Occurrence of food-borne diseases among patients presenting at a health facility in the O.R. Tambo District, Eastern Cape Province, South Africa

By

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DECLARATION

I **NANDISA NONOPA NDLAME** declare that ‘Occurrence of food-borne diseases among patients presenting at a health facility in the O.R. Tambo District, Eastern Cape Province, South Africa’ is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

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ABSTRACT

Outbreaks of food-borne disease (FBDs) are frequent in South Africa. However, although notifiable, they are poorly investigated and not often reported. Consequently, there is limited understanding of the burden of FBDs within the rural areas of South Africa. The aim of this study was to investigate the occurrence of FBDs among patients patronising a government facility in the Eastern Cape province for the period 2016 – 2020. A cross-sectional study design using retrospective quantitative data was adopted for this study. All data of patients who were treated for FBD-related illnesses over the study period were included in the study. Data was analysed using descriptive statistics and multivariate analysis. The Statistical Package STATA (Stata/MP 18) was used to analyse the data. Significance was assessed at $P < 0.05$. Most cases of FBDs were caused by consuming meat from cattle that had been injected with medicine (42%, n=176), followed by eating meat from dead cattle (26.25%, n= 110), cattle bitten by snakes (12.89%, n=54), chicken served at school (6.44%, n=27), and meat from dead sheep (4.30%, n= 18). A spike in the number of cases of FBDs was observed between January and June in 2016, 2018 and 2020. Throughout the study period except for 2017 and 2019, the lowest number of cases of FBDs was observed between July and December. Comorbidities like diabetes, TB, and HIV positive, plus pregnancy were associated with severe FBDs leading to increased probability of being admitted. The study highlighted the necessity for educating rural people about the dangers of food of animal origin and the role of comorbidities on the burden of FBDs on health care provision. Results reported here can guide policies that could help reduce the burden of FBDs on the health care system in rural South Africa. A one health approach that includes members of the veterinary team, medical personnel, local leaders and environmental health officers is needed to design and develop intervention strategies and education programmes.

Keywords: Food of animal origin, FBDs, food safety, burden of food borne diseases, medical records, hospital admission, health care system, rural South Africa, comorbidities, consumption of meat

OPSOMMING

Die uitbreking van voedsel-oordraagbare siektes kom algemeen in Suid-Afrika voor. Hoewel dit egter aanmeldbaar is, word die siektes nie genoegsaam ondersoek nie en ook dikwels nie gerapporteer nie. Gevolglik is daar ’n beperkte begrip van die las van voedsel oordraagbare siektes in die landelike gebiede van Suid-Afrika. Die doel van hierdie studie was om die voorkoms van voedsel-oordraagbare siektes onder pasiënte in ’n regeringsfasiliteit in die Oos-Kaap-provinsie vir die tydperk 2016 tot 2020 te ondersoek. ’n Deursneestudie-ontwerp met die gebruik van terugwerkende kwantitatiewe data is aangeneem vir hierdie studie. Alle data van pasiënte wat vir voedsel oordraagbaarverwante siektes oor die studietydperk behandel is, is ingesluit in die studie. Die meeste gevalle van voedsel oordraagbare siektes is veroorsaak deur die inname van vleis van vee wat deur medisyne ingespuit is (42%, n=176), gevolg deur die inname van die vleis van dooie vee (26.25%, n=110), vee wat deur slange gebyt is (12.89%, n=54), hoenders wat by skole bedien is (6.44%, n=27) en vleis van skape wat gevrek het (4.30%, n=18). Daar is tussen Januarie en Junie in 2016, 2018 en 2020 ’n styging waargeneem in die getal gevalle van voedsel-oordraagbare siektes. Dwarsdeur die studietydperk, behalwe vir 2017 en 2019, is die laagste getal gevalle van voedsel-oordraagbare siektes waargeneem tussen Julie en Desember. Siektetoestande soos diabetes, TB en HIV/Vigs is geassosieer met erge voedsel-oordraagbare siektes wat gelei het tot ’n styging in die waarskynlikheid om opgeneem te word. Die studie het die noodsaaklikheid beklemtoon om mense van die platteland op te voed oor die gevare van voedsel van diere-oorsprong en die rol van siektetoestande wat betref die druk van voedsel-oordraagbare siektes op gesondheidsorgvoorsiening. Die resultate wat hier gegee word kan beleide rig wat kan help om die druk van voedsel oordraagbare siektes op die gesondheidsorgstelsel in landelike Suid-Afrika te verminder. ’n Een gesondheidbenadering wat lede van die veeartsenyspan, mediese personeel, plaaslike leiers en omgewingsgesondheidsamptenare insluit, is nodig om ingrypingstrategieë en opvoedingsprogramme te ontwerp en te ontwikkel.

Sleutelwoorde: Voedsel van diere-oorsprong, voedsel-oordraagbare siektes, voedselveiligheid, druk van voedsel-oordraagbare siektes, mediese rekords, hospitaaltoelating, gesondheidsorgstelsel, landelike Suid-Afrika, komorbiditeite, verbruik van vleis.

ISISHWANKATHELO

Ukuqhambuka kwezifo ezithwalwa kukutya (FBDs) kuxhaphakile eMzantsi Afrika. Nangona kunjalo, noxa ziqapheleka, aziphandwa ngokwaneleyo kwaye akusoloko kunikwa ngxelo ngazo. Ngenxa yoko, kukho ukusilela kokuwuqonda umthwalo weeFBD kwiindawo ezisemaphandleni eMzantsi Afrika. Injongo yolu phando yaba kukuphonononga ukuvela kweeFBD phakathi kwezigulana eziquqa kwiziko likarhulumente kwiphondo leMpuma Koloni kwisithuba sonyaka ka2016 – 2020. Kolu phando kwakhethwa uyilo lophando olugxile kwindawo ethile kusetyenziswa iinkcukacha zophando/idatha zentyilobungakanani yeziganeko ezadlulayo. Zonke inkcukacha zezigulana ezanyangelwa izigulo ezinxulumene neFBD ngexesha lophando ziye zabandakanywa kolu phando. Iinkcukacha zophando zihlalutywe ngokusebenzisa iinkcukachamanani ezichazayo kunye nohlalutyo lwezinto ezininzi ezixubileyo (multivariate). Uninzi lweziganeko zeFBD zabangelwa kukutya inyama yeenkomo ezazitofwe ngeyeza (42%, n = 176), zilandelwe ziziganeko zokutya inyama yeenkomo ezifileyo (26.25%, n= 110), inyama yenkomo elunywe yinyoka (12.89%, n=54), inyama yenkuku ephakwa esikolweni (6.44%, n=27), nenyama yegusha ezifileyo (4.30%, n= 18). Ukunyuka kwamanani kwaqapheleka phakathi kwenyanga kaJanyuwari noJuni ngonyaka ka2016, 2018 no2020. Kulo lonke eli xesha lophando ngaphandle konyaka ka2017 no2019, kwaqatshelwa elona nani liphantsi leziganeko zeFBD phakathi kukaJulayi noDisemba. Izigulo ezihambelanayo (comorbidities) ezinjengeswekile, iTB neHIV kunye nokukhulelwa zaba zizo ezanxulunyaniswa neFBD enobungozi nto leyo eyakhokelela ekwandeni kwamathuba okulaliswa. Olu phando lubalule imfuneko yokufundiswa kwabantu basemaphandleni ngobungozi bokutya okumvelaphi yako zizilwanyana kunye nenxaxheba yezigulo ezihambelanayokumthwalo weeFBD ekuhanjisweni kweenkozo zempilo. Iziphumo ezichazwe apha zingasisikhokelo kwimigaqonkqubo enokuncedisa ekunciphiseni umthwalo kwinkqubo yokukhathalelo lwezempilo kuMzantsi Afrika onendawo ezisemaphandleni. Indlela enye yezempilo ebandakanya amalungu eqela lonyango lwezilwanyana, abasebenzi kwezempilo, iinkokheli zokuhlala, amagosa ezempilo kwezokusingqongileyo iyafuneka ukuze iyile kwaye iphuhlise izicwangcisoqhinga zongenelelo neenkqubo zemfundo.

Isigama esingundoqo: ukutya okumvelaphi zizilwanyana, iziFo eziThwalwa kukuTya (FBDs), ukhuseleko lokutya, umthwalo wezifo ezithwalwa kukutya, iirekhodi zonyango

KAKARETSO

Ho qhoma ha mafu a bakwang ke dijo (di-FBD) ho etsahala kgafetsa Afrika Borwa. Leha ho le jwalo, le hoja a tsejwa, ha a batlisiswe hantle mme ha a tlalehwe hangata. Ka lebaka leo, ho na le kutlwisiso e fokolang ya boima ba di-FBD ka hara dibaka tsa mahaeng tsa Afrika Borwa. Sepheo sa phuputso ena ke ho batlisisa ho ba teng ha di-FBD hara bakudi ba yang kgafetsa setsing sa mmuso porofenseng ya Kapa Botjhabela bakeng sa nako ya 2016 - 2020. Moralo wa phuputso o fapaneng o sebedisang datha ya morao-rao wa sebediswa bakeng sa phuputso ena. Datha yohle ya bakudi ba ileng ba alafshwa bakeng sa mafu a amanang le FBD nakong ya phuputso e kenyeleditswe phuputsong. Datha e ile ya hlahlojwa ho sebediswa dipalo-palong tse hlalosang le manollo ya dintho tse fapaneng. Bongata ba di-FBD bo bakwa ke ho ja nama ya kgomo e tshetsweng moriana (42%, n=176), ho latelwe ke ho ja nama ya dikgomo tse shweleng (26.25%, n=110), dikgomo tse lonngweng ke dinoha (12.89%). n=54), nama ya kgoho e jewang sekolong (6.44%, n=27), le nama ya dinku tse shweleng (4.30%, n=18). Keketseho ya palo ya diketsahalo tsa FBD e ile ya bonwa dipakeng tsa Pherekgong le Phupjane ka 2016, 2018 le 2020. Nakong yohle ya phuputso ntle le 2017 le 2019, palo e tlase haholo ya diketsahalo tsa FBD e ya bonwa dipakeng tsa Phupu le Tshitwe. Mafu a kang lefu la tswekere, lefuba le HIV, hammoho le boimana a ne a amahanngwa le di-FBD tse matla tse lebisang ho eketseheng ha monyetla wa ho kena sepetlele. Phuputso e ile ya totobatsa tlhokahalo ya ho ruta batho ba mahaeng ka dikotsi tsa dijo tsa tlhaho ya diphoofolo le karolo ya mafu hodima boima ba di-FBD ka phano ya tlhokomelo ya bophelo. Diphetho tse tlalehilweng mona di ka tataisa maano a ka thusang ho fokotsa boima ba di-FBD tsamaisong ya tlhokomelo ya bophelo mahaeng a Afrika Borwa. Katamelo e le nngwe ya bophelo bo botle e kenyelletsang ditho tsa sehlopha sa bongaka ba diphoofolo, basebeletsi ba tsa bongaka, baetapele ba dibaka le diofisiri tsa bophelo bo botle ba tikoloho e ya hlokahala ho rala le ho hlahisa maano a ho kenella le mananeo a thuto.

Mantswe a sehlooho: Dijo tsa tlhaho ya diphoofolo, di-FBD, polokeho ya dijo, boima ba mafu a bakwang ke dijo, ditlaleho tsa bongaka

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AGE	Acute Gastroenteritis
AHT	Animal Health Technician
AIDS	Acquired Immunodeficiency Syndrome
B.CO	B. Complex
DAFF	Department of Agriculture, Forestry and Fisheries
DARDLEA	Department of Agriculture, Rural Development, Land and Environmental Affairs
ELISA	Enzyme-linked Immunosorbent Assay
EPEC	Enteropathogenic *Escherichia coli*
FBD	Food-borne diseases
HEV	Hepatitis E Virus
HIV	Human Immunodeficiency Virus
iNTS	invasive nontyphoidal Salmonella
IV	Intravenous
ME	Marginal Effect
MRSA	Methicillin-resistant *Staphylococcus aureus*
NCD	Non-Communicable Diseases
NTS	Non typhoidal *Salmonella*
OR	Odd Ratio
RTE	Ready-to-eat
SAB	*Staphylococcus aureus* bacteraemia
SABS	South African Bureau of Standards
SPSS	Statistical Package for Social Science
TB	Tuberculosis
TJA	Total Joint Arthroplasty
WHO	World Health Organisation

CHAPTER 1
INTRODUCTION
1.1. Background

Adley & Ryan (2016) define food-borne disease (FBD) (also known as a food-borne illness) as any illness or disease resulting from the consumption of food which is contaminated with pathogenic bacteria, parasites or viruses or consumption of food that has toxins formed by bacteria growing on or in the food item. The latter is known as food-borne intoxications as opposed to food-borne infections that are caused by ingestion of bacteria, viruses or parasites (Adley & Ryan 2016; Bintis, 2017). Bintis (2017), also points out that symptoms resulting from foodborne infections take longer to develop due to the incubation period that is required. The seriousness of the FBDs is due to food-borne pathogens that have zoonotic potential to cause diseases or even death.

According to Shonhiwa et al. (2018), globally food-borne diseases (FBDs) and the associated morbidities and mortality are recognised as public health concern. In 2005, it was reported that diarrhoea caused 220 million deaths with 96 000 deaths among children (WHO, 2016). According to recent reports, on a global level, annually FBDs cause 600 million illnesses, 420 000 overall deaths and 125 000 deaths among children under five years (WHO, 2021). These statistics clearly indicate that foodborne illnesses are a consistent problem. Focker & Van der Fels-Klerx (2020) argue that losses that are production and trade related are huge economically because of the recalling incidents of contaminated food. The Borgen Project (2021) concluded that the lack of resources and knowledge at underfunded health facilities hampers diagnoses of the FBDs. STOP (2022) added that complications and symptoms will have accelerated by the time a patient goes to hospital. As a result, additional health care expenses are incurred, and people lose their income due to losing their jobs as a result of foodborne illnesses (WHO, 2019). Approximately US$15 billion is spent on medical expenses by households, adding to the health care expenses. In Africa alone it is estimated that 91 million people get ill from consuming contaminated food and about 137 000 of the infected die. Moreover, according to Bisholo et al. (2018), Africa has the highest burden of FBDs.

The most common symptoms of food poisoning or illnesses is a diarrhoea, which has potential to lead to death. Furthermore, Africa is the most affected followed by Southeast Asia (Gates, 2016). However, within the rural areas of South Africa there is limited understanding of the burden of FBDs (Bisholo et al., 2018). This is due to the shortage of information on the burden of food-borne infections and/or intoxications in rural settings. Only three studies from South Africa was sourced from the literature in this subject (Bisholo et al., 2018; Ramalwa et al., 2020; Shonhiwa et al.,2019). For example, Bisholo et al. (2018) investigated the prevalence of food-borne diseases in the rural areas of the Eastern Cape. However, this study was between 2012 to 2014, which suggest that the information is now outdated. Moreover, Ramalwa et al. (2020) and Shonhiwa et al. (2019) studies looked at the foodborne disease outbreaks that were reported to the National Institute for Communicable Diseases (NICD). However, these studies were conducted at a national level and data is not segregated to show which of these cases are from rural areas. Therefore, data on the burden of food-borne infections in rural areas is limited and there is an urgent need to feel this knowledge gap.

Therefore, this study investigated the occurrence of FBDs in the study area based on person, place and time. The study also investigated the factors that are significantly associated with the FBDs using retrospective data from hospital records.

1.2. Research problem

In South Africa, outbreaks of food-borne disease are frequent and notifiable but are poorly investigated and not often reported (Ntshoe et al., 2021). It is common among rural people to disagree with the information given by Animal Health Technicians (AHTs) on matters concerning food safety. For example, people in rural areas believe that there is no justifiable reason for throwing away meat. This may be due to the lack of knowledge, and this kind of attitude promotes the occurrence of FBDs. This lack of knowledge could be attributed to the fact that a many people especially in the rural areas are not educated about FBDs. When they contract a FBD, the only time they are taken to a health facility is when someone is seriously ill. For example, according to Shonhiwa et al. (2018), out of 11,155 people who got ill with FBDs, only 8680 visited a hospital, meaning that 1932 people were probably treated at home.

These facts notwithstanding, there is no evidence of studies that have investigated the cases of FBDs in the study area. This is attributed to the fact that there is not enough capacity for forecasting and tracking FBDs even though there have been several food-borne outbreaks in school children across different provinces. A good surveillance system is a necessity because it could be used to monitor FBDs and prevent them from spreading (Bisholo et al., 2018).

In addition, according to Noah & Ostrowski (2016) food safety is not included in primary and high school's curricula as compared teenage pregnancy and drug abuse that are covered extensively. A lack of FBDs awareness programmes in the community contributes to outbreaks that can be avoided. In addition, according to Niehaus et al. (2011) generally there is underreporting of food-borne diseases outbreaks in South Africa.

While there is underreporting food-borne diseases by the public, the situation is even worse at national institutes (Ramalwa et al., 2020; Shonhiwa et al.,2019). Ideally, health workers are required to report all food-borne cases to the NICD, however it has been noted that a lot of these cases are not reported (Ramalwa et al., 2020). This leads to information gaps on the extent foodborne illnesses in the country as information from NICD is not a true reflection of the actual burden of FBDs. Furthermore, collecting primary data from respondents could be limited when they are required to recall over an extended period of time. Therefore, health facilities remain a critical stakeholder in accessing reliable area-specific data. Area-specific data is critical for design of targeted interventions. In view of discussion in the preceding paragraphs, it is hypothesized that the burden of FBDs in the study area is high. However, there is no evidence of studies that have investigated the occurrence of FBDs in the study area so as to address the objectives this study seeks to achieve.

1.3. Aims, research questions and objectives.

1.3.1 Aim

The aim of the study was to investigate the occurrence of FBDs among patients treated at local municipal hospital, O.R. Tambo District, Eastern Cape for FBDs, between the years 2016 to December 2020.

1.3.2 Objectives

Therefore, the present study was guided by the following objectives:

- To determine the number of patients treated for various FBDs over the study period.
- To describe the monthly, yearly and seasonal trends of FBDs cases over the study period.
- To investigate probability of admission of FBD patients with comorbidities

1.3.3 Research question

The objectives of this study were achieved by answering the following research questions.

- How many cases of FBDs were treated at hospital under study over the study period?
- Have the number of cases of FBDs observed at the hospital under the study period increased over time?
- Is the admission of patients with FBDs independent of season, immune status and special conditions (i.e., pregnancy)?

1.3.4. Hypothesis

The following hypothesis was tested in this study:

- Ho: People presenting with FBDs who are immunocompromised and have comorbidities are not more likely to be admitted as compared to those who are do not have these conditions.
- HA: People presenting with FBDs who are immunocompromised and have comorbidities are more likely to be admitted as compared to those who are do not have these conditions.

1.4 Significance of the study

The study contributes to the scant literature on the occurrence of FDBs especially in rural South Africa. Information generated in this study can be used as reference for researchers conducting research in this field.

