“A Review on the prevalence and Detection of Bacterial contamination in Common Food and Associated Health Risk”

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A thesis submitted to the Department of Mathematics and Natural Sciences in partial fulfillment of the requirements for the degree of
B.Sc. in Microbiology

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Declaration

It is hereby declared that

1. The thesis submitted is our own original work while completing degree at BRAC University.
2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The thesis does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. I/We have acknowledged all main sources of help.

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Approval

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Ethics Statement:

Hereby, we, Sangita Baidya & Tasmia Rahman consciously assure that for the manuscript "A Review on the prevalence and Detection of Bacterial contamination in Common Food and Associated Health Risk" the following is fulfilled:

1. The study correctly acknowledges co-authors and co-researchers' significant contributions.
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Abstract

Foodborne diseases are becoming a serious public health problem throughout the world, with 48 million illnesses and 3,000 fatalities projected in the United States each year. Over 1.7 billion cases of diarrheal disease-related deaths in children are recorded worldwide each year, with the bulk of these cases attributed to polluted food and water. Food-borne infections cause more medical care and fatalities in children under the age of four than in any other age group. Foodborne illness is caused by two different factors: food intoxication and food infection. Foodborne illness agents are capable of not just decapitating large numbers of people, but also of causing severe mortality and disability. There is increasing evidence that persons from minority racial and ethnic groups are more likely to contract foodborne illnesses. The food and beverage industries constitute a key part of the economy in many countries. Every day, they serve millions of people with a wide range of ready-to-eat (RTE) meals and drinks sold and occasionally prepared in public spaces. Food sources as diverse as meat, fish, natural goods, vegetables, grains, and cereals based on ready-to-eat food variations, frozen produce, and refreshments are included in road-distributed food types. RTE foods are ones that have not been further treated before being ingested in a way that considerably lowers microbial load. According to the World Health Organization, contaminated foods are responsible for up to 70% of diarrheal infections, and food-borne illnesses are the leading cause of death, killing an estimated 2.1 million people globally, the majority of whom are children in developing countries. *Clostridium botulinum, E. coli, Salmonella spp., Listeria monocytogenes, Yersinia enterocolitica, Staphylococcus aureus, Shigella spp., Bacillus cereus, and Campylobacter jejuni* are the most prevalent foodborne pathogens in the bacterial domain. *Escherichia coli, Shigella sp., Staphylococcus sp., Bacillus spp., Klebsiella spp., Listeria monocytogenes*, and other foodborne pathogens have all been documented. This review will highlight the Prevalence and

Detection of Bacterial contamination in Common Food and Associated Health Risk. It will give an idea of the Spoilage microbes, Epidemiology of Bacterial Contamination, Prevalence and Emergence of Antimicrobial Resistance in food contaminating bacteria and each of these components. Side effects and/or challenges of each component have also been included.

Keywords: Food; Street Food; Ready-to-Eat Food; Foodborne; Contamination; People; Illness; Child; Bacterial; WHO

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List of Acronyms:

AMB	Aerobic-mesophilic bacteria
AMR	Antimicrobial resistance
AMU	Antimicrobial usage
BCSIR	Bangladesh Council of Scientific and Industrial Research
BSTI	Bangladesh Standard and Testing Institution
CAB	Consumers Association of Bangladesh
CDC	Centers for Disease Control and Prevention
CFU	Colony-forming unit
CSPI	Center for Science in the Public Interest
CTT	Cefotetan
DEC	Diarrheagenic *E. Coli*
DGHS	Directorate General of Health Services
EAEC	Enteroaggregative Escherichia coli
EC medium	Escherichia coli medium
ETEC	Enteropathogenic *E. Coli*
FBD	Food-borne disease
GHP	good hygiene practices
HACCP	hazard analysis critical control point
HUS	Hemolytic uremic syndrome
ICDDR, B	International Center for Diarrheal Disease Research, Bangladesh
IDD	Iodine deficiency disorders
IPM	Imipenem
LAB	Lactic acid bacteria
LTB/ LSB	Lauryl tryptose broth/ lauryl sulfate broth
MDR	Multidrug resistance
MPN	Most probable number
MRI	Multiple antibiotic resistance index
NAFDAC	National Agency of Food and Drug Administration Control
NSAS	Non-Staphylococcus aureus staphylococci
NTM	Nontuberculous mycobacteria

PCR	Polymerase chain reaction
PF	Poultry farm
RFLP	Restriction fragment length polymorphism
RTE	Ready-to-eat
SPM	Supermarkets
SSOP	Standard Sanitation Operating Procedure
STEC	Shiga Toxin-producing Escherichia coli
SVM	Street-vendor stalls
TCC	Total coliform count
TFC	Total fecal count
TNTC	Too numerous to count
TSSC	Total *Salmonella*-*Shigella* count
TVAC	Total viable aerobic count
TVBC	Total viable bacteria count
TVC	Total viable count
WHO	World health organization

1. Introduction

Every year, over 1.7 billion occurrences of diarrheal disease-related fatalities in children are reported globally, with the majority of these cases ascribed to tainted food and water (Banik et al., 2018). Albeit the majority of illnesses are minor and self-restricting, more genuine illnesses do occur, resulting in 128,000 medical care and 3000 fatalities (Behravesh et al., 2011). Food causes more illness in kids under the age of four than in any other age range, yet food-borne diseases cause more medical cares and deaths in individuals over 50. Foodborne infections are a rising major public health concern across the world, causing an expected 48 million ailments and 3,000 deaths in the United States annually (Scallan et al., 2011). It is assessed that, in Bangladesh 30 million instances of food-borne disease occur each year (Khairuzzaman et al., 2014). Diarrheic illnesses are ubiquitous in Bangladesh, consistently more than 5% of all deaths in children under the age of five each year occurs from diarrhea (Zakhariev, 1969). According to the International Center for Diarrheal Disease Research, Bangladesh (ICDDR, B), there were 501 hospitalizations each day for diarrhea caused by food and water-borne infections (Banik et al., 2018). In industrialized nations, up to 30% of the populace experience the ill effects of food borne infections every year, though in underdeveloped nations up to 2 million passing are assessed each year (WHO, 2007a, b).

There are two distinct reasons why foodborne disease arises and they are Food Intoxication, Food Infection. Foodborne disease agents not only decapitate huge groups of individuals but can also cause significant death and disability (Faruk & Akhter, 2012). There is now mounting evidence that people from minority racial and ethnic groups are more prone to developing foodborne diseases. Biological contamination, chemical contamination, physical contamination, and cross-contamination are the four forms of contamination that can occur (Gorman et al., 2002; He et al., 2010; Kher et al., 2013).

In many nations, the food and beverage industries are a significant element of the economy. They serve millions of people every day with a broad variety of ready-to-eat (RTE) meals and drinks sold and occasionally made in the streets or public areas (Biswas et al., 2010). Ghanaians rely significantly on street foods (P. N. T. Johnson & Yawson, 2000), with over 60% of mothers in one Accra slum supplementing their children's nutrition with street food (Mensah et al., 2002). Because of its simple accessibility, appeal, flavor, and look, the consumption of street meals is rapidly growing. Although street meals are popular in most parts of the world due to their low cost, there are certain public health issues regarding them (Hossain & Dey, 2019). Road distributed food varieties incorporate food sources as different as meat, fish, natural products, vegetables, grains, and cereals based on ready-to-eat food varieties, frozen produce, and refreshments (Guadu et al., 2016). It is obvious that the consumption of street vended meals is widespread and plays an important role in providing the daily nutritional needs of urban populations; consequently, the safety of these foods is critical and merits special consideration (Were et al., 2020). The following are the top three reasons why people eat fast food: a. limitation of time b. going outside from home c. monetary constraint (Faruk & Akhter, 2012).

Ready-to-eat (RTE) foods are those that have not been further processed before being consumed in a way that reduces the microbial burden significantly (Cabedo et al., 2008). Food from fast-food restaurants may not always be microbiologically safe. Infrastructure, food processing and packaging, cooking, cleaning, and serving equipment, water quality, and food worker personal hygiene are the primary causes of microbial contamination (Mensah et al., 2002; OK & E, 2005). According to a survey, food sellers in Bangladesh have insufficient knowledge and understanding of food safety problems. In highly populated cities in a developing country like Bangladesh, the health risk caused by street-sold food is significant

(Mamun et al, 2013). Approximately 62-78% of all shops on Bangladesh's roadsides sell such products; 58-66% of these shops are located alongside open drains, sewers, manholes, and dumpsters; and 94% of these shops serve drinking water from municipal tap water, which is quite often presumed to be contaminated (CAB, 2010)(Parveen et al., 1970). After rickshaw pulling, road selling is presumably the second most significant work opportunity for the metropolitan poor in Bangladesh, and especially significant for youthful and moderately aged men who have relocated to Dhaka in the previous five to ten years (Bank, 2007). This overview and official labor insights showed that somewhere in the range of 90,000 and 100,000 road merchants sell arranged foods, and around 418,000 individuals, or 2.9% of Dhaka's complete populace rely upon the revenue produced by road food merchants (e.banjamin, 2011). This information demonstrates that every seller serves 84 clients each day overall. This suggests that very nearly 8,000,000 individuals or 55% of the number of inhabitants in Dhaka take some road food on a daily basis (e.banjamin, 2011). An extensive number of road food merchants are selling different appealing and brilliant food products focusing on school-going kids around a few school-based areas in Dhaka City and its edges (Al Mamun et al., 2013).

The food-borne episode is a major problem for general wellbeing and the economy. Current adjustment in food manufacture, preparing pursues, and quickly changing food routines of the buyer are significant components for the expanding utilization of road food varieties. Food-borne disease (FBD) addresses a significant overall medical issue and presently it's anything but a wide scope of the disease brought about by viral, bacterial, parasitic, and substance defilement of food (Bondi et al., 2014). In excess of 250 distinct sorts of infections, microbes, parasites, poisons, metals, and prions are related to foodborne sicknesses in people (Dh et al., 2008). According to the WHO, contaminated foods may cause up to 70% of diarrheal infections, and food-borne diseases are the largest cause of illness, killing an estimated 2.1 million people worldwide, the majority of whom are children in underdeveloped countries (Mehlhorn, 2015). In the domain of bacteria, *Clostridium botulinum, E. coli, Salmonella spp., Listeria monocytogenes, Yersinia enterocolitica, Staphylococcus aureus, Shigella spp., Bacillus cereus,* and *Campylobacter jejuni* are among the most common foodborne pathogens (Karunasagar et al., 2002). Flavors are known to hold onto an enormous number of microorganisms which incorporate individuals from the family Bacillus, anaerobic spore formers, enterococci, individuals from Enterobacteriaceae, an assortment of yeast and mold, and microbes like coagulase-positive staphylococci (Rane, 2011). Moreover, Typhoid occurs at a rate of 3.9 episodes per 1000 persons per year in urban ghetto inhabitants, and the risk of acquiring typhoid is 8.9 times higher in pre-school children (2-5 years) (Brooks et al., 2005). Diarrhea has been identified as one of the leading reasons for hospitalization in Ghana, and diarrheal infections are directly responsible for 16 percent of fatalities among African children under the age of five (Bruce et al., 2005).

Incipiently, raw veggies may be damaged during harvesting and shipping, releasing plant nutrients and supplying substrates for microorganisms existing on the surface of the vegetables to thrive. Furthermore, the quantity and kind of pathogens contained on the surface of fresh salad vegetables may change or increase as a result of processing (F. Rahman & Noor, 2012). Organic fertilizers used in the fields represent a significant threat to public health. The different enteric infections, diarrhea, anthrax, salmonellosis, listeriosis, Crohn's disease, thrombocytopenic purpura, neurological problems, arthritis, and other bacterial diseases are highlighted (Cray & Moon, 1995; SNOWDON et al., 1989; Strauch, 1991).

Besides, fisheries and aquaculture areas have become the second most significant producers in trade profit of Bangladesh, giving about 3.74% in public GDP, 2.7% in export income, and 22.23% in the farming area (DoF, 2007). Although there are 129 fish preparing enterprises in Bangladesh, just 62 plants have EU endorsement. So keep up with the quality of the frozen fish for its acknowledgment in global trade just as preventing consumer health issues (Sanjee & Karim, 2016). Fish, shellfish, and fish items ranked second on Bangladesh's exportable products list, with frozen shrimp accounting for 72.4 %, or nearly US$ 428 million (DoF, 2007).

Furthermore, Broiler meat in Bangladesh is well known in the shopper market in light of its simple edibility and as a minimal expense source of animal protein. The advanced poultry industry can give arranged Ready-to-eat chickens in under about a month and a half through genetic selection, enhanced nutrition, and sharp wellbeing the executives rehearse (Yashoda et al., 2001). These days antibiotics are utilized as remedial specialists to treat bacterial illnesses in serious cultivating frameworks (Yashoda et al., 2001). Unique consideration ought to keep up with in light of the fact that living creatures are hosts to an enormous number of various microorganisms dwelling on their skin or quills. The majority of these bacteria are killed during the butchering process. Contamination can happen at any point during the manufacturing process, from feather plucking to freezing (Faruque et al., 2019).

Additionally, food is one of the fundamental requirements of individuals while water is another term for life, with the human body consisting of 75% water. As per the WHO/UNICEF Joint Monitoring Program for Water Supply and Sanitation (2000), roughly 20-40% of metropolitan water frameworks in the non-industrial nations don't sanitize their water supplies (Sarker et al., 2016). Every year, 34 million people die across the world, the majority of them are youngsters (Pillay et al., 1994). In Bangladesh, 19.4 million people are still consuming water that exceeds national health guidelines. As per the 2013 MICS research, over 41% of individuals consume water contaminated with feces, ascending to 61.7% on utilization point (Shahid, 2019). Also, fresh juices are now preferred over soft drinks by Wellbeing cognizant consumers. They provide vitamins and minerals (calcium, phosphorous, sodium), as well as bioactive compounds (glycosides, flavanone antioxidants, hydroxycinnamic acid) that aid in improving human health, helps in keeping up with blood lipid profiles in hypercholesterolemia patients, inhibiting breast cancer, defeating urinary tract infections, and protecting against cardiovascular disease (Eva et al., 2017).

