due to the fact that electricity supply is erratic [14].

Having established that the domestic refrigerators for food storage are not as sterile as popularly opined, there comes the need to investigate their microbiological quality and their potential risk as reservoir of food and water borne infections in Calabar, Nigeria.

## 2. Methods

### 2.1. Study Area

This study was carried out in Calabar Metropolis. Calabar is the capital of Cross River State in the coastal Southern Nigeria. The city is divided into Calabar South and Calabar Municipal Local Government Area with an area of 406 km<sup>2</sup> and a population of 371022 as at the 2006 census (Simon, 2010). Calabar features a tropical monsoon climate with a lengthy wet season spanning ten months [18]. Sampling points included various randomly selected areas of Calabar Metropolis within the two Local Government Areas.

#### ETHICAL CONSIDERATIONS

Ethical approval was obtained from the State Ministry of Health and Human Research Ethics Committee, Calabar before proceeding with the study. Informed

consent was sought from each respondent before questionnaires were administered and taking of samples for laboratory analysis. The privacy, dignity, and autonomy of the respondents were maintained accordingly throughout the conduct of the study.

### 2.2. Sample Collection

A hundred and fifty (150) samples were obtained from 50 household refrigerators accessed with consent of the owners. Samples were taken from the base, shelves and sides of the refrigerator using sterile swab sticks moistened in sterile peptone water and transported back to the Laboratory for analysis within one hour of collection.

#### CULTURE MEDIA

Different culture media were prepared according to manufacturers' specifications. The media included Blood Agar, Cysteine-lactose Electrolyte Deficient (CLED) Agar, Salmonella Shigella Agar (SSA), Mannitol Salt Agar and Thio-sulphate Citrate Bile Salt (TCBS) Agar and Sabouraud Dextrose Agar (SDA) for fungal isolation.

#### IDENTIFICATION OF ISOLATES

Initial identification of bacteria isolated was based on their cultural and morphological characteristics. Further identification was by biochemical characteristics employing standard procedures.

#### GRAM-STAINING

A thin smear of a 24- hour culture was made on a clean grease-free slide and was heat fixed by passing the slide quickly over a Bunsen burner flame after air-drying. The prepared smear was then flooded with crystal violet solution for about one minute followed by the addition of Gram's iodine solution. This was allowed to react for 60 seconds after which 95% ethanol was added for about 30 seconds. The smear was counterstained with safranin solution for about 1 minute, washed with water and blotted dry with filter paper. The specimen was examined under an oil immersion microscope. Purple colour signifies a Gram-positive organism while pink to red signifies Gram- negative.

#### BIOCHEMICAL CHARACTERISTICS OF ISOLATES

This entails the examination of the biochemical properties of the isolates using various tests that included the following:

#### CATALASE TEST

The differentiation of bacteria that produce the enzyme catalase from non-catalase producers is achieved using this test. Catalase acts as a catalyst in the breaking down of hydrogen peroxide to Oxygen and water, two to three ml of 3% hydrogen peroxide solution was poured into a test tube. A 24 hour culture of the test organism from the nutrient agar was emulsified in the hydrogen peroxide solution. The release of bubbles immediately indicated a positive test while it was negative when no bubble was formed.

#### METHYL RED TEST

This involves the use of buffered glucose peptone water in which entero bacteria are being cultured. The test produces sufficient acidity from the fermentation of glucose to give a red colour with the indicator methyl red. The test was performed by inoculating a colony of the test organism into 0.5ml of sterile glucose phosphate broth. After over- night incubation at 37°C for 24 hour, five

drops of kovac's reagent were added to the culture and the mixture was shaken gently. The formation of a red ring on the surface of the culture indicated a positive reaction while no colour formation indicated a negative reaction

#### COAGULASE TEST

A portion of an isolate was picked using a sterile wired loop and emulsified in physiological saline solution on a clean grease- free slide to give a thick suspension and mixed well. The formation of macroscopic clumps within 10-15 seconds indicated a positive result while the absence of macroscopic clumps indicated a negative result.

#### OXIDASE TEST

This is particularly useful for the differentiation of pseudomonas from other Gram-negative bacteria. A strip of whatmann filter paper was impregnated with 10% aqueous solution of *tetra methyl-p-phenylene-diamine hydrochloride*. A wire loop was used to pick a colony of the test organism and rubbed on the wet filter paper impregnated with the oxidase reagent. Development of purple or deep blue colorations after about 5 minutes was recorded as a positive reaction.