The results of the study can also be used to inform policies and design intervention programs that can assist in fighting the scourge of FBDs especially in rural South Africa. This information can be used by the hospital that supplied the data to educate the general public about FBDs especially the affected areas (based on hospital records) and to advise the community on how to prevent FBDs.

1.5. Definition of terms

Food-borne disease: Any illness that is caused by ingestion of food that is contaminated with bacteria, non-infectious chemicals, parasites, toxins and viruses, (Hoffmann & Scallan, 2017).

Occurrence: an unexpected event that happens (Cambridge, 2022b).

Ready to eat food: is described as a food that is pre-prepared that requires no additional ingredients and can be reheated in its container for a maximum of 15 minutes (Howard et al., 2012).

Pathogen: refers to a microorganism that can cause or causes a disease (Casadevall & Pirofski, 2012)**.**

Bacteria: are very tiny organisms that cause lots of diseases and they can be found everywhere (Cambridge, 2022a).

Food safety: refers to food preparation, handling and storage routines in order to prevent injury and food-borne illnesses, (Sesotec, 2020).

Patient: is a person who is taken care of by a medical doctor or dentist or who receives medical care (Cambridge, 2022).

Non communicable diseases are a conditions or diseases that are known to affect or occur in individuals over a long period of time and the transmission of causative agents from an affected person to another is not known. Examples of non-communicable diseases are cancer, cardiovascular conditions, type 2 diabetes, and chronic respiratory condition (Daar et al. 2007).

1.6. Limitations of the study

Since the study used secondary data, it was limited to variables that were collected by the hospital that provided the data. For example, there were no laboratory findings in the data that could have been used to confirm the causative agents of the FBDs in the study area. The data also lacked crucial variables such as age and other socio-demographic data, which limited the analysis thereof. However, this being the first study in the study area, the study provides baseline data that can be used to inform further studies and development of control strategies to reduce the prevalence of FBDs in the study area.

1.7. Outline of the thesis

The dissertation has been arranged as follows:

Chapter 1: Presents the introduction and background of the study, including research problem, aims of the study, research question, objectives of the study, significance of the study, definitions of terms that are used in the study, the limitation of the study and the outline of the thesis.

Chapter 2: Presents literature review of the previous studies that are related to the current study.

Chapter 3: Outlines the research methodology used in conducting the study and the details about where the study was conducted.

Chapter 4: Presents the findings of this study.

Chapter 5: Presents the discussion of the results.

Chapter 6: Presents the conclusion of the study by describing major findings and the recommendations.

CHAPTER 2

LITERATURE REVIEW

This chapter provides an overview of the occurrence of FBDs, their causes, selected food-borne pathogens, and the impact of food-borne diseases. Factors associated with FBDs, and occupational risk factors are also discussed.

2.1. Causes of food-borne diseases.

There are different causes of food-borne illness, and they include bacteria, viruses, chemicals and parasites (WHO, 2022a). Each of these are explained below.

2.1.1 Bacterial causes of food-borne diseases.

Adley & Ryan (2016) mentioned that there are 31 main food-borne pathogens (pathogens means bacteria, viruses, parasites, chemicals) that are capable of causing diseases. *Salmonella*, nontyphoidal *Salmonella*, *Campylobacter*, *Listeria* and Shiga toxin producing *Escherichia coli* are the significant ones and are as a result usually monitored by the national authorities. Sometimes, monitoring is usually accompanied with in-depth assessment of outbreaks of FBDs to assess trends and to determine necessary steps to combat future outbreaks.

According to Heredia & García (2018), *Campylobacter*, *Escherichia coli*, *Salmonella enterica* and *Listeria monocytogenes* are some of the many foodborne pathogens that are associated with food producing animals namely turkeys, cattle, pigs, and chicken.

I. Salmonella

According to Su & Chiu (2007) D.E. Salmon was an American bacteriologist from whom the pathogen *Salmonella* derives its name. This pathogen belongs to the *Enterobacteriaceae* family and is a gram negative species, (Livermore, 2012).

According to Brenner et al. (2000), S. bongori and S. enteric are two species that are grouped in Salmonella. The usual habitat for the *Salmonella* species and subspecies is cold blooded animals and the environment except for *S. enterica* subsp. which is habitat in warm blooded animal. Foods like eggs, tomatoes and sprouts are the culprits in most illnesses. Maurer & Lee (2005) are of the view that faecal contamination during processing of meats is the primary cause of *Salmonella* contamination of foods. In field application with animal manure may also contaminate fruits and vegetables with *Salmonella* or irrigation water. Contamination of fruits may also occur during produce processing with water that is contaminated by human or animal waste.

People who are at high risk are those who work or live with high risk animals namely turtles, ducks, chickens and lizards and children under the age of 5 years (Claveland, 2022). The common symptoms of salmonella infection include diarrhoea, vomiting, fever and abdominal cramps. These symptoms can last for 4 to 7 days (Mayo clinic 2002). Preventative measures include avoiding uncooked eggs. Uncooked meats should be kept separate from cooked food, produce and Ready-to-Eat (RET) foods to avoid cross contamination. Hands need to be washed as well as utensils and surfaces after coming in contact with poultry or raw meat.

a) Difference between typhoidal and Nontyphoidal *Salmonella*

According to Gal-Mor et al. (2014), there are two salmonella groups: typhoidal and non-typhoidal. In humans, these two types of *Salmonella* show different immune response and disease despite their similarity. Nontyphoidal *Salmonella* (NTS) has a global burden while typhoidal *Salmonella* is endemic in developing countries such as those in Africa and Southeast Asia. This is due to low living standards and poor sanitation.

The strains of typhoidal *Salmonella* are human host specific while NTS strains have various host specificity. In addition, while a vaccine for typhoidal *Salmonella* is available, the NTS do not have a vaccine (Smith et al., 2016).

Gal-Mor et al. (2014) adds that NTS causes gastroenteritis while typhoidal *Salmonella* causes enteric fever. Symptoms for both NTS and typhoidal *Salmonella* are watery diarrhoea, acute gastroenteritis and sustained fever and chills, respectively. After one ingests the NTS pathogen the symptoms appear within 6 to 12 hours while for typhoidal *Salmonella* serovars they appear within 14 days.

According to several authors NTS belong to *Salmonella enterica* subspecies *enterica* and is a gram – negative bacteria (Gao et al., 2019; Bush & Vazquez-Pertejo 2022). The main subspecies responsible for NTS infections include Enteritidis, *S.*

Typhimurium, *S.* Newport, *S.* Heidelberg, and *S.* Javiana (Bush & Vazquez-Pertejo,
2022). In Africa, the main causes of invasive nontyphoidal Salmonella (iNTS) are *Salmonella* Typhimurium (Gao et al., 2019; Uche at al., 2017) and Enteritidis (Uche at al., 2017). In sub-Saharan Africa NTS is said to be a major cause of invasive disease (iNTS). Available epidemiological data suggests that NTS is endemic in sub-Saharan Africa, with almost half of the global cases, occurring in this region (Gilchrist & MacLennan, 2019).

Contaminated produce like peanuts, fruits, tomatoes, and spinach are associated with NTS outbreaks. Transmission is through person to person contact as well as contact with pets, reptiles, and rodents (Gal-Mor et al., 2014).

Non-typhoidal salmonella infections manifest as meningitis and bacteraemia. Fatality rate is high and antimicrobial resistance is common. Fever is the most common symptom for iNTS while pneumonia has also been observed (Gilchrist & MacLennan, 2019). While tentative diagnosis can be reached based on symptoms, a blood culture is used for confirmatory diagnosis of iNTS.

Non-typhoidal salmonella infections is treated by empirical antibiotics (Gilchrist & MacLennan, 2019). The commonly used antimicrobials to treat iNTS include: fluoroquinolones, azithromycin and cephalosporins which is third-generation (Wen et al., 2017). Ciprofloxacin is recommended as first line of treatment. Cotrimoxazole, moxifloxacin and levofloxacin can be used or alternatively cefotaxime, ceftriaxone and cephalosporins as extended spectrum. A 14-day duration is recommended for treatment of the invasive disease (Kariuki et al., 2015).

Health-care workers or food handlers can use oral ciprofloxacin 500 mg every 12 hours for a month for eradication purposes. After a few weeks of administration of drugs to document the elimination of the infection a follow up stool culture should be obtained. It is paramount to prevent foodstuff contamination from infected humans and animals. All the nontyphoidal *Salmonella* infections cases must be reported to the relevant authorities (Bush, &Vazquez-Pertejo, 2022).

I. Campylobacter

In 1963 *Campylobacter* was established after *Campylobacter fetus* was renamed from *Vibrio fetus* and this genus belongs to a *Campylobacteraceae* family. *Campylobacter* species are characterised by a curved bacteria or rod-shaped gram-negative spirals. *Campylobacter* consists of 26species, 2 provisional species and 9 subspecies (Kaakoush et al., 2015). According to WHO, (2020) *Campylobacter* causes a zoonotic disease called *Campylobacteriosis.* Globally, it is among the top four diarrhoea causing organisms.

The source of this disease is food such as raw and contaminated milk, meat, and uncooked meat products as well as contaminated ice (Donnison & Ross, 2014). Kaakoush et al. (2015) mentioned that humans contract it mainly through poultry. In a study conducted by Journal (1977), it was confirmed that the source of infection to some patients was from dressed and live chickens.

According to Tegtmeyer et al. (2021) fever, diarrhoea, malaise and abdominal pain are some of the symptoms shown when one is infected with *Campylobacter*. Donnison & Ross (2014) also added that symptoms of the person infected with *Campylobacter* take about 3-6 days and include, headache, nausea, vomiting. From the above said symptoms, Blaser (1997) added that a watery diarrhoea develops, and it becomes a bloody diarrhoea after lots of movements by the bowel. The severity of the abdominal pain can be an imitation of appendicitis.

Donnison & Ross (2014) mentioned that death in very young children, elderly people or those infected with AIDS can happen, but it is rare. Various degree of frequency on miscarriage, hepatitis and pancreatitis complications have been reported. Patients with severe fever or bloody diarrhoea may require treatment.

Rehydration and electrolyte replacement are the recommended treatment for *Campylobacteriosis.* However, Donnison & Ross (2014) recommend that for invasive cases, antimicrobial treatment be administered.

Preventative measures include food chain control measures, from farm to fork, biosecurity enhancement in poultry farms and good hygienic practices at abattoirs. Bacterial treatment can reduce the disease from contaminated food. Raw and cooked foods cross contamination should be avoided in restaurants and at home in order to prevent *Campylobacteria* occurrence.

II. Listeria Monocytogenes

According to Gray & Killinger (1966)*, Listeric* infection or *Listeria monocytogenes* (*L. monocytogenes*) was first observed in Heyem in France and Henle in Germany in the years 1891 and 1893 respectively. This observation was done from a dead patient in which a gram-positive rod-shaped pathogen was isolated from a tissue section. This pathogen belongs to *Carynebacteriaceae* family. *L. monocytogenes* is a small grampositive pathogen with rounded end diphtheroid-like rod and non-spore forming. The pathogen has 11 serotypes known as 1a,1b,2, 3a, 3b,4a,4b,4c, 4ab,4d and 4e.

CDC (2016) is of the view that *Listeria Monocytogenes* is the main causative bacteria for *Listeriosis* and is mainly found in poultry, cattle, soil and water. Food processing plants that process various meats as well as raw milk and milk products can also contain the bacteria. Kayode et al. (2020) added that primarily this bacterium is transmitted by water and food that is contaminated, followed by animals to human transmission where skin lesions develop. According to Chersich et al. (2018), the foodborne diseases epidemiology is also associated with changes in climate. *Listeriosis* occurrence has been linked to spikes in high summer temperatures and ambient temperatures. Food cooling chains can be broken down due to extreme hot weather temperatures associated with climate change, resulting in food products rapid rise in the number of bacteria. Lengthened dry seasons and different patterns of rainfall also play a huge role in transmitting the bacterium.

According to the CDC (2016), pasteurisation and cooking are the only ways to kill *Listeria* because this bacterium can grow in refrigerator's cold temperatures. Newborns, pregnant women, immunocompromised and elderly people are at a risk of getting infected. According to Anelich (2018) the common symptoms of *Listeriosis* include headache, muscle and joint pains, fever, vomiting, nausea and watery diarrhoea. Antibiotics are used to treat *Listeriosis*. An urgent medical care is required by pregnant women, newborns, immunocompromised and elderly people while most infected people take a week to recover. Prevention methods include practicing good hygiene in the kitchen, no drinking of raw milk (unpasteurised), thoroughly cooking fish and other meats, perishable foods to be consumed as soon as possible, leftovers to be covered and refrigerated within 2 hours and be used in less than 4 days. Cross contamination at the kitchen should be avoided, (CDC, 2016).

III. *Escherichia coli*

According to CDC (2014), *E. coli* is a bacterium and it belongs to a *Enterobacteriaceae* family. It is a gram-negative bacillus (Nataro & Kaper, 1998).

Escherichia coli, is a gastrointestinal pathogen with five pathotypes known as, EPEC, ETEC, EIEC, EAEC and EHEC (Meng et al.,2014). The harmless strains are *E coli 026,* while *E coli 0157* causes sickness. This disease causing bacterial can be found in drinking water, dairy products and hands that are contaminated with faecal matter.

Declan Iwu et al. (2020) suggests that the use of cattle faecal manure for agricultural purposes is responsible for transferring *E coli* 0157 to the soils. Water run offs from such fields contaminate streams and rivers.

Humans get infected when they consume food that has been produced from contaminated soil or farm using water that is polluted with the pathogen for irrigation purposes. Greene et al. (2003) also added that other sources of getting infected are through contaminated water, food, infected person, and interaction with infected animal. It is believed that healthy cattle are an important reservoir for *E coli* 0157.

E coli 0157 symptoms usually show after 3 to 4 days and they range from vomiting, nausea, mild diarrhoea then watery diarrhoea followed by bloody diarrhoea, stomach tenderness, cramping and pain, (Mayo Clinic, 2022).

According to Yang et al. (2017), the Enteropathogenic *Escherichia coli (EPEC)* strain was identified in 1945 and is the most important diarrheal pathogen in young kids.

According to Mead & Griffin (1998) there is a controversy around the use of antimicrobial treatment and therefore preventative measures of avoiding consumption of unpasteurized milk, undercooked meat, handwashing and reporting of bloody diarrhoeal are recommended.

IV. *Bacillus cereus*

Bacillus cereus (B. cereus) belongs the *Bucillus* family which is endospore-forming facultatively anaerobic and gram-positive member and consist of five species (Griffiths & Schraft, 2017).

Food poisoning is commonly caused by *B. cereus* (Brown, 2020). This is a common soil saprophyte bacterium and therefore is easily spread by plant-based food. The bacteria produce very resilient spores. In the U.S. an estimated 63000 cases are reported yearly. Globally, as per the report by Carroll et al. (2022), a total of 25,6000 infections are caused by *B. cereus* annually. In South Africa cases of *B. cereus* were recorded in a study that was conducted in Pretoria by Nortjé et al. (1999). The broiler chicken, vienna sausage, ground beef, salami and ham were sampled for aerobic counts. *B. cereus* was observed in all the samples except from ham and one ground beef.

Another study by Jensen et al. (2003) showed that the change of seasons has an effect on *B cereus* isolation. For example, isolation rate of *B cereus* from faecal samples from scholars changed from 43% during summer season to 24.3% during winter season.

A study by Rana et al. (2020) on samples of ready to eat (RTE) meat, milk, water, and beverages. *B. cereus* was isolated from 76% of the samples. Foods with cheese yielded the most (25.0%) isolates of *B. cereus*, while water and cream-based foods yielded the least isolates (8.3%) of *B. cereus*.

According to Brown (2020) and Jensen et al. (2003) *B. cereus* has the diarrheal (abdominal pain and diarrhoea) and emetic types (vomiting and nausea). These symptoms can vanish after 24 hours without treatment. Rice is said to be the main culprit. This bacterium easily survives during the cooking process and grows best in room temperature. The bacterium can also be found in eggs, soups, puddings, vegetables and meat and dairy products. Good personal hygiene, keeping cooked hot food at 60°C and cold food below 4°*C*, preventing cross contamination, adequate disinfecting and cleaning of equipment are the preventative measures for this bacterium.

V. *Clostridium perfringens*

According to Bauer & Kuijper (2017b)*, Clostridium perfringens (C. perfringens)* is part of the *Clostridiaceae* family. This bacterium is anaerobic spore-forming and gram-positive and consists of 5 toxin types known as A, B, C, D and E (Van Immerseel et al., 2010). It is found in the environment, animal intestines, poultry, and raw meat, and it multiplies under conditions where food is kept under unsafe external temperatures between 4 to 60°C. The bacterium has a protective coating from the spores which assists it to survive (CDC, 2021).

A diarrhoea causing toxin is produced after someone swallows the bacteria. Poultry, meat, gravies are common sources of this bacteria. This bacterium is common in prisons, hospitals, schools and nursing homes. In November and December are when the outbreaks normally occur in the United State of America (USA). Older people and young children are at high risk, but anyone can get *C. perfringens* (CDC, 2021).

According to Canada Health (2018), the common symptoms include stomach cramps, nausea, loss of appetite, bloating and diarrhoea. These symptoms appear within 6 to 10 hours after ingesting contaminated food. The illness lasts for 8 to 12 hours. In elderly people and children, symptoms may last for up to 1 to 2 weeks.

Plenty of fluids need to be taken to avoid dehydration caused by diarrhoea. To prevent food contamination with *C. perfringens,* it is advisable to keep warm food at safe temperatures (60°C) while cold food should be kept at 4°C. Poultry and beef should be cooked at safe temperatures, leftovers must be refrigerated at 4°C or colder within 2 hours. If the outside temperature is above 32°C, refrigerate within an hour and leftovers to be reheated at 73c° before serving (CDC, 2021).

2.1.2 Viruses that cause food-borne illnesses.

Human beings are surrounded by microbes. The multiplication of viruses happens in living cells only and cannot survive for prolonged periods outside the host. Food-borne diseases are said to be caused by over 100 types of enteric viruses (Bintsis, 2017).

Viruses are disease causing agents that reproduce only within the host's living cells (Modrow et al., 2013). Just like bacteria, viruses are responsible for food poison and infections. However, unlike bacteria, viruses do not reproduce in food making it very difficult to detect (O'Shea et al., 2019). In 2015, out of the reported outbreaks of foodborne diseases, viruses accounted for 9.2% of the outbreaks (Bintsis, 2017).

I. Hepatitis A virus

According to Velebit et al. (2019), Hepatitis A viruses and Noroviruses are the most significant causes of viral food-borne diseases. According to Mayo clinic (2022), Hepatitis A causes infection of the liver. This results in the liver not being able to function properly.