As well, milk has a significant nutritional value, not only for the infants and the human user but also for bacteria, thus the quality of dried milk products is significantly relying on the germs found in liquid milk (Wouters et al., 2002). As a matter of fact, milk powder is utilizing for a variety of reasons in our nation, including the making of ice cream, curd, custard, pudding, and other milk-based foods, in addition to its usage in the manufacture of regular liquid milk and, in some cases, baby food (S. Ahmed & Anwar, 1970). Protein, vitamins, calcium, phosphorus, magnesium, zinc, and other minerals found in milk and dairy products are essential for the restorative living of individuals of all ages and genders. A 'dairy product' is a milk-based product that keeps the nutritional benefits of milk while also making it more appealing to customers (S. Das et al., 2015). Milk can be sullied by Tuberculosis, brucellosis, and mastitis-infected cows, as well as from human transporters of having typhoid fever, diphtheria, dysentery, and scarlet fever (S. Ahmed & Anwar, 1970). Toxin-producing *E. coli, Salmonella,* and *Listeria monocytogens* were also linked to raw or sufficiently pasteurized milk consumption6. Staphylococcus aureus may be found in the udders and teats of cows, contaminating the milk (Jayarao & Henning, 2001; R. Tahiri, n.d.). Lactic acid bacteria (LAB; *Lactococcus, Lactobacillus, Leuconostoc, Streptococcus,* and *Enterococcus*) are generally the major microbial community in bovine, goat, sheep, and buffalo milk before pasteurization (J. Yu et al., 2011). Fluid dairy products are more readily tainted with microorganisms than dried dry milk products, according to expertise (Pal et al., 2016). Filling machines and gaskets with biofilms are the primary sources of post-pasteurization contamination of dairy products (Dogan & Boor, 2003).

Since the mid-1990s, there has been an expanding number of flare-ups of new produce-associated foodborne sickness recognized universally and endeavors are being made to determine these sanitation issues (Sivapalasingam et al., 2004)(Berger et al., 2010)(T A U X E 1 A N D & Hedberg, 2021). In developed countries, administrative bodies working with food standards, namely the Center for Science in the Public Interest (CSPI), Centers for Disease Control and Prevention (CDC), Food Net, and so forth, are effectively played an active role to supervise food-related problems, while in developing nations like Bangladesh, such regulatory framework is not that conspicuous to guarantee local health safety (Noor & Feroz, 2017). The Bangladesh Pure Food Ordinance, 1959, Bangladesh Pure Food Rules, 1967, the Food Grain Supply (Prevention of Prejudicial Activity) Ordinance, 1956, the Radiation Protection Act, 1987, the Iodine Deficiency Disorders (IDD) Prevention Act, 1989, the Essential Commodity Act, 1990, and the Fish and Fish Product (Inspection and Quality Control) Rules, 1997 are among the constitutional provisions that govern products in Bangladesh (G. M. R. Islam & Hoque, 2013). As per the report of the Directorate General of Health Services (DGHS), the immensity of diarrheal illnesses is caused essentially by hazardous products. Between 2003 and 2009, over 18,000,000 individuals suffered from diarrhea, according to the research (Atahar Ali, 2013). Knowing the microbiological security of street distributed food sources is a significant factor to see the value in the wellbeing issues identified with road food sources so that concerned associations should find legitimate ways to further develop wellbeing and sterilization regarding this area (Muleta & Ashenafi, 2001).

Food contamination by microorganisms can happen at any point in the food chain. Deterioration of food includes any change, which makes food unsatisfactory for human utilization (Pal et al., 2016). Between the final production process and utilization, ready-to-eat food items are ingested without any treatment (Vrdoljak et al., 2016). The purpose of this study is to explain the current state of knowledge about the potential and features of street food contamination, to characterize the existing diagnostic status of street food-borne microorganisms, and to create suggestions that may be beneficial in managing overall food security.

2. Types of Spoilage Microbes:

2.1 ***Psychrotrophs:***

Psychotropic microorganisms are cold-loving organisms that like to develop at low temperatures and make up a significant portion of the bacteria found in raw milk (Pal et al., 2016).In cheese, psychotropic bacteria including *Achromobacter spp., Alcaligenes spp., Flavobacterium spp., and Pseudomonas spp*. cause problems (Fernandes, 2008).

2.2 ***Listeria Monocytogenes*:**

Listeria monocytogenes is a prominent foodborne zoonotic organism with significant public health implications. *L. monocytogenes* noncompliance was most common in soft and semi-soft cheeses prepared from raw or low heat-treated cow's milk (Verraes et al., 2015). It is a common pathogen that has been isolated from a range of fish as well as meat products in retail marketplaces (Dillon et al., 1992). Healthy humans may develop a slight digestive disruption, a flu-like condition, or just become asymptomatic carriers after being exposed to *L. monocytogenes* (Schuchat et al., 1991). Immunocompromised people, pregnant women, neonates, and the elderly, on the other hand, are in danger of serious sickness if they become infected (Cabedo et al., 2008).

2.3 ***Coliforms:***

Coliforms are Gram-negative, rod-shaped bacteria that are facultatively anaerobic. The formation of gas from glucose (and other sugars) and the fermentation of lactose to acid and gas within 48 hours at 35°C were employed as recognition markers (Hitchins et al., 1998). *E. coli* belongs to the coliform group, which comprises organisms from the genera Escherichia, Klebsiella, Enterobacter, Citrobacter, and *E. coli.* Coliforms have long been employed as an indicator microorganism to assess fecal pollution and, possibly, the presence of enteric microbes in drinking water.

2.4 ***Fecal coliforms:***

Fecal coliforms are bacteria that digest lactose in EC medium and produce gas within 48 hours at 45.5 ° C. Fecal coliforms are thought to be somewhat closely linked to fecal contamination in warm-blooded animals than other members of the coliform family.

2.5 ***E. coli:***

E. coli is a bacterium that may cause infections in humans, most commonly in immunocompromised individuals or when gastrointestinal barriers are breached. However, 'nonpathogenic' E. coli strains can infect the body if they penetrate via the digestive tract (Biswas et al., 2010). *E. coli* strains induce diarrhea and hemolytic uremic syndrome (HUS). The Gram-negative, rod-shaped bacteria *Escherichia coli (E. coli*) is widely found in the lower intestine of warm-blooded organisms (endotherms).

The acronym Shiga Toxin-producing Escherichia coli (STEC) represents a group of *E. coli* bacteria that generate potent toxins that can cause serious disease. In Germany, for example, a significant incidence of a hemolytic-uremic syndrome associated with sprouts was caused by STEC O104:H4 (Bezuidt et al., 2011). ETEC strains are characterized by the presence of a couple of plasmid-encoded enterotoxins, the thermostable poison, and the thermolabile poison. ETEC strains are the most widely recognized reason for infantile diarrhea of the bowels among all *E. coli* pathotypes and the most regular reason for loose bowels in explorers to impoverished nations (Canizalez-roman et al., n.d.).
Episodes brought about by Diarrheagenic *E. coli* (DEC) strains have been firmly connected to the utilization of polluted food and water (Canizalez-roman et al., n.d.).

2.6 ***Salmonella:***

As indicated by the Centers for Disease Control and Prevention, *Salmonella* is the main source of bacterial foodborne sickness causing roughly 1.4 million nontyphoidal ailments, 15,000 hospitalizations, and 400 deaths in the USA every year (Prevention, 2010). Where, *Salmonella spp*. accounts for 6.4% of bacterial isolates from diarrheal cases in Dhaka (S. K. Das et al., 2013)
Salmonellosis is a human and animal irresistible infection caused by two *Salmonella* species, *S. enterica*, and *S. Bongori,* and is defined clinically by one of three significant disorders: septicemias, acute enteritis, and chronic enteritis (Pal, 2005) (OIE, 2010). Despite the fact that *Salmonella* is heat-resistant and inactivated by industrial cooking, its presence in non–heat-treated RTE food, or RTE food cross-contaminated after cooking, can constitute a health danger to the consumer (Dega et al., 1972)(Doyle & Mazzotta, 2000)(Ng et al., 1969).

Non-typhoidal *Salmonella* causes more than 93 million instances of gastroenteritis worldwide annually, with 155,000 fatalities. Of these cases, 80.3 million cases were assessed to be foodborne (Majowicz et al., 2010)(Liyuwork et al., 2013). Approximately, 93.8 million human cases of salmonellosis are reported annually worldwide (Majowicz et al., 2010). Children under the age of one year are by far the most often afflicted. Salmonellosis is a disease that profoundly influences the very young and the elderly in humans, and immunocompromised people are more vulnerable to *Salmonella* infections at lower infective doses than healthy adults (Pal et al., 2015). This is especially significant in poor countries like Ethiopia, where HIV/AIDS is quite common and *Salmonella* is a common opportunistic infection among HIV/AIDS patients (Birhaneselassie, 2013). Arthropods may manually transport organisms in endemic regions.

2.7 ***Y. enterocolitica:***

Y. enterocolitica is widely distributed in the environment and animal species, representing a risk of human infection. Pigs are the major source of pathogenic *Y. enterocolitica* strains for humans (Huovinen et al., 2010). Untreated water, tainted milk (unpasteurized or insufficiently purified), tofu, or bean sprouts are also likewise linked to foodborne diseases (Sabina et al., 2011).
Y. enterocolitica is a diverse bacterial species. There are two subspecies of this organism (*Y. enterocolitica* subsp. enterocolitica and subsp. palearctica) (Huovinen et al., 2010)(Sabina et al., 2011). The strains belonging to biotypes 1B and 2–5 *Y. enterocolitica* are deemed harmful for animals and humans, out of the six known biotypes (Neubauer et al., 2000). *Y. enterocolitica* pathogenicity is largely determined by the presence of numerous genes known as virulence factors. These genes make it easier for bacteria to infiltrate a vulnerable creature, escape the immune system and thrive under adverse environments (Białas

et al., n.d.). It holds pathogenic characteristics in food items maintained in the freezer (at around –18°C) for up to many months, representing a severe risk to consumers.

The prevalence of potentially pathogenic *Y. enterocolitica* in wild boar, deer, roe deer, and wild ducks poses a serious epidemiologic danger, as does close contact among hunters and the disemboweled gastrointestinal system (Bancerz-Kisiel et al., 2011, 2012). The boar populace serves as a reservoir for *Y. enterocolitica*, which assumes a significant part in the study of disease transmission of the infection

2.8 ***Staphylococcus aureus:***

S. aureus is a gram-positive coccus, impervious to warmth, drying, and radiation. Its strains can be pathogenic and somewhat nonpathogenic. They produce illness when the microbes infect food. They produce a few compounds that are linked with staphylococcal obtrusiveness and numerous extracellular substances some of which are heat-stable enterotoxins that render the food varieties hazardous despite the fact that it seems typical. (Prescott et al., 2005). Nausea, vomiting, stomach cramps, prostration, and diarrhea are some of the signs and symptoms of staphylococcal food poisoning. In hospitals and the community, some strains can cause a wide range of illnesses. (Donnenberg, 2005).

2.9 ***Bacillus cereus:***

Bacillus cereus is a gram-positive bacterium that is boundless in nature and food that causes foodborne illnesses. *B. cereus* can cause food contamination even at exceptionally low portions, with more than 10^3 *B. cereus* g^-1 considered hazardous for utilization. (Granum & Lund, 1997). Albeit cold vegetable dishes in sauce RTEs go through handling steps, they are generally not exposed to heat; subsequently, microorganisms can't be totally wiped out on the new vegetables. Many pathogenic bacteria, including B. cereus, may produce viscous, heat, and drought-resistant spores. These characteristics increase spore retention and make removing them from production line preparation surfaces difficult (S. Yu et al., 2020).

Diarrhea is related with four divergent enterotoxins, the hemolysin BL (HBL, encoded by hblA, hblC, and hblD), non-hemolytic enterotoxin (NHE, encoded by nheA, nheB, nheC), enterotoxin FM (EntFM, encoded by entFM), and the cytotoxin K (CytK, encoded by cytK). (Beecher et al., 1995)(Berthold-Pluta et al., 2019; Granum et al., 1999; Lund et al., 2000; Lund & Granum, 1996; Tran et al., 2010). EntFM is identified with cell wall peptidases (CWPs) which can cause illnesses like loose bowels. (Tran et al., 2010). Other than food contamination, *B. cereus* is additionally connected with genuine diseases such as pneumonia, bacteremia, endophthalmitis, necrotizing fasciitis, osteomyelitis, and endocarditis. (Bottone, 2010; Ikeda et al., 2015; Rishi et al., 2013). Vomiting because of *B. cereus* disease is normally connected with starch-containing food varieties (Fricker et al., 2007) (Delbrassinne et al., 2015) which are accepted to advance the development of *B. cereus* and its creation of emetic toxins (Griffiths & Schraft, 2017).

3. Epidemiology of Bacterial Contamination:

Foodborne illnesses affect around 30% of the population in developed countries (Pal et al., 2014). The epidemiological investigations to propose that food varieties add to countless food contaminations are insufficient, because of the scarcity of inadequacies in information about significant boundaries in the food chain order and host-microbe collaborations; in any case, there have been a few reported instances of food contamination flare-ups because of food sources.

3.1 National Perspective:

Every human being is at danger of developing infection from foodborne pathogens because eating is a basic human requirement. This is true not only in developing nations but also in many developed nations. In light of the health risks caused by street-sold food in densely populated cities in developing countries like Bangladesh, a cross-sectional study has revealed that food sellers lack appropriate knowledge and understanding of food safety problems (Al Mamun et al., 2013). The majority of street meals in Bangladesh are maintained at temperatures ranging from 0 to 50 degrees Celsius. This encourages dangerous bacteria including *E. coli, Staphylococcus aureus, Bacillus spp., Pseudomonas spp., Klebsiella,* and *Salmonella* typhi to proliferate.