#### FERMENTATION TEST

This determines the ability of organisms to ferment sugars including glucose, mannitol, sucrose, etc. phenol red broth was prepared and sugars were incorporated at a final concentration of 1%. To detect gas production, Durham tubes were placed in inverted positions in each test tube. Each test isolate was inoculated and incubated at 37°C for 24 hours. An un-inoculated medium was used as control. Utilization of the sugars was indicated by formation of a yellow coloration on the medium while production of gas was shown by creation of space at the end of the Durham tubes. Organisms used for the fermentation test were grown in a medium having the following composition:

Peptone	10%
NaCl	0.1%
Bromocresol sugar	1.0%
Fermentation sugar	1.0%

#### CITRATE TEST

About 5ml of 5% of koser's citrate medium was prepared and dispensed into screw cap tubes. The mixture was inoculated and then incubated at 37°C for 3 days, blue coloration of the medium indicated citrate utilization while a green a green colour indicated negative reaction.

### 2.3. Parasitology

Saline solutions of swabs were spun at 1500rpm for 5 minutes; the supernatant decanted and a drop the sediment carefully placed on each end a clean grease free slide. A drop of Lugol's iodine was added to one end, a cover slip applied to both preparations and the slide examined under the microscope at x10 and x40 magnifications for parasites identification.

## 3. Results

Table 1 shows the prevalence of microbial pathogens in the refrigerator samples assessed. Bacteria had the highest prevalence 150/150 (100%) followed by fungi 48/150 (32%) and parasites 12/150 (8%).

Table 2 displays the frequency of microbial isolates in the refrigerator samples assessed.

Among the bacterial isolates, *Staphylococcus aureus* was the most frequently isolated (27.3%) followed closely by *Escherichia coli* (20.2%), *Shigella* spp (13.0%), *Pseudomonas aeruginosa* 11.9%, and *Aeromonas hydrophilla* 8.3%. Others were *Kliebsiella pneumoniae* and *Salmonella typhi* 5.9 % each, *Streptococcus pyogenes* 4.7% and *Proteus mirabilis* 2.3%. *Candida albicans* was the most frequently isolated among the fungal isolates (54.0%) followed by *Penicillium* spp (43.2%), and *Aspergillus flavus* (2.7%). *Ascaris lumbricoides* and *Entamoeba histolytica/dispar* were the parasites detected at a frequency of 50% each.

Table 3 shows the frequency of distribution of bacterial isolates based on the refrigerator compartments. In the base, *S. aureus* had the highest frequency of distribution (29.2%) followed by *E. coli* (26.8%), and *Shigella* spp (12.1%). *Pseudomonas aeruginosa* and *Proteus mirabilis* had the same and lowest distribution (2.4%). In the shelves, *S. aureus* had the highest distribution (34.8%) followed *P. aeruginosa* (16.2%), and *Shigella* spp (13.9%). *Kliebsiella pneumoniae* and *Salmonella typhi* had equal and the least distribution 6.9%. In the sides, *S. aureus* was the most distributed (40.6%) followed by *E. coli* (21.0%) and *Aeromonas hydrophilla* (13.5%).