The hepatitis virus is small and forms part of *Picornaviridae* family (O'Shea et al., 2019). Human and vertebrates are the natural hosts for viruses. It is normally transmitted through human faeces and ingestion of contaminated water or food (BITK, 2022). According to literature, Hepatitis A is highly contagious. A diseased person can infect others by being in contact with them (WHO, 2022b) as the infected persons can remain without symptoms for a while (O'Shea et al., 2019). Unsafe water, lack of hygiene and sanitation are associated with the hepatitis A high risk infection (WHO, 2022b) therefore this virus is very common in developing countries due to poor sanitation (O'Shea et al., 2019). However, residents of these areas usually develop immunity to this virus (O'Shea et al., 2019). Freezing, chemicals, heat and desiccant are said to be favourable environmental conditions where Hepatitis A is very stable even though it does not grow in environment (Bintsis, 2017).

There were 1000 incidents of illness and 3 deaths caused by an outbreak of Hepatitis A in 2003 in the Pennsylvania-USA. Imported green onions from Mexico farms were linked to this outbreak as a result, imports were banned from the infected farms. Outbreaks of Hepatitis A in 2013 and 2014 in Europe resulted in 1,400 incidents and were associated with berry mix and frozen and fresh strawberries (Bintsis, 2017).

Children are said to be asymptomatic, but adults are not. Symptoms of infection include loss of appetite, fever, diarrhoea, yellow eyes or skin, fatigue, vomiting, joint pains and stomach pains (CDC, 2020). As the infection progresses, it then results in an inflamed liver. Homeless people, people who have hemophilia, travellers to hepatitis A high prevalent country, infected people and those that are on drugs are vulnerable to hepatitis A (Khatri, 2021; O'Shea et al., 2019). WHO (2022b) suggests that a blood test is used to diagnose the virus.

Hepatitis A has no treatment. The liver heals completely when the infection is cleared by the immune system. Other ways of treatment are resting, consumption of fluids, taking small portions of food and avoiding alcohol (Langan & Goodbred, 2019).

According to Kahn (2022) hepatitis A can be avoided by making sure that after a bathroom visits, hands are properly washed using warm water and soap before drinking and/or eating. Eating from street restaurants should also be avoided because sanitation is usually a challenge at these establishments. In addition to this, in countries where hepatitis A is prevalent, it is advisable to drink bottled water, while in areas where hygiene and sanitation is low, consumption of raw or peeled vegetables or fruit should be avoided.

II. Hepatitis E

Similar to Hepatis A, Hepatitis E virus (HEV) causes infection of the liver. HEV is found in infected person's stool (CDC, 2021a). According to Sana et al. (2022), death from HEV is estimated at 55,000 while infection is approximately 20 million per year. Continents like Africa, Central America, Asia and Middle East have the most incidents of this disease. In the Middle East and North Africa, HEV comes second in causing hepatitis irregular incidents. But according to the WHO (2022c), HEV is commonly found in South and East of Asia (WHO, (2022c; O'Shea et al., 2019). WHO (2022f), is of the view that Hepatitis E virus (HEV) is responsible for causing liver inflammation and has 1,2,3 and 4 genotypes. It is only in humans where 1 and 2 genotypes are found. Wild boars, pigs and deer have 3 and 4 genotypes.

According to Sherman (2021), HEV has different genotypes that occur in different countries or regions. North Africa, Asia and India have genotype 1 and 2. West Africa and Mexico has genotype 2 and genotype 3 is found in North America and Asia. Genotype 4 has only been detected in European countries and Asia. A total of 8 genotypes have been isolated and they are named according to number such as HEV1 etc. (O'Shea et al., 2019), with varying hosts animals.

In developed countries Hepatitis E is usually transmitted by consuming venison, shellfish, undercooked or raw pork and wild boar meat (CDC, 2021a). Hepatitis E is a veterinary public health risk disease that is transmitted by consuming undercooked or raw wild animals or pig's meat (Velebit et al., 2019; O'Shea et al., 2019). In addition to this, WHO (2022c) suggests that drinking water that has been contaminated by faeces transmits the virus.

Symptoms such as nausea, fever, vomiting, abdominal pain, enlarged liver and anorexia start showing on an infected person after a month and half of incubation period (Kamar et al., 2014). Chronic liver patients and pregnant women are more likely to die from Hepatitis E infection. Healthy persons usually present with mild symptoms which disappear without treatment (Sherman, 2021). However, a liver transplant is usually required to treat acute infection. Preventative measures for HEV, include drinking clean water, faeces to be disposed appropriately and handwashing with clean water (González et al., 2022). To prevent infections, Sherman (2021) suggests that people need to avoid street vended foods, un-bottled water, undercooked or raw seafood, pork or meat products as well as uncooked vegetables. Undercooked or uncooked pork, wild meat or boar sausage should be avoided if travelling to Europe.

III. Norovirus

Food-borne illnesses are mostly caused by the *Norovirus*. There is no relation between the influenza virus that causes flu and the *Norovirus*. This virus is commonly known as a stomach bug, food poisoning or stomach flu (CDC, 2022b). NSH (2021) described the *Norovirus* as a winter vomiting bug.

The *Norovirus* is transmitted by touching the mouth after coming in contact with objects or surfaces that are infected by the virus, coming in contact with an infected person and consuming food touched or prepared by an infected person. O'Shea et al. (2019) added that that transmission is mainly due to poor personal hygiene, contaminated water or fresh produce that was watered with contaminated water. The military, nursing homes, cruise ship and hospitals are most prone to outbreaks (Bintsis, 2017).

After exposure to the disease, symptoms appear after a day or two. Normally infection clears within 72 hours. The common symptoms observed among infected persons are vomiting, diarrhoea and stomach pains (Mayo clinic, 2022b); malaise, myalgia and fever (O'Shea et al., 2019). Higuera (2021), indicated that *Norovirus* can be treated by acetaminophen, over the counter (OTC) antidiarrheals, ibrufen and antiemetics, as antibiotics are not recommended.

According to Watson (2020), preventative measures against the *Norovirus* include washing hands for at least 20 seconds using water and soap after changing a diaper or using the restroom. Secondly, raw vegetables and fruits should be thoroughly washed before consumption and contaminated foodstuff should be discarded appropriately. Shellfish and oysters should be cooked prior to consumption. An infected person should not prepare food for 48 to 72 hours after recovery. Bintsis (2017) dispute these preventative measures saying that the persistence of the viruses on food and environment would make infection hard to prevent.

2.1.3 Chemicals that cause food-borne illnesses.

According to Clifton (2019), any substance made up of gas, liquids and solids qualifies to be a chemical. Chemical contamination means chemical existence that should be absent or its presence is above the required amount that will interfere with safety (Rather et al., 2017). Heavy metals like lead, mycotoxin, acrylamide, and organic pollutants like dioxins are examples of chemical contaminants (FSA, 2021).

i) Lead

Lead is found on the crust of earth and is a poisonous metal that occurs naturally (WHO, 2022c). According to WebMD (2022), the main sources of lead poisoning are lead-based paints and water pipes. After lead is ingested, it is taken up in the bloodstream and gets stored in bones, organs, teeth, and tissue. The physical and mental development for children aged 6 years and below is hugely affected by lead poisoning. A study that was done by Nriagu et al. (1996) in rural and urban areas of the Western Cape Province, South Africa showed that the level of lead in the blood of children was >10 ug/dl. Also, some studies done in other countries on the African continent suggest that lead poisoning in children is a common problem. NHS (2022) mentioned that symptoms that maybe observed among affected children including vomiting, loss of appetite, constipation, delayed development, tiredness, abdominal pain, and hearing loss. With adults, symptoms include headache, abdominal pain, muscle and joint pain, memory loss, miscarriages in women and high blood pressure. Fatalities can happen when lead poisoning is at extreme levels (Mayo clinic, 2022b). For treatment, chelation therapy on repeat is said to assist in reducing lead in the body, and for control purposes, lead sources need to be identified and be eliminated (D'souza et al., 2011).

ii) Mycotoxin

Mycotoxin is a toxin produced by mould or fungus. Susceptible food stuff includes dried fruit, grains, coffee, and dried beans. One gets sick on consuming food items that contain mycotoxins of high level.

Consuming milk from a cow that ingested mycotoxins can make one ill (FDA, 2022b). One can also get mycotoxin through direct contact or it can be airborne (Hogan, 2021).

According to WHO (2018), vomiting, gastrointestinal problems and nausea are the symptoms shown by an infected person. To control mycotoxin poisoning, crops should be dried well and in addition good agricultural practices must be adopted (Bennett & Klich, 2003). WHO (2018) also added that buying fresh nuts and grains, proper storage of food help prevents mycotoxin poisoning. Damaging of grains prior and during drying should be avoided, and whole grain inspection must be done to help minimise the occurrence of mycotoxin.

iii) *Acrylamide*

According to FAO (2022), Acrylamide is a toxic chemical which has a potential of causing cancer. Cooking or preparing food at high temperature forms this toxic chemical. This chemical is used to treat wastewater and drinking water (ACS, 2019).

FACT (2020) indicated that foods like bread, potato crisps, breakfast cereals, French fries and crackers are prone to the formation of acrylamide. The symptoms of acrylamide include nausea, speech disorder, sweating, numbness and muscle pain (Le Roux-Pullen, 2011). Diagnosis of acrylamide poisoning is done by doing a urine and blood tests (CDC, 2018a).

To reduce the formation of acrylamide, prolonged immersing and blanching of potatoes is said to be effective (Onishi et al., 2015). In addition, ACS (2019) think that roasting and frying potato should be avoided. Steaming and boiling are the preferred methods of cooking potatoes, because they do not lead to production of acrylamide. It is also advisable not to use refrigerator to keep potatoes because it could result in production of acrylamide when they are cooked.

iv) *Dioxins*

Dioxins are persistent environmental pollutants and compounds that are chemically related. They can be found in animal's fatty tissues and the environment. Through the supply chain of food such as fish, milk products, meat and eggs, human beings get exposed to dioxins. (WHO, 2016). Manufacturing and waste industries can expose its workers to dioxin if the substance is present during manufacturing or burning of waste (CDC, 2017).

The nervous system, reproductive function, immune system, and the hormonal system become damaged by the effect caused by dioxin in human health. Dioxins are suspected to be carcinogenic (Epa, 2022).

Thermal desorption, incineration and vitrification are techniques used to treat dioxin contaminated debris and soil. An ideal temperature for destroying dioxins during incineration is 1200 degrees Celsius (CLU-IN, 2022). Formation of dioxins should be reduced in order to prevent it from affecting people (WHO, 2016).

2.1.4 Moulds that cause food-borne illnesses.

Mould is a fungus that grows by producing mould spores. A preferred place for mould growth is a dark and damp environment. Food, flood or leaking areas and ceilings are some of the places where mould can grow. There are illnesses that are caused by toxins produced by moulds (URI, 2016). According to WTS, (2023) there are three important mould namely *Aspergillus* which has a circular shape with yellow and green in colour; *Cladosporium* is hard to identify and forms in black, green and yellow clusters and *Stachybotrys* (Black mould) which grows in wood and cracks, a black-greenish fungus that is hardly airborne.

Information by CDC (2019) indicated that a person especially with compromised immune system can, after a few days and weeks develop mould infection from

Aspergillus and others. People who have been affected by mould show the following symptoms: watery eyes, sneezing, itchy nose, eye and throat, dry skin, and runny nose. Asthmatic patients can experience symptoms such as shortness of breath, coughing, tight chest and wheezing (Mayo clinic, 2021).

Blood tests, CT scans, culture of specimen and biopsy are ways of diagnosing the mould infection (CDC, 2019). For treatment of mould infection, voriconazole is used as treatment of Aspergillus. The other ways of treatment include AMB-based therapy, antifungals like voriconazole and Posaconazole and echinocandis such as anidulafungin, minafungini and caspofungin (Kontoyiannis & Lewis, 2015). To control mould, cleanliness is important. A refrigerator needs to be cleaned as mould spores grow there. The house humidity should be kept below 40% (USDA, 2013). During storage, temperature and grain *aw* should be accurately monitored and by means of physical assistance moistening of grain should be reduced. Grain moisture should be kept below fungal growth (Fleurat-Lessard, 2017).

2.1.5 Parasites that cause food-borne illnesses

According to Zolfaghari et al. (2018) human beings can be infected by parasites through food that is contaminated with parasites. Some animals such as pigs, cattle, poultry, sheep, fish, boars and wild animals are capable of infecting human beings with parasites resulting in food-borne illnesses. Rush (2022) mentioned that helminths and protozoa are the parasites sub-groups that cause infection in people. Below are different sub-groups of parasites together with how they are acquired, the symptoms presented in humans when infected, preventative and control measures and possible treatments. Based on information by USDA (2017) *Giardia doudenalis or intestinalis*, *Cyclospora cayetanensis, Taenia saginata/Taenia solium (Tapeworms), Cryptosporidium parvum, Trichinella spiralis and Toxoplasma gondii* are different types of parasites. The above-mentioned sub-groups of parasites will be discussed below.

i. Giardia doudenalis or intestinalis

CDC (2021) defined *Giardia duodenalis* as a protozoan. It was initially named *Cercomonas intestinalis* by Lambi in 1859. The parasite was later on renamed

Giardia lambia in 1915 by Stiles. However, despite this, the name *Giardia duodenalis* is considered the right name for this protozoan.

Giardiasis is a parasitic waterborne infection and is very common around the world (Halliez & Buret, 2013; Nazer, 2023). One can acquire this parasite from an infected person and through water that has not been treated appropriately (Hill & Nash, 2015). Although *G. intestinalis* affects everyone, this infection is most prevalent in children (Nazer, 2023; Samie et al., 2020).

The most common symptoms for Giardiasis include asymptomatic and chronic diarrhoea observed from infected individuals (Nazer, 2023). Other symptoms include dehydration, nausea, diarrhoea, stomach cramps, fatigue and bloating (Cleveland Clinic, 2020). Benson (2022) indicated that to properly diagnose Giardiasis, a sample of their stool is usually taken from a suspected person and sent to the laboratory for analysis. Brazier, (2018); Mahmoud et al. (2014) reported that this parasitic infection is effectively treated by Metronidazole drug.

Pre-cautionary measures to prevent Giardiasis infection include avoiding swallowing water when swimming and drinking untreated water from rivers, lakes and taps. Additionally, personal hygiene practices such as washing hands with soap after changing diapers and after visiting restrooms and avoiding oral faecal exposure are highly recommended (MN, 2022). Regular hand hygiene practices, fresh vegetables and fruits should be cleaned or peeled prior eating and avoid drinking impure water are some of the control measures for Giardiasis (MedilinePlus, 2016). MN (2022), also mentioned that infected people need to avoid swimming, practice regular hand cleansing with detergent after bathroom use and before eating, they can only go to work after a day after recovery and should avoid having sex till diarrhoea is gone.

ii. *Cyclospora cayetanensis*

Cyclosparo cayetanensis is a parasite that causes an acute gastroenteric parasitic infection called *Cyclosporiasis (*Hadjilouka & Tsaltas, 2020). This parasite is perfectly analysed microscopically (FDA, 2022a). According to literature immunocompromised people, infants and elderly are at high risk of contracting the *Cyclosporiasis* (Mathison & Pritt, (2021). The prevalence of the parasite can be seen in areas where sanitation is poor or in native areas (Li et al. (2019) and Mathison & Pritt, (2021), and is transmitted through orofecal route (Li et al., 2021). Fresh contaminated leafy greens and berries are the main vehicle of infection (Almeria et al., 2019).

According to the FDA (2022), the incubation period for *Cyclospora cayetanensis* is normally 7 days. Watery diarrhoea, nausea, stomach cramps, loss of appetite and fatigue are the most common symptoms observed among infected people (Chacin-Bonilla & Santin (2023); FDA (2022)). In previous studies by Chacin-Bonilla & Santin (2023) and CDC (2020), sulfamethoxazole or trimethoprim were used as treatment on infected patients. Immunosuppressed patients were successfully treated with cotrimoxazole. In addition to this lots of fluids also needs to be consumed as part of the treatment program. Cases related to travelling can be treated by Ciprofloxacin. To prevent infection from *cyclospora* infection people are advised to keep away from polluted water and food especially in places where there is lack or poor sanitation.

It is also recommended that water for irrigation should be sanitized in order to minimise contamination of parasite in pastures and plant packages (Hadjilouka & Tsaltas, 2020). Another way to prevent this protozoa infection as mentioned by CDC (2020), is to use warm soapy water to wash hands and utensils such as dishes, chopping boards, and counter tops also act as preventative measures. Vegetables and fruits should also be washed properly before cooking and consumption. Peeled, cut and cooked vegetables and fruits needs should be refrigerated and stored separately from sea food, poultry and meat.

iii. *Taenia saginata/Taenia solium (Tapeworms)*

As reported by WHO, (2022) *Taeniasis* is a term used for the tapeworm's intestinal infection. *Taenia asiatica, Taenia saginata* and *Taenia solium* are the three parasites that result in *Taenasis* in humans. Out of the three parasites, the most with adverse effects in human health is *T. solium*. Infected and undercooked pork has cysticerci that if consumed by humans result in *T.solium*, while *T.saginata* on the other side is caused by consumption of a larva cysts from undercooked or raw beef (Marie & William, 2022).

Sato et al. (2018) revealed that *T. asiatica* and *T. solium*'s secondary host is swine and on the liver; brain and muscle, respectively. *Taeniasis saginata's* secondary host is bovine and cysticerci is found in the muscle. According to literature by Okello & Thomas (2017); WHO (2022), developing and low to middle countries such as Latin America, Asia and Africa have a high burden of the taeniasis infection. Dharmawan et al. (2020) cited that some of the risk factors for *T. saginata* could be due to close contact between humans and animals.

According to a study by Hou et al. (2023), vomiting, headache, nausea, tight chest and dizziness are some of the symptoms that may be observed on Taeniasis infected people. Diarrhoea, hunger pains and flatulence are other symptoms that may be observed (Marie & William, 2022; Yi-jiang et al., 2020).

Dixon et al. (2022) also revealed that T. solium can result in neurocysticercosis which causes disorders such as seizure or epilepsy. According to previous studies by WHO (2022) and Okello & Thomas (2017), the root cause of epilepsy among people who reside in countries of low income is T. solium. This is due to the fact that human beings and roaming swine live in close proximity.

Diagnosis for Taenia infections in humans is done by taking stool specimen, which is then tested by microscope at the laboratory (CDC 2020b). Ncube (2022) on the other hand, cattle blood samples are used to test for *Taenia saginata* infection. According to Parija (2022) the ELISA test is used for neurocysticercosis diagnosis in case of *T.solium* infection.

