



(REVIEW ARTICLE)



A review on the biological food hazards found in restaurants

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Abstract

Biological food hazards are identified through the contamination of food by microorganisms which can be found in the air, food, water, animals, and in the human body. There are many different types of microorganisms such as, bacteria, viruses, parasites and fungi all of which are influenced by many factors that would lead to the likelihood of contamination of food. As long as conditions are suitable, almost all food can harbor some kind of biological hazard. The results of this study were done descriptively and placed into adequate tables. The results included six common pathogenic bacteria; *Campylobacter jejuni*, *Listeria monocytogenes*, *Escherichia coli*, *Clostridium perfringens*, *Staphylococcus aureus* and members of the *Salmonella spp.* They were found to be in wide variety of foods inclusive of fruits, vegetables, seafood, meats, milk and eggs. Six common food parasites, they include three protozoans (*Toxoplasma gondii*, *Giardia intestinalis* and *Cryptosporidium parvum*), one roundworm (*Trichinella spiralis*) and two tapeworms (*Taenia saginata* and *Taenia solium*), the beef and pork tapeworm, respectively. Five common foodborne viruses associated with restaurants: Hepatitis A virus (HAV), Hepatitis E virus (HAE), Rotavirus, Norovirus and Sapovirus and four common mycotoxins that primarily affect humans through the consumption of contaminated food are shown. They are the aflatoxins, ochratoxin A, patulin and the trichothecenes (deoxynivalenol, nivalenol). More studies are needed on these biological hazards with regards to their epidemiology especially in the less developed countries, in order to better understand their effects.

Keywords: Biological; Food; Hazards; Restaurants; Microorganisms

1. Introduction

A restaurant is a business establishment where meals and beverages are prepared and served to customers who would usually sit and dine at this place. Some restaurants offer a takeout service in which the customer is allowed to purchase food and beverages from the restaurant and then leave with it to go elsewhere (34).

In recent years, more and more people have been eating out. This is mostly due to the fact that people, especially independent young adults (working, studying, training, etc.) have less time to actually cook a meal and sit down to eat it (22). Some persons including that of the independent young population may have more than one job which further chips away the 24 hours in a day that they have, leaving them with even less time to spend doing other activities not related to their work, study, training, etc. They would much rather go out and buy something, typically from somewhere that sells food to eat.

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Eating out in cases that are not just ‘grabbing a bite’ or ‘a quick meal’ tend to be those that revolve around but are not exclusively limited to lunch with a friend, dinner with a date, a meal with colleagues, treating someone to a meal, etc. In general, those situations that involves one or more persons sitting down at a table to enjoy a meal (typically within or just over the timespan of an hour). In these cases, customers would enter the restaurant order a meal from a menu and then dine. Of course, in order to attract customers and keep them, restaurants employ different strategies. These include but are not limited to making and serving different food suited to the customers, having a capable serving staff, creation of a comfortable atmosphere, advertising, events, etc. In general restaurants provide a setting that more or less suits the needs or desire of the customers. For example, dining at home is well and good but after a time one may develop the desire for something new, a new dining experience. This is where restaurants may come in. They provide that new refreshing feeling that one may seek, along with a delicious meal and soothing sounds (maybe). Provision of a good meal, enticing setting along with good prices (a must for a successful restaurant) owes to the success of most successful restaurants (36).

1.1. History of restaurants

The known history of restaurants dates back to 1680s in Paris where A La Petit Chaise (originally a wine merchant) began to give away food with the wine that was served. In the 1700s and before, chefs would typically be employed to private individuals such as lords and dukes. In other cases, some would be working at inns and taverns where they would typically only cook one meal and the commoners would either take that one meal or go somewhere else to get a meal. The other option would be to starve. Overtime, primarily in Europe and North America, restaurants became more and more advanced, they started having more options for customers to choose from, better settings, better chefs, better cooking methods, etc. All of these more or less came about either directly or indirectly through competition with each other until restaurants arrived at what we know today (36).

As would be expected a venture such as this is not without its risks and obvious problems. First and foremost, problem being health concerns followed closely by the issue of making a profit. In the beginning, health concerns were not looked at seriously. For the most part, if the food tasted good that was enough for the customers. The most obvious source of these risks are food hazards. According to the World Health Organization, 1 in 10 people fall ill every year from eating contaminated food and 420,000 died as a result. Of this number, about 50% were directly related to restaurants. Of this number roughly a third of these were young children under the age of 5. Being so young, their immune systems lack the ability to fight off the infection and they died as a result (53).