3.1.1 Street Foods:

Vendors in Bangladesh aren't well-informed about fundamental food safety risks, according to a new report. Where there is no convenient access to running water, vendors typically use carts and stands. Garbage and wastewater are frequently dumped in surrounding streets, attracting rats and insects and providing food for them. In several circumstances, toilets are not readily accessible, forcing sellers to dispose of their waste in neighboring locations (Muhammad et al., 2015). According to sources, Enteropathogenic *E. coli* (ETEC) seems to be the most common cause of diarrhea in Bangladesh and is transmitted via contaminated water and food.

Bacterial contamination of foods can be caused by unsanitary practices such as skinning, chopping, processing, trimming, packing, and many more. Some Bangladeshi Street sellers appear to disregard the necessity of personal cleanliness when preparing food. It was discovered in the investigation led by (Ghosh et al., 2020) that, concerning and cleanliness upkeep of the food, it was tracked down that 85% of the food had been exposed to flies, as a result, bacteria *Providencia spp*. were discovered. Likewise tracked down that 87.5% road food merchants didn't have clean fingernails and roughly half of the time they utilized the leftover oil for frying 1 to 3 times. *Staphylococcus, Salmonella, Campylobacter, Escherichia coli, Clostridium perfringens,* and *Vibrio cholera* have been the pathogens most frequently isolated in such incidents.

A study conducted by (Muhammad et al., 2015) shows that Total coliforms were found in abundance in betel-leaf and jhal-muri, with counts of 2075 MPNg and 1750 MPNg, respectively. Somosa (12 MPNg), singara (16 MPN g), and cup-cake (16 MPN g) had the lowest levels. A comparison to somosa (75%), sola (50%), and bun, jhal-muri, hog-plum, betel-leaf, peaju, sheek-kabab, singara, and vhel-puri were determined to be 100% infected with coliforms in an undesirable range (25%). However, coliforms were not found in the cup-cake or sweet (0%). So, out of the 48 RTE food samples, 29.16% were free of coliforms. All the food samples including singara and somosa were determined to be 100% affected with an unsatisfactory range with *E. coli*. 16.67 % of the 48 RTE food samples were determined to be E. coli-free.

Following (Hossain & Dey, 2019), 6.67 % of the specimens had a large number of live *E. coli* cells (>5×10^5 CFU/g), indicating a significant risk of infection. Also, *E. coli* was found in 11 of the 15 Tomato Sauce samples and 14 of the 15 Plum Sauce samples. Furthermore, the sauce is a global custom that spans not only street cuisines but also international cultures. Adding flavor and moisture to food by dipping and dunking it in liquid might cause difficulties (Trecene et al., 2019). There were 11 and 13 infected *Salmonella* spp. samples among 15 Tomato Sauce and 15 Plum Sauce samples, accordingly. Besides, it's suspected that eating Plum Sauce is riskier than consuming Tomato Sauce. The cause for the increased mean value of Enterobacteriaceae and *E. coli* contamination in Plum Sauce is unknown (Ali et al., 2006; Gupta et al., 2012). Turmeric powder is an antibacterial ingredient that can lower the quantity of viable bacteria in Tomato Sauce (Ali et al., 2006; Gupta et al., 2012). In this research, it was discovered that up to 80% of total food samples tested positive for *Salmonella* spp., indicating a major health risk while eating Bangladeshi street foods (Hossain & Dey, 2019).

According to the report of (Faruk & Akhter, 2012), Samosa had the largest total viable bacterial count of 2.7×10^4 cfu/g, whereas patties had the lowest amount of 1.1×10^3 cfu/g. A total coliform positive result was found in 44% of the specimens. The overall coliform count was 4.55×10^2 cfu/g on average. The fried chicken had the largest amount of 2.33×10^3 cfu/g, whereas patties had the lowest amount of 3.5×10^1 cfu/g. The existence of fecal coliform was found in 8% of the samples. The total fecal coliform count was 2.15×10^1 cfu/g on average. The fried chicken had the largest amount of 1.9×10^2 cfu/g, whereas patties had the lowest level of 1.0×10^1 cfu/g. Coliform growth was not seen in 92% of the samples.

Furthermore, a study on Microbial Status and Multidrug Resistance Pattern of Pathogenic Bacteria by (Banik et al., 2018) showed that Potato balls from Banani (10^{11} CFU/g) and Rampura (10^{10} CFU/g), soup from Agargaon (10^{10} CFU/g), and puffed rice from Farmgate (10^8 CFU/g) had the most noteworthy mean TVC. Most noteworthy TCC and TSAC values were seen from potato balls from Banani. Fried eggplant from Agargoan showed TCC check (10^8 CFU/g) trailed by the comparable outcome from a similar thing gathered from Nilkhet. The greatest TSSC was found in puffed rice from Baridhara, while the least was found in fried chickpeas from Nilkhet. Sugarcane juices had the greatest concentration of TVC (10^8 to 10^{10} CFU/mL). Hog plum from Banani, contrastingly, had the lowest microbial count; TCC (10^4 CFU/gm) and TSSC (10^3 CFU/gm).

Only 30% of the examined street food samples had an unacceptable level (total coliform > 100 per gm), whereas the remaining 70% had a tolerable level (total coliform 100 per gm), according to the research (Ghosh et al., 2020)
According to an investigation, 44.5 % of food samples (n = 110) were determined to be unacceptable (total coliforms 100 per g or ml), whereas 55.5 % were deemed to be acceptable (total coliforms b100 per g or ml). Food tests gathered from the more youthful food merchants (aged 15–24 years) were more averse to be unacceptable than the examples gathered from other more established age gatherings (Al Mamun et al., 2013).

Table 1: Microbiological analysis of various Street Foods:

Street Foods	Total Bacterial Count	Total Coliform count	Total Fecal Coliform Count	References
Chicken Sandwich	3.4×10^3 CFU/g	2.33×10^3 CFU/g	10	(Faruk & Akhter, 2012)
Fried chicken	5.0×10^3 CFU/g	0	0	
Chicken cutlet	3.8×10^3CFU/g	0	0	
Pizza	2.0×10^3	1.85×10^2 CFU/g	15	
Meat kebab	1.57×10^4 CFU/g	0	0	
Burger	1.77×10^4 CFU/g	3.5×10^1 CFU/g	0	
Patties	1.10×10^4 CFU/g	1.20×10^3 CFU/g	0	
Samosa	2.70×10^4 CFU/g	0	0	
Singara	1.77×10^4 CFU/g	0	0	
Vegetable roll	2.20×10^4 CFU/g	2.5×10^2 CFU/g	0	
Tea	2.6×10^6 CFU/mL	9.6×10^4 CFU/mL	7.0×10^4 CFU/mL	(Hassan et al., 2018)
Fuchka	4.4×10^6 CFU/mL	6.1×10^5 CFU/mL	6.1×10^4 CFU/mL	
Chotpoti	6.1×10^6 CFU/mL	1.2×10^5 CFU/mL	6.6×10^4 CFU/mL	
Salad	2.1×10^6 CFU/mL	9.6×10^4 CFU/mL	1.9×10^4 CFU/mL	
Cup Cake	6.19×10^4 CFU/ g^{-1}	16 MPN/g^{-1}	Not Applicable	(Muhammad et al., 2015)
Jhal muri	1.66×10^7 CFU/ g^{-1}	1750 MPN/g^{-1}		
Bun	3.11×10^5 CFU/ g^{-1}	100 MPN/g^{-1}		
Hogplum	1.87×10^6 CFU/ g^{-1}	66 MPN/g^{-1}		
Betel-leaf	1.49×10^7 CFU/ g^{-1}	2075 MPN/g^{-1}		
Sola	6.24×10^4 CFU/ g^{-1}	1105 MPN/g^{-1}		
Peaju	4.96×10^4 CFU/ g^{-1}	1050 MPN/g^{-1}		
Sheek-kabab	2.63×10^4 CFU/ g^{-1}	23 MPN/g^{-1}		
Velpuri	1.96×10^4 CFU/ g^{-1}	1750 MPN/g^{-1}		
Sweet	3.39×10^5 CFU/ g^{-1}	22 MPN/g^{-1}		

3.1.2 Fish & Meat:

Fish:

Fish might be sullied at different phases of transport, preparation, and handling. This pollution might be identified with the raw materials, workforce, and handling apparatuses like forklifts through spillage, bug, and pest harborage. Moreover, fish can get contaminated during stockpiling and handling (BRYAN, 1980; Gangarosa et al., 1968). Bacterial development in the frozen fishes is one of the fundamental causes of food decay or defilement of fish. Consequently, the microbiological investigation of the frozen fish tests and fish handling materials (water and ice) goes about as the marker of fish quality assurance (Sanjee & Karim, 2016)

In the investigation (Sanjee & Karim, 2016), the all-out coliforms count went from 5 MPN/g to 28 MPN/g and fecal coliforms check was from 3 MPN/g to 8.3 MPN/g. The greatest microbiological limit for the TVAC which distinguishes between excellent and substandard quality goods is 5×10^5cfu/g. The TVAC of the examined tests went from 2.8×10^5 to 4.9×10^5cfu/g which was beneath the greatest permissible breaking point.

A study has been reported, For the shrimp and prawn samples, total counts ranged from 2.04x10 to $4.5\text{x}10^5$ and 1.08x10 to 1.2x10 cells individually where the most elevated include was found in the sample D1 ($4.5\text{x}10^5$) and D2 ($1.2\text{x}10^5$); followed by samples B ($5.9\text{x}10^3$), C1 ($4.5\text{x}10^3$) and C2 ($1.2\text{x}10^3$) while samples A and E had a low check of $2.04\text{x}10^2$ and $1.08\text{x}10^2$ separately. The shrimp coliform counts varied from $5.4\text{x}10^2$ to $8.5\text{x}10^5$ cells, while the prawn counts varied from $5\text{x}10^2$ to $4.4\text{x}10^4$ cells, both exceeding the zero CFU/ml limit. The *Salmonella*-Shigella (SS) tally ran somewhere in the range of $0.26\text{x}10^2$ and $0.96\text{x}10^4$ cells for the prawn and from $0.15\text{x}10^2$ to $1.1\text{x}10^4$ cells for the shrimp, likewise surpass the constraint of $1.0\text{x}10^2$ CFU/ml (Hena et al., 2008).

Meat:

Foodborne illnesses are not just connected with the utilization of poultry meat yet additionally it's prepared items that have extraordinary general wellbeing importance (Faruque et al., 2019). The connection between the utilization of meat and wellbeing is diverse. Overweight, obesity and hypertension were shown to be more prevalent than any other ailments among broiler meat consumers, both male and female. Males who eat broiler meat had hypertension, hyperlipidemia, digestive problems, constipation, and diabetes at a disturbing rate with 35.3 %, 22.7 %, 18.7 %, %, and 7.3% individually, whereas males who never eat broiler meat had these maladies in rate with 16%, 10%, 14%, 6%, and 4% in some regard (Faruque et al., 2019).

According to the report stated by (Faruque et al., 2019), the total viable count (TVC) of 15 broiler meat samples was $4.3\text{x}10^6$ CFU/gm on average. The least TVC was determined to be $2.3\text{x}10^4$ CFU/gm and the maximum was found to be $3.6\text{x}10^7$ CFU/gm. The smallest TCC value was $1.6\text{x}10^3$ CFU/gm and the largest was $1.5\text{x}10^5$ CFU/gm. The average result was found to be $3.6\text{x}10^4$ CFU/gm.

Table 2: Microbiological analysis of Fishes and Meats:

Sample		Total Count	Total Coliform Count	*Salmonella*-Shigella count	References
Fish		2.8×10^5 to 4.9 $\times10^5$ cfu/g	5 MPN/g to 28 MPN/g	3 MPN/g to 8.3 MPN/g.	Sanjee & Karim, 2016
P. monodon	A	$2.04\text{x}10^2$ CFU/ml	$5.4\text{x}10^2$ CFU/ml	$0.15\text{x}10^2$ CFU/ml	Hena et al., 2008
	B	$5.9\text{x}10^3$ CFU/ml	$5.3\text{x}10^2$ CFU/ml	$0.45\text{x}10^3$ CFU/ml	
	C1	$4.5\text{x}10^3$ CFU/ml	$4.5\text{x}10^3$ CFU/ml	$0.2\text{x}10^2$ CFU/ml	
	D1	$4.5\text{x}10^5$ CFU/ml	$8.5\text{x}10^5$ CFU/ml	$1.1\text{x}10^4$ CFU/ml	
M. rosenbergii	C2	$1.2\text{x}10^3$ CFU/ml	$5.1\text{x}10^3$ CFU/ml	$1.2\text{x}0^3$ CFU/ml	Hena et al., 2008
	D2	$1.2\text{x}10^5$ CFU/ml	$4.4\text{x}10^4$ CFU/ml	$0.96\text{x}10^4$ CFU/ml	
	E	$1.08\text{x}10^2$ CFU/ml	$5.0\text{x}10^2$ CFU/ml	$0.26\text{x}10^2$ CFU/ml	
Broiler Meat	Highest	$3.6\text{x}10^7$ CFU/gm.	$1.5\text{x}10^5$ CFU/gm	5.6×10^3 CFU/gm	Faruque et al., 2019
	Smallest	$2.3\text{x}10^4$ CFU/gm	$1.6\text{x}10^3$ CFU/gm	3.1×10^3 CFU/gm	

	Average	4.3×10^6 CFU/gm	3.6×10^4 CFU/gm.	4.6×10^3 CFU/gm	

3.1.3 Juice & Water:

Freshly squeezed or pressed juices made from fruits and vegetables are extremely popular worldwide, both in terms of taste and health benefits. However, such juices, particularly unpasteurized juices, have been demonstrated to be a significant source of bacterial pathogens, including *Salmonella*, *E. coli* O 157:H7 (M. S. U. Ahmed et al., 1970). During the long months of March to August in Dhaka, Bangladesh's main city, about 94% of the populace, including foreigners of all ages and socioeconomic levels, pick and drink freshly squeezed or pressed juices in huge amounts, particularly mango, pineapple, papaya, and apple (M. S. U. Ahmed et al., 1970). With a massive rise in the number of customers, roadside eateries in Khulna have encountered extraordinary development over the most recent 10 years, and all the more especially during the most recent 5 years.