Effective treatment of Taenia infection includes administering albendazole, praziquantel, niclosamide and tribendimidine drugs (Okello & Thomas, 2017). Control measures for Taenia include slaughter management (meat inspection), maintaining of the quality of food, monitoring of parasites and adherence to legislation (Chu et al., 2022).

iv. Cryptosporidium parvum

Cryptosporidium is a single-cell protozoan parasite which inhabits in water. *Cryptosporidium parvum* and *Cryptosporidium hominis* are a duo that transmit disease to humans (Shaposhnik et al., 2019). Dumaine et al. (2020) reported that *Cryptosporidium* is responsible for causing diarrhoea in patients with AIDS and children in underdeveloped countries. King et al. (2019) confirmed this, noting that in poor countries *Cryptosporidium spp* can result in mortality among infants below one year. *Cryptosporidium parvum* causes cryptosporidiosis (zoonotic) and is a crucial public health issue in some countries (Guo et al., 2021).

Enbom et al. (2023) revealed that transmission of *Cryptosporidium* is mainly through faecal-oral route. Food handlers and raw vegetables are capable of transmitting Cryptosporidium (Nasser, 2022). Helmy & Hafez (2022) also reported that *Cryptosporidium* transmission is by person to person, ingestion of contaminated food or water, breathing in of oocysts infected air, animal to person contact and dirty water from the swimming pool.

Cryptosporidium symptoms may include watery diarrhoea, vomiting, weight loss, nausea (Shaposhnik et al., 2019). The symptoms on patients with compromised immune system are the same but severity is more. According to Helmy & Hafez (2022), symptoms may range from fatigue, anorexia, nausea, flatulent, medium watery diarrhoea with abdominal pain. Sneezing, coughing and phlegm may occur if one has inhaled oocysts infected air.

ELISA test, conventional sequencing and qPCR are used to confirm *Cryptosporidium* infection (Nyirenda et al., 2023). Nitazoxanide is the only single drug administered to susceptible patients, however its effectiveness is limited (Dumaine et al., 2020).

Previous literature by Dumaine et al. (2020) and King et al. (2019) revealed that vaccine for preventing occurrence of *Cryptosporidium spp.* is available. In order to prevent contracting *Cryptosporidium*, Enbom et al. (2023) suggest using appropriate protective clothing such as facial mask when in contact with bovine, to prevent inhalation of infected air as well as splashes of faecal contents.

v. Trichinella spiralis

According to Rayia et al. (2022) *Trichinella spiralis* is a nematode worm that lives in a tissue and causes Trichinellosis which is a zoonotic food-borne disease that occurs globally. Human beings can acquire *T. spiralis* from infected pigs, due to ingestion of undercooked or raw pork or pork sausages that have *T. spiralis* larvae (Bai et al., 2022). The most common symptoms of Trichinellosis in humans include: diarrhoea, nausea, abdominal pain and vomiting (Cheung et al., 2023). These signs can be seen between 7 to 21 days following exposure. Additional symptoms such as headache, facial edema, gastroenteritis, mylgia, and fever have also been reported in the literature (Grzelak et al., 2020). A study by Nkoke et al. (2023) revealed that *T.spiralis* infected individuals can also develop neurological disorders and myocarditis which may result in death if left untreated. *Trichinellosis* diagnosis can be done using ELISA as mentioned by Grzelak et al. (2020) and western blot (Pavic et al., 2020).

Trichinellosis is treated by Corticosteroids, nonsteroidal anti-inflammatory drugs and mebendazole (Pavic et al., 2020). Albendazole can also be used to treat an infected individual (Nkoke et al., 2023). Bai et al. (2022) indicated that taking care of animals as well as practicing public hygiene can minimise infections of T. spiralis. Public education and proper management on commercially produced swine is necessary and effective in minimising pork parasite infestation and Trichinellosis outbreaks (Cheung et al., 2023).

vi. Toxoplasma gondii

According to Attias et al. (2020) *Toxoplasma gondii* is a zoonotic parasite that is of veterinary and medical importance. *Toxoplasma gondii* causes an illness known as toxoplasmosis. According to Matta et al. (2021) this zoonotic parasite is transmitted between humans and animals. Immuno-suppressed individuals are susceptible to death from toxoplasmosis infection due to reactivation of the central nervous system's infection.

T.gondii is transmitted to humans following consumption of undercooked or raw meat from sheep and pigs (Attias et al., 2020). It can also be transmitted by consumption of uncooked vegetables or water contaminated with feline faeces (Almeria et al., 2019). Stelzer et al. (2019) reported that hosts for *T.gondii* are felids and household cats.

Symptoms shown by infected person mimic diseases such as Q fever, flu, mumps, fatigue, Lyme disease and mylgia (Dubey, (2021). Ifijen et al. (2023) added that headache, muscle pain, fever or asymptomatic are other symptoms of *T. gondii*. In patients with a suppressed immune system, this parasite can cause symptoms of central nervous system. The technique known as polymerase chain reaction (PCR) is used for diagnosis of *T. gondii* in humans (Liu et al., 2015).*Toxoplasmosis* can be cured by pyrimethamine and sulfadiazine administration as there is currently no suitable vaccine (Ifijen et al., 2023).

2.2. The impact of food-borne diseases

According to the WHO (2022), foodborne illnesses have a huge impact on socioeconomics. Trade, tourism and healthcare systems can hugely be harmed because of the outbreaks.

2.2.1. Economic impact

Adley & Ryan (2016) are of the view that globally, FBDs are still not under control, and so outbreaks that cause economic and health losses are still a common occurrence. Economically, FBDs can have severe consequences on food companies, people, and reputation of the country.

Jaffee et al. (2019) also reported that approximately US $110 billion is lost in productivity and medical expenses due to unsafe food in low-and middle-income economies yearly. Hussain & Dawson (2013) confirmed this view, noting that in the US alone about $7 billion estimated costs is spent on food safety incidents. In South Africa, the costs associated with the listeriosis outbreak in 2018, is estimated to be around R1 billion (News Desk, 2018).

According to literature these costs are due to customer notifications, food removed from shelves, damages payments due to lawsuits (Hussain & Dawson, 2013). In addition to this, economy also gets negatively affected as the employees stay home to recover from such illnesses. For example, in 2009 the United State of America (USA) had an outbreak of Salmonella/ Peanut products, and the estimated amount was $70 million.

2.2.2. The health impacts.

Unhygienic food production practices, harvesting and preparation are the main causes of food-borne diseases. Foodborne illnesses can be mild, and one can easily recover in a few days. But FBDs can also be severe resulting in hospital admission and in certain cases patients can even die (Adley & Ryan, 2016). For example, 300 000 and 5000 hospitalization and deaths respectively of food-borne illnesses in US are reported on yearly basis (Hussain & Dawson, 2013).

While foodborne illness affects both developed and developing nations, developing countries carry the biggest, with approximately 30% of the total affected population residing in these countries (Abebe et al., 2020). For example, in Africa acute illness of 91 million and deaths of 137,000 are due to foodborne hazards, (Harvard, 2019).

2.3. Occurrence of foodborne diseases in South Africa

Literature indicates that South Africa is not immune to food-borne diseases outbreaks. Although, there are 31 main food-borne pathogens (as indicated under section 2.1.), in this section only the reported common outbreaks in South Africa will be discussed. According to literature the most prolific outbreaks include *Listeriosis* and *Salmonellosis* (Arias-Granada et al., 2021). This also includes *Shigella* and *Staphylococcus.* A brief discussion of each is discussed below.

2.3.1 Outbreak of *Listeriosis*

Tchatchouang et al. (2020) reported the world's largest outbreak of listeriosis that was witnessed in South Africa. The outbreak was characterized by cases that progressively increased from January 2017 to July 2018. A total of 1060 listeriosis laboratory confirmed cases were reported by the National Institute of Communicable diseases (NICD), with 216 deaths recorded. According to reports, Gauteng, Western Cape and KwaZulu-Natal were the three provinces that were largely affected by this outbreak (WHO, 2018; Tchatchouang et al., 2020). Based on the epidemiological investigations, a food production facility producing ready-to-eat (RTE) processed meat products was responsible for the outbreak because it was contaminated with Listeria. monocytegenes. According to the South African Government (2018), unlike other bacteria, *Listeria* can grow in refrigerator's cold temperatures. However, cooking and pasteurisation kills *Listeria.*

Thomas et al. (2020) also reported the outbreak of listeriosis. In their study, they came to a conclusion that 50% of the cases reported were pregnancy associated, and 87% of the cases occurred in neonates. WHO (2018), confirmed this, noting that over 40% neonates were affected either during pregnancy or delivery. In addition to this, literature further indicates that other vulnerable groups that were largely affected by listeriosis include elderly and people with decreased immunity (WHO, 2018; Ismail et al., 2020). For example, it is reported that HIV infected individuals were more likely to develop complications such as meningitis or even die from listeriosis infection (Thomas et al., 2020).

Another study by Shonhiwa et al. (2018) indicated that 4 *Listeriosis* pathogens were isolated from food samples. This was done due to 327 reported cases in three provinces of Gauteng, KwaZulu Natal and Mpumalanga between 2013 and 2017. Out of these cases, affected individuals were 11,155, where 8680 visited the hospital, with admission of 494 patients and deaths of 49 people.

2.3.2 Outbreak of *Salmonellosis*

The National Department of Health (2016) mentioned that *Salmonella*, is the most common causes of food-borne illnesses. In a review of studies by Ramatla et al. (2022), *Salmonella* prevalence was found in all provinces in South Africa except in the Free State where there were no published studies. This was confirmed by Muvhali et al. (2017), who revealed that over 197 cases were reported in 6 South African provinces between 2013-2015 (Muvhali et al., 2017). In addition to this in February 2016, 33 cases including 2 deaths caused by *Salmonella* were reported across 5 South African provinces. Many cases are contracted through food eaten from street vendors and restaurants.

Ramalwa et al. (2020) reported in his recent investigation that, outbreaks of *nontyphoidal Salmonella* pathogen were identified and associated with informal slaughtering of food animals. This shows that there is a need for health education in communities where food animals are slaughtered informally. An outbreak of Salmonella was also reported in a study that was conducted among school children that had consumed food from the National School Nutrition Programme (Motladiile et al., 2019). According to this study, this outbreak was linked to the ingestion of samp by school children resulting in 164 of them having acute gastroenteritis (AGE) symptoms.

2.3.3 Prevalence of *Shigella*

Literature on the outbreak of shigellosis in South Africa is scanty (Keddy et al., 2012). However, there is evidence that *shigella* is one of the common causes for food-borne illnesses in the country. For example, 429 cases of invasive shigellosis were laboratory confirmed between January 2003 and December 2009 (keddy et al., 2012). Between March 2018 and August 2020, Shigella spp was the second most isolated pathogen from comprehensive epidemiological, environmental and laboratory investigations that were conducted and 20 people are said to have died (Ramalwa et al., 2020). In addition to this, a total of 6 *Shigella* species were isolated in a study that was conducted in Gauteng, KwaZulu Natal and Mpumalanga between 2013 and 2017. This was done due to an outbreak of 327 reported cases of FBDs. It is said that 49 deaths occurred while only 494 patients were admitted out of a total of 8680 patients who had visited the hospital (Shonhiwa et al., 2018).

2.3.4 Outbreak of *Staphylococcus*

Evidence has shown that *staphylococcus* has also been isolated in South Africa (Ntshiqa et al., 2016; Sibanyoni, 2017). According to Ntshiqa et al. (2016) 51 cases of *Staphylococcus enterotoxin* were reported in 3 hospitals in Pretoria in May 2015. Patients were said to have eaten at a certain hotel and presented symptoms of stomach cramps and vomiting, diarrhoea, nausea and fever. CDC (2018) added that after consumption of contaminated drink or food, symptoms appear within half an hour to 8 hours. *Staphylococcus* is not contagious. Ntshiqa et al. (2016) further reported that within 24 hours, all the patients were treated and discharged. An isolation of *Staphylococcus enterotoxin* from the chicken that was part of the meal for the patients was done.

Based on information by CDC (2018), food handlers with poor hand hygiene are responsible for most of the outbreak. During food preparation, it has been established that there is a relationship between poor hand hygiene and *staphylococcus* infections. Awareness of hand washing is important to prevent such outbreaks. Based on the study conducted in Mpumalanga province on a National Schools Nutrition Programme by Sibanyoni (2017), *Staphylococcus* was isolated in one or more of the 192 swabs that were collected for tests. This was done as part of the food safety measures for participating schools.

2.4. Food-borne diseases risk factors

Anything that rises the probability of disease development is known as a risk factor (NCI, 2022). These risk factors include the time and temperature control, inadequate cooking, inappropriate storage of food, and the use of contaminated equipment (CDC, 2017).

2.4.1 Time and temperature control

According to AIFS (2020), time and temperature control is one of the factors associated with FBDs because for harmful pathogens to grow and cause food-borne illness in people, they need certain time and temperature. Kralj (2020) suggests that food needs to be monitored from arrival, storing and serving. For example, when ordering food if the food temperature is inappropriate upon delivery, such food must be rejected. Freezers and fridges and holding equipment should be monitored daily. AIFS (2020) added that for the prevention of harmful bacteria growth in high -risk foods, one must ensure that food stays out of the Temperature Danger Zone. Using or throwing out of food is determined by applying a 2- or 4-hour practice for high-risk foods and is done in the Temperature Danger Zone.

2.4.2 Inadequate cooking

Inadequate cooking is another risk factor for foodborne illnesses. According to literature, some food requires to reach an internal temperature enough to destroy bacterial pathogens like Salmonella that may be present in food (Odo & Wagner, 1975). Therefore, utilization and implementation of proper procedures on cooked foods taking into consideration internal temperature prior to serving is important (Kralj, 2020). In support of this, Qekwana et al. (2017) in a study that was conducted on meat during traditional slaughter ceremonies, concluded that food outbreaks are prevented by cooking meat for long periods and consuming it immediately.

2.4.3 Improper food storage temperature

AIFS (2020) concluded that in order to keep food safe for consumption it is important to store food properly. Most people get sick from FBDs due to contaminated food that has been stored inappropriately. When receiving food from deliveries, it must be done at a correct temperature of less than 5 °C. High risk foods must be stored properly and timeously and must be kept away from Temperature Danger Zone for too long.

2.4.4 Contaminated equipment

According to Jensen (2016), the use of contaminated equipment and utensils poses a risk of food being exposed to food-borne pathogens. There are different ways where cross contamination can take place if sanitation and cleaning is lacking. There is a build-up of pathogens that are dangerous together with food residues on equipment and utensils. The unsafe food handling practices by food handlers is a common cause of contamination. This is where dangerous bacteria, parasites and viruses are allowed to contaminate food. The consumption of these pathogens results in consumers getting sick. To prevent cross contamination, food handlers need proper food safety training and education. These include washing of hands, sanitizing of equipment, cleaning of surfaces, etc. Qekwana et al. (2017) added that the Health Act 63 of 1977 of South Africa states that there may be no contact with food if a person is suspicious of carrying or suffering from a contagious condition or disease that can be transferred through food.

2.4.5 Food from unsafe source

Based on information by Kralj (2020), where food is sourced is one of the risk factors that leads to numerous outbreaks. The key aspect of food safety, is where one sources the food ingredients. It is important to get food from trusted suppliers to lower the risk of getting food ingredients that are contaminated. In addition, Krippel (2017) mentioned that when inspection control takes place at the approved suppliers, it ensures a safe supply of food.

2.4.6 Poor health and personal hygiene

Appropriate and cleanable footwear and materials need to be provided to food handlers to avoid poor personal hygiene. To enhance the safety of food, in the area of production, items like cell phones, pencils or books should be avoided. Without adhering to precautionary measures, hygiene zones are crossed when sanitizing by employees. Therefore, signage for expected hygiene and zone identification must be visible to limit cross contamination (Hanlin, 2021).

According to Kralj (2020) good hygiene and employee wellness practices can enforce a good plan for food safety. Policies need to be established to address workers on specific practices that must be carried out by employees prior to work, and during their working hours.

2.5. Occupational health risk factors

Risk as associated with occupational health and safety is the probability that if there is a hazard exposure on someone it would result in serious health issues or harm an individual (HSA, 2022). There are several occupational risk factors that are mentioned in the literature. A brief discussion of these follows below.

Odetokun et al. (2020) mentioned that workers at slaughterhouses may contract zoonotic diseases from animals and other way around. Diseased animals that are slaughtered at unregulated slaughter facilities contribute a lot in spreading zoonotic diseases (Cook et al., 2017). With regards to traditional slaughter, it has been observed that men compared to females are at a higher risk of occupational health hazards and zoonotic diseases. A study that was conducted by Qekwana et al. (2017), to assess the occupational health and food safety risks associated with the traditional slaughter and consumption of goats in Gauteng, South Africa found that that men were the only ones doing the slaughter.

Research by Nkonki-Mandleni et al. (2019), noted that lack of access to veterinary services and knowledge of zoonotic diseases worsens the risk of FBDs. Buttigieg et al. (2018) mentioned that in Serbia there was spread of *B. abortus* and *B. melitensis* among humans and animals due to lack of veterinary knowledge and importation of non-regulated infected animals from bordering countries. This resulted in the first case of Brucellosis reported in 1947, followed by 40 cases of human infections reported between 1951 and 1970. Van de Venter (2000) added that most farmers lack education and therefore use outdated production methods. They usually use communal farming, or they have very small farms, and the animals have close contact with them. In addition, eradication and control programmes do not exist or if they do it's only a few that they know about them. This favours transmission of zoonotic diseases including FBDs.

According to Cook et al. (2017) wearing of protective clothing when slaughtering helps to prevent contamination of meat products and prevent zoonosis like brucellosis, tuberculosis and leptospirosis from spreading to the meat handlers. However, wearing of protective clothing during the slaughtering process is not common among traditional slaughter practitioners. This has been attributed to lack of formal training amongst traditional slaughter practitioner's (Qekwana et al.,2017). In addition, according to Qekwana et al. (2017) another serious public health problem associated with traditional slaughter, is that clothes worn during slaughter are only changed when traditional slaughters got home. These actions increase the risk of FBDs and transmission of zoonotic pathogens from the place of slaughter to homes. Disposable protective clothing during slaughter is advisable to mitigate the spread of FBDs.

2.6. Population groups that are vulnerable to food-borne illnesses.

According to Evans & Gwynne (2020) patients of low socioeconomic status, children, disadvantaged groups, the elderly, and ethnic minorities are known as vulnerable population (vulnerable to FBDs). This group's situation is worsened by lack of access to adequate health care. CDC (2022) mentioned that food poisoning can affect anyone, but vulnerable groups get severe illnesses easily due to inability of bodies to prevent sickness and germs. The most affected population groups are elderly people aged from 65 years and above. This is because germs are not easily removed by their weak immune system. As a result, this age group gets most hospital admissions. Five-year-olds and younger children also get affected due to their not fully developed immune system. FDA (2020) also added that people who have their immune system weakened due to human immunodeficiency virus/ acquired immunodeficiency syndrome (HIV/AIDS), diabetes, alcoholism, chemotherapy also get easily infected because of the weak immune response. Women who are pregnant are easily infected with FBDs because their immune system is altered. This can result in death, premature delivery, miscarriage, stillbirth and sickness of the baby.