1.2. Food hazards

A food hazard or food safety hazard is defined as any biological, chemical or physical property that may result in food becoming unsafe for human consumption (2). These can be different substances of varying natures due to the fact they allergies have many triggers that are different for each person.

1.2.1. Physical food hazards

Physical hazards are foreign objects that have found their way into food or food products. They can be naturally occurring objects such as stems, dirt, airborne debris, etc. Unnatural hazards are those which generally originate from the interaction of man with the food. These would include metal fragments, pieces of plastic, glass fragments, etc. Consuming these would result in physical damage to the consumer. This primarily would be seen in damage to the digestive tract as these objects would cut and rip away at the delicate tissue lining our digestive tracts. General inspection and food safety regulations are the best means to prevent physical hazards from getting into food that will be served to customers (48).

1.2.2. Chemical food hazards

Chemical hazards are those substances that can either be naturally occurring or added to food during some stage of handling and/or processing before it is consumed. Chemical hazards include mycotoxins, pesticides, food additives, processing induced chemicals (ethanol, benzene, chloropropanols, etc.) among others (48). These harmful chemicals would often result in damages such as infection, malnutrition, gastrointestinal problems, pain, bleeding, etc. To prevent contamination of food by chemical hazards proper cleaning procedures and sanitation requirements are essential. Ingredients to be used must be washed and prepared adequately so as to remove the likes of residual pesticides and other toxins that are usually present on the surface. Spoilt food must not be used.

1.2.3. Biological food hazards

Biological food hazards are distinguished by the contamination of food by microorganisms. These microorganisms are found in the air, food, water, animals, and in the human body. They are incredibly small and some provide benefits to our anatomy whereas others are detrimental. The detrimental ones are usually the cause of foodborne illness which can occur if they make their way into the food we eat (12). There are many different types of microorganisms, each of which can negatively impact health. These are bacteria, viruses, parasites and fungi. Many factors would influence the likelihood of contamination of food by these. They include temperature, pH and moisture of the food. Temperatures between 40°F and 140°F are optimum for bacterial growth along with pH levels between 5 and 8. They would require a source of moisture to proliferate outside a body. The source of moisture is usually found on or near food sources (19).

Bacteria and viruses are members of a class of organisms referred to as microorganisms. They are microscopic organisms that exist as unicellular, multicellular, or cell clusters in the environment or within a body. Microorganisms are widespread and diverse in nature and are beneficial to life, but some can cause serious harm to humans which may result in death. Bacteria and viruses are primarily responsible for most foodborne illnesses and are the greatest threat to food safety in the world. A parasite is an organism that lives on or in a host organism. It receives nutrients from or at the expense of its host. Parasites are different from bacteria or viruses because their cells share many features with human cells including a defined nucleus (48).

1.3. Pathogenic Bacteria

Bacteria are single-celled living organisms found virtually everywhere. They are generally considered to be the most important causative agents of foodborne illnesses due to their ability to grow fast in foods that are moist, warm, has a low pH and protein rich. Foods such as milk, poultry, fish, meat and shellfish are common food items that support the growth of bacteria. Most bacteria are not harmful to us while some can make people ill by living and multiplying inside our bodies (e.g., *Salmonella*, *Escherichia coli*, etc.). Others such as *Staphylococcus aureus* and *Bacillus cereus* produce toxins in foods which result in people falling ill because of the toxins when contaminated food is consumed. The presence of these organisms is not what would cause disease. The amount of them instead existing on or in food that we eat is what is important. We all have some varying number of these harmful bacteria within or on our bodies and the food we eat. We do not notice them due to their small number. However, when conditions are suitable and they start to multiply, we should be concerned as they pose a serious health risk (19). For instance, listeriosis, a disease caused by the bacteria *Listeria monocytogenes* would normally go unnoticed in the body for quite some time. During this period, the disease would progress through the body and cause complications such as meningitis and sepsis. The latter seeing the body attacking its own tissues and organs in response to an infection. Meningitis is the inflammation of the protective membranes covering the brain and spinal cord. This is just one of many foodborne illnesses caused by bacteria (48).

1.4. Foodborne viruses

Viruses are microscopic infectious organisms. They are smaller than bacteria (about 1/100 the size of most common bacteria). Viruses are composed of an RNA or DNA genome that is protected by a protein coat. Bacteria can multiply outside a cell, viruses on the other hand, cannot multiply outside of a living cell. Viruses tend to be more resistant to harmful substances than bacteria. They are resistant to heat, freezing, drying, ultraviolet light, high and low pH, etc. In most cases viruses are transmitted due to human-to-human contact. However, when it comes to food, viral bodies may be expelled from the mouth and/nose of the food handler and land on the food. They can remain in an infective state (can cause infection) for weeks or months in food and water. Viruses can also be spread via the fecal oral route. Thus, adequate hygienic practices must be adhered to in order to avoid contamination of food by foodborne viruses to some extent. In essence, any food or food product that is within close proximity to human sewage outlets and animal sewage are at risk for contamination by viruses. Adequate washing and cooking are needed to minimize and/or prevent contamination (48).