Also, water assumes a significant part in controlling metabolic action just as keeps up with physiological exercises and yet can cause infection whenever devoured focally polluted state. As indicated by the World Health Association, non-potable water causes consistently around 4 billion instances of diarrhea each year, with several million cases of enteric illnesses. The most straightforward way to know the quality of drinking water is to look for the indicator bacteria Escherichia coli in the water and fruit juices, which indicates the existence of focally contaminated other dangerous microorganisms that are tricky to culture and present in very small numbers (Eva et al., 2017).

As reported by (M. S. U. Ahmed et al., 1970), in all of the newly produced fruit juices, the mean total viable count revealed the existence of microorganisms in the range of 3.00×10^2 to 9.60×10^8. Coliforms were found in all of the samples, with counts ranging from 43 to >2400/100 ml. Fecal coliform was found in all samples with concentrations ranging from 7 to >2400/100 ml. For the most part, it surpasses the Gulf guideline for total coliforms. As vendors do not use boiling water and WASA water in Dhaka city is severely polluted, *Salmonella* might have entered through the water (Parveen et al., 1970). This water is often used for diluting juices or other components, and utensils are used for cleaning and making juices.

In the investigation of (Eva et al., 2017) it was found that Four juice samples exhibited the highest development of lactose fermenting coliform bacteria in a hypothetical test, with the 2400 MPN/100ml juice showing the most growth. With 920 MPN/100ml juice sample, the second-highest increase was seen. 2 MPN/100ml juice had the lowest number of coliform bacteria capable of lactose fermentation. The water sample with the highest concentration of lactose fermenting coliform bacteria was 2400 MPN/100ml. The sample with 1600 MPN/100ml drinking water had the second greatest growth. With 2 MPN/100ml water, the lowest number of coliform bacteria capable of lactose fermentation was found.

Another study shows the mean MPN index value was 3.05 ml-1, indicating that the water samples were unfit for human consumption. Dark centered or nucleated colonies with metallic sheen were seen in this investigation, indicating that all of the specimens tested positive for coliforms (Sarker et al., 2016).

Furthermore, a survey showed (Shahid, 2019), two of the three examples are discovered to be respectably hazardous as the level is 10-100 for every 100ml. In addition, two of the samples have a TC level of 10-100 for every 100ml, which is classified as potentially hazardous as per WHO. The remaining six samples had more than 100 to 610 coliforms, indicating an extremely high amount of TC in filtered drinking water. Around 20% of the samples are determined to fulfill the criteria, with the remaining 20% being somewhat hazardous. Rest 60% examples are considered as high danger level of complete coliform pollution adhering to both Bangladesh and WHO standards.

It was found that the standard value of EC (Electrical Conductivity) in Bangladesh is 1200 µS/cm and five distinct wards which have a greater worth of EC contrast with the standard value and it produces various health hazards issue as nausea, cramps, diarrhea, and related headaches (Overview et al., 2019). It was tracked down that just one ward has a higher value than the standard value of chloride as per Bangladesh. The total iron value of Ward 9 surpasses Bangladesh's standard value, while all other wards' samples are within the acceptable range. According to a question-and-answer poll, it discovers that puri is preferred by 43.5 % of Khulna city residents. 73.9% of individuals experienced different foodborne and waterborne illnesses. Diarrhea affects 14 out of every 25 persons and is caused by the consumption of contaminated food and water (Overview et al., 2019).

3.1.4 Dairy Products:

Water (87.20%), protein (3.50%), fat (3.70%), milk sugar or lactose (4.90%), ash (0.70%), and dry matter (12.80%) are the main components of milk.

During milking procedures, however, it is polluted by the exterior of the udder and surrounding areas, dairy utensils, milking equipment, the milking man's hands, as well as soil and dust. Bacteria, yeasts, and molds get access to milk in this manner, forming the typical flora of milk (Uddin et al., 1970). The lacteal secretion produced by the entire milking of one or more healthy cows 5 days after and 15 days before parturition, which includes at the very least 8.5% milk solids and at least 3.5 % milkfat, is classified as milk (Fda, 2009). In cold crude milk that has been stored, Gram-negative bacteria often represent more than 90% of the microbial populace (Martins et al., 2006; Samaržija et al., 2012). The flavor, taste, and texture of final meals may be influenced by microorganisms found in milk and milk items (J. Yu et al., 2011). A portion of the past nearby investigates inside Dhaka city, Bangladesh uncovered that crude or un-sanitized milk and milk items could be an exceptionally proficient vehicle for bringing an enormous number of individuals to possible microbiological dangers, ultimately leading to the start of different illnesses (Afroz et al., 2014; Marjan et al., 2014; Yasmin et al., 2015).

In an investigation (S. Ahmed & Anwar, 1970), Staphylococcus counts differed from $6.0x10^1$ to $8.2x10^2$ cfu/g. Since their existence is typically represented as a post-processing sanitary indication, the presence of a large number of staphylococci in dry powder milk demonstrates inadequate post-processing sanitation. Yeasts and molds were discovered in the examples of four organizations. Their appearance in milk or milk items is typically viewed as a deteriorating factor. Moreover, according to a study (Uddin et al., 1970), the sample obtained from Uttara had the greatest total viable bacterial count ($2.36x10^9$) while the sample collected from Mohammadpur had the least total viable bacterial count ($2.0x10^8$). The sample from Tongi had the greatest coliform bacterial count ($8x10^6$ cfu/ml), whereas the sample from Asulia had the least coliform count ($1.0x10^4$ cfu/ml). The sample taken from Uttara had the largest $4.7x10^7$ cfu/ml staphylococcal count.

Also, 6 samples were discovered to be contaminated with Klebsiella spp. (10^2 cfu/mL), a family of bacteria. Staphylococcus spp. were identified in nearly half (9) of the samples, with counts ranging from 10^2 to 10^3 cfu/mL. Vibrio spp. and Pseudomonas spp., however, were found in 9 and 7 samples, respectively, with an average of 10^2 cfu/sample (Malek et al., 2016).

3.2 Global Perspective:

Foodborne pathogens are found in street foods globally that have been reported in several studies. However, a higher amount of such pathogens is found in the street foods of developing countries than in developed countries. Poor food cleanliness and handling, cross-contamination, and time and temperature abuse during storage and preparation are the major factors that contribute to foodborne illness in most impoverished developing nations (Ismail et al. 2016). The most common foodborne pathogens that have been reported are *Escherichia coli, Shigella sp., Staphylococcus sp., Bacillus spp., Klebsiella spp., Listeria monocytogenes*, etc. These foodborne pathogens cause various infections such as diarrhea, cholera, typhoid fever, and food poisoning are caused. **(**Tabashsum et al. 2013)**.**

3.2.1 Street Food:

Vending street food serves an essential socioeconomic function in satisfying the food and nutritional needs of urban populations at low- and intermediate-income levels (Riet et al. 2002). So that most of the street food vendors remain uneducated and have less knowledge about healthy hygiene food & safety. When compared to producing food on the premises, the process of preparing street food is more susceptible to bad environmental conditions (Ismail et al. 2016). Foods sold on the street, unclean preparation and handling, and a lack of water availability for cleaning make street food one of the most common sources of foodborne infections. Salmonellosis is one of the most common infections caused by consuming contaminated food found in a study by (Raza et al. 2021).

Food contamination sold by street vendors could be caused by a lack of infrastructure such as water connections, poor drainage systems, and refrigerating facilities (Islam et al. 2015), though All food workers in Malaysia are required to get vaccinated against typhoid and to complete a mandatory food handling training (Food Act 1983 (Malaysia) (Act 281). In Kualalampur, Malaysia, there is reported Data analysis revealed a weak negative relationship between the vendor's level of cleanliness and the mean total coliform in street food sold at Chow Kit ($r=-0.33$, $p >0.05$) and the mean presence of *E. coli* in the food sold at Chow Kit vendors ($r=-0.440$, $p<0.05$) based on the Spearmen Rho correlation test by (Rahim et al. 2019). The maximum contamination was detected with 87 percent of the total sample on total viable count. The average number of total viable cells per gram of street food sold by Chow Kit vendors was 4.07± 0.63 Log CFU/g. Total coliforms were detected in 43% of the samples, with an average of 4.19± 0.89 Log CFU/g. Meanwhile, E. coli was detected in just 6% of all samples, with a mean of 4.40± 1.97 Log CFU/g. *S. aureus* was found in 33 percent of the total samples, with an average of 3.88±0.86 Log CFU/g. *Salmonella spp*.

had not found in any of the samples (Rahim et al. 2019). The mean *E. coli* presence was higher than the ICMSF's standard of more than 2 Log CFU/g (Rahim et al. 2019)

In developing nations, food is the most common mode of transmission of traveler's diarrhea (Adachi et al. 2002). A study indicated in Guadalajara by (Koo et al. 2008) that, 27(42%) of 64 vegetable samples tested positive for coliforms, compared to 17(25%) of 67 vegetable samples tested positive in Houston (P p.04). Foods from Mexico had a median coliform concentration of 16,000 cfu/g of vegetable sample, compared to 22,000 cfu/g of vegetable sample from Houston (P p.20) .In the case of cooked vegetables, coliforms were found in 10(67%) of 15 samples from Guadalajara, compared to 3(10%) of 30 samples from Houston (P<.001) Therefore by calculating , It showed that the rate of contamination (P<.001) and median coliform count (P=.01) of cooked vegetables from Guadalajara were substantially greater than those of cooked vegetables from Houston when served hot. Coliform contamination was found in eight (42%) of 19 vegetable samples acquired from Guadalajara buffets, compared to five (24%) of 21 vegetable samples obtained from Houston buffets (P=.22). Four of the 27 samples of coliform bacteria isolated from vegetable samples in Guadalajara were positive for enterotoxigenic coliforms, according to microbiological research. An enteroaggregative phenotype was found in 13 of 27 coliform bacterial strains recovered from Mexican samples using the Ep-2 cell adherence assay. Coliforms from 4 of 17 samples of contaminated Houston veggies were enterotoxigenic, and 11 of 17 samples were enteroaggregative. *Enterobacter cloacae, Klebsiella oxytoca, Pantoea species, and Pseudomonas fluorescens* were the most common enterotoxigenic bacteria identified from the two sites.*E. cloacae, K. oxytoca, and Klebsiella pneumoniae* were the most prevalent enteroaggregative bacteria found. From their investigation, coliform contamination rates in Guadalajara veggies were substantially higher than in Houston vegetables, regardless of whether the vegetables were boiled or prepared and served hot.

Furthermore, research showed (Denis et al. 2016) over a four-year period, a significant number of fresh fruits and vegetable samples were gathered and analyzed for the presence of a range of bacteria in six distinct commodity categories (leafy vegetables, tomatoes, leafy herbs, green onions, cantaloupes, and berries). The control chart for the leafy vegetable samples reveals five periods that stand out: June and July 2009 in the region of possible concern (yellow) and August 2009, July 2010 and 2012 in the area of worry (red). This implies that over the four-year period, the percentage of positive samples was substantially greater than usual during many summer months. Contamination of leafy vegetables by the bacterial pathogens studied was found to be infrequent and intermittent; nevertheless, when the data was analyzed, certain tendencies appeared, including generic E. coli. In most geographical locations, leafy vegetables proved to be more often polluted in the summer.

Despite its popularity, street food is frequently found to be contaminated with germs and linked to foodborne diseases (Das et al. 2010). According to a research in India, 42 percent of working women and men between the ages of 25 and 45, and 61 percent of students between the ages of 14 and 21 consume food from the streets at least once a day (Sunita et al. 2004). Depending on the amount of colony forming units collected after the APC, food samples were divided into three categories (satisfactory, acceptable, and unsatisfactory) (ICMSF, 2006), (Were et al. 2020). A presumptive test revealed that all four kachumbari samples (100%) were coliform positive (Were et al. 2020). Total coliform levels in Kachumbari from all vending stalls were 4.12 log10 cfu/g, 4.26 log10 cfu/g, and 4.21 log10 cfu/g, respectively, which did not match the quality standards (4.00 log10 cfu/g) for ready-to-eat meals (Were et al. 2020).

Total coliform levels were found in all of the kachumbari samples (100 percent), but not in the samosa or sausage samples. *E. coli* was found in two-fourths of kachumbari samples (50.0 percent), but not in samosa or sausage samples. In none of the samples tested, *Salmonella* was found (Table 1) (Were et al. 2020).