2.7. Monitoring food-borne illnesses

According to Cambridge (2021), in an organization (business, school or government), a certain division that does certain activities is known as a department. In South Africa, three departments namely Department of Agriculture, Forestry and Fisheries, Department of Trade and Industry as well as the Department of Health are responsible for quality legislation and food safety (ASC, 2022). The roles of the different departments are outlined below.

2.7.1 The Department of Agriculture, Land Reform and Rural Development (Formerly called Department of Agriculture, Forestry and Fisheries)

There are two directorates that are responsible for food safety under the Department of Agriculture, Land Reform and Rural Development (DALRRD). These are Veterinary Public Health Directorate and Food Safety and Quality Assurance. Veterinary Public Health Directorate facilitates the provision of veterinary preventative measures and control of animal by-products and safely production of animal products. Its function is mainly to harmonize and facilitate matters of animal welfare and the development of standards and norms for matters pertaining to veterinary public health. The Food Safety and Quality Assurance Directorate is responsible for controlling safety and quality of food of some agricultural products under Agricultural Products Standards Act, 1990 (Act No. 119 of 1990) and regulates the production, import, sale and export of alcohol products under the Liquor Products Act, 1989 (Act 60 of 1989) (DALRRD, 2022).

2.7.2. The National Department of Health

This department is responsible for improving the health status by constant prevention of diseases and illnesses. It also aids good well-being and improving on equity, quality, access, efficiency and sustainability of delivery of health care (Government, 2023). The National Health Laboratory Services under the National Department of Health assists in outbreak or incident investigation of FBDs. To successfully control an outbreak, an instant investigation is important. Early and fruitful interventions curb morbidity and mortality (NICD, 2012).

2.7.3 The Department of Trade and Industry

The focus of this department is commercial and economic policies that have to do with food trading. The enforcement of the law is done to assist customer protection and monitoring of business and commercial activities. Provision of protection for consumers from products that are harmful, the right to complain about a product, returning the said products and the right of being compensated for poor quality products is done by the Department of Trade and Industry (ASC, 2022). The South African Bureau of Standards (SABS) is under this department and its role is to ensure that standard of products such as raw meat, water, crops, bulk foods and processed foods are maintained to minimise their impact on humans and the environment (SABS, 2021).

2.8. Legislation Applicable to food safety

The making of laws by national, state or local legislature is known as legislation (Ray, 2022). According to FACS (2019) and Scott (2017), food legislation is done by the National Department of Health, the Department of Agriculture, Land Reform and Rural Development (previously called Department of Agriculture, Forestry and Fisheries -DAFF) together with the Department of Trade and Industry. This is done through the parliament's acts.

The following are the acts (legislation) that are regulated by DAFF: Animal Diseases Act, 1984 (Act No.35 of 1984), Meat Safety Act, 2000 (Act No.40 of 2000), Agricultural Product Standards Act, 1990 (Act No.119 of 1990), Animal Protection Act, 1962 (Act No. 71 of 1962), Veterinary and Para-Veterinary Professions Act, 1982 (Act No 19 of 1982), Animal improvement Act, 1998 (Act No. 62 of 1998), Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Act, 1947 (Act. No. 36 of 1947), Animal Identification Act, 1998 (Act No. 6 of 2002), Liquor Products Act 1989 (Act No.60 of 1989) and Performing Animals Protection Act 1935 (Act No. 24 of 1935). South African Government (2009) added that DAFF also regulated the plants food's export and import.

The Animal Diseases Act, 1984 (Act No.35 of 1984) according to the Government Gazette, (1984) provides for the control of animal parasites and diseases, for animal health promotion and all matters connected. The Meat Safety Act, 2000 (Act No.40

of 2000) provides for promotion of meat safety and safety of animal products, establishing and maintenance of important national standard for abattoirs, to control import and export of meat, the meat safety scheme establishment and provision of any other matter of concern (RSA, 2000). The Agricultural Product Standards Act, 1990 (Act No.119 of 1990), assist in providing regulations of export and sale of some agricultural products, regulate sale of some agricultural products that are imported, and regulation of other products and other matters connected (Gov, 1990).

The Animal Protection Act, 1962 (Act No. 71 of 1962), assist in consolidation and amendment of laws related to the prevention of animal cruelty (CER, 2023). Veterinary and Para-Veterinary Professions Act, 1982 (Act No 19 of 1982), it's for provision of the establishments, functions, and powers of the South African Veterinary Council, for a person who practices as a veterinary profession and para-veterinary profession to be registered and for regulating veterinary profession and para-veterinary profession practices (Journal, 1984). Animal improvement Act, 1998 (Act No. 62 of 1998), this Act assist in providing for breeding, utilizing and identifying genetically quality animals for purposes of improving performance and production for the Republic's interest and any other matter in connection with (Staatskoerants, 1998). Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Act, 1947 (Act. No. 36 of 1947), for the provision of registration of farm feeds, fertilizers, sterilizing plants and some remedies, to control the sale and importation of farm feeds, fertilizers, seeds and some remedies and any other related matters (FAOLEX, 1947). Animal Identification Act, 1998 (Act No. 6 of 2002), assist in managing the national Animal Identification register on marks that help during stock theft and help in property identification and traceability (Agriculture, 2008). Liquor Products Act 1989 (Act No.60 of 1989) for provision of control on production and sale of products of alcohol, the properties and composition of products and using of particulars connected to the sale of products; for the scheme establishment; to regulate on export and import of some products of alcohol and any other matters connected with (ACTS, 2022). Performing Animals Protection Act 1935 (Act No. 24 of 1935) for regulating the training and exhibition of performing animals (Gazette, 1935).

Human's food safety is regulated by Foodstuff, Cosmetics, and Disinfectants Act, 1972 of the health's department. This also includes baby's food and formulas. The foodstuff importation, labelling and manufacturing are included in the Act. The National Health Act, 2003 regulates the foodstuff hygiene. International Health Regulation's Act, 1974 is for the application of International Health Regulations, endorsed by the World Health Assembly and for provision of incidental matters (FACS, 2019; Scott, 2017).

Standards Act, 1993 is responsible for the regulation of fishery products like canned and frozen stuff and canned meat through the South African Bureau of Standards which falls under the department of Trade and Industry (Scott, 2017).

CHAPTER 3
RESEARCH METHODOLOGY

3.1. Introduction

This section presents the research methodology, which are specific techniques or procedures used to identify, select, process, and analyse information about a topic (Wilkinson, 2021). Under this section the study area where the research is sited, study design and study population are presented. Furthermore, data source and how the data was analysed are also presented.

3.2. Study area

The present study was conducted in a public hospital in Mhlontlo Local Municipality (which consists of Qumbu & Tsolo towns), Eastern Cape Province, Southeast of South Africa (Figure 1). This hospital predominantly caters for residents of Mhlontlo locations. The area is mostly rural and populated by Xhosa, Coloured, Indian/Asian, and White people. Its population is approximately 188,226 (Wikipedia, 2022). Mhlontlo is very hot and cold in summer and winter months respectively. The maximum temperatures vary between 0 to 41 degrees Celsius, with rainfall experienced mostly in the summer months. Growing vegetables and rearing livestock are the main economic activities in the study area.

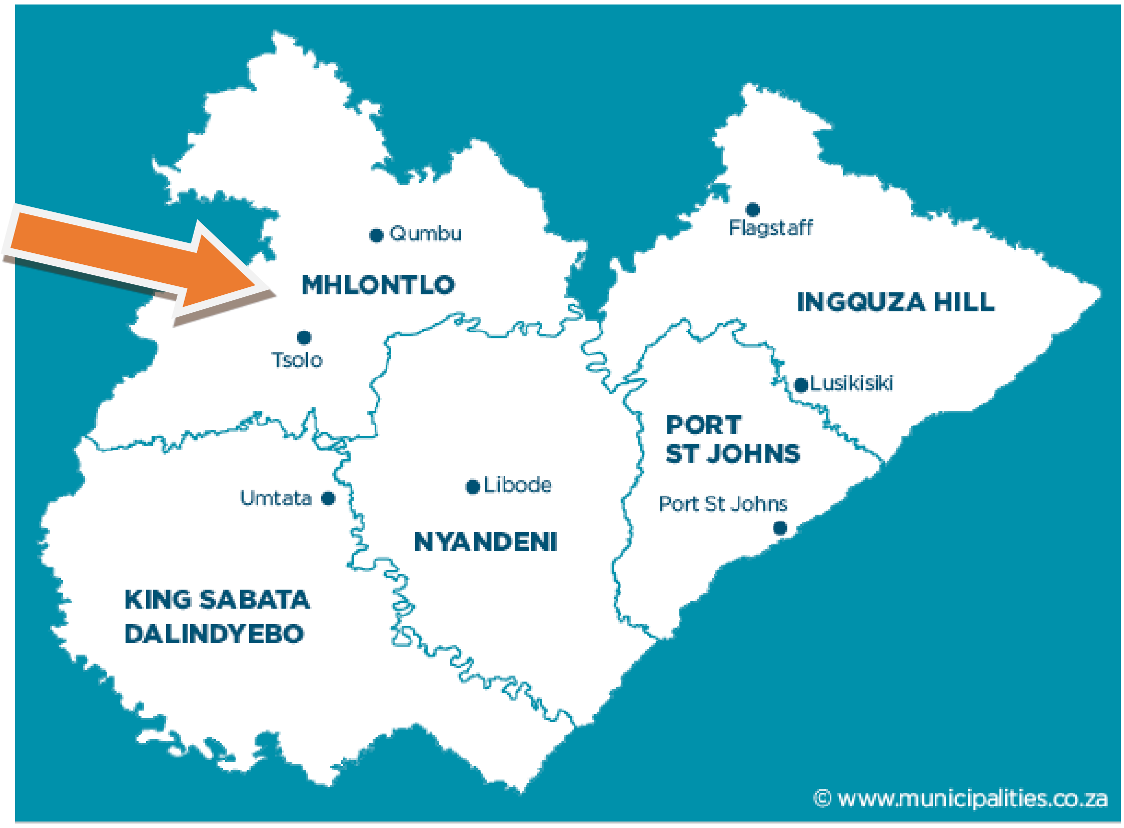

Figure 3: 1 A map showing OR Tambo district where the hospital that provided the data is located (Kohnert, 2003)

3.3. Study design

A cross sectional study design using retrospective data was adopted to realise the objectives of the present study. Cross-sectional research design is an observational study design where variables are not manipulated, its characteristics are considered at once, happens once at a time and the characteristics of the population are analysed (Levin, 2006).

The reason for choosing cross sectional study among others is because it does not require a lot of time, the data can be used for various type of research and contains multiple variables (Goldman & Pabari, 2020). In addition, the design is quantitative because it involves computing numbers of cases by person, place and time (Thomas et al., 2020).

3.4. Study population

According to a study by Majin (2018), a group of selected individuals to be studied or treated is known as study population. This group of individuals are selected on the basis of the inclusion criteria that relates to variables being studied which is the main characteristics of the study population.

In the present study, the study population included all patients that attended the selected hospital between January 2016 and December 2020. Only data of patients who presented themselves at this facility with FBD related complaints were included in the study.

3.5. Data Sources and data management

3.5.1 Data source

Retrospective data from the hospital that services the residents of Mhlontlo Municipality was used. Only data collected between January 2016 and December 2020 was included in this study.

3.5.2 Data management

The following variables were extracted from the data: daily cases of foodborne diseases recorded, age of the patient, name of the location where patient resides, immune-compromised status of the patient, special conditions (i.e., pregnancy) that the patient had, and suspected food involved.

A Microsoft Excel spread sheet was used to capture and store the data extracted from the hospital records. Thereafter, the data was evaluated for missing values and any inconsistencies such as improbable values.

3.5.3. Data analysis

The Statistical Package STATA (Stata/MP 18.0, StataCorp, College Station, TX, USA) was used to analyse the data.

a) Descriptive statistics

The proportions of cases of foodborne diseases by person, time and place were calculated and presented as graphs and tables. The temporal trend of cases was analysed and presented as a line graph.

b) Inferential statistics

Inferential analysis was conducted in two stages. The first stage involved univariate analysis to test for simple associations between the predictor variables and the outcome variable (Admitted). All variables with the alpha level ≤ 0.20 in the univariate model were selected for inclusion in the multivariate model (ANNEXURE I: Supplementary Material A).

In the second stage a multivariable binary logistic regression model was fit to the data to assess the factors that were significantly associated with being admitted following exposure. The backward elimination selection method was used to select variables to retain in the final binary logistic regression model. The assumptions of the binary logistic regression model were checked before fitting the model.

Confounding was assessed by comparing the changes in effects measures with and without the suspected confounders. A change of ≥20% of the effect measures of any variable in the model following removal of a variable, meant that the variable was a confounder and was a result retained in the model irrespective of whether it was significant or not.

Because some variables had either low numbers or zero in some cells, it was not possible to test for interactions in the final effects model. Therefore, interaction terms were not retained in the final effects model. Odds ratios (ORs) and their 95% confidence intervals were computed for variables included in the final model (ANNEXURE II: Supplementary Material B).

The Wald test was used to test for individual predictors in the model. With Ho: Coefficient of an independent variable is not significantly different from zero; therefore, by failing to reject the Ho, it means that removing the variable from the model will not ruin the model fit. Results of the Wald test are summarized in Supplementary Material C.

The Log likelihood ratio test was used to compare models. The model fit of the final effects model was tested using a Hosmer-Lemeshow goodness of fit test. Based on the results, there was a good model fit ($p > 0.05$) (ANNEXURE III: Supplementary Material D).

The results of the sensitivity analysis are presented in Supplementary Material E (ANNEXURE IV). The predictive power of the model was assessed using the ROC curve. With the area under the ROC curve of 0.589, it was concluded that the final model does a fairly good job in predicting true positive and true negative values of the response variable (Admitted). After deciding on the final effects model, margins were computed using effect measures of the final model.

3.6. Ethical and legal considerations

The study's main stakeholder was the Eastern Cape Department of Health because they are in possession of patient's data at the health facility. The permission to conduct the study was requested from the Eastern Cape Department of health (Annexure B). Also, the Research Ethics Committee of the College of Agriculture and Environmental Science of the University of South Africa granted the research ethics clearance for the study (Ref #: 2022/CAES_HREC/047) (Annexure A).

The rights of administrations, authorities and participants were honoured by the researcher. The right to independence, confidentiality, voluntary participation and anonymity are some of the ethical considerations (Sim and Waterfield, 2019; Alrehaili and Mutaha, 2020) and fearfulness (Hammersley, 2021; Leedy and Ormrod, 2021). To keep the participants anonymous during the study is what is meant by the term anonymity (Trochim, 2000). The maintenance of patient's anonymity was enabled by making sure that responses and information received from the records was confidentially handled. The researcher needed not to take patient's names from the medical records. In addition, there was a guarantee that collected information from the medical records at the hospital could not be associated with patients. One of the conditions from Eastern Cape Department of Health was that no work was permitted to be published or presented at conferences without permission from the department that provided the data.

The data for this research was confidentially kept and only people who could access it were the authorised people and the researcher. The data was stored on a password protected computer after the study had been finalised. No personal identifiable information was extracted from the hospital data so as to keep the patients from whom the data was collected anonymous.

Since there was no direct contact with participants in this study, there were no people use ethics related issues. Furthermore, no interviews were conducted and therefore the consent forms were not needed.

CHAPTER 4

RESULTS

4.1. Introduction

This section contains results of the research project. The results are presented as tables and figures. The results presented include the following: demographic profile of the respondents; the frequency of the comorbidities, symptoms, and treatment information of the respondents; the proportion of patients by the causes of food-borne disease; and the causes of food-borne diseases per location.

4.2. Demographics characteristics

As demonstrated in **Table 4.1,** 53.46% (n=224) of the patients were males, while the females made up the remaining 46.54% (n=195) of the study population. The patients who were unemployed constituted the majority (49.16%; n=206) of the patients, followed by scholars (48.45%; n=203), with the patients who indicated that they were employed making up the least number of patients (2.39%; n=10).

Table 4: 1 Demographic profile of the respondents (N= 419)

Variable	Level	Frequency	Percentage
Sex	Male	224	53.46
	Female	195	46.54
Total		**419**	**100**
Employment status	Unemployed	206	49.16
	Employed	10	2.39
	Scholar	203	48.45
Total		**419**	**100**

4.3. Comorbidities and symptoms

As shown in **Table 4.2,** the majority (77.09%, n=323) of patients did not have information on their hypertension status. As a result, only 5.25% (n=22) were hypertensive, while 17.66%; (n=74) were not. Only 3.34% (n=14) of the patients were HIV positive, while the majority (96.66%; n=405) were HIV negative. Patients who had diabetes made up 6.44% (n=27) of the study population, while 93.56% (n=392) were diabetes negative. A small number of patients had tuberculosis

(2.15%, n=9), while the majority (97.85%, n= 410) were TB negative. Pregnant patients constituted only 3.10%; (n= 13) of the study population.

Table 4: 2 Comorbidities and symptoms recorded among the patients (N=419)

Variable	**Level**	**Frequency**	**Percentage**
Comorbidities			
Hypertension	Positive	22	5.24
	Negative	74	17.66
	Unknown	323	77.09
Total		**419**	**100.00**
HIV	Positive	14	3.34
	Negative	405	96.66
Total		**419**	**100.00**
Diabetes	Positive	27	6.44
	Negative	392	93.56
Total		**419**	**100.00**
Tuberculosis	Positive	9	2.15
	Negative	410	97.85
Total		**419**	**100.00**
Pregnancy	Positive	13	6.67
	Negative	182	93.33
Total		**195**	**100**
Symptoms			
Diarrhoea	Yes	282	67.30
	No	137	32.70
Total		**419**	**100**
Vomiting	Yes	284	67.78
	No	135	32.22
Total		**419**	**100.00**
Abdominal pain	Yes	178	42.48
	No	241	57.52
Total		**419**	**100.00**
Bloody diarrhoea	Yes	60	14.32
	No	359	85.68
Total		**419**	**100.00**
Headache	Yes	151	36.04
	No	268	63.96
Total		**419**	**100.00**
Loss of energy	Yes	71	16.95
	No	348	83.05
Total		**419**	**100.00**

Most of the patients (67.30%, n= 282) presented with diarrhoea and vomiting (67.78%, n =284). Meanwhile, 42.48% (n =178) of the patients had abdominal pains. Bloody diarrhoea was observed in 14.32% (n= 60) of the patients. Headaches were reported by only 36.04% (n =151). Patients that presented with loss of energy made up 16.95% (n= 71) of the study population.

4.4. Treatment administered to patients

As shown in **Table 4.3,** different treatments were given to patients who were treated for food poisoning related illnesses. Intravenous (IV) solution was the most commonly administered treatment (71.36%, n= 299), followed by vitamin B Complex (B.co) which was administered to 16.95% (n= 71) of patients.

Flagyl was the most frequently administered antibiotic, given to 93.32% (n =391) of the patients. This was followed by ampicillin (32.70%; n = 137) and amoxilin (29.36%; n =123). Panadol used for pain management, was prescribed for most (95.47%, n = 400) of the patients.