Gastroenteritis (characterized by vomiting, diarrhea and stomach pain) is the most common result of infection with a foodborne virus. The human norovirus is the most common cause of this. It is very contagious and results in vomiting and diarrhea. Infection usually takes place from having direct contact with an infected person, touching contaminated surfaces and placing it in or near to the mouth without washing hands and the consumption of contaminated food or water. Hepatitis and rotavirus are two others found in food. Hepatitis affects the liver and causes jaundice due to the blockage or obstruction of the bile duct.

1.5. Foodborne Parasites

An organism that derives its nourishment and protection from other living organisms are known as parasites. The organism that they parasitize is called their host. Over the years, several parasites have emerged as significant causes of foodborne illnesses (48). Parasites would normally live and reproduce on or within the tissues and organs of its hosts (animals and plants). With respect to foodborne illnesses and humans, most can be found within the intestines and their eggs are often excreted in feces. Foodborne parasites are primarily transmitted from host to host through the consumption of food and/or water that is contaminated with eggs or the organism itself. They may also be transmitted by touching feces of an infected host and then without adequate washing of hands, putting it into the mouth. Parasites are found in many different shapes and sizes. They range from 1 to 2 micrometers to around or in rare cases over 2 meters long. They can be whip shaped, round, oblong, etc. Examples of foodborne parasites include *Toxoplasma gondii*, *Giardia intestinalis*, *Trichinella spiralis*, *Taenia saginata* (beef tapeworm) and *Taenia solium* (pork tapeworm). Parasites primarily attach themselves at some point in the digestive tract with the most common place being the intestines as this is where they would be able to pillage the most nutrients from us. They may spread to, virtually, any part of the body otherwise.

1.6. Fungi

Fungi are distant relatives of plants. They can be unicellular or multicellular eukaryotic organisms. Being eukaryotic, their cells contain a membrane bound nucleus in which there is DNA. They lack chlorophyll and chloroplast. Fungi come in a variety of colors. This is owed to their cellular pigments. These pigments are closely associated with the cell wall and serve the function of shielding the organism to some extent from the harmful effects of ultraviolet radiation. They are heterotrophic in nature. There are some fungi which are edible such as, puffballs, morels, coral fungi, etc. Others, can be toxic to humans. Pathogenic fungi are normally associated with food crops and fungal contamination of food is a widespread cause of disease, globally. In particular, the toxins they produce are the main cause of disease. These mycotoxins (toxic substance produced by certain fungi) aflatoxins, ochratoxins, patulin, etc. (50). After ingestion, symptoms would include upset stomach, dizziness, shortness of breath, chills, vomiting, etc. Mycotoxins are deadly due to the fact that many cause severe illness such as cancer and immune deficiency. Others are fast acting poisons which can kill in a matter of minutes (1).

When it comes to food, different types of fungi would normally be found growing with or on crops. After harvesting and processing, some may remain in or on the product and make it to our plates. Others, may be mostly destroyed in the processing and cooking stages of food however, the mycotoxins produced by some may persist and make it to our plates and into our bodies where they can wreak havoc. Mycotoxins have the potential to be deadly substances and as such must be taken seriously (1).

In general, as long as conditions are suitable, all food can harbor some kind of hazard that can cause harm to our bodies. With respect to biological hazards, some foods are more likely to be harboring them than others. These include chicken, beef, pork, seafood, fruits and vegetables, raw milk and milk products. These foods are very common in a vast majority of restaurants. As such, one should be aware of the hazards associated with them due to the fact that they are common items eaten by all. Hygienic practices, being aware of the restaurant setting and adequate food handling practices, are enough to avoid most instances of food hazards.

2. Material and methods

- The method that the researcher used for this review involved the retrieval, assessment and evaluation of research papers that were relevant to common biological food hazards present in restaurants.
- Papers and additional information were searched for using the internet. Terms that were used included: biological food hazards in restaurants, bacteria in restaurants, virus in restaurants, fungi in restaurants, parasites in restaurant food and control measures for biological hazards.
- The search for relevant scientific papers was limited to those publications between the years 2000–2021. However, relevant information that was found while researching were utilized from papers published between the years 1970–2000.
- Papers were grouped according to the information they have.
- The results and discussion section of this scientific review paper consisted primarily of information from the past 20 years starting from the year 2000 to the year 2020.