**Table 1. Prevalence of Microbial Pathogens in the Refrigerator Samples Assessed**

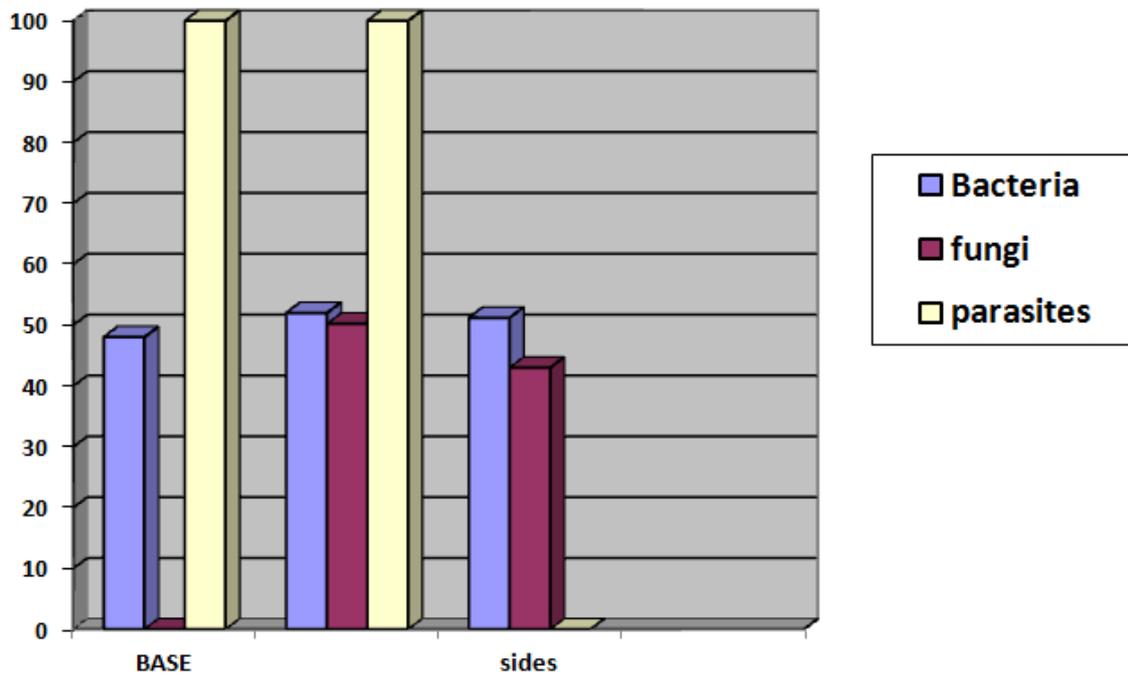
Microbial Isolates	Frequency n =150	Percentage prevalence (%)
Bacteria	150	100
Fungi	48	32
Parasites	12	8

**Table 2. Frequency of microbial isolates in the refrigerator samples assessed**

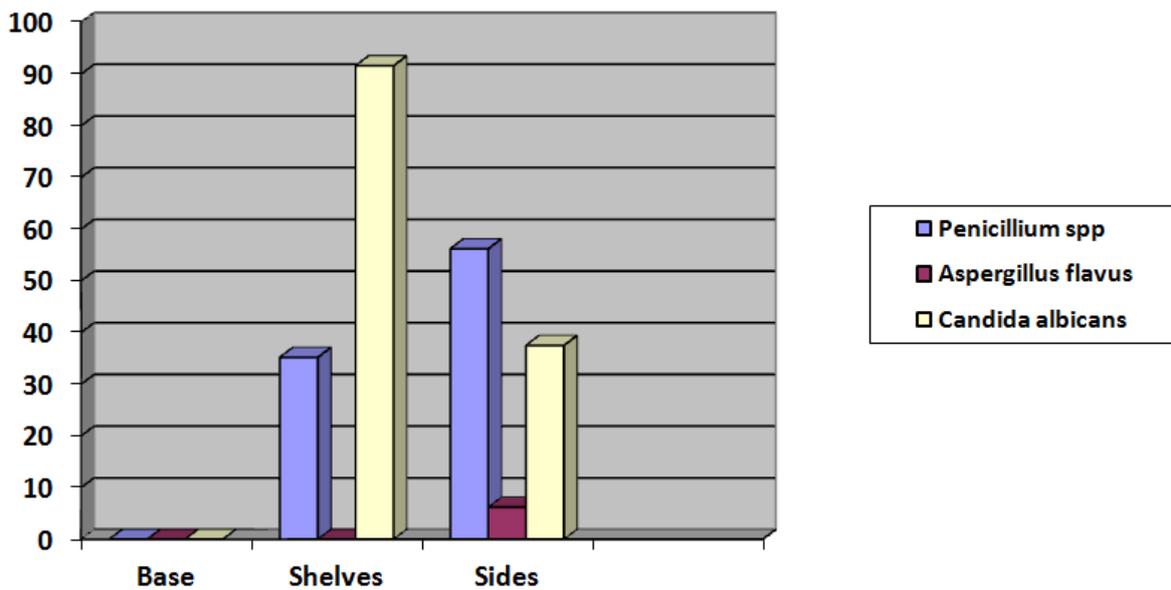
Organism	Frequency (%)
<b>BACTERIA</b>	
<i>Staphylococcus aureus</i>	27.3
<i>Escherichia coli</i>	20.2
<i>Shigella</i> spp	13.0
<i>Pseudomonas aeruginosa</i>	11.9
<i>Aeromonas hydrophilla</i>	8.3
<i>Kliebsiella pneumoniae</i>	5.9
<i>Salmonella typhi</i>	5.9
<i>Streptococcus pyogenes</i>	4.7
<i>Proteus mirabilis</i>	2.3
<b>FUNGI</b>	
<i>Candida albicans</i>	54.0
<i>Penicillium</i> spp	43.2
<i>Aspergillus flavus</i>	2.7
<b>PARASITES</b>	
<i>Ascaris lumbricoides</i>	50.0
<i>Entamoeba histolytica/dispar</i>	50.0