Table 3: prevalence of indicator organisms and pathogens detected in food samples:

Indicator organism	**Food sample**			**Reference**
	Samosas (n=4)	Sausages(n=4)	Kachumbari (n=4)	(Were et al. 202**0)**
Total coliforms (TC)	0 (0%)	0 (0%)	4 (100%)	
E. coli	0 (0%)	0 (0%)	2 (50.0%)	
Salmonella spp.	0 (0%)	0 (0%)	0 (0%)	

Almost all of the vendors in this survey (100%) did not have access to fresh running water ((Were et al. 2020). Re-used water contains scattered organic elements that operate as a culture medium for a variety of pathogenic microbes, putting food safety at risk (Birgen et al. 2020)

Foodborne disease linked to the eating of street meals has been recorded in India and other parts of the world. (FAO 1988; Estrada-Garcia et al. 2004; Chumber et al. 2007). Das-Mohapatra et al. (2002) found *E. coli, Shigella sp., Staphylococcus sp., and Bacillus sp*. in four popular street foods (including Panipuri) in Bhubaneswar city,whereas Das et al. (2010) found that street foods in Bangalore city, such as Panipuri, Bhelpuri, and Chaat, were contaminated with high loads of pathogens *Streptococcus faecalis, Escherichia coli, Staphylococcus aureus, Bacullus sp., Klebsiella sp., and Pseudomonas sp*. are some of the bacteria that we found, and they all agree with our findings. (Das-Mohapatra et al. 2002; Das et al. 2010) As reported by (Madhuchhanda et al. 2011) the pH of liquid samples was found to be extremely acidic (pH2.5–3.0), whereas the pH of solid samples was found to be between 5.5 and 6.0. The inclusion of tamarind juice and other acidic components to the khatta pani accounts for its extreme acidity. On all of the media tested, however, nine (66.7%) samples of potato masala demonstrated a viable aerobic bacterial load.The bacterial load on NA(105–1010) was the highest, followed by MA (106–107). The major occurrence of *Enterobacter sp., Escherichia coli, and Klebsiella sp.* could be related to poor vendor personal hygiene, unsanitary food handling, improperly cleaned dishes, and the use of raw vegetables such as cucumber and onion.

Pani puri is one of the most popular street meals in Nepal. Despite its widespread popularity, convenience of availability, and low cost, it is frequently linked to a variety of food-borne illnesses (Barro et al. 2007). Moreover, Street-Vended Indian Chaats sold in almost all the cities throughout India including Bangalore. A present study was undertaken (Arijit et al. 2010) to investigate microbiological quality of Indian Street foods such as chaats & the majority of the samples tested showed pathogenic contamination with *fecal coliforms*. All of the analyzed samples had a high concentration of *fecal coliforms* and *fecal streptococci*, indicating that the chaats were of low bacteriological quality. Total viable bacteria count in all samples ranged from 0.4-3x10^4 cfu g^{-1}, *fecal coliforms* from 0.03-0.14x10^4 cfu g^{-1}, and *fecal streptococci* from 0.2-11x10^4 cfu g^{-1}. Also *E. coli* and *Streptococcus faecalis* had the highest numbers of 0.03-0.14x10^4 cfu g^{-1} and 0.2-11x10^4 cfu g^{-1}, respectively, among the bacterial pathogens recovered in this investigation, followed by *Staphylococcus aureus* and *Bacillus sp.*

Another study (Yadav et al. 2009) shows, out of 120 samples examined, 84(70%) were found to be contaminated with harmful bacteria, whereas the remaining 30% were confirmed to be non-contaminates. The bulk of the samples were found to be contaminated with harmful bacteria of various types. Pani masala 46 (76.67%) and solid matter 38 (63.33%) were both found to be substantially polluted. The total viable count of bacteria in masala pani varied between 90-182x10^5 CFU and 50-121x10^5 CFU from crowded and noncrowded vendors, respectively, while solid matter masala varied between 80-130x10^5 CFU and 46-118x10^5 CFU (Yadav et al. 2009).

Pathogenic microorganisms have been found in food particles and water over inadequately cleaned cutlery too (PiragineKO et al. 2005). When linked with insufficient sanitary conditions of handlers and utensils, *Staphylococcus aureus* and *Escherichia coli* are primarily responsible for outbreaks of food poisoning (Vanderzant et al. 1999). The presence of this microorganism indicates a lack of basic hygiene training for handlers during the preparation of these foods, because when the analysis is performed, coliforms of gastrointestinal origin are sought, but it is known that *Enterobacter* and *Klebsiella* strains included in this group may have non-fecal origin (water, soil, and vegetables), as shown by the presence of this microorganism (Silva et al. 2002).

In Ghana, street food is primarily made and processed by hand before being served to the general public at various lorry terminals, along the route, or by nomadic sellers (Mensah et al. 2002). Traditional processing methods, improper keeping temperature, and poor personal hygiene of food workers are all major sources of contamination in ready-to-eat foods (Barro et al. 2006). According to the investigation, some Ready-to-eat food were found higher level of bacterial contamination level than the national standard of Ghana.

Table 4: Microbiological Bacterial analysis of various street foods in Ghana:

Sample	Bacterial Contamination level	National Standard (cfu/ml)	Reference
Fufu	6.36 log10 cfu/g	<5.0 log10 cfu/g	Feglo et al. 2012
Ice-kenkey	5.580.52 log10 cfu/ml	<5.0 log10 cfu/ml	Feglo et al. 2012
Salads	5.13 log10 cfu/g	<5.0 log10 cfu/g	Ghana Standard Board (2003). Local Reference Standards GS 7006, 1-44.
Red Pepper sauce	5.92 log10 cfu/g	<5.0 log10 cfu/g	Feglo et al. 2012
Macaroni	5.48±0.97 log10 cfu/g	<5.0 log10 cfu/g	Feglo et al. 2012
Cocoa drinks	6.16 log10 cfu/ml	<5.0 log10 cfu/ml.	Feglo et al. 2012

Another study conducted by (Bereda et al. 2016) shows that, the aerobic mesophilic count in all of the samples ranged from 1.9-4.6*10^6 CFU/g to 0.9-8.3$10^4$ CFU/g coliform. The number of *S. aureus* bacteria per gram ranged from 1.3-4.1x10^4 CFU/g. In comparison to the other food sample items, the bacteriological count of organisms was higher in 'Pasta' and 'Sambusa.' In general, gram-positive organisms dominated 61.6 percent of the samples. Besides some other study result by (Djibrine et al. 2018) establish that the mesophilic total aerobic flora count reveal that the sandwiches are densely packed, with the highest value of 11.2x10^6 CFU/g. The 42 samples had an average load of 6.35x10^6 CFU/g in FAMT. When compared to the MAF, the samples have a compliance rate of 19.05 percent.

Thermotolerant coliforms were found in 36 of the 42 sandwich samples, with a 14.29% compliance rate. 3.0x10^6 CFU/g was the highest load found. The average CFU/g obtained was 0.65x10^6 CFU/g. The average sample size was 0.11x10^6 CFU/g, while the high *E. coli* load was 0.42x10^6 CFU/g. The rate of compliance was 47.62%. *Salmonella* compliance was 100%, which means no *Salmonella* was found in any sample. *Staphylococci* that were coagulase-positive were detected in 19 of the 42 samples. 70x10^4 CFU/g is the highest load, whereas 0 is the lowest. 23 of the 42 samples are in compliance with the norms, resulting in a 54.76% conformance rate. These findings could be explained by a lack of hygiene procedures, particularly the control of hardware device disinfection, because contamination could have arisen from the same work instruments and work surface in this investigation.

In another study based on Microbiological quality of selected street foods from a restricted area of city, Brazil conducted by (Hanashiro et al. 2004) established that, according to the criterion employed, around a third (35%) of the street food samples were unfit for ingestion; 50% of them were left unprotected for sale. In terms of hygienic conditions, fecal coliforms were found in 22 samples (55%) (>3 MPN/g), 50% of which had critical values. In one cold sandwich sample, B, fecal coliform levels reached >2.4 105 MPN/g.

In the investigation of a study based on Bacteriological Quality and safety of Street Vended Foods in Delta State, Nigeria carried by (Samuel et al. 2012), all of the street food samples were found to be contaminated, with bacterial counts ranging from 1.2 x 10^2 cfu/g to 1.1 x 10^7 cfu/g. Sixty Nine percent(73/106) of the screened street food samples had a total bacterial count of > 10^4 cfu/g and were classed as unsatisfactory, while thirty-one percent(33/106) had a total bacterial level of <10^4 cfu/g and were rated as satisfactory. In the food samples, the total coliform count ranged from 36 to 2100 MPN/g. Sixty-seven percent (71/106) of the street food samples showed total coliform levels higher than the recommended limit of <100 coliform/g, whereas 33% (35/106) had acceptable levels.

On the other hand, Pathogenic bacteria such as *Salmonella spp., Listeria monocytogenes, and Staphylococcus aureus* were not found in microbiological investigations of grilled pork samples. All samples contained AMB and LAB, with densities ranging from 2.6 to 7.4 Log10 CFU g^{-1} (Dona et al. 2019). The amount of *AMB* (3.3±0.9 Log10 CFU g^{-1}) and *Enterobacteriaceae* (1.6±1.5 Log10 CFU g^{-1}) in the water used during the production of grilled pork slices was reasonably low. (Dona et al. 2019). Total coliforms were found at a concentration of 1.5±0.8 Log10 CFU ml-1, which is higher than the CECMA-recommended limit of 1.0 Log10 CFU/100 ml. (Dona et al. 2019). But the density of *AMB, Enterobacteriaceae, E. coli, yeasts,* and *molds* dropped significantly (p.05) after grilling, falling below the Health Protection Agency's allowed limits (Health Protection Agency 2009).

According to the report based on Microbial levels on street foods and food preparation surfaces in Mangaung Metropolitan Municipality stated by (Lenetha et al. 2019), Thaba Nchu (≤50 cfu/g ×10^5 cfu/g), Bloemfontein (≤48 cfu/g×10^5 cfu/g), and Botshabelo (≤33 cfu/g×10^5 cfu/g) all had high bacterial levels. These high microbial counts are problematic because they indicate that food workers do not always use proper food handling and preparation practices. The samples collected in Botshabelo (1.1×10^4 cfu/m^2 –1.1×10^6 cfu/m^2) had a higher microbial count than those obtained in Bloemfontein (1.1×10^4 cfu/m^2 –1.1×10^5 cfu/m^2) and Thaba Nchu (1.1×10^4 cfu/m^2 –1.1×10^5 cfu/m^2).

Another most popular & common complementary liquid or semi-liquid substance or condiment which served with food to add moistness and flavour is roadside dipping sauce. However, gradual or double dipping in sauces can result in food poisoning from a variety of sources (Treceme et al. 2019). Direct double dipping can immediately transfer saliva - various oral bacteria, such as *Streptococcus, Prevotella,* and *Veillonella*, can be introduced into the sauce via direct dipping. Strep throat, skin illness, and nausea caused by Streptococcus species induce stomach pains and vomiting (Barcelon et al. 2015).

Furthermore, in a survey showed (Treceme et al. 2019), Sweet Sauce Sample 1 has a negative Coliform Bacteria test after 24 hours and 48 hours. There are six LTB/LSB (Lauryl Tryptose Broth) and (Lauryl Sulfate Broth) 10-1 to 10-6, each with three sample tubes; if the first three tubes turn negative after 24 hours, it will continue to incubate for 48 hours until it becomes positive. The positive tube has bubbles on the top LTB tube, whereas the negative tube has no bubbles on the LTB tube, indicating whether the result is positive or negative. *E. coli* was found to be positive; *S. Aureus* was found to be negative; dilution water was found to be negative, uninoculated tubes/blank was found to be negative, and biosafety/air monitoring (Open Plate) showed no growth of Coliform Bacteria. Sweet Sauce Sample 2 has a negative Coliform Bacteria test after 24 hours and 48 hours. There are six LTB/LSB (Lauryl Tryptose Broth) and (Lauryl Sulfate Broth) 10-1 to 10-6, each with three sample tubes; if the first three tubes turn negative after 24 hours, it will continue to incubate for 48 hours until it becomes positive. The positive tube has bubbles on the top LTB tube, whereas the negative tube has no bubbles on the LTB tube, indicating whether the result is positive or negative. However, the presence of Coliform Bacteria in the sweet sauce utilized by street food sellers resulted in a concentration of 3.0 MPN/mL. The result of 3.0 MPN/mL is within the safe range, and there is no need to perform a confirmatory test because the presumptive test was negative and the Biosafety/ Air Monitoring (Open Plate) revealed no growth of Coliform Bacteria.

In terms of Ready-to-Eat meat items, four of the nine *Salmonella*-positive cured dried sausage samples were *L. monocytogenes*-negative, while three of the *Salmonella*-positive samples were also *L. monocytogenes*-positive. (Cabedo et al. 2007). The *Salmonella*-positive cooked ham sample was also positive for *L. monocytogenes* with a colony count >100 CFU/g, whereas the *Salmonella*-positive frozen chicken croquettes sample was negative for the other pathogen (Cabedo et al. 2007). Moreover, it is calculated & rated that the pathogen's colony counts were <100 CFU/g, with the exception of one frozen cannelloni sample, which had a colony count of 2,600 CFU/g. *Salmonella* was not found in any of the 484 RTE dairy samples, nor in any of the 139 RTE meals or dessert samples. This indicates that processing cleanliness was adequate and that no contamination occurred in the plant after processing. (Cabedo et al. 2007).

On the other hand, study evidence stands on Coliform Contamination of Peri-urban Grown Vegetables and Potential Public Health Risks from Kumasi, Ghana oversees by (Abbas et al. 2016), while the Salmonella spp. test was negative in all of the samples, the total coliform, fecal coliform, and Escherichia coli bacterial count were all positive in all of the samples across the three vegetable categories.