3. Results

Table 1 Common pathogenic bacteria that can be present in food in restaurants

Author(s)	Pathogenic bacteria	Sources	Incubation period	Illness caused	Symptoms	Duration of illness
(Fung, <i>et al.</i> , 2011).	<i>Salmonella spp.</i>	Raw or undercooked meat, fruits, vegetables, nuts, eggs, contaminated water.	6 hours to 6 days.	Gastroenteritis	Vomiting, fever, stomach cramps and diarrhea.	2 to 7 days
(Kaakoush, <i>et al.</i> , 2015). (Kvalsvig, <i>et al.</i> , 2014). (Coker, <i>et al.</i> , 2002).	<i>Campylobacter jejuni</i>	Unpasteurized milk, chicken, shellfish, contaminated water.	2 to 5 days. 1 to 3 days for high-risk groups.	Campylobacteriosis	Vomiting, fever, stomach cramps and diarrhea (may be bloody).	7 to 10 days
(Magalhaes, <i>et al.</i> , 2014). (Buchana, <i>et al.</i> , 2017).	<i>Listeria monocytogenes</i>	Unpasteurized milk, soft cheese, raw fruits and vegetables, smoked seafood.	1 to 70 days. 11 hours to 1 day for high-risk groups.	Listeriosis	Fever, diarrhea, invasive listeriosis (disease has spread beyond the gut); fatigue, muscle aches, confusion, convulsions, death as a result of complications.	2 to 10 weeks
(Caprioli, <i>et al.</i> , 2014).	<i>Escherichia coli</i> 0157-H	Undercooked meat, unpasteurized milks, untreated water, and feces of infected organisms, unwashed fruits and vegetables.	1 to 10 days.	Hemorrhagic diarrhea, diarrhea, pneumonia	Severe diarrhea (usually bloody), stomach pain, vomiting.	1 to 10 days
(Hailegebreal, 2017). (Labbe, <i>et al.</i> , 2014).	<i>Clostridium perfringens</i>	Beef, poultry, over steamed foods, soil, decaying vegetation.	6 hours to a day.	<i>Clostridium perfringens</i> enteritis, gastroenteritis	Diarrhea and stomach cramps.	Usually, 24 hours
(Stewart, 2017).	<i>Staphylococcus aureus</i>	Undercooked meat, unwashed fruits and vegetables, contaminated water, fecal oral contamination.	1 to 6 hours (in some cases symptoms arise as early as 30 minutes after exposure)	Gastroenteritis	Severe abdominal cramps, diarrhea, vomiting and nausea.	Usually, 24 hours

Table 2 Common foodborne parasites found in restaurants

Author(s)	Parasite	Source	Incubation period	Illness caused	Symptoms	Duration of illness
Protozoa						
(Hill, <i>et al.</i> , 2016).	<i>Toxoplasma gondii</i>	Drinking contaminated water, undercooked meat (pork, lamb and wild game primarily) contaminated with cysts, organ transplants.	5 to 23 days	Toxoplasmosis	Flu-like symptoms such as muscle aches and pains along with swollen lymph glands.	1 to 3 weeks.
(Ryan, <i>et al.</i> , 2019).	<i>Giardia intestinalis</i>	Drinking contaminated water, undercooked meat contaminated with cysts, putting unwashed hands into mouth after touching infected feces.	7 to 10 days	Giardiasis	Watery diarrhea, abdominal cramps, gas and nausea. Severe cases may experience dehydration and weight loss.	2 to 6 weeks for normal cases. 6 months to years for chronic cases.
(Chalmers, 2014).	<i>Cryptosporidium parvum</i>	Contaminated soil, food and water. Ingesting infected fecal matter.	2 to 10 days	Cryptosporidiosis	Watery diarrhea, stomach cramps, fever, upset stomach.	3 days to 2 weeks
Roundworm						
(Gamble, 2014).	<i>Trichinella spiralis</i>	Consumption of raw or undercooked meat that is infected with larvae.	1 to 2 days to 2 to 8 weeks	Trichinosis	Diarrhea, nausea, fever, headaches, vomiting, abdominal pain.	1 to 8 weeks.
Tapeworms						
(Parkhouse & Harison, 2014). (Robertson, 2016). (Rodriguez-	<i>Taenia saginata</i>	Consumption of raw or undercooked beef.	10 to 14 weeks	Taeniasis (caused by adult tapeworms).	Abdominal pain, weight loss, lack of appetite, diarrhea, nausea,	10 to 14 weeks