Loperomide used for the treatment of diarrhoea was administered to 15.75% (n = 66) patients, while half 50.84% (n=213) of the patients received oral solutions. Meanwhile, 28.64% (n = 120) and 15.51% (n = 65) of the patients received hyoscine and buscopan respectively (Table 4.3).

Table 4: 3 The percentage of the patients who received the various treatment for FBDs or illnesses.

Treatment	Level	Frequency	Percentage
IV	Yes	299	71.36
	No	120	28.64
Total		**419**	**100.00**
IV with B.co	Yes	71	16.95
	No	348	83.05
Total		**419**	**100.00**
Panado	Yes	400	95.47
	No	19	4.53
Total		**419**	**100.00**
Antibiotics			
Flagyl	Yes	391	93.32
	No	28	6.68
Total		**419**	**100.00**
Amoxilin	Yes	123	29.36
	No	296	70.64
Total		**419**	**100.00**
Ampicillin	Yes	137	32.70
	No	282	67.05
Total		**419**	**100.00**
Antidiarrheal			
Loperomide	Yes	66	15.75
	No	353	84.25
Total		**419**	**100.00**
Oral solution	Yes	213	50.84
	No	206	49.16
Total		**419**	**100.00**
Hyoscine	Yes	120	28.64
	No	299	71.36
Total		**419**	**100.00**
Buscopan	Yes	65	15.51
	No	354	84.49
Total		**419**	**100.00**

4.5. Sources of food-borne diseases

Eating meat from cattle injected with medicine was responsible for most of the cases (42%, n=176) (Table 4.4). This was followed by consuming a dead cattle (26.25%, n= 110), consuming cattle bitten by a snake (12.89%, n=54), consuming chicken served at school (6.44%, n=27), and eating meat from a dead sheep (4.30%, n= 18).

Some patients got sick after consuming sour milk (1.67%, n= 7), water from a river (1.19%, n= 5), ready-to-eat (RTE) meat (1.19%, n= 5), spoilt rice (0.95%, n= 4), wild mushrooms (0.72%, n=3) and a sick chicken (0.72%; n=3). For each of the following foods: samp & beans, spoilt chicken, and unpasteurized milk, two people (0.48%, n= 2) respectively got sick. Only one case (0.24%, n= 1) was linked to eating meat from a dead goat.

Table 4: 4 The proportion of patients by the sources of food-borne disease (N= 419)

Variable	**Level**	**Frequency n**	**Percentage %**
FBDs sources	Dead cattle	110	26.25
	River water	5	1.19
	Dead sheep	18	4.30
	Injected cattle	176	42.00
	Samp & beans	2	0.48
	Dead goat	1	0.24
	Wild mushroom	3	0.72
	Cattle bitten by snake	54	12.89
	Ready to eat meat	5	1.19
	Unpasteurised milk	2	0.48
	Spoilt rice	4	0.95
	Sick chicken	3	0.72
	Sour milk	7	1.67
	Chicken from school	27	6.44
	Spoilt chicken	2	0.48
Total		**419**	**100.00**

4.6. Food-borne diseases recorded by year and months

The number of cases of FBDs recorded each year between 2016 and 2020 are summarised and presented in **Figure 4.1.** For each of the years 2016, 2018 and 2020, there was a spike in the number of cases of food-borne diseases between January and June. The lowest number of cases were observed between July and December throughout the study period, with the exception of 2017 and 2019 when another spike in the number of food-borne diseases was observed between September and December.

The year that recorded the highest number of food-borne cases was 2018 (n= 222, 52.98 %). This was followed by 2016 (n= 94, 22.43 %), and 2017 (n= 49, 11.69 %).

The years in which the least number of food-borne cases was reported were 2019 and 2020, (n= 18, 4.30%; n= 36, 8.59% respectively).

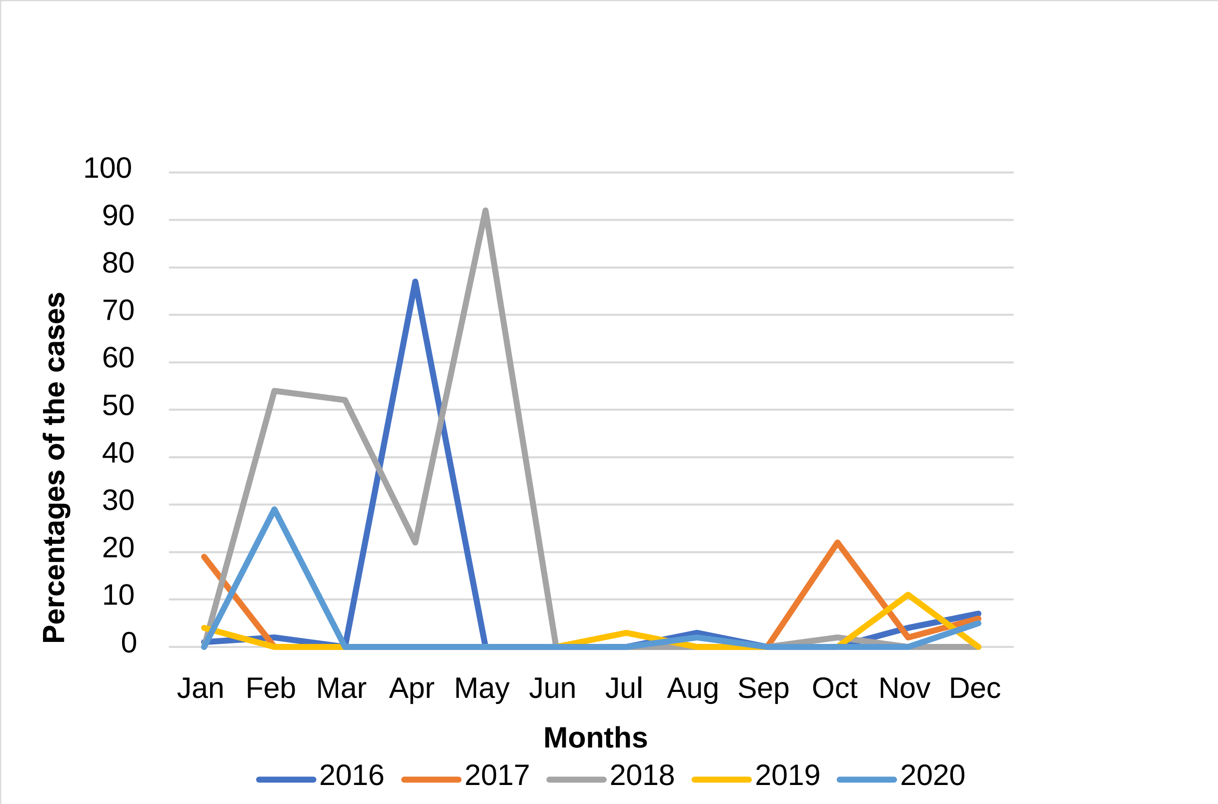

Figure 4: 1 Number of cases of FBDs observed by year over the study period

4.7. Sources of food borne diseases by location

Table 4.5 below shows sources of food-borne diseases in different locations. Consumption of meat from dead cattle accounted for 25,81% cases of FBDs observed in eight locations. Consumption of meat from dead sheep was reported in four (n=4) locations and accounted for 12,9% cases of FBDs reported in over the study period.

Cases of FBDs associated with drinking of water from a river and consuming of sour milk came from two (n=2) locations for each variable and were responsible for 6,45% of the FBDs cases observed in the study. On the other hand, cases of FBDs due to consumption of meat from cattle injected with medicine was observed in five (n=5) locations. These constituted 16,13% of the cases observed in the study.

Consumption of samp and beans, meat from dead goat, eating of wild mushroom, consumption of meat from cattle bitten by a snake, consumption of ready-to-eat meat, drinking of unpasteurized milk, consumption of spoilt rice, eating meat from a sick chicken, eating chicken served at school and consuming of spoilt chicken meat were responsible for 3,23% of the FBDs cases for each variable, and all these were each observed in only one location over the study period.

Table 4: 4 Sources of food-borne diseases in different locations (N=419).

Variable (FBD Sources)	Number of locations/villages affected	Frequency (n)	Percentage (%)
Dead cattle	8	110	25.81
Dead sheep	4	18	12.9
River water	2	5	6.45
Injected cattle	5	176	16.13
Samp&Beans	1	2	3.23
Dead goat	1	1	3.23
Wild mushroom	1	3	3.23
Cattle bitten by snake	1	54	3.23
Ready-to-eat-meat	1	5	3.23
Unpasteurized milk	1	2	3.23
Spoilt rice	1	4	3.23
Sick chicken	1	3	3.23
Sour milk	2	7	6.45
Chicken from school	1	27	3.23
Spoilt chicken	1	2	3.23
Total	**31**	**419**	**100**

4.8. The proportion of patients admitted to hospital

Overall, both females and males accounted for 31,50% (n= 132) of the admissions. However, as shown in **Figure 4.2,** females made up the majority 34.87% (n= 68) of admissions, while males made up the remaining 28.57% (n= 64).

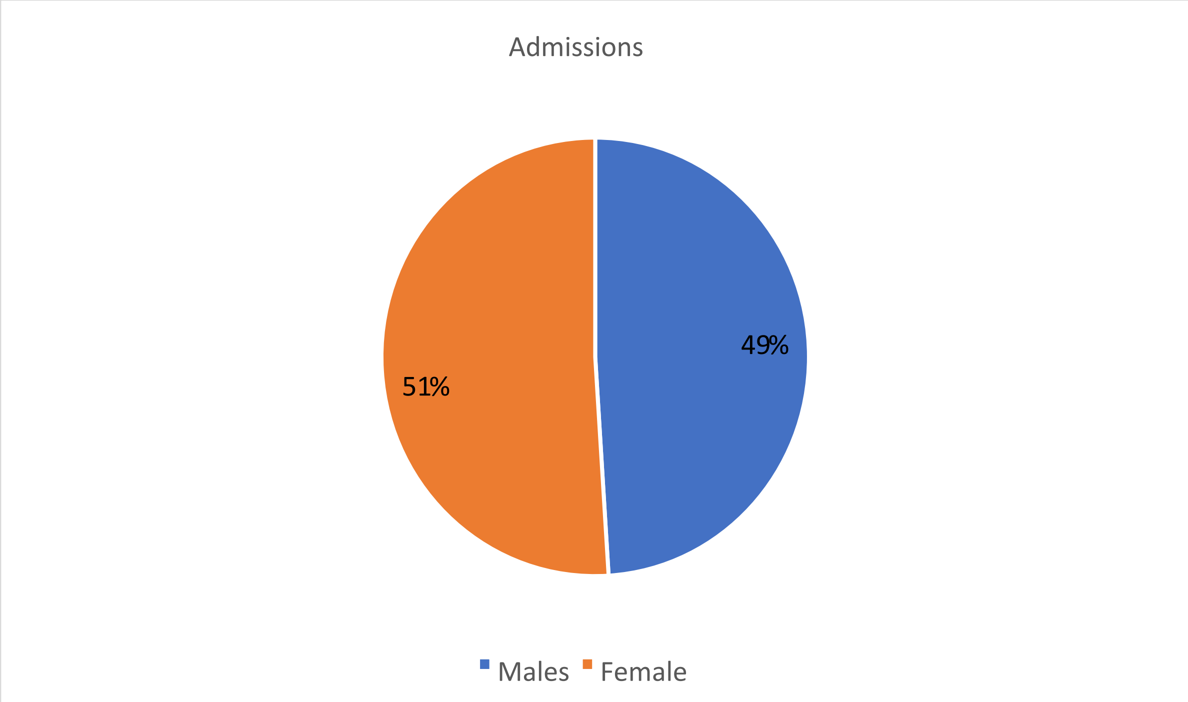

Figure 4: 2 The proportion of patients admitted to hospital by sex over the study period, 2016-2020.

4.9. The probability of being admitted

Marginal probabilities of patients presenting with FBDs, being admitted were determined as explained under section 3.4.3 and are presented in **Table 4.5**. Overall, the results revealed that patients who had comorbidities had a high probability of being admitted. For example, patients who had diabetes had a higher probability of being admitted with Marginal Effect (ME) of 0.64 while those without diabetes had a lower probability (ME=0.29) of being admitted. Likewise, patients with TB had a higher probability of being admitted with a ME of 0.66 than those who were TB negative (ME=0.31). The variable pregnancy was also highly significant, showing that patients who presented with symptoms of FBDs and were also pregnancy had higher probability of admission (ME=0.61) when compared to those that were not pregnant (ME=0.30). The HIV positive patients had a higher probability of being hospitalized (ME = 0.34), while patients who were HIV negative had lower probabilities of being hospitalized (ME = 0.31).

Table 4: 5 Marginal probabilities of being admitted if the patient had a comorbidity

Variables	Levels	Margins	Std error	95% [a]CI Lower limit	95% [a]CI Upper limit	Pvalue
Diabetes	Ref No	.2921679	.0226264	.2478209	.3365148	0.000
TB status	Yes	.6420508	.0904089	.4648525	.8192491	0.000
Pregnancy	Ref No	.3073466	.0222343	.2637682	.350925	0.000
	Yes	.6652839	.1558684	.3597874	.9707804	0.000
HIV status	Ref No	.3053877	.022311	.261659	.3491164	0.000
	Yes	.6157083	.1332839	.3544766	.87694	0.000
	Ref No	.3138431	.0223681	.2700024	.3576837	0.000
	Yes	.3493021	.1235771	.1070954	.5915089	0.005

[a]CI= Confidence Interval

CHAPTER 5
DISCUSSION OF THE RESULTS

5.1. Introduction

The preceding chapter details the discussion of the results obtained from the retrospective data obtained from the hospital. The focus was on the demographic information of the patients, comorbidities and symptoms observed among the patients, the percentage of the patients who received the various treatment for food-borne diseases (FBDs) or illnesses, the proportion of patients by the causes of the FBD, number of cases of FBDs observed in each year, causes of FBDs in different locations, and the proportion of patients admitted to hospital by sex. This chapter will concentrate on the analysis and discussion of the results obtained in the preceding chapter.

5.2. Demographic information of the patients

In this study, males made up over half of the population who were treated for FBDs at the hospital. These results are corroborated by the findings by Osei-Tutu & Anto (2016), who reported that in Ghana, FBDs were mostly reported by males as compared to females. Similarly, males constituted a higher proportion of patients with FBDs in a descriptive study conducted in China between 2016-2020 (Qi et al., 2022). According to Qekwana et al. (2017) male members of the community usually perform the slaughtering process. Moreover, this is done while not wearing protective clothing. This places them at a higher risk of exposure to FBDs. In addition, generally, women are known to have better food handling practices than men, for example, a study that was conducted by Girmay et al. (2022) among food establishment managers, revealed that females were more likely to have good food handling practices than their male counterparts. Tessema et al. (2014) in a study conducted in Ethiopia also observed that females had better food handling practices. In view of this, the fact that men in this study constitute a large proportion of those who reported FBDs was expected.

Based on the results reported in this study, the unemployed respondents constituted almost half of the entire population who reported FBDs at the hospital. Dastile et al. (2017) are of the view that knowledge of meat safety (which is part of food safety) by employed people tends to be good. Liana et al. (2010) observed that consumers who are educated were most likely to be updated about food safety issues. A study done in South Africa by Nkhebenyane & Lues (2020) reported that people with a grade twelve education knew about chances of food contamination if it is reheated. It can thus be concluded that education plays a big role in awareness of FBDs because of the knowledge that one gets from reading various sources.

It has been observed that unemployment is significantly associated with food insecurity (America, 2023) and can thus predispose people to consumption of low quality food such as meat from dead and or sick animals. Therefore, the high proportion of patients who were unemployed that was observed in this study, could also be attributed to high food insecurity levels experienced by unemployed people. According to a study by Mhlanga & Hassan (2022) about 75% of South African families utilize public health facilities because social grants is their only source of income. This means that they cannot afford fees charged by private hospitals and hence are restricted to seeking medical attention predominantly from government hospitals. This could therefore be another explanation for why the majority of patients who were treated at the hospital with FBDs belonged to the unemployed category.

This study also found that patients who were scholars constituted almost half of the study population. These findings could be explained by what was reported by AlMohaithef (2021) in his study that was conducted in Saudi Arabia in which he observed that students had poor knowledge of food-borne pathogens. Another related study by Osei-Tutu & Anto (2016) also concluded that students tended to lack knowledge about food safety.

5.3. Number of cases of FBDs observed by year

In the current study, a spike in the number of food-borne diseases were observed between January and June months. This was expected because during the summer season (November–January) and the beginning of winter seasons (May-July) farmers tend to experience lots of problems related to the health of their animals (Mbati et al., 2003). Furthermore, it is during these same months that environmental temperatures tend to be very high, which is a risk factor for food getting spoilt. These two phenomena could explain the spike in FBDs observed over the same period. It is possible that sick animals that die instead of being thrown away, get eaten during these periods, and as a result, the likelihood of exposure to food that is not safe for human consumption from a microbiological point of view is high. Although a few farmers experience health related problems with their animals all year around (January – December), between spring and beginning of winter seasons is when the tick burden is mostly at its highest. The results showed that in 2017 and 2019 there was a spike in cases of FBDs between September and December, which is the rainy season in the Eastern Cape where the study was conducted. This is in agreement with a study conducted in Ghana by Osei-Tutu & Anto (2016), in which it was observed that the wet season had peaks of the FBDs infections. In support of this, Smith & Fazil (2019) also concluded that pathogens are shed mostly by livestock during extreme heat resulting in environment and crops being affected.

In addition, a study done in towns in the USA by Akil et al. (2014) showed that *Salmonella* infections were associated with extreme temperatures where four *Salmonella* cases were observed due to 1-degree Freight temperature increase. Lues et al. (2010) confirmed these findings by revealing that *E. coli* infection was lower in winter season–than in summer. According to Duchenne et al. (2021), climate and weather changes can affect FBDs. For example, aftermath events of El-Nino increased diarrheal cases and the number of *Salmonellosis* incidents observed after weeks of high temperatures. Another study done in Brazil by Storto et al. (2021) is in assent with the above statement saying that during the hot and rainy season, when there are high temperatures the contamination of microbial is noticed.

5.4. Comorbidities observed among the patients

It was observed although not widespread, that some patients had certain underlying health conditions. The comorbidities and other underlying conditions observed among patients of the current study included hypertension, HIV and diabetes. Some of the patients were pregnant.

With regards to hypertension, some patients with FBDs in this study were also hypertensive. Similar to the findings of this study, Shinha (2015) also found one (n=1) patient with hypertension in his study on Campylobacter gracillis in the United states. In the same study, it was concluded that a medical history of hypertension is likely to cause susceptibility in patients with FBDs. Findings of the present study are further confirmed by findings of a study by Yousefian et al. (2022), who reported that a

Hispanic woman who was infected with Listeriosis was hypertensive. Likewise, a study done in South Africa revealed a case where a male patient who had *L. monocytogenes* infection was also hypertensive (Schutte et al., 2019).