Table 5: Bacterial mean coliform contamination level count:

Name of the samples	Mean total coliform/100 ml	Lowest mean fecal coliform/100 ml count	Highest mean fecal coliform/100 ml count	Mean Escherichia coli bacteria count	Mean total coliform contamination Level count	fecal coliform contamination level count	Reference
Spring onions	$9.15x10^9$	$1.5x10^8$	Not Found	$p<0.04$	Not Found	$p<0.02$	Kabila et al. 2015
Lettuce	$2.2x10^7$	Not Found	$4.15x10^7$	Not Found	Not Found	$p<0.02$	
Cabbage	$4.2x10^7$	Not Found	Not Found	$p<0.02$	$p<0.03$	$p<0.02$	

In Nigeria, it has been appeared in a study (Clarence et al. 2009) that, fresh meat pie given as a control grew between $3x10^3$ and $5x10^3$ cfu/g, whereas room air preserved meat pie (pastry/minced meat) grew between $2.3x10^4$ and $3.8x10^4$ cfu/g and the refrigerated sample grew between 8 $x10^3$ and $1.5x10^4$ cfu/g after 2 days. Fresh meat pie was used as a control, and no substantial growth was seen. The cfu/g was $3x10^3$, whereas room air maintained for 2 days ranged from 1.0 $x10^4$ to 4.0 $x10^4$ cfu/g for S. aureus and 2 x 10^3 to 4 $x10^3$ cfu/g for E. coli, and refrigerated samples for 2 days ranged from 2 $x10^3$ to 8 $x10^3$ cfu/g for isolates from minced meat for S. aureus alone and 2 $x10^3$ cfu/g for *E. coli.* The control was fresh meat pies from the kiosk, which had a microbiological load of 8 $x10^3$ - $2.8x10^4$ cfu/g. The room air preserved beef pie had a TNTC of $3x10^{-4}$ and a refrigerated cfu/g of 1.7 $x10^4$ - 2.8 $x10^4$. However, Food combinations such as pastries, salads, sauces, and soups have been regularly implicated in food poisoning outbreaks, according to recent research. Around 90% of the samples had less than 1100 MPN/g of B. cereus, which is the commonly recognized limit for B. cereus contamination; however, the remaining samples all had more than 1100 MPN/g, showing that high levels of contamination in some RTE meals may cause food illness (Yu et al. 2020).

3.2.2 Drinks & Beverages:

Fresh Fruit juices are still widely comprehended as a healthier option as well as immensely popular worldwide. Although freshly squeezed fruit juices have a significant level of fecal coliform contamination, according to microbial tests found in a study (Sabbithi et al. 2017). Moreover, Fruit juice merchants who did not cover storage jars with lids had a significant frequency of E. coli.

3.2.3 Ready-to-Eat Salads:

Foodborne illnesses are not just stands with raw or fried vegetables or fruits but also mixed salads. Research has been evaluated of Microbial Contamination of Street-Vended Fruit Salad in Calabar, Nigeria supervises by (Brooks et al. 2014), fruits are susceptible to microbial contamination due to their continual interaction with dirt, dust, and water, as well as handling during harvest and post-harvest processing. Damaged surfaces, such as punctures, wounds, cuts, and splits, can potentially allow pathogenic germs to infiltrate the fruits. Salmonella sp. has been found to survive and develop rapidly on water melon stored at room temperature, with the degree of contamination remaining unchanged after the melon was refrigerated. 90% of the samples exhibited high total viable counts, ranging from 3.49x 10^5 to 6.8 x 10^5 colony forming units per gram of salad homogenate, according to the results. The presence of fecal coliform E. coli in salad samples indicates fecal contamination, which is frequently linked to faecally contaminated water, waste water, or sewage sludge. It's likely that the vendors didn't properly wash the fruits, or that they utilized feces-contaminated or waste water to wash the fruits used in the salad. The overall fecal coliform counts in this study ranged from 1.8x10^5 to 2.6x10^5 cfu/g of the samples, which is substantially beyond the recommended limit for fruit-related foods. So, contamination with S. aureus could have occurred through handlers, whereas B. cereus could have occurred by soil contact with the fruit.

Furthermore, a study on Microbial safety of raw mixed-vegetable salad sold as an accompaniment to street vended cooked rice in Accra, Ghana by (Ameko et al. 2012) shown the results of the survey that the sources of raw vegetables, modes of transportation from the source and storage before processing, as well as the modes of processing and sale, make raw mixed vegetable salads a potential source of food poisoning from microbial contamination when served alongside street-vendered cooked rice. According to the results of the microbiological study of raw mixed vegetable salads, 20% of the vendors had salads with microbial loads over 5 x 10^4 cfu/g (Log10 4.70 cfu/g) in the mornings, and this climbed to 80% of the vendors in the afternoons. Apart from polythene bags, all other containers (such as sacks, open trays, baskets, and wooden-sieve net cages) do not protect fresh vegetables from dust and other kinds of contamination during transportation from the source to the site of preparation.

The majority of RTE salads and RTE sprouts examined in this study had poor microbiological quality, and several contained NTM linked to sickness found in a study conducted by (Cerna-cortes et al. 2014). Because RTE-salads and RTE-sprouts do not require extra preparation before eating, pathogens that are part of their microflora may be present. causing a public health issue Vegetables can be transformed into bacteria such as Salmonella at any point during the process the process of food manufacturing. According to this study, it is also found that A total of 59% of RTE salads did not meet the 093 standard (21% from SPM and 38% from SVS, P= 0.001). FC was identified in 32% of samples, but only 8% of these exceeded the regulatory guideline's acceptable limit. Food samples should only include up to 5.17 log10 CFU per g (150,000 CFU/g) of AMB and up to 100 MPN/g of FC, according to the official 093 standard.

According to the results of the microbiological study conducted by (Ameko et al. 2012) of raw mixed vegetable salads, 20% of the vendors had salads with microbial loads over 5 x 10^4 cfu/g (Log10 4.70 cfu/g) in the mornings, and this climbed to 80% of the vendors in the afternoons. Eventually 90 out of 100 questionnaires were delivered at random to potential clients. 81 percent of customers stated they had never had diarrhoea after eating salad with cooked rice, and 81 percent said they bought salad with cooked rice on a regular basis; 13 percent thought raw vegetable salads were healthy, 67 percent unwholesome, and 10% were unsure.

This is due to the fact that the salads retain enough moisture to encourage microbial development, and the natural protective layer on the leaves against microorganism invasion may have been removed during harvesting, storage, transportation, and processing. (Samarajeewa et al. 2005).

3.2.4 Dairy & Meat:

In the food sector, the dairy products business is moving toward safe milk and products. Food-borne illnesses, food poisoning, and zoonosis are all risks that raw milk and fresh dairy products pose to consumers' health and nutrition, according to public health surveillance. Bacterial germs of significant public health concern, such as coli-forms, particularly *Salmonella* and *Escherichia coli (E. coli),* have been discovered in the gastrointestinal tracts of numerous domestic animals, including chickens, as part of the natural flora (Mpundu et al. 2019).

However, due to a lack of stringent sanitary procedures, most chicken is infected throughout the production process, from primary to secondary to final product. (Allen et al. 2007). Salmonella and E. coli are common causes of acute and chronic food poisoning in poultry and people across the world (Panisello et al. 2002). Salmonella infections can also be obtained via untreated raw milk or untreated water, although poultry meat intake, particularly fresh chicken meat, remains the most common cause of infection. (Heuvelink et al. 2009) ;(Abe et al. 2008)

A univariate analysis revealed that a high daily dressing frequency was related to contamination level ($p < 0.001$), as well as the availability of hand washing soap in the abattoir ($p < 0.001$), the source of water ($p < 0.001$), a lack of training on chicken handling ($p < 0.001$), the lack of inspection of dressed chickens ($p < 0.001$), and the daily frequency of general abattoir inspections ($p < 0.001$) (Mpundu et al. 2019).

It is found in an investigation, the presence of coliforms in these yoghurt brands is of serious public concern because of the health implications for yoghurt consumers (Mbaeyi-Nwaoha et al., 2012). They reported that E. coli and coliforms must not be detectable in any 100 ml of yoghurt sample, according to the standard set by the National Agency of Food and Drug Administration Control (NAFDAC) (Mbaeyi-Nwaoha et al. 2012). Also, some strains of this bacterium species have been linked to food poisoning, osteomyelitis, bronchopneumonia, and septicemia, all of which are serious diseases (Arora et al. 2012).

4. Prevalence and Emergence of Antimicrobial Resistance in food contaminating bacteria

4.1 National Perspective:

4.1.1 Prevalence:

The country is now dealing with an increase in the prevalence of food-borne infections (Hossain & Dey, 2019). The presence of microbiological contamination such as E. coli, *Salmonella* spp., Vibrio spp., Listeria spp., and Shigella spp. showed the risk of consumers contracting enteric infections (Rahman & Noor, 2012).

Studies recommend that the expanded danger of death in more established grown-up patients hospitalized with *Salmonella* or Campylobacter disease might be because of the rising prevalence of comorbidities (Behravesh et al., 2011).

According to (F. Rahman & Noor, 2012), the prevalence of Staphylococci (2×10^5 to 5.95×10^7 cfu/g) in almost all of the salad results demonstrated that these raw vegetables provide a health concern. However, the presence of coliform microscopic organisms additionally demonstrates possible fecal defilement, and the prevalence of fecal coliform was recorded as about 33% in this investigation where, fecal contamination was identified in five examples (Faruque et al., 2019). The fecal coliform test revealed that 7 of the 15 non-*E. coli* coliform isolates are fecal (46.7%) (Naratama & Santoso, 2020)

An investigation run by (Biswas et al., 2010) shows that *E. coli* was found in 90.90 % of vegetable-based RTE meals. All those other RTE samples of fish, meat, and cereals were substantially infected with *E. coli* at 71.42 %, 70%, and 68.18 %, respectively. In this work, high yield genomic DNA was isolated from two *E. coli* specimens. Two DNA samples had A260 values of 1.8199 and 1.7968. The A260/A280 ratio was 1.943 in one case and 1.86 in the other. The majority of digested DNA fragments were 300 to 3000 bp in size.

In addition, Coliforms and *E. coli* were found in 70.84 % and 83.33 % of RTE foodstuffs sold on the street, respectively.(Muhammad et al., 2015). Where, the general prevalence of *E. coli* was found in 37.86 % of foods, 29.63% of milk, 49.02% of chicken meat, and 70% of beef, according to cultural, staining, and biochemical attributes (M. A. Rahman et al., 2018)

Research (Sufia Islam et al., 2015)has shown, *Salmonella* spp (50 %), *E. coli* (46 %), *Shigella spp* (20%), and *Vibrio spp* (2%) were among the bacteria found in the food samples using culture and biochemical analysis methods. When tested serologically, therefore, the one potential Vibrio isolate and all of the potential *Salmonella* isolates were negative*. S. flexneri* X-variant and *S. flexneri* 2a were found in just two samples. A PCR-based test confirms the existence of the EAEC gene in singara, cake, and buttered bun (13%) and the ETEC gene in lemon juice among the 23 *E. coli* isolates (4%). *E. coli* and Shigella spp. were found in 12 % of food samples from street food vendors, but neither *Salmonella* nor Vibrio spp. Only 4/23 (17%) isolates tested positive for pathogenic *E. coli*.

In an investigation, it was found that, in 83.33 % (25 out of 30) and 80% (24 out of 24) of the total samples, *E. coli* and *Salmonella* spp. were detected, respectively. In 13.33 and 10% of the samples, the amounts of Enterobacteriaceae *E. coli* were higher than permissible limits.(Hossain & Dey, 2019).

Also, according to (Tabashsum et al., 2013), 23 *Bacillus spp*. were isolated from 33 street food samples, and API 50 CHB recognized 12 of them as Bacillus spp. *Bacillus atrophaeus*, *Bacillus globigii,* and *Bacillus licheniformis* were detected as the isolates. Across the research, no *B. cereus* strains were found. From 39 street food specimens, 15 Pseudomonas spp. were recovered. 24 Lactic acid fermenting bacteria (LAB) were confined from 39 food samples. Various types of LAB distinguished utilizing API 50 CHL included *Lactobacillus Brevis, L. pentosus, L. plantarum, L. collinoides, L. salivarius, Lactococcus lactis, L. raffinolactis, Weissella confusa, Pediococcus pentosaceus, Leuconostoc mesenteroiode* In this examination, higher than the ICMSF suggested (under 10^6 CFU/g) levels of vigorous bacterial populaces and coliform bacterial (under 11 CFU/g) populaces were seen in the greater part of the samples tried.

(Hena et al., 2008) founds that, *Vibrio sp.* 43.75 % and *Salmonella* sp. 25% were the most often isolated bacteria, appearing in virtually all samples, trailed by Flavobacterium sp. 12.5%, Shigella sp. 12.5%, and *Staphylococcus aureus* 6.25 %. Moreover*, E coli* was found in **53%** of the samples in this investigation, which is a substantial cause for worry along with *Salmonella* spp. was detected 26.7 % in this research, compared to 15.39 % in prior investigations.(Faruque et al., 2019)

The prevalence of *Salmonella* was 7.89 % of 124 samples and fecal contamination was an issue of frustration. 7 examples of juices (7.89%) showed the presence of coagulase-positive *Staphylococcus aureus*, the presence of this microorganism in juices demonstrates extreme pollution due to improper handling (M. S. U. Ahmed et al., 1970). In 64.91 % of the samples, *Bacillus cereus* was found. *Streptococcus* was also found in 5.26 percent of the juice samples. Total fungus counts are also greater, with values ranging from 1.0×10^1 to 8.05×10^4 cfu/ml.(M. S. U. Ahmed et al., 1970). During the 10 years, 552 fatalities (or.5% of all cases) were documented (Behravesh et al., 2011). The number of case-patients who died as a result of *Salmonella* infection was 4 times greater than that in individuals infected with *Campylobacter* and 61 pregnant women were found to have listeriosis, which was verified in the lab (Behravesh et al., 2011).