Morales, <i>et al.</i> , 2016).					passing live worms in the stool.	
(Parkhouse & Harison, 2014). (Robertson, 2016). (Rodriguez-Morales, <i>et al.</i> , 2016).	<i>Taenia solium</i>	Consumption of raw or undercooked pork.	8 to 10 weeks	Taeniasis (caused by adult tapeworms). Cysticercosis (caused by larval stage tapeworm).	Weight loss, lack of appetite, diarrhea, nausea, passing live worms and proglottids in the stool.	8 to 12 weeks

Table 3 Common foodborne viruses found in restaurants

Authors	Virus	Source	Incubation period	Illness caused	Symptoms	Duration of illness
(Rezeutja & Cook, 2014).	Hepatitis A virus	Consumption of raw or undercooked meat, fruits, vegetables and other foods that has the virus present on it.	15 to 50 days	Hepatitis	Sore throat, nausea, diarrhea, vomiting, constipation, splenomegaly, hepatomegaly, abdominal discomfort, jaundice	2 to 24 weeks
(Cook, <i>et al.</i> , 2014).	Hepatitis E virus	Consumption of contaminated water, infected meat.	2 to 10 weeks	Hepatitis	Nausea, vomiting, fever, dark urine, clay colored stool, abdominal pain, jaundice	1 to 6 months
(Unuvar, 2018). (Khora, 2018).	Rotavirus	Consumption of contaminated water, infected undercooked food.	1 to 3 days	Gastroenteritis	Severe watery diarrhea, vomiting, fever, abdominal pain, dehydration	3 to 7 days
(Duizer & Koopmans, 2014). (Hoover, <i>et al.</i> , 2020).	Norovirus	Consumption of contaminated food or water, shellfish.	12 to 48 hours	Gastroenteritis	Diarrhea, vomiting, nausea, stomach pain, fever, headache, body aches.	1 to 3 days
(Usuku, & Kumazaki, 2014). (Kumazaki, <i>et al.</i> , 2008).	Sapovirus	Consumption of contaminated food or water, touching contaminated substances and then putting it into our mouths.	1 to 4 days	Gastroenteritis	Diarrhea, vomiting, nausea, abdominal pains, fever, muscle aches, malaise.	1 to 3 days

Table 4 Common foodborne mycotoxins from associated fungi found in restaurants

Authors	Mycotoxins	Associated Fungi	Source	Illnesses caused	Symptoms
(Pitt, 2014).	Aflatoxins	Aspergillus spp. (Aspergillus flavus, Aspergillus parasiticus, Aspergillus niger, etc.)	Maize, peanuts, wheat, rice, walnuts	Aspergillosis which can lead to aflatoxicosis.	Cough, wheezing, chest pains, vomiting, convulsions, hemorrhaging, liver damage, liver cancer
(Pitt, 2014).	Ochratoxin A	Penicillium verrucosum, Aspergillus ochraceus, Aspergillus carbonarius	Maize, coffee beans, cocoa beans, soya beans, wine, beer, dried fruits	Aspergillosis, Ochratoxicosis	Anemia, fatigue, headache, apoptosis, decreased lymphocytes, increased reactive oxygen radicals, yellow palms.
(Pitt, 2014).	Patulin	Penicillium expansum, Penicillium patulinum	Apples and apple products, plums, strawberries, grapes, bananas.	Patulin toxicity	Nausea, gastrointestinal disturbances and vomiting
(Pitt, 2014).	Trichothecenes (Deoxynivalenol, nivalenol)	Fusarium graminearum,	Wheat, barley, oats, rice,	Trichothecene toxicosis	Abdominal pain, acute myocarditis, hair loss, anorexia, anxiety, shortness of breath, cramps, cough, gastroenteritis.

Table 5 Common food that are primarily associated with biological food hazards

Author(s)	Biological hazards	Commonly associated food
(Fung, <i>et al.</i> , 2011).	<i>Salmonella spp.</i>	Beef, chicken, eggs, fruits, chicken nuggets, pork, vegetables.
(Kaakoush, <i>et al.</i> , 2015). (Kvalsvig, <i>et al.</i> , 2014). (Coker, <i>et al.</i> , 2002).	<i>Campylobacter jejuni</i>	Poultry, fish, and shellfish.
(Magalhaes, <i>et al.</i> , 2014). (Buchana, <i>et al.</i> , 2017).	<i>Listeria monocytogenes</i>	Dairy, meat, fish, and vegetables.
(Caprioli, <i>et al.</i> , 2014).	<i>Escherichia coli</i> (<i>E. coli</i> O157:H7)	Poultry, beef, unpasteurized milk, unpasteurized juices, vegetables.
(Hailegebreal, 2017). (Labbe, <i>et al.</i> , 2014).	<i>Clostridium perfringens</i>	Meat and meat products, stews, soups, milk.
(Stewart, 2017).	<i>Staphylococcus aureus</i>	Meat and meat products, poultry and egg products, milk.
(Hill, <i>et al.</i> , 2016).	<i>Toxoplasma gondii</i>	Wild game meat (deer, wild birds, etc.), poultry.
(Ryan, <i>et al.</i> , 2019).	<i>Giardia intestinalis</i>	Roots crops (potatoes, eddoes, cassava, etc.), vegetables.