With regards to HIV, previous studies (Beck & Smith, 2022) have shown that people with HIV are highly susceptible to FBDs. In addition to this, literature by Schutte et al. (2019) showed that a male patient who was diagnosed with *L. monocytogenes* was HIV positive as well. Similarly, a young male patient who tested positive for both *Salmonella* and Hepatitis C infections was HIV positive (Murray et al., 2023).

Diabetes was also observed among patients who visited the hospital with FBDs. This finding was expected because similar findings have been reported by several other authors. For example, Patricia & Obayashi (2012) and Charlesworth & Mullan (2023) reported similar findings in which individuals that suffered from diabetes were at a high risk of being infected by food-borne diseases. Also, a study by Yousefian et al. (2022) reported that an American female who was diabetic was infected with listeriosis.

Pregnant individuals were also observed among the respondents. In corroboration with the results of the current study, Allakky et al. (2022) mentioned that a Nigerian study reported that half of the population of pregnant women showed *Staphylococcus* infections. Tam et al. (2010) revealed that pregnant women have high chances of contracting food-borne diseases like *Salmonella enterica* and *Listeria monocytogenes* because of the decreased functioning of immunity.

5.5. The impact of comorbidities on the burden of food borne diseases

Comorbidities have been reported to increase severity of infections due to the compromised immune status of the victims (FDA, 2020). Therefore, the association between the FBD patients with underlying health conditions and them being admitted was investigated. In this respect, it was observed that although not widespread, some patients had underlying health conditions. The low number of patients with comorbidities could be linked to age of the population under study and/or due to underreporting.

The patients who were diabetic had high chances of being admitted if they contracted FBD. These results are in line with findings of previous studies (Vallejo et al. 2022;

Xu et al. 2023). For example, Vallejo et al. (2022) reported that hospitalization was common amongst patients who also had diabetes in their study that was conducted on Listeriosis in Spain. Similar findings were also observed by Xu et al. (2023) who cited that a diabetic patient affected by Listeriosis had a high chance of being hospitalized. This is also supported by Evans & Gwynne (2020) who indicated that diabetic people are at high risk of infections due to poor control of glycemic state. This poor control of glycemic then results in the damage of neutrophils (white blood cells) which are the first line of defense for immune system. Subsequently, when neutrophils are compromised the immune system cannot respond promptly to food-borne infection. This could explain why in a study by Wahab et al. (2023), a Salmonella enteritidis infected male with diabetes was admitted to hospital, and why being diabetic in the present study was associated with a higher probability of being admitted.

On the other hand, Cheong et al. (2022) observed an association between extra -pulmonary tuberculosis with high infections of Salmonella spp in comparison with pulmonary tuberculosis. However, findings of the present study are consistent with results observed by Jiang et al. (2023) in which they detailed an incident of hospital admission of a male patient that had a history of tuberculosis and experienced arthritis due Salmonella Dublin and Staphylococcus hominis. Another research by Librianto et al. (2021) also reported a case of a hospitalized Salmonella enterica infected male patient who was later diagnosed with tuberculosis.

In the current study, pregnant patients had a high probability of being hospitalised. Ünüvar (2018); Charlesworth & Mullan (2023), revealed that pregnant women have high probability of acquiring food-borne illnesses. This may be due to some complications as reported by Parisot et al. (2016), who noted that pregnant females with Shigellosis could experience cervix changes and contractions of the uterine and that normally leads to premature birth or miscarriage. In event of this happening, the likelihood of that patient being admitted is high. Another study by Delcourt et al. (2019) reported that a three and half months' pregnant female was hospitalized due to infection of salmonella. According to the FDA (2018), the reason why pregnant women are prone to being infected with food-borne illnesses is because of their altered immune system during pregnancy. Though this alteration is natural, it is however difficult for the immune system of a pregnant person to beat off dangerous pathogens. The unborn child is said to be at risk of getting infected with FBDs due to the immune system's inability to fight off harmful microorganisms because of the inadequate development of their immune system. However, according to The Bump (2023), food-borne illness like Listeriosis occur every year and the ratio of infection is 1:7; resulting in slim chances of pregnant women being admitted in the hospital. Furthermore, when pregnant women in the USA are affected by Toxoplasma gondii they are mostly not recognised and no obvious signs and symptoms are experienced if they have acute acquired infection (Montoya & Remington, 2008).

The results of this study suggest that HIV positive patients had high chances of being hospitalized. This was anticipated because HIV infected persons are prone to foodborne illness and hospitalization due to their weakened immune system (USDA, 2006). The function of the immune system is to fight infections. Therefore, if the immune system is not functioning well then one can easily get infected. Similar findings were also reported by Johnstone et al. (2023) who found that the majority of patients who were admitted with FBDs between 2018-2021 in South Africa were also infected with HIV. Rathore et al. (2023) corroborated these findings in their study that was also conducted in America, revealing that an HIV positive patient was admitted to a health facility due to Arcobacter spp. infection. However, there are studies that have observed a reduction in hospital admissions of HIV infected people with FBDs. For example, Burke et al. (2021); Hontelez et al. (2016) observed that Malawian and South African hospitals admissions were reduced substantially amongst HIV positive with FBDs patients. This has been attributed in the literature to effective treatment programs on which HIV patients are placed after diagnosis.

5.6. Symptoms observed among the patients

The results of this study revealed that diarrhoea was a very common symptom among the patients seen over the study period. According to Bisholo et al. (2018) diarrhoea is the most common symptom seen on a person affected by food-borne illness. These findings are in line to those reported by previous studies (Riaz et al. 2023; Gourana, 2020) that reported that diarrhoea was one of the main symptoms for food poisoning. Similar findings have also been observed in several other studies. For example, in a FBD outbreak that was linked to a School Nutrition Programme in the North West province, majority of patients presented with diarrhoea as a symptom (Matladiile et al., 2019). Ayomide et al. (2022) reported that diarrhoea was observed in children in Nigeria and the cause was due to norovirus. Likewise, Yousefi et al. (2018) in their study revealed that cases of diarrhoea were observed on patients at a referral hospital in Iran.

Vomiting was the second most commonly observed symptom in the patients in this study. According to Horn (2008) vomiting serves as a natural response against food poisoning. Therefore, vomiting after consuming contaminated food is not surprising. Hebbard & Metz (2007) and Musa et al. (2023) also pointed out that most of the time vomiting is a result of food-borne infection. The findings of this study are consistent with those reported by Sala et al. (2005) who observed vomiting in 72% of hospital workers during a food poising outbreak in the Central Region of Catalonia, Spain. The current results are further supported by Yousefi et al. (2018) who revealed that vomiting was one of the symptoms amongst patients who had consumed wheat groats in Iran.

Abdominal pain was another of the symptoms reported by patients in this study. Dietrich et al. (2021), confirms that abdominal pains are a common symptom amongst people that are infected with FBDS. This is supported by findings of a study by Bhat et al. (2008), carried out in India, in which abdominal pains were among the reported symptom by the victims of FBDs. In addition, abdominal pains were noted as a major symptom by three different families in Nigeria (Si, 2009).

Thirdly, in this study, bloody diarrhoea was also a common symptom among respondents. These results are similar with those reported in Japan by Isobe et al. (2014) who observed that bloody diarrhoea was the main symptom observed during outbreaks of FBDs. Similarly, Yousefi et al. (2018) also revealed that patients who were victims of food poisoning in Kerman, Iran had bloody diarrhoea as one of the symptoms.

Less than half (39%) of patients in the current study experienced headaches. These results correspond with those seen by Kunwar et al. (2013), who reported that headache was observed in cases that were treated during a food poisoning outbreak at a military camp. Dallal et al. (2023) recorded a case of a headache that was experienced by Iran residents after consuming different food items. Gourana (2020) also mentioned that headache is one of the symptoms of foodborne illness. However, contrary to findings of the present study, in the latter study headache was reported in the majority (85%) of the patients. The reason for different findings may be that in the current study FBDs were linked to a number of causes as opposed to the outbreak in the military camp which was linked to just one source. Therefore, cases in the current study are likely to have been infected with various FBDs and as alluded to in Chapter 2. Symptoms of FBDs vary from one FBD to the other.

Fatigue is often seen in most patients infected with FBDs. For example, in a study that was conducted by Musa et al. (2023) among tertiary students in Nigeria, fatigue was observed in nearly 50% of the subjects, while in a study by Parnmen et al. (2021), it was experienced by 72% patients. However, contrary to what has been reported in the literature, in the current study less than 20% of patients reported feeling fatigued. The difference between the current study and other studies cited above, is probably due to difference in causative organisms.

5.7. Treatment administered

Kumari et al. (2022) concluded that IV fluids are useful during treatment of food-borne illness because they prevent dehydration. Almost half of the patients in the present study were given intravenous (IV) treatment. Adhikari (2017) mentioned that hard dehydration caused by Norovirus, a FBD pathogen, is mostly treated by IV solution. A similar report by Sahu et al. (2021) revealed that IV fluids were used to treat foodborne infected people in India.

In the current study, few patients received intravenous (IV) therapy with vitamin B complex (B.co). According to Hilton (2022) the benefits of IV therapy with B.co include increased energy, cognitive function improvement and the nutrients are absorbed directly to the bloodstream resulting in quick effectiveness. Similarly, Williams (2020) revealed that IV therapy with B.co is good for patients who experience gastrointestinal disorders. In agreement with this, Clair (2023) revealed that the benefits of IV with B.co administration include delivery of essential vitamins into one's body thus improving energy levels, cell health and good digestion. In the present study, some patients were reported to have had low energy and therefore, administration of IV with B.co was needed to assist the affected patients to regain strength.

Panado was one of the most commonly administer treatments to patients in the present study. This was expected because it is common practice to prescribe panado due to its beneficial effects in victims of FBDs. According to Adcock ingram (2023) panado is a paracetamol that is beneficial for pain relief. For example, it has been mentioned that paracetamol is commonly used for abdominal pain management from paediatrics to adults (Nagendra et al., 2022). In support of this view, paracetamol was also used to treat patients in an Ethiopian study, who experienced symptoms due to food-borne illness (van Wagenberg et al., 2022). Usage of paracetamol to treat FBDs, was also reported by Moscatt et al. (2022) where it was used in treating Listeriosis cases in Italy.

Most of the patients in the present study received antibiotics. In their study conducted in Tanzania, Parsons et al. (2015) also reported the use of the antibiotic flagyl to treat patients in an outbreak of FBDs. The use of flagyl to treat FBDs, is also supported by Sterling (2018), who suggests that antibiotics like flagyl can be used to treat some food-borne illnesses. However, Patricia & Obayashi (2012) are of the view that unless the symptoms are severe, antibiotics are not a necessity for treatment of food-borne illnesses. The idea of not using antibiotics in all cases of FBDs was also mentioned by Kumari et al. (2022) who suggested that the use of antibiotics in cases of *Salmonella* can result in gastroenteric complications.

In this study, results showed that some patients received the amoxicillin. This was expected because the amoxicillin is used to treat several FBDs. For example, according to Madjunkov et al. (2017) amoxicillin is effective for the treatment of *Listeriosis*. While according to Nisa et al. (2023), amoxicillin can be used to treat *Salmonella*. Furthermore, LDPH (2013) mentioned that amoxicillin can be administered to treat anthrax gastrointestinal infection.

Ampicillin antibiotic was also among the antibiotics administered, albeit to few patients in the present study. In fact, the use of ampicillin to treat FBDs is widely practiced. This is consistent with the report by Moscatt et al. (2022) in which patients affected by *Listeria* were given ampicillin. A similar study confirmed that *Listeriosis* in pregnant women can be managed by ampicillin (Tam et al., 2010). A related report by Madjunkov et al. (2017) mentioned that pregnant women affected by *Listerias* can be given ampicillin as treatment. Nisa et al. (2023) added that septicaemia and meningitis are mostly treated by ampicillin.

The antidiarrheal treatment known as Loperamide was given to relatively few patients in this study. This was not expected given the widespread occurrence of diarrhoea among patients in the present study. Moreover, several studies have indicated that Loperamide was effective for managing diarrhoea in patients. For example, in a related previous study by Koo et al. (2010) said that Loperamide is effective for the treatment of diarrhoea. Lembo et al. (2022) also confirmed that Loperamide can be used to manage diarrhoea. Another study by Leung et al. (2019) announced that loperamide is effective for the treatment of traveller's diarrhoea.

As expected, some patients in the present study were treated with oral solutions. The oral solution is used to manage dehydration. This is supported by Sahu et al. (2021) who mentioned that oral solution was used to treat Indian residents during a FBD outbreak. Identical studies by Kumari et al. (2022) and van Wagenberg et al. (2022) also indicated that oral solution is one of the treatment used to treat victims of foodborne illness against dehydration. This is necessary because proper electrolyte and hydration management is essential for the treatment of FBDs (Senbeta, 2023).

Hyoscine was administered to a few patients as treatment. According to Nagendra et al. (2022) Hyoscine is beneficial for the treatment of abdominal pains. Consistent with findings of this study, Hyoscine was administered to Indian patients who experienced abdominal pain and vomiting during an outbreak of food-borne illness (Sahu et al., 2021).

In the present study, ~~a~~ few patients received Buscopan medication for the treatment of abdominal pain. Contrary to the current study, previous research shows that Buscopan is one of the common treatment regimens for patients infected with FBDs. According to Tong & Benjamin Chun-Kit Tong (2017), Buscopan is an abdominal pain relief treatment. For example, in a study by Kilic et al. (2010) Buscopan was administered to all the 2 469 patients that were treated during a *Salmonella* outbreak in Isparta. However, similar to the findings of the current study, Raut et al. (2017) revealed that Buscopan was administered to only to 39% patients in their study that was looking at treatment approaches for the management of poisonings in India.

The fact that there were various causal reasons for symptoms in the current study could explain why unlike in other studies, Buscopan was administered to only a few patients.

5.8. The proportion of patients by the sources of food-borne disease

The results of this study showed most patients contracted foodborne illness after eating meat from a cow injected with medicine. According to Mutua et al. (2017), treating sick animals at home without the guidance of a veterinary officer is a common practice amongst communal farmers. However, in the event that these animals do not recover, literature shows that these animals are slaughtered and consumed (Sitali et al., 2017). It is recommended that after an animal has been treated with medicine, a withdrawal period as stipulated by the manufacturers should be observed before the animal can be slaughtered for human consumption (Dairy-Cattle, 2019; Anthony et al., 2001), to prevent people eating such meat from getting sick due to medicine administered to the animal. It is therefore possible that patients in this study did not adhere to the withdrawal period for the drug that had been used to treat the animal.

In the current study, results indicated that some patients fell ill after consuming a dead cow while others became ill after they had consumed a dead sheep. The South African Meat Safety Act (Act 2000), prohibits slaughtering of animals apart from abattoirs. According to RSA, (2000) nobody may slaughter animal anywhere, under his or her possession at any location and may not provide or sell meat for animal or human consumption except if it is from the abattoir. Exception is given where one slaughters for religious or own consumption purposes and does not permit eating of meat from a dead animal.

Another study conducted in Laikipia in Kenya confirmed these findings, revealing that up to 95% of the respondents confessed to consuming meat from dead animals and even sold such meat (Kamau et al., 2021). According to Archer et al. (2013), contact with animal tissues, and blood was a predominant risk factor in a study that was conducted in South Africa between 2008-2011. This is worrisome as this practice predisposes people to diseases such as Rift valley fever (Mutua et al., 2017; Kamau et al., 2021; Archer et al., 2013), brucellosis, anthrax, Q fever, and leptospirosis (Kamau et al.,2021). In view of these findings, it is evident that lack knowledge of the dangers of eating dead or sick animals is wide spread on the continent. For example, Dastile et al. (2017) reported that purchasing meat from unknown origins is common practice. According to Jaja et al. (2018), informally supplied meat does not get to be checked and supply of poor quality contaminated meat and its products increase the spread of FBDs.

Only one case was linked to eating meat from a dead goat in this study. However, eating meat from a dead goat was also reported by a study in Libya by Christie et al. (1980) in which six individuals became sick after consuming goat meat. Tests were conducted and *Yersinia pestis* antibodies were found in the serum of one of the goats. These cases of human plague were a result of plague infection which goats are highly susceptible to. A case was recorded in the USA where a food store had samples of goats' hearts that tested positive for *Toxoplasma gondii.* Given that these parasites are zoonotic, customers who eat such meat are at risk of contracting FBDs (Dubey et al., 2011).

Donovan (2012) is of the view that an animal can only succumb to snake venom if it has had several snake bites and lots of venom injection. In addition, the health condition of the animal and age, and the size of the snake and where the animal is bitten are other factors that can determine if the animal may survive. However, getting sick after consuming meat from an animal that was bitten by a snake has been reported in the literature. For example, approximately 50 people fell sick and were taken to hospital after consuming meat from an animal bitten by a snake in a small town in the Eastern Cape, South Africa (Herbert, 2018). Similarly, 17 people also fell ill after consuming goat meat from a goat that was bitten by a snake in India (Tiruvallur, 2014). This is consistent with what was observed in the present study, where patients who had eaten meat from a cow bitten by a snake were recorded at the hospital that supplied the data. However, these reports notwithstanding, some scientists argue that it is not possible that the sickness is caused by a snake Venom. They argue that people get sick because the meat gets spoilt but not due to the venom (Herbert, 2018). The argument is supported by Case (2011) who cites a restaurant owner in China who served chicken that had been bitten by a snake but none of the customers experienced any FBDs symptoms. Apparently, the venom turns into an enzyme after it has been heated and this enzyme is beneficial for clearing blood vessels in humans. This is further supported by Gilmore (2023) who also mentions that the venom is an enzyme which at extreme temperatures denatures, and the poison gets destroyed.

In the present study, some patients got ill by consuming chicken served at school. According to the CDC (2022a) this could be attributed to ingesting undercooked poultry meat or drinks and food that has been contaminated with raw poultry products. Dworkin et al. (2004) made similar observations in their study that was conducted in Illinois, in which they revealed that 157 people got sick after consuming chicken served at a school. In the latter study, the outbreak was associated with ammonia. These findings corroborate those of Chanachai et al. (2008) who reported that a school worker and some students experienced symptoms such as vomiting, fever and headache symptoms after consuming chicken at school. *Sallmonella* group C and *Shiggella* group D were the causative agents. Independent Online (IOL) (2011) also reported a case in the Eastern Cape province, South Africa, where hostel school children developed cramps and vomiting following ingesting of chicken that was contaminated. Klontz et al. (1994) reported that people reusing chopping boards used for cutting chicken or raw meat without washing them, can lead to cross contamination which largely contributes to outbreaks of food-borne illnesses during different stages of preparing food (Greig & Ravel, 2009).

Other patients in this study, acquired sickness after consuming sour milk. An incident almost identical to this was reported by Dayimani (2016) who reported that 1000 school children developed diarrhoea after consuming sour milk. Mafani (2022) also reported that sour milk which had exorbitant yeast levels resulted in Escherichia coli (*E. coli*) infection that caused gastrointestinal related sickness.