Table 6: List of the prevalence of various bacteria responsible for food contamination:

Organisms	Food	Prevenance	References
E. coli	RTE Food	83.33%	(Hossain & Dey, 2019)
		37.86%	(M. A. Rahman et al., 2018)
		46%	(Sufia Islam et al., 2015)
		63.18%	(Biswas et al., 2010)
		83.33%	(Muhammad et al., 2015)
		53%	(Faruque et al., 2019)
	Milk	29.63%	(M. A. Rahman et al., 2018)
	Vegetable	90.90%	(Biswas et al., 2010)
	Fish	71.42%	(Biswas et al., 2010)
	Chicken Meat	70%	(Biswas et al., 2010)
		49.02%	(M. A. Rahman et al., 2018)
	Beef	70%	(M. A. Rahman et al., 2018)
Pathogenic E. coli	RTE Food	17%	(Sufia Islam et al., 2015)
EAEC	Buttered Bun	13%	(Sufia Islam et al., 2015)
ETEC	Juice	4%	(Sufia Islam et al., 2015)
Salmonella	RTE food	50%	(Sufia Islam et al., 2015)
		80%	(Hossain & Dey, 2019)
	Shrimp	25%	(Hena et al., 2008)

	Juice	7.89%	(M. S. U. Ahmed et al., 1970)
	Broiler Meat	26.7%	(Faruque et al., 2019)
Staphylococcus aureus	Shrimp	6.25%	(Hena et al., 2008)
	Juice	7.89%	(M. S. U. Ahmed et al., 1970)
Shigella Spp.	RTE Food	20%	(Sufia Islam et al., 2015)
		12%	(Sufia Islam et al., 2015)
	Shrimp	12.5%	(Hena et al., 2008)
Vibrio Spp.	RTE Food	2%	(Sufia Islam et al., 2015)
	Shrimp	43.75%	(Hena et al., 2008)
Bacillus cereus	Juice	64.91	(M. S. U. Ahmed et al., 1970)
Streptococcus	Juice	5.26%	(M. S. U. Ahmed et al., 1970)
Flavobacterium spp.	shrimp	12.5%	(Hena et al., 2008)
Coliforms	RTE Food	70.84%	(Muhammad et al., 2015)
Fecal Coliform	Broiler Meat	33%	(Faruque et al., 2019)
	RTE Food	46.7%	(Naratama & Santoso, 2020)

4.1.2 Antimicrobial Resistance:

Antibiotic resistance has now emerged as one of the most serious threats to world health and food security. Antibiotic resistance in some cases happens normally naturally, although it is most commonly caused through antibiotic overuse in living creatures(Sanderson et al., 2016);(Diehl & LaPara, 2010); (Dodd, 2012). Antibiotic resistance develops when the microorganisms alter their reaction towards antibiotics and the treatment no longer works as it should (Shahid, 2019).
Food is likewise a significant factor in the spread of antimicrobial resistance. Such exchange can happen through deposits of antibiotic agents in food like poultry meat, through the exchange of resistant food-borne microbes, or through the ingestion of safe strains of the original food microflora and resistance move to pathogenic microorganisms (J. R. Johnson et al., 2007)(Pesavento et al., 2007)

Antimicrobial resistance has been observed to be on the rise among enteropathogens, particularly E. coli, in past years, occasionally resulting in point-break circumstances when no antibiotic treatment choices exist (Laupland & Pat, n.d.) (Lynch et al., 2013) Antibacterial resistance testing indicated that the majority of the isolates are resistant to amoxicillin (64%) but susceptible to ciprofloxacin (76%), azithromycin (72%), sulfamethoxazol (84%), and gentamycin (56%), respectively (Hassan et al., 2018). *E. coli* isolates of chicken flesh were exceptionally resistant to oxytetracycline (92%) trailed by sulphonamide-trimethoprim (84%), Amoxycillin (76%), erythromycin (60%). Also, Ciprofloxacin and gentamicin (100%) in beef samples were significantly resistant trailed by erythromycin (86%) and oxytetracycline (71%) (M. A. Rahman et al., 2018).

A study conducted by (Banik et al., 2018) shows that the multi-drug resistance profile of possible food-borne pathogens is concerning. *Salmonella* spp. had the greatest rate of resistance to tetracycline, vancomycin, penicillin, and streptomycin (100%), trailed by rifampicin (95%), meropenem (80%), and azithromycin (75%). Some other isolates, Campylobacter spp. and S. aureus, were discovered to be susceptible to nalidixic acid, with 15% and 10% resistance respectively, while the most elevated susceptibility was found against Imipenem (80%). Meropenem (60%), azithromycin (45%), streptomycin, and ciprofloxacin (both were 40%) sensitivity was moderate in the most powerful fecal coliform E. coli. Furthermore, nalidixic acid, vancomycin, penicillin, and tetracycline were ineffective against E. coli, which had a 100% resistance rate. Tetracycline (100%) and streptomycin, penicillin, and vancomycin resistance were found in Klebsiella spp.

Into the bargain, Antibiotic sensitivity patterns indicated that Pseudomonas spp. isolates were resistant to numerous antibiotics (min 10 and max14 antibiotics), whilst Enterococcus isolates were not resistant to any of the 16 antibiotics tested. Antibiotic sensitivity patterns indicated that *E. coli* O157, *Salmonella Listeria spp.*, and *Yersinia spp.* isolates were resistant to several drugs (min 4 and max 12 antibiotics). Multiple antibiotics were resistant to LAB strains (min 9 and max 16 antibiotics (Tabashsum et al., 2013).

In another investigation (Faruque et al., 2019), *E. coli* showed exceptional resistance from Ampicillin (80%) and Amoxicillin (70%). Where Nalidixic acid and Erythromycin resistance were found in 40% of the cases. About 90% *of E. coli* showed susceptibility to Ciprofloxacin, 80% to Gentamicin, 60% to Tetracycline, and 50% to Norfloxacin. *Salmonella* spp. demonstrated 100% resistance from Ampicillin, 90% from Amoxicillin, and profoundly sensitive to Ciprofloxacin (80%). About half were resistant to Nalidixic Acid and Norfloxacin though susceptible to Erythromycin (60%) and Gentamicin (50%). Methanolic and ethanolic plant extracts (both 30% and 40%) had strong antibacterial activity against E. coli. Methanolic and ethanolic extracts had average zones of inhibition of 13 and 14.33, correspondingly, where 40% ethanolic plant remove extract was more intense than the 30%. Against isolated *Salmonella* spp., no inhibitory zone was produced.

Besides, Rifampin and Tetracycline resistance was 100% in *E. coli* isolated from crude milk, likewise 50% resistance to Nalidixic Acid, but 100% sensitivity to Imipenem; Isolates of Klebsiella spp. showed 100% susceptibility to Imipenem and strong resistance to Tetracycline, Nalidixic Acid, and Rifampin. Whereas, Staphylococcus spp. secluded from crude milk showed 100% resistance against Rifampin and Nalidixic Acid but 100% sensitivity to Gentamicin, Chloramphenicol, Imipenem, Kanamycin, and Ciprofloxacin (Uddin et al., 1970).

In addition (Malek et al., 2016) have shown that all of the pathogenic isolates in this research had a multidrug resistance (MDR) phenotype. Apart from imipenem, *Vibrio spp*. and *Pseudomonas spp*. isolates were considered to be significantly resistant (88.88 %) to all antibiotics tested. Eight antibiotics were discovered to be resistant in *Staphylococcus aureus* isolates, whereas ciprofloxacin, gentamicin, and imipenem were shown to be susceptible. Imipenem, gentamicin, erythromycin, and chloramphenicol were discovered to be sensitive to *Klebsiella spp*. Where else, Amikacin sensitivity was high in all *E. coli* isolates. Gentamicin (100% sensitivity), ciprofloxacin, neomycin, azithromycin, oxytetracycline, and erythromycin were all hyper delicate to *E. coli* isolates from milk samples (M. A. Rahman et al., 2018). However, they were resistant to amoxicillin (50%) and sulphonamide-trimethoprim (47%) as well as doxycycline (44%) (M. A. Rahman et al., 2018)

Interestingly, numerous researchers have found a solid link between antimicrobial usage (AMU) in animals and the high prevalence of antimicrobial resistance (AMR) (Aidara-Kane, 2012; Marshall & Levy, 2011). For centuries, colistin (polymyxin E) has been utilized to treat, prevent diseases, and promote growth in food animals all throughout the globe (Catry et al., 2015; Poirel et al., 2017; Rhouma et al., 2016).

In the research led by (Salequl Islam et al., 2020), mcr-1 gene was found in almost one-third of the isolates from poultry chicken feces. In bacteria from both poultry and local chicken feces, the carriage of mcr-2 variations was observed to be substantially lower (3–4%). Certain mcr-1 and mcr-2 co-occurrences were also discovered. The presence of mcr-3, mcr-4, and mcr-5 was not observed in any of the isolates. PCR technique was used to test the colistin resistance genes mcr-1 to mcr-5 in 149 chicken isolates. The mcr-

1 and mcr-2 genes were found in 43 (28.9%) and 5 (3.4%) of isolates from a mixture of poultry and local chicken excrement, accordingly. mcr-1 was detected in 36.4 % of poultry bacteria (36/99) and 20% of local chicken isolates (10/50), respectively. Colistin sulphate was found to be used by 12 poultry farms (60 percent, 12/20) for therapeutic or growth enhancement. One batch of domestic hens (20 percent, 1/50) had a record of colistin use. The 12 farms exposed to colistin generated 71 isolates, 33 of which were mcr-positive (46.5 percent). The rest non-exposed hens' feces, on the other hand, revealed 16.7% mcr-carrying isolates (13/78). As a result, colistin-exposed bacteria had a significantly greater concentration of mcr ($p<0.001$). Furthermore, the calculated MIC values for all mcr-positive isolates ranged from >16 to >128 g/mL, confirming the link between mcr genes and colistin resistance. Compared to PFs chickens, local chickens were less likely to use colistin as a therapy or growth enhancer This study identified mcr-bearing colistin-resistant enteric bacteria in 5 Bangladeshi districts, and the findings are predicted to be generalizable to the rest domain of the country.

4.2 Global Perspective:

4.2.1 Prevalence:

The world is now negotiated with high prevalence of food-borne infections. The presence of microbiological contamination such as *E. coli, Salmonella spp., Vibrio spp., Listeria spp., Shigella spp., S. enteritidis, S. typhimurium, Enterobacter sp., Klebsiella sp., Pseudomonas sp.,* etc. indicated a risk of enteric illnesses in consumers.

Moreover, the multiplex PCR findings revealed that *Salmonella spp*. were found in 49 of 121 RTE food samples (40.4 percent), with 34 (69.39 percent) being identified as *S. enteritidis* and 15 (30.61 percent) being identified as *S. typhimurium* (Raza et al.2021).

According to a study (Were et al. 2020), based on the enumeration of total coliforms, *E. coli*, and *Salmonella spp*. in this investigation, the overall occurrence of food contamination was 41.7 percent (Derbew et al. 2013). Also, *Enterobacter sp*. was found in the largest percentage of samples (28.8%), followed by *Escherichia coli* (13.6%) and *Klebsiella sp* (10.6 percent). However, minor percentages of *Salmonella paratyphi* (1.5 percent), *Micrococcus* (3.0%), and *Bacillus spp*. (3.0%) were found. (Das et al. 2011).

However, the presence of *Salmonella sp*. was found in 36.6% (n =11) of the 30 samples examined in another study (Chesca et al. 2020). The legal requirement for positive coagulase Staphylococcus is $1.0x10^3$

CFU / g, and according to the findings, 46.6% (n =14) of the samples evaluated had this microbe present in excess of the permissible standards. (Chesca et al. 2020). The results obtained acquire a relevant and concerning role, because in addition to being a group of bacteria that indicates unhygienic food manipulation, it is responsible for several pathologies of clinical and epidemiological importance, as it resides in the nasopharynx, mouth, intestinal tract, and several areas of the skin, commonly characterized as asymptomatic carriers (Guerreiro, et al.).

In the mornings, *Pseudomonas, S. typhi*, and *S. faecalis* were identified more frequently in salads than in the afternoons, but *Shigella sp*. contamination was found at the same frequency in both mornings and afternoons. In the mornings, *Pseudomonas* was identified in 6.7 percent of the samples and in the afternoons, it was found in 20% of the samples. *S. typhi* was found in 33.3 percent of morning samples and 66.6 percent of afternoon samples, respectively. *S. faecalis* contamination was found in 80 percent of morning samples and 93.3 percent of afternoon samples, respectively. *S. faecalis and Shigella sp.* were found in more samples than the other isolates. (Ameko et al. 2012).

An investigation (Bereda et al. 2016) discovered that harmful germs were present in 95 percent of the meals. *E. coli* 68 (51.5%), *S. aureus* 85 (64.4%), and 26 (19.7%) *Salmonella spp*. were recovered from the foods tested. *Enterobacteriaceae* (22.1%) dominated the aerobic mesophilic bacterial flora of street vended foods, followed by *Staphylococcus* (18.4 percent), *Pseudomonas spp.* (11.4 %), and *Bacillus* (11.2%). *Micrococcus* (10.6 %), gram negative *coccus* (8.9 %), *Streptococcus* (7.2 %), and other gram-negative rods (4.95 %) were. *Lactobacillus* (6%) and *Enterococcus* (4.2%) were also among the most common aerobic mesophilic bacteria in the four food categories studied.

Another study run by (Brooks et al. 2014) shows that, 18 of the 20 street food samples tested (90 %) were contaminated with bacteria of various types. *E. coli* was found in 40% of the contaminated samples, whereas *Staphylococcus aureus* and *Bacillus cereus* were found in 55% and 35% of the samples, respectively.

However, in a different study (Dona et al. 2019) indicated that, *Enterobacteriaceae* and *E. coli*, both hygiene indicator microorganisms, were found in 41.6 and 25 % of the samples, respectively, whereas *B. cereus, C. perfringens*, yeasts, and molds were found in 54.2, 45.8, 54.2, and 58.3 % of the samples, respectively. *Enterobacteriaceae* are utilized as markers of hygiene conditions and food contamination following heat treatment because of their thermo-sensitivity. (Health Protection Agency (2009). It's possible that their existence in grilled pork is due to insufficient heat treatment and/or a lack of sanitation after cooking (Dona et al. 2019). *E. coli*, on the other hand, is a good sign of fecal contamination. As a result, samples that tested positive for this bacterium were most likely exposed to human or animal feces as a result of improper handling after cooking. (Cerna-cortes et al. 2012).