(Chalmers, 2014).	<i>Cryptosporidium parvum</i>	Apples and apple products (juices, salads, etc.), salads fresh fruits.
(Gamble, 2014).	<i>Trichinella spiralis</i>	Meat (pork, deer, etc.,).
(Parkhouse & Harison, 2014). (Robertson, 2016). (Rodriguez-Morales, et al., 2016).	<i>Taenia saginata</i>	Beef and beef products (sausages, ground meat, etc.).
(Parkhouse & Harison, 2014). (Robertson, 2016). (Rodriguez-Morales, et al., 2016).	<i>Taenia solium</i>	Pork and pork products (sausages, ground meat, etc.).
(Rezezutja & Cook, 2014).	Hepatitis A virus	Sandwiches, salads, fruits, shellfish.
(Cook, et al., 2014).	Hepatitis E virus	Game meat (deer, wild hogs, etc.), pork, beef, fruits, vegetables.
(Unuvar, 2018). (Khora, 2018).	Rotavirus	Ready to eat foods (salads, sandwiches, fresh fruits and vegetables.
(Duizer & Koopmans, 2014). (Hoover, et al., 2020).	Norovirus	Fresh fruits, leafy greens (lettuce, cabbage, etc.). oysters.
(Usuku, & Kumazaki, 2014). (Kumazaki, et al., 2008).	Sapovirus	Shellfish (oysters, clams, etc.), fresh fruits and vegetables.
(Pitt, 2014).	Aflatoxins	Rice, walnuts, cornbread.
(Pitt, 2014).	Ochratoxin A	Wine, beers, dried fruits, cocoa products.
(Pitt, 2014).	Patulin	Apples and apple products
(Pitt, 2014).	Trichothecenes (deoxynivalenol, nivalenol)	Oats, rice, barley.

Table 6 Control measures for biological food hazards

Authors	Biological hazard	Control measures
(Fung, et al., 2011). (Kaakoush, et al., 2015). (Kvalsvig, et al., 2014). (Coker, et al., 2002). (Magalhaes, et al., 2014). (Buchana, et al., 2017). (Caprioli, et al., 2014). (Hailegebreal, 2017). (Labbe, et al., 2014). (Stewart, 2017).	Bacteria	<ul style="list-style-type: none"> • Wash hands thoroughly before and after eating, and after going to the bathroom • Sanitize as best as possible, fruits and vegetables before eating, • Check with your local health department to find out which restaurants are in the danger zone when it comes to the incidence of food hazards. • Avoid letting raw meats come into contact with other foods while cooking • Do not allow children to share bath water with anyone who has symptoms of gastroenteritis. • Careful washing of hands after any contact with farm animals • Wear disposable gloves when changing diapers.
(Hill, et al., 2016). (Ryan, et al., 2019). (Chalmers, 2014). (Gamble, 2014). (Parkhouse & Harison, 2014). (Robertson, 2016). (Rodriguez-Morales, et al., 2016).	Parasites	
(Rezezutja & Cook, 2014). (Cook, et al., 2014).	Viruses	

(Unuvar, 2018). (Khora, 2018). (Duizer & Koopmans, 2014). (Hoover, et al., 2020). (Usuku, & Kumazaki, 2014). (Kumazaki, et al., 2008).		<ul style="list-style-type: none"> • Make sure ground meat reaches an internal temperature of at least 160°F • Avoid drinking any non-chlorinated water
(Tola & Kebede, 2016). (Pitt, 2014).	Fungi (mycotoxins)	Early harvesting of groundnuts, using preventative measures to reduce mold or fungus growth in crops both in the field and in storage, removal of contaminated produce, appropriate storage of products.