**Table 3. Frequency of Distribution of Bacterial Isolates Based on the Refrigerator Compartments (%)**

Refrigerator compartments	Number of organisms (%)								
	<i>E. coli</i>	<i>S aureus</i>	<i>Shg spp</i>	<i>A hydrophilla,</i>	<i>P aeruginosa,</i>	<i>K pneumonia</i>	<i>S typhi</i>	<i>S pyogenes</i>	<i>P mirabilis</i>
Base	26.8	29.2	12.1	9.7	2.4	4.8	7.3	4.7	2.4
Shelves	11.6	34.8	13.9	9.3	16.2	6.9	6.9	0	0
Sides	21	40.6	6.7	13.5	6.7	2.2	0	6.7	0



**Figure 1. Distribution of Microbial Pathogens Based on the Refrigerator Compartments (%)**



**Figure 2. Distribution of Fungal Species Based on the Refrigerator Compartments (%)**

**Table 4. Frequency of Parasites Species Based on the Refrigerator Compartments (%)**

Refrigerator Compartments	<i>Ascaris lumbricoides</i>	<i>Entamoeba histolytica/dispar</i>
Base	100	0
Shelves	0	100
Sides	0	0

Figure 1 shows the distribution of microbial pathogens based on the refrigerator compartments. Bacterial isolates had a total highest frequency of 52% in the shelves. Fungi isolates had a frequency of 43% in the sides and Parasites had equal distribution in the base and shelves (100%).

Figure 2 is on the distribution of fungal species based on the refrigerator compartments assessed. The base had no fungal isolates. *Candida albicans* had the highest

frequency of occurrence in the shelves (91.6%). *Penicillium* spp had a distribution of (56.2%) in the sides and *Aspergillus flavus* (6.2%).

Table 4 shows the frequency of distribution of parasites based on the refrigerator compartments. The sides had no distribution of parasites. The base and the shelves had equal distribution (50%) of *A. lumbricoides* and *Entamoeba histolytica/dispar*, respectively.

#### 4. Discussion

In this study, a total of 150 samples from different compartments (base, shelves, sides) of fifty (50) randomly selected household refrigerators were analyzed for potential microbial pathogens, hence determine their role in the transmission of food and water borne infections in Calabar metropolis.

Bacteria had the highest prevalence of 100%, followed by fungi 32% and parasites 8%. This is indicative of total contamination by pathogenic and non-pathogenic microbes. The levels of contamination observed in domestic refrigerators are likely to be influenced by a range of factors including the nature and levels of initial contamination introduced on contaminated foods, the presence and absence of effective packaging, the hygiene of those preparing and placing foods into the refrigerator, and the efficiency and frequency of refrigerator maintenance and cleaning [3]. These undesirable organisms may have entered the refrigerators from unwashed raw foods, leaking packages from improperly packed foods (meats, eggs, and milk), unclean hands, through an opened refrigerator door, warm temperature, and unclean container surfaces introduced into the refrigerator. These can cause direct or cross contamination of other stored foods and persist in internal surfaces [19] and, if ingested, may result in food borne illness.

This could be as result of parasite not known to survive at refrigeration temperatures and its occurrence could be likely be due to unwashed fruits, vegetables and contaminated water stored in the refrigerators.