According to (Dona et al. 2019) findings, 12.5% of grilled pork samples (*C. perfringens*) to 21% (*Enterobacteriaceae* and *E. coli*) were unfit for human consumption. In the seasoning condiments, *B. cereus*, *C. perfringens*, yeast, and molds were found with loads of 2.5±1.5, 1.8±1.3, 1.9±1.4, and 1.8±1.1 Log10 CFU g^{-1}, respectively.

Candida guilliermondii, a yeast, and the bacteria *Corynebacterium jeikeium, Psychrobacter phenylpyruvicus,* and *peptostreptococcus tetradius*, among others, were found in the RapID data found in a study by (Lenetha et al. 2019). Moreover, all of these bacteria are prevalent on human skin and could have been introduced to the meat by food handlers' hands because no one was wearing gloves during the food preparation and serving. The meat samples from the three sites were likewise found to contain *Staphylococcus aureus* (Thaba Nchu, Botshabelo and Bloemfontein). Also, Prevotella bivia, a bacterium common in the vaginal system, was also discovered in Thaba Nchu's meat sample. This data suggests that food handlers do not wash their hands after going to the restroom.

When comparing carrot and onion samples, the percentage of contamination with foodborne pathogens was found to be higher in carrots. Microbiological investigation of salads revealed *E. coli* contamination in carrot (98.1%) and onion (75.5%) samples. *Salmonella* was found in 60% of the carrot samples and 34% of the onion samples, respectively. (Sabbithi et al. 2017). Also, Improper chopping board maintenance was strongly linked to *Salmonella spp.* and *Yersinia spp*. infection, whereas an untidy wiping cloth was strongly linked to *S. aureus* contamination. (Sabbithi et al. 2017). In addition, *E. coli* contamination was linked to peeled fruits (particularly sapota) maintained in a container without a lid ($p<0.085$); those serving dusting non-disposable serving glasses ($p<0.072$); and not cleaning the blender after use ($p<0.092$). (Sabbithi et al. 201).

Furthermore, in 12.5 %, 2.5 %, and 22.5% of street samples, respectively, *B. cereus, S. aureus,* and *E. coli* were found*. E. coli* and *B. cereus* infection rates were 22.5 % and 12.5%, respectively. Only one sample (3logCFU/g) (2.5 %) contained S. aureus, implying that recontamination of food by this bacterium after cooking is uncommon. Various bacterial isolates were identified as *Escherichia coli, Klebsiella sp.,* and *Streptococcus faecalis* based on growth on selective and differential medium and biochemical assays & the presence of Pseudomonas sp. in the food samples suggested that these street-vendered items were unsanitary (Arijit et al. 2010).

The presence of coagulase is a sign that something is wrong. The presence of Staphylococcus aureus in the chaats (Fig. 4) with a count of $0.01\text{-}0.8\text{x}10^4$ cfu g^{-1} could be explained by the fact that it is a component of the normal microflora found on/in various regions of the human body (Nester et al. 2001). As well as *Bacillus cereus*, a mesophilic spore-former, is important in food because it produces heat-sensitive (diarrheal) and heat-stable (emetic) toxins that cause food poisoning (Bryan et al. 1992).

According to another study (Adigun et al. 2020), in carcasses, the total prevalence of NSAS and *S. aureus* was 64.2% and 11.9% ($p<0.0001$), respectively, with NSAS being discovered more frequently than *S. aureus* in samples from outlets. Furthermore, NSAS and *S. aureus* were found in 87.2% and 17.0% of all outlet-associated poultry carcasses, respectively, and the difference was significant ($p<0.00001$). In the carcass drip, the prevalence of NSAS and *S. aureus* was 41.1% and 31.1 percent, respectively (p 5<0.07; Table 2). The prevalence of NSAS (p 5<0.0002) and *S. aureus* (p 5<0.0001) differed significantly across the six townships. Coliforms and aerobic bacteria were found in 61.6% and 85.4% of all rinse water samples, respectively, with statistically significant variations between locations ($p<0.05$). While 68.1% of the outlets' rinse water samples tested positive for coliform bacteria, 87.2% tested positive for aerobic bacteria (p5<0.03). In both the carcass swab and the carcass drip, the prevalence of NSAS was higher than that of *S. aureus.*

According to the findings of (Alemu et al. 2018), 169 (48.7%) of the vegetable samples were infected with germs. Cabbage was the most commonly infected vegetable (69, 71.9%), followed by carrots (69, 71.9%). (35, 56.5 percent). There were four bacterium species found, with E. coli being the most common bacterial contamination of vegetables (109, 31.4 percent). Further binary logistic regression analysis revealed that tomato was 2.244 times more likely than green pepper to be contaminated with bacteria (AOR: 2.244; 95

percent CI 1.112, 4.529). Cabbage, on the other hand, has a 73.5 percent lower chance of being infected (AOR: 0.265; 95 percent CI 0.133, 0.529). *E. coli* is a fecal coliform bacterium that is commonly discharged in feces and is readily apparent in environments where open defecation is widespread (like Ethiopia). It has been analyzed elements that contribute to or prevent bacterial contamination of vegetables for the first time, most likely for the first time. When compared to green pepper, tomatoes were 2.244 times more likely to be contaminated with bacteria, while cabbage was 73.5 percent less likely to be contaminated. (Alemu et al. 2018).

A study recommends that (Oruese et al. 2013), *Salmonella spp.* were found in 6 (42.9 %) of the fourteen samples analyzed, while *Escherichia coli* were found in 12 (85.7 %). *Salmonella spp.* were found in 50.0 % of cabbage and 50.0 % of lettuce, respectively, whereas *Escherichia coli* were found in 79.6 % and 20.4 % of cabbage and lettuce, respectively. *Escherichia coli* (77.1%) was found to be the most common bacteria, followed by *Salmonella spp*. (22.9%) and other microbes identified from vegetable samples. Because *Salmonella spp.* and *Escherichia coli* are all enterotoxigenic and cause gastroenteritis, their separation from cabbage and lettuce constitutes a food safety concern. The presence of *E. coli* in this investigation indicated a lack of sanitary standards in the processing of these salad veggies, or contamination during harvest.

To Prevalence of *Listeria monocytogenes* and Salmonella in Ready-to-Eat Food like as frozen & cooked foods, *Salmonella serotypes*, on the other hand, were isolated from 12 (0.9 percent) of the 1,379 samples examined. They were found in 1 (1.5%) of the 65 frozen chicken croquette samples studied, 1 (2%) of the 53 cooked ham samples, 9 (11.1%) of the 81 cured dried pork sausage samples, and 1 (1.2%) of the 84 smoked salmon samples (Cabedo et al. 2008).

Different prevalence rates have been established in various countries; Salmonella prevalence rates as high as 70% have been reported in Portugal (Bajaj et al. 2003). *E. coli*, like Salmonella, is a bacterium that thrives in both people and animals' intestines. It's generally employed as a marker for fecal contamination, which comes primarily from human fecal contamination of water or food (Mpundu et al. 2019). A wide range of plant and animal items, particularly poultry, are possible sources of *E. coli* infection (Mpundu et al. 2019).

4.2.2 Antimicrobial Resistance:

Antimicrobial resistance (AMR) has emerged as one of the most serious public health issues of the twenty-first century, posing a threat to the effective prevention and treatment of an ever-widening range of infections caused by bacteria, parasites, viruses, and fungi that are no longer susceptible to common antibiotics (Prestinaci et al. 2015). Food has an important role in the spread of antimicrobial resistance.

According to a study (Yu et al. 2020), More than 82.34 percent of the isolates were resistant to most b-lactam antibiotics, although CTT and imipenem (IPM) resistance was only 13.59 percent (50/368) and 0.27 percent (1/368), respectively. All detected B. cereus strains were classified as MDR strains according to the criteria of multidrug resistance (Magiorakos et al., 2012), and > 98.91 percent of the isolates were resistant to five or more antimicrobials.

In another research conducted by (Das et al. 2011), to introduce four essential oils (Clove, Cinnamon, Turmeric leaf, and Japanese mint) directly to the liquid and solid parts of Panipuri, an experiment was designed to study the antibacterial efficacy of four essential oils (Clove, Cinnamon, Turmeric leaf, and Japanese mint) that showed relatively better antibacterial activities (on the basis of the preliminary screening). Except for *Micrococcus tetragens* and *Salmonella paratyphi*, all isolates were susceptible to gatifloxacin, polymixin B, norfloxacin, tetracycline, and erythromycin. Polymixin B was the sole antigen that *Micrococcus tetragens* was sensitive to. All of the microorganisms were carbenicillin and ampicillin resistant.

Moreover, the percentage of isolates in the MRI ranged from 15.4 to 92.3%. *Salmonella paratyphi* (72.4), *Shigella dysenteriae* (57.1), and *Bacillus sp*. had the highest MRI percent (92.3), followed by *Micrococcus tetragens* (72.4), *Salmonella paratyphi*(72.4), *Shigella dysenteriae*(57.1), and *Bacillus sp* (50.0).The bacteria Escherichia coli(15.4) had the lowest MRI percent, indicating its resistance to antibiotics.

However, during the main screening of essential oils using the disc diffusion method, it was discovered that *Arizona sp., Bacillus sp., Enterococcus sp., Staphylococcus sp.,* and *Vibrio sp*. all showed 100% susceptibility to the various essential oils. Consequently antibacterial efficacy of essential oils (Turmeric leaf, Japanese mint, Clove, and Cinnamon) in varying concentrations revealed that all of these oils were able to kill the pathogens of the liquid khatta pani within 24–72 h of incubation at a concentration of 125 l/10 ml as well as 250 l/10 ml irrespective of Set No. 1(sterilized samples inoculated with 40 l of bacterial consortia) and 2 (pathogen-containing unsterilized samples) (Das et al. 2011).

Besides, All *S. enteritidis* isolates (34/34) were erythromycin and chloramphenicol resistant, while all *S. typhimurium* isolates were erythromycin resistant. Amoxicillin resistance was also found in *S. typhimurium* and *S. enteritidis* (Raza et al. 2021). In addition to, Kanamycin sensitivity was found in all *S. typhimurium* isolates, while only one sample of *S. enteritidis* was resistant to t,he antibiotic (25/34, 73.53 percent). (Raza et al. 2021).

5. Conclusion:

Pathogenic microorganisms are predominant in the climate and food chains in worldwide including Bangladesh due to climatic and socioeconomic conditions. All provided food should, in theory, be devoid of any microbial infections.

RTE meals should be prepared using Good Hygienic Techniques, and storage practices should be established to reduce microbial contamination of food that is widely consumed. To improve food safety, it is also advised that an adequate hazard analysis critical control point (HACCP) approach should be developed, as well as closer supervision of RTE food by relevant authorities, should be performed.

For instance, the Consumers Association of Bangladesh (CAB), VOCTA (customer), which has directed road food reviews and coordinated mindfulness, campaigns through conventions, courses, workshops, and strategy promotion. The electronic and print media are likewise associated with giving public consciousness of safe road food sources. It is significant not to fail to remember that the road food sources comprise a highly diverse area and the intercessions should be painstakingly arranged by keeping various viewpoints like gender, auxiliary crowd, and neighborhood customs into thought.

Some street food samples have alarmingly high amounts of multidrug-resistant (MDR) bacteria. This is a major worry for human wellbeing and the administrative organizations should take the required steps to enhance the sanitation of street food. From an investigation, it was found that, because of their edibility and nontoxic nature, as well as antioxidant and powerful antibacterial characteristics, some essential oils could be employed in food items as antibacterial agents and natural food preservatives (M. Das et al., 2012).

Also, Sellers should be supplied with Fundamental administrations to guarantee the safety of their goods (World Health Organization, 1996). Malaysia is the only country in the world that provides certified street sellers with accommodations to perform their business (Rane, 2011). Significant public and global specialists should approach to figure explicit laws, enactments, and rules for working road food distributing in the nation, and to bring all road food merchants under inclusion of these guidelines straight away.

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Furthermore, the poultry industry's healthy development is under threat due to the rising density of poultry farms and infectious illnesses in poultry caused by harmful microorganisms. Hence, utilization of clean estimations seems, by all accounts, to be critical to lessen the bacterial contamination subsequent to the handling of meat.

As several strains become resistant to conventional antibiotics, careful antibiotic usage should be addressed in broiler production. *Azadirachta indica* leaf extract has strong antibacterial action against E. coli. It is suggested that the bioactive chemicals responsible for this antibacterial action be isolated and separated and that medicinal plants be used to reduce bacterial contamination in broiler meat (Faruque et al., 2019).

It is necessary to be extra cautious when consuming water that has not been adequately filtered, and sanitation procedures should be emphasized in order to limit the number of other bacteria that might cause contamination. Maintaining pipes, inspecting all water transporters on a regular basis, and, most notably, creating general awareness among citizens seems to be efficient options. Government organizations like Bangladesh Council of Scientific and Industrial Research (BCSIR) and Bangladesh Standard and Testing Institution (BSTI) should embrace measures to instruct the merchants about sanitation and sterile practices and uphold satisfactory rules for juices particularly newly prepared juices, which currently lack such norms and protocols.

Moreover, powder milk is devoured fundamentally by youngsters in Bangladesh, in this way, a Standard Sanitation Operating Procedure (SSOP) ought to be kept up with, which is an essential program of Hazard Analysis and Critical Control Point (HACCP), to limit the danger of contamination.
Raw milk ought to be purified so that milk stays liberated from pathogenic microorganisms. It's important to keep the fridge at the right temperature. Successive utilization of antibiotics ought to be halted as antibiotic-resistant bacteria are ceaselessly expanding. To decrease the danger of pollution on the farm and in the milk processing facility, good hygiene practices (GHP) are required during milking and ensuing milk handling.

For the time span, however, further in-depth research is direly required. Food-borne infection is a serious public health issue that needs immediate action. If combined with PCR, RFLP pattern analysis might be beneficial for the molecular identification of harmful organisms in various species. It is suggested that the capabilities in research laboratories should be set up to undertake complex studies related to molecular techniques used to recognize and distinguish foodborne pathogens (Noor et al., 2015).

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