4. Discussion

Foodborne illnesses are an area of concern as they are everywhere and cause billions of dollars' worth of losses to producers, consumers and pretty much everyone in between. Biological food hazards are spread primarily through the fecal oral route. These hazards are the ones most often associated with gastroenteritis (inflammation of the stomach and intestinal walls). Common symptoms of gastroenteritis include nausea, vomiting, stomach cramps and diarrhea. Biological hazards can be a bacteria, parasite, virus or fungi. Of these, bacteria and viruses are responsible for most foodborne illness and are the biggest threat to food safety. In most of these cases where the average person is infected, occurrences of illness would tend to resolve themselves with adequate hydration and a suitable diet. Foods often implicated with relevance to outbreaks of foodborne illnesses include meat, fish, milk, cheese, salads, fruits and shellfish (8).

According to the first table, there are six common pathogenic bacteria that are present in restaurant food. These are *Campylobacter jejuni*, *Listeria monocytogenes*, *Escherichia coli*, *Clostridium perfringens*, *Staphylococcus aureus* and members of the *Salmonella spp.* They were found to be in wide variety of foods inclusive of fruits, vegetables, seafood, meats, milk and eggs. They are primarily spread through the usage of food and other food items that have been contaminated with these bacteria which would then pass on to humans. The primary route through which humans are infected is the fecal oral route. Upon ingestion, they would have varying incubation periods. These may be influenced greatly by whether or not the infected person has a strong immune system or not. Of note with regards, these common pathogenic bacteria are the number of organisms required to cause disease. There must be a specific amount present on the food upon ingestion in order to cause illness. These numbers are; as few as 15 to 20 organisms for susceptible hosts. Usually >100,000 organisms for healthy adults (*Salmonella spp.*) (20), 1,000 to 10,000 organisms (*Campylobacter jejuni*) (29), 100 to 1,000 organisms for high-risk groups and around 100,000 for the general population (*Listeria monocytogenes*) (35), 100 and 1000 organisms (*Escherichia coli*) (4), 1,000,000 and 100,000,000 organisms (*Clostridium perfringens*) (33) and >1,000,000 organisms (*Staphylococcus aureus*) (49). These numbers are greatly influenced by the health of a person. Generally, symptoms of illness for these pathogenic bacteria found in the food include vomiting, fever, stomach cramps and diarrhea. With adequate hydration, most mild cases of illness would clear up within a few days. Others, would require medical treatment to be resolved. In severe cases most often occurring in persons that are immunocompromised, serious complications and death are very likely to occur.

Table two shows that there are six common food parasites. They include three protozoans (*Toxoplasma gondii*, *Giardia intestinalis* and *Cryptosporidium parvum*), one roundworm (*Trichinella spiralis*) and two tapeworms (*Taenia saginata* and *Taenia solium*), the beef and pork tapeworm, respectively. The protozoans primarily spread through the consumption of contaminated food and water. Through the consumption of these contaminated foods, infection is highly likely. These infections include toxoplasmosis (caused by *Toxoplasma gondii*), giardiasis (infection in the small intestine caused by *Giardia intestinalis*), cryptosporidiosis (caused by *Cryptosporidium parvum*), trichinosis (caused by *Trichinella spiralis*), taeniasis (caused by *Taenia saginata* and *Taenia solium*) and cysticercosis (caused by *Taenia solium*). Toxoplasmosis is counted among five parasitic infections that are neglected in the United States (6). The beef and pork tapeworms *Taenia saginata* and *Taenia solium* respectively, are acquired when we consume beef or pork that is raw or undercooked. Taeniasis refers to the parasitic infection of humans with the tapeworms *Taenia saginata*, *Taenia solium* and *Taenia asiatica* (Asian tapeworm). There are usually little to no symptoms of taeniasis, however, *T. saginata* taeniasis would cause more symptoms than the other two due to the beef tapeworm being larger in size (up to 10 meters) compared to the pork tapeworm, and the Asian tapeworm (around three meters). Symptoms of taeniasis are indicative of digestive problems due to the worms taking essential nutrients from us as well as physically blocking our intestines. Cysticercosis occurs when larval cysts of *T. solium* infects tissue such as the brain muscle and others in the body. Symptoms of this disease are dependent on where the infection is within the body and the immune response of

the infected person. If they are in the nervous system, symptoms such as seizures, dizziness, vomiting, nausea, headaches, altered vision, accumulation of excessive fluid in the skull and inflammation would occur. Cysts in the eyes would affect vision causing vision loss, hindered eye movement, inflammation of the eye and/or retina. Usually, cysts that are not in the nervous system are asymptomatic and are just noticeable as hard lumps under the skin. Untreated, taeniasis and cysticercosis can last for two to three years. With treatment, they would clear up within a matter of days to weeks (5).