This study revealed the presence of food related pathogens with *Staphylococcus aureus* being the most frequently isolated among the bacterial species (27.3%), closely followed by *Escherichia coli* (20.2%), *Shigella* spp (13.0%), *Pseudomonas aeruginosa* 11.9%, and *Aeromonas hydrophilla* 8.3%. Others were *Kliebsiella pneumoniae* and *Salmonella typhi* 5.9 % each, *Streptococcus pyogenes* 4.7% and *Proteus mirabilis* 2.3%. Fungal isolates encountered were *Candida albicans* (54.0%) *Penicillium* spp (43.2%), and *Aspergillus flavus* (2.7%) while *Ascaris lumbricoides* and *Entamoeba histolytica/dispar* were the parasites detected at a frequency of 50% each. Kumar, [19] also isolated various bacterial pathogens including *Salmonella* sp., *Citrobacter* sp., *Shigella* sp., and *Proteus* sp from the refrigerators of Vellore district in India.

*Staphylococcus aureus* and *Escherichia coli* were the most frequently isolated bacteria in this study but the frequency of *Staphylococcus aureus* (27.3%) is higher than some previous reported detection, e.g. 5% (Scott *et al.*, 1982), close to 27.4% reported by Spiers *et al.* (1995) and 20% [20] Unlike the other microbial pathogens which principally enter domestic kitchens, on previously

contaminated raw foods, *S. aureus*, as a common inhabitant (up to 50%) of the human nose, throat, and skin [21] is perhaps more likely to contaminate foods and refrigerators by direct or indirect human contact during domestic food handling and storage. As a gram-positive organism, it is relatively resistant to drying and is, therefore, more likely to become dominant than more desiccation-sensitive organisms, especially in the low water activity conditions which prevail in domestic refrigerators. *Escherichia coli* is widely accepted indicator of fecal contamination, suggesting that the refrigerator interior surfaces are frequently contaminated by import of contaminated raw foods or by poor personal hygiene. Although some strains of *E.coli* are harmless, Enterohaemorrhagic *E.coli* are capable of producing one or more toxins and a particular serotype O157:H7 have been associated with haemorrhagic colitis and traveler's diarrhea [22].

Other frequently occurring bacteria like *Shigella* spp have been associated with dysentery; *Pseudomonas aeruginosa* presence and could be attributed to improperly packed food sources (raw milk) or have been already growing inside the refrigerator due to improper sanitation and is quite harmful to human health. The presence of *Aeromonas hydrophilla* has been associated with meat, fish, vegetables stored in the refrigerator causing gastroenteritis. *Salmonella typhi* and *Kliebsiella pneumoniae* are enteric organisms that can cause typhoid fever and Hemolytic Uremic Syndrome (HUS), respectively [23] *Salmonella* spp is a frequent contaminant of food preparation surfaces and are equally easily spread through the domestic environment for up to four (4) days. Surface associated *Salmonella* still becomes a significant cross-contamination risk, meaning this pathogen can multiply under condition of mild temperature abuse in cross contaminated foods [3]. *Kliebsiella pneumoniae* could be as result of fecal contamination of food sources stored in the refrigerator. *Streptococcus pyogenes* (4.7%) could be associated with its median temperature multiplication in food items such as eggs, milk and have been associated with acute sore throat.

The lowest bacteria isolated, *Proteus mirabilis* (2.3%), are not usually associated with food borne illness and generally considered non-pathogenic to a healthy adult. However, their presence although not a direct concern in terms of food safety, serves to highlight the sheer diversity of microorganisms which can colonize and survive on refrigerator surfaces [24].

The presence of fungi pathogens in refrigerators as confirmed in this study could be as result of the disposal of fungal spores through dust, soil and in environment where food substances are grown, prepared, kept before being stored in the refrigerator. *Candida albicans* with the highest frequency of occurrence (54.0%) might be due to the fact that they are a form of yeast that is normally found in the lower bowel, the vagina and the skin. They are found everywhere in the environment and in citric fruits, vegetables, breads, ice cream, stored for a prolonged time in the refrigerator. They have been associated with oral thrush, superficial and systemic candidiasis. *Penicillium* spp had a frequency of occurrence (43.2%) and could have survive in the refrigerator cause of the moisture that keep them alive and in foods stored for long. *Penicillium* spp

have been associated with the production of mycotoxins, a poisonous substances that are harmful to health. *Aspergillus flavus* (2.7%) have been known to be associated with the production of aflatoxins in foods and vegetables left for too long in the refrigerator which are known potent carcinogens.

The presence of *Ascaris lumbricoides* and *Entamoeba histolytica/dispar* could likely be as a result of contaminated raw vegetables, fruits and water that drips from already contaminated foods stored in the refrigerator. They have been associated with vomiting, diarrhea and stomach cramps.