Table three shows five common foodborne viruses associated with restaurants. They are the Hepatitis A virus (HAV), Hepatitis E virus (HAE), Rotavirus, Norovirus and Sapovirus. The two hepatitis viruses HAV and HAE are RNA viruses that cause the liver disease, hepatitis (15). The infection can develop without presenting any signs or symptoms. Patients may report symptoms that are not indicative of hepatitis over a short period of time. These may come with or without jaundice. In the event of symptoms arising, patients may report several symptoms ranging from flu-like symptoms to liver failure. Hepatitis A is usually short lived (weeks) whereas Hepatitis E tends to last longer (months). Rotavirus, Norovirus and Sapovirus all cause inflammation of the stomach and intestinal lining leading to symptoms of gastroenteritis. The rotavirus is more prevalent in younger children and due to the risk of dehydration, it can become life threatening. Norovirus is more prevalent in adults where its symptoms tend to be milder and shorter lived. Sapovirus is short lived and mild like the norovirus but, it is predominant in children of five years and under. The gastroenteritis caused by these three viruses would clear up on its own with adequate hydration and rest along with a suitable diet for its duration (15). They are all spread via the fecal oral route thus, appropriate hygiene is needed to reduce their instances. In rare cases, severe complications would arise and these would most often occur in immunocompromised patients. In other cases, severe dehydration may become life threatening in young children (15).

From table four, four common mycotoxins that primarily affect humans through the consumption of contaminated food are shown. They are the aflatoxins, ochratoxin A, patulin and the trichothecenes (deoxynivalenol, nivalenol). For the most part, the fungi themselves cause little to no health effects. It's the mycotoxins they produce that poses a risk to our health. In general, mycotoxicosis is term used to describe the toxic effects of mycotoxins. These toxins would most often affect the liver, kidneys and lungs as they are the ones most susceptible to them. Part of the name of the toxin involved is commonly used to describe a particular mycotoxicosis. For example, ochratoxicosis refers to the toxicosis being associated with the ingestion of ochratoxins. Many different fungi may produce the same mycotoxin while at the same time being morphologically similar to each other making exact identification on site unreliable until lab testing. However, being produced by different fungi the effects of the toxins are still the same (1).

Table five shows at risk foods when it comes to biological food hazards. These are the foods that when consumed, one is more likely to be affected by some biological hazards than when consuming other foods. In most instances, the food would have become contaminated with the hazard during handling.

Table six shows the control measures that can be used to significantly reduce the instances of biological food hazards in our food. Of course, it would be extremely difficult to reduce the instances to zero, but with these measures consumers can have a sense of assurance that the food they are consuming is safe for consumption.

5. Conclusion

From the research carried out, it can be concluded that biological hazards in restaurants are a very real threat to consumers. They would primarily cause gastroenteritis, an illness which many would prefer not to encounter due to its symptoms. It was found that common pathogenic bacteria responsible for foodborne illnesses in association to restaurants are; *Campylobacter jejuni*, *Listeria monocytogenes*, *Escherichia coli*, *Clostridium perfringens*, *Staphylococcus aureus* and members of the *Salmonella spp.* Some of the common foodborne parasites causing foodborne illness in association to restaurants are; *Toxoplasma gondii*, *Giardia intestinalis*, *Cryptosporidium parvum*, *Trichinella spiralis*, *Taenia saginata* and *Taenia solium*. common foodborne viruses responsible for incidences of foodborne illness pertaining to restaurants are; Hepatitis A and Hepatitis E virus, Norovirus, Rotavirus and Sapovirus. Foodborne fungi of concern in restaurants included *Aspergillus flavus*, *Aspergillus parasiticus*, *Aspergillus niger*, *Penicillium verrucosum*, *Aspergillus ochraceus*, *Penicillium expansum*, *Penicillium patulinum* and *Fusarium graminearum*. To control these biological food hazards, good hygiene is of paramount importance, as an act as simply taking the time to adequately wash your hands is enough to adequately reduce your chances of becoming ill from a biological food hazard. This is especially important when it comes to restaurants as customers would be holding money, touching doorknobs, and faucets, all of which may be contaminated. For other hazards, more direct measures are needed.

Beneficiaries

From the research done, information assessed and interpreted in this research paper can be utilized by:

- Students pursuing studies in relevant areas.
- The University of Guyana
- Ministry of Public Health
- Guyana Food Safety Authority
- Members of the Local Community
- Restaurant owners in Guyana

Relevant authorities and concerned individuals can utilize this research in order to put steps into place that would see a reduction in the incidences of foodborne illness due to biological food hazards.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors hereby declare that this manuscript does not have any conflict of interest.

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