*Staphylococcus aureus* had the highest frequency (40.6%) of distribution in the shelf; this could be as a result of *S. aureus* being a normal flora of the skin, when food items are placed with dirty hands into the shelf of the fridge causes cross contamination to other foods leading to food poisoning. The sides of the refrigerators assessed had the highest frequency of distribution for *S. aureus* (40.6%). The sides has a highest temperature in the refrigerator, it's not suitable for storage of perishable items and it easily colonized with insects; fleas, cockroaches, ants, when the refrigerator door is opened a lots. These insects carry pathogens which can survive at median temperature in the sides of the fridge, growing and cross contaminating ready-to-eat food and other stored items in the refrigerator. *S. aureus* have been associated with food poisoning. The base had *E. coli* at the frequency of (26.8 %). Substances stored in the base are; eggs, raw meats, vegetables, cans, drinks and *E. coli* have been associated with these sources and could cause traveler's diarrhea.

In **Figure 1**, fungal distribution based on the compartment of the refrigerator assessed, the sides had a high frequency of distribution of *Penicillium* spp (56.2%), this could be as a result of the sides been a damp, shady area of the refrigerator and *Penicillium* spp been a mold that is found everywhere, hence, its dry spores could be found there. When the dry spores harbours there, it could spread easily to other compartment and subsequently contaminates stored and it's have been associated with mycotoxins. The shelf had the highest occurrence of *Candida albicans* (91.6%). This could be attributed to the shelf, a compartment that is drawn out with the hands to place food items in the refrigerator, the yeast, *C. albicans* could be transferred into the refrigerator with dirty hands. This spreads to other compartment contaminating stored food items.

Parasites had equal distribution in the base and shelf (50%). This could likely be as a results of raw fruits and vegetables stored in this compartment by the householders could be contaminated with parasites (*Ascaris* and *Entamoeba*) spreading to other food items and could lead to food and water borne illnesses and even outbreaks.

In comparing the overall microbial pathogens distribution based on the compartments of the refrigerators assessed **Figure 1**, it was found that the shelves had the highest distribution of microbial pathogens compared to the sides and the base.

In this study, it was seen from analysis of the questionnaires that most households had erratic electricity supply and this affected the temperature regimes of the refrigerators. This resulting change in the refrigerator temperature will allow the growth of mesophilic organisms which can be pathogenic and therefore increases the risk of food borne disease [14,25].

The lack of hygiene in over half of the sampled domestic refrigerators is a risk for contracting a food borne illness among the householders in Calabar. Additionally, the frequent introduction of contaminants vehicles (fruits, vegetables, meats, poultry and eggs) to refrigerators without previous washing, which was a common practice noted among study participants, promotes a continuous inoculation. The presence of microorganisms in the refrigerator affects the microbial quality of the food kept in it.

## 5. Conclusion

Despite the widely recognized efforts of people to keep microorganisms at bay from their refrigerators in order to avoid cross contamination, morbidity and mortality are on the upward swing of the demand curve central to the effects of this cross- contamination.

This study has shown that food pathogens can survive on domestic refrigerators surfaces and therefore pose a risk of cross-contamination. Thus a number of potential food related pathogens including *Staphylococcus aureus*, *Escherichia coli*, *Shigella* spp, *Salmonella typhi*, *Aeromonas hydrophilla*, *Penicillium* spp, *Ascaris lumbricoides* and *Entamoeba histolytica/dispar* were encountered in the studied refrigerators in the Calabar Metropolis . This study has also shown that the different compartment of the refrigerator contributes to the frequency of pathogens isolated from the refrigerators. During the course of this study, it was observed that irregular power supply, poor level of cleanliness, constant opening of the refrigerator doors greatly accounted for the presence of microbial pathogens and spoilage of food items stored in the refrigerators.

The spread, growth and survival of food pathogens can be controlled with correct food storage and preparation practices, regular cleaning and disinfection of food contact sites. As we rely more and more on refrigeration as a means of food preservation, it is crucial that the public be made aware that the refrigerator can in fact represent a significant niche for the persistence and dissemination of food borne pathogens. The importance of temperature control and regular efficient cleaning regimes need to be communicated to the public so that, effective management and cleaning of refrigerators makes them consistently reliable elements of the chilled food chain, and less likely to act as significant sources of human food borne diseases.

## Statement of Competing Interests

The authors have no financial interests or conflicts of interest.

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