A few respondents in the current study, contracted food-borne illness through drinking of water from the river. Kinge et al. (2010), in a study that was in Northwest province, South Africa, observed that water that was meant for animal and human consumption was contaminated with *E. coli*. Therefore, there are risks that are associated with using water from open sources or water sources shared with animals (Kamau et al.,2021). Apart from bacterial contamination, such water sources can also be contaminated with chemicals. For example, Khoza (2019) reported that river water that was shared by both animals and human was contaminated with caustic soda and oils. As a result, a herder lost his life due to drinking poisoned water and residents were not able to access drinking water. In a recent study by Govender (2023) it was observed that beaches in Durban had critical *E. coli* levels that rendered the water unsafe for recreation and consumption. The problem of contaminated water has also been reported by S.A.News (2023), that revealed that a few provinces in South Africa recorded more than a thousand cases of cholera caused by water from unreliable sources. In light of this, educating the target audience about cholera took place in order to prevent future infections.

A small number of patients got sick due to consumption of ready-to-eat (RTE) meat. Infection from ingesting RTE meat is not new in South Africa. For example, Thomas et al. (2020) reported 937 cases of *Listeria monocytogenes* infections due to eating polony, a type of RTE. In Canada's seven regions, Williams (2008), reported 56 cases which resulted in 21 deaths following an outbreak of listeriosis. However, Oguttu et al. (2014) found different results in his study regarding the safety of RTE meat in a study that was done in Tshwane informal businesses, where RTE chicken had low risks of falling ill after consuming contaminated with Staphylococcus *aureus (S. aureus)*. This is due to the fact that *S. aureus* seldom gets to a 105 cfu/g threshold which is said to produce enough poison to cause staphylococcal intoxication in humans. The latter study corroborates the findings of the current study, suggesting that although infection from RTE meat does happen, it is not predominant.

Literature shows that cooked rice is susceptible to *Bacillus cereus* contamination (Albaridi, 2022; Rahnama et al., 2023). Rice contamination is linked with leftovers and keeping rice at room temperature (Albaridi, 2022). In a study by Albaridi (2022), approximately 50% of cooked rice samples tested positive for *B. cereus.* However, the occurrence of food-borne illness through eating spoilt rice was low in this study. This could be attributed to rice not being widely eaten in the study area. Similar to the current study, Alcorn & Ouyang (2012) also reported cases of FBDs associated with consuming rice. In a study conducted in Saudi Arabia, cases where rice was associated with *Salmonella* outbreak were also recorded (Aljoudi et al., 2010).

Although few people who got sick by consuming wild mushroom in the present study, elsewhere large numbers of people getting ill due to consuming mushrooms has been reported. For example, a study done in China by Li et al. (2021) observed about 10,036 cases of food-borne illness outbreaks that were caused by mushroom between 2010 and 2020. Another study by Todda (1997) reported that mushrooms were one of the causes of outbreaks of FBDs that were reported in Hungary and Israel. This implies that people may not be aware of the dangers of consuming wild mushrooms, and therefore the public needs to be educated about the dangers of consuming wild mushrooms to lessen the burden of FBDs caused by consuming mushrooms (Hakan et al., 2010). Eating a sick chicken reportedly caused food-borne illness in a couple of patients in this study Arcobacer butzleri was the causative agent for the outbreak.

There were respondents in the present study who got sick after consuming samp & beans. Pillay et al. (2011) indicates that staples such as samp, uphuthu are popular in SA. While the results of this study show that the likelihood of getting sick from consuming such foods is low, nonetheless there is evidence in the literature to suggest that it does occur. For example, Motladiile et al. (2019) revealed that 164 pupils' in Northwest province, South Africa, developed acute gastroenteritis symptoms after ingesting beans, maize meal (samp) and vegetables. *Salmonella Heidelberg* in samp was the cause of the outbreak due to poor storage. Similarly, one school in Gauteng province also experienced an outbreak as a result of consuming beans and samp. In this case, *Clostridium perfringens* was the causative agent (Msomi, 2017).

Findings of the current study also showed that unpasteurized milk caused food borne illness in some of the patients. According to a study conducted by Headrick et al. (2011) in the United States of America (USA), outbreaks of FBDs due to illegally sold raw milk have been recorded. Consumption of raw milk causes outbreak of food-borne illness that can be prevented. Another study that was done in Qatar by Garcell et al. (2016) found that unpasteurized camel milk was implicated in the outbreak of human brucellosis in one family. *Brucella melitensis* and *Brucella abortus* were singled out on serology and blood culture. Prevention of future occurrences can be minimized by educating farm personnel about Brucellosis and its negative impact on people and animals. Similar information was shared by Archer et al. (2013) who added that in some South African provinces pathogenic Rift valley fever had affected some people who consumed unpasteurized milk. Preventative measures like surveillance strengthening to avoid future epizootics is important.

5.9. The proportion of patients admitted to hospital by sex

In the present study, both females and males accounted for 31,50% (n= 132) of the patients seen at the hospital that were admitted. However, female patients were the majority (55%; n=68) among patients who were admitted in this study. This contrasts with what other studies have observed. For example, Xu & Yang (2022) reported in their study conducted in China that males were more likely to be admitted compared to females. Similarly, Nyundo et al. (2017) in a study conducted in Tanzania reported that male patients were more likely to be admitted for intestinal parasitic problems compared to females. Bouchriti et al. (2021) also in a study conducted in a Moroccan town observed that females were far less likely to be admitted compared to their male counterparts. However, the higher numbers of females admitted as compared to the number of males that was observed in the present study, could be due to the fact that females are better at seeking medical help compared to males (Novak et al., 2019). According to a study by Qekwana et al. (2017) males are at a higher risk of contracting zoonosis due to the fact that slaughtering is mainly done by them and most of the time without protective clothing. This means that more males may be getting infected but their poor medical seeking habits could explain the low numbers of males admitted as compared to females observed in this study.

CHAPTER 6

CONCLUSSION & RECOMMENDATIONS

6.1. Recapitulation of the aim and objectives of the study

The aim of the study was to investigate the occurrence of FBDs among patients treated at a hospital in **O.R. Tambo District,** Eastern Cape for food-borne diseases (FBDs). Based on the aim of the study, the following three objectives were formulated: (i) to describe the number of patients treated for FBDs over the study period, (ii) to describe the monthly, yearly and season trends in FBDs numbers, (iii) to investigate the impact of comorbidities on the burden of FBD.

6.2. Overview of the conclusions of the study

A general overview of the conclusions is presented in this section, and is based on the findings of the study with reference to the objectives the study set out to achieve. Overall, it is concluded that the burden of FBDs is highest among vulnerable members of society such as the young and those with low formal education levels. The findings of this study also suggest a gender predisposition to FBDs among people in the rural areas, with the men carrying a higher burden.

The spike in the number of food-borne diseases observed between January and June months and 2017 and 2019 between September and December is indicative of a heightened burden of FBDs during the warmer months, which coincides with the time when animals are likely to get sick, treated, die, slaughtered and consumed. This is also the time when food stuff easily gets spoilt especially when there is no means to preserve the food of animal origin such as refrigeration especially during the hot months of the summer season.

The study demonstrated that comorbidities heighten the risk of being admitted among patients presenting with symptoms of FBDs, which increases the burden of FBDs on the health care system.

6.3. Recommendations

Based on the findings, the following recommendations are made:

Prevention measures

Since there was a spike in certain months, animal owners need to be informed about the animal diseases that occur during those months and be educated about the measures to be taken in order to reduce cases of animals dying from such diseases which would lead to consumption of meat from dead animals. Health education regarding FBDs needs to be done especially amongst males and children since they made up most of the cases.

Some key variables such as age and other socio-demographic, laboratory results, length of admission period for each patient and number of deaths (including causes) were not collected by the hospital that provided the data. Therefore, the hospital should consider including these variables and others that could facilitate more detailed analysis.

Lastly, it is recommended for everyone admitted with any form of comorbidities be referred to a dietician to offer proper guidelines and dietary advice in order to minimise re-occurrence of FBDs and assist in managing the said comorbidity.

Policy recommendations

The role of food of animal origin in the causing FBDs is alarming. Meat safety awareness programs are needed in the study area in order to curb the burden of FBDs in the area of study. A one health approach is needed where public health practitioners, veterinary officials and health care providers team up to design policies and strategies to curb the burden of FBDs associated with food of animal origin. This has potential to ease pressure on the public health care system and release the limited resources to be used elsewhere within the health sector.

The above-mentioned factors should be considered when designing programmes to promote food safety among the study area and the province where the hospital is located. In addition, food safety educational awareness programmes should focus on people with comorbidities that have a heightened risk of being admitted when they contract FBDs.

Recommendations for future research

It is recommended that future studies also focus on other comorbidities such as cardiovascular diseases, respiratory conditions and others in order to determine the vulnerability on patients presenting with FBDs because these comorbidities have significance impact on one's quality of life and increased costs for their health-care. It would also be good to investigate re-occurrence of food-borne illness among the patients post discharge to determine if they had understood the importance of not consuming contaminated food.

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ANNEXURES

Annexure 1: Supplementary Material A. - Variables with the alpha level ≤ 0.20 in the univariate model.

Variable	Level	Admitted		Not Admitted		P-value
		n	**%**	**n**	**%**	
Sex	Males	64	28.57	160	71.43	0.172
	Females	68	34.87	127	65.13	0.172
Total		**132**	**31.50**	**287**	**68.13**	
Employment Status						
	Not Employed	68	33.01	138	66.99	
	Employed	5	50.00	5	50.00	0.261
	Scholars	59	29.06	144	70.94	0.261
Total		**132**	**31.50**	**287**	**68.50**	
Comorbidities						
Hypertension	None	33	44.59	41	55.41	
	Hypertension	19	86.36	3	13.64	0.000
	Missing	80	24.77	243	75.23	
Total		**132**	**31.50**	**287**	**68.50**	
HIV status	Negative	127	31.36	278	68.64	
	Positive	5	35.71	9	64.29	0.772
Total		**132**	**31.50**	**287**	**68.50**	
Diabetes	No	115	29.34	277	70.66	
	Yes	17	62.96	10	37.04	0.001
Total		**132**	**31.50**	**287**	**68.50**	
TB status	No	126	30.73	284	69.27	0.031
	Yes	6	66.67	3	33.33	0.022
Total		**132**	**31.50**	**287**	**68.50**	
Pregnancy	No	124	30.54	282	69.46	0.030
	Yes	8	61.54	5	38.46	0.018
Total		**132**	**31.50**	**287**	**68.50**	
Symptoms						
Diarrhoea	No	43	31.39	94	68.61	
	Yes	89	31.56	193	68.44	1.000
Total		**132**	**31.50**	**287**	**68.50**	
Vomiting	None	26	19.26	109	80.74	
	Yes	106	37.32	178	62.68	0.000
Total		**132**	**31.50**	**287**	**68.50**	
Abdominal Pain	No	55	22.82	186	77.18	

	Yes	77	43.26	101	56.74	0.000
Total		**132**	**31.50**	**287**	**68.50**	
Bloody Diarrhoea	No	99	27.58	260	72.42	
	Yes	33	55.00	27	45.00	0.000
Total		**132**	**31.50**	**287**	**68.50**	
Headache	No	86	32.09	182	67.91	
	Yes	46	30.46	105	69.54	0.744
Total		**132**	**31.50**	**287**	**68.50**	
Low Energy	No	93	26.72	255	73.28	
	Yes	39	54.93	32	45.07	0.000
Total		**132**	**31.50**	**287**	**68.50**	
Treatment						
IV	No	4	8.16	45	91.84	
	Yes	88	29.43	211	70.57	0.000
IV plus B.co	Yes	40	56.34	31	43.66	0.000
Total		**132**	**31.50**	**287**	**68.50**	
Flagyl	No	13	46.43	15	53.57	
	Yes	119	30.43	272	69.57	0.092
Total		**132**	**31.50**	**287**	**68.50**	
Panado	No	6	31.58	13	68.42	
	Yes	126	31.50	274	68.50	1.000
Total		**132**	**31.50**	**287**	**68.50**	
Antibiotic						
Amoxillin	No	44	27.67	115	72.33	
	Yes	44	35.77	79	64.23	0.344
Ampicillin	Yes	44	32.12	93	67.88	0.344
Total		**132**	**31.50**	**287**	**68.50**	
Loperamide	No	96	27.20	257	72.80	
	Yes	36	54.55	30	45.45	0.000
Total		**132**	**31.50**	**287**	**68.50**	
Oral solution	No	52	25.24	154	74.76	
	Yes	80	37.56	133	62.44	0.008
Total		**132**	**31.50**	**287**	**68.50**	
Antidiarrhoea						
Hyoscine	No	51	21.79	183	78.21	
	Yes	57	47.50	63	52.50	0.000
Buscopan	Yes	24	36.92	41	63.08	0.000
Total		**132**	**31.50**	**287**	**68.50**	

Annexure 2: Supplementary Material B- Odds ratios (ORs) and their 95% confidence intervals

Variables	**Levels**		**Std error**	**Odd ratio**	**95% confidence limits**		**Pvalue**
Diabetes	*Ref*				Lower limit	Upper limit	
	No						
	Yes		1.863765	4.48903	1.989523	10.12876	0.000
TB Status	Ref						
	No						
	Yes		3.439159	4.742718	1.14494	19.64591	0.032
Pregnancy	Ref						
	No						
	Yes		2.257337	3.832756	1.208338	12.15721	0.023
HIV positive	Ref						
	No						
	Yes		.6960791	1.185349	0.3749646	3.747159	0.772

Annexure 3: Supplementary Material C – Results of the Wald test

Variables	**Levels**	**Std error**	**z**	**Margin**	**95% confidence limits**		**Pvalue**
Diabetes	*Ref*				Lower limit	Upper limit	
	No	.0226282	12.91	.2921574	.247807	.3365078	0.000
	Yes	.0903976	7.10	.6422148	.4650388	.8193908	0.000
TB Status	Ref						
	No	.0222372	13.82	.3073762	.263792	.3509603	0.000
	Yes	.156127	4.25	.664044	.3580406	.9700473	0.000

Pregnancy	Ref						
	No	.022301	13.69	.3053363	.2616094	.3490633	0.000
	Yes	.1329198	4.65	.6175471	.357029	.8780651	0.000

Annexure 4: Supplementary Material D - The Log likelihood ratio test using a Hosmer-Lemeshow goodness of fit test

Variables	**Levels**	**Std error**	**z**	**Odd ratio**	**95% confidence limits**		**Pvalue**
Diabetes	*Ref*				Lower limit	Upper limit	
	Yes	1.86437	3.62	4.491023	1.99059	10.13232	0.000
TB Status	Ref						
	Yes	3.416788	2.14	4.713587	1.138498	19.51511	0.032
Pregnancy	Ref						
	Yes	2.272735	2.28	3.863319	1.219582	12.23799	0.022

Annexure 5: Supplementary Material E - The results of the sensitivity analysis

Variables	**Levels**	**Std error**	**z**	**Margin**	**95% confidence limits**		**Pvalue**
Diabetes	*Ref*				Lower limit	Upper limit	
	No	.0226264	12.91	.2921679	.2478209	.2478209	0.000
	Yes	.0904089	7.10	.6420508	.4648525	.4648525	0.000
TB Status	Ref						
	No	.0222343	13.82	.3073466	.2637682	.350925	0.000
	Yes	.1558684	4.27	.6652839	.3597874	.9707804	0.000
Pregnancy	Ref						
	No	.022311	13.69	.3053877	.261659	.3491164	0.000
	Yes	.1332839	4.62	.6157083	.3544766	.87694	0.000
HIV	Ref						
	No	.0223681	14.03	.3138431	.2700024	.3576837	0.000
	Yes	.1235771	2.83	.3493021	.1070954	.5915089	0.005

Annexure 6: Ethics approval letter from Unisa

UNISA university of south africa

UNISA-CAES HEALTH RESEARCH ETHICS COMMITTEE

Date: 10/02/2022

Dear Ms Ndlame

Decision: Ethics Approval from 10/02/2022 to 31/01/2025

NHREC Registration # : REC-170616-051
REC Reference # : 2022/CAES_HREC/047
Name : Ms NNN Ndlame
Student #: 34773002

Researcher(s): Ms NNN Ndlame
34773002@mylife.unisa.ac.za; 078-403-8406

Supervisor (s): Prof JW Oguttu
joguttu@unisa.ac.za; 011-471-3353

Working title of research:

Occurrence of food-borne diseases among residents of Mhlontlo local municipality, O.R. Tambo district, Eastern Cape Province, South Africa

Qualification: MS Agriculture

Thank you for the application for research ethics clearance by the Unisa-CAES Health Research Ethics Committee for the above mentioned research. Ethics approval is granted for three years, **subject to further clarification, and submission of the relevant permission letter and yearly progress reports. Failure to submit the progress report will lead to withdrawal of the ethics clearance until the report has been submitted.**

The researcher is cautioned to adhere to the Unisa protocols for research during Covid-19.

Due date for progress report: 31 January 2023

The progress report is available on the college ethics webpage:
https://w2.unisa.ac.za/www.unisa.ac.za/sites/corporate/default/Colleges/Agriculture-%26-Environmental-Sciences/Research/Research-Ethics.html

Please note the following for further attention:

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

1. Please provide more detail on the anonymisation of the data: It is the committee's understanding that the data will be the hard copy patient files, which raises the question how the hospital will anonymise the data before providing it to the researcher? It will be time consuming for the hospital to work through all the files in order to provide anonymised data to the researcher? Therefore, the committee requests a written undertaking from the hospital that they are willing to do so. If the hospital is not able to do so, the researcher is requested to provide a declaration that if the files are not anonymised, that she will not record the names and that, to the best of her knowledge, none of her relatives have been admitted to this specific health institution.
2. Furthermore, the committee requests that the researcher stipulate that only she will obtain access to the data, and indicate how, where and under whose supervision from the institution it will be done (e.g. at the hospital under supervision of an employed nurse or data record keeper in the out-patient clinic). This person can then verify that only anonymised data has been captured by the researcher.
3. Please indicate the period of records that will be included in the study (e.g. records from 2018 onwards).
4. The committee has some concerns whether the researcher will obtain sufficient quality data to deliver a Masters qualification – as the researcher indicates, food borne diseases are severely underreported and a previous similar study (Bishode et al (2018)) investigated 378 files from three clinics over a period of two years and found only four reported cases? The researcher needs to be aware of this possible limitation. Please note that if it becomes necessary to expand the study, the researcher must submit an amendment request to the committee that specifies the changes and obtain ethics clearance before implementing these research activities.
5. The committee suggests that the researcher consider making the following changes to the research proposal:

a. Change the wording of one of the objectives to read – To establish the association between FBDs and variables such as age, gender, immunocompromised status and non-communicable diseases (NCD).

b. In the first sentence of the background section the student states that FBDs is **the** major concern in public health. Since we know there are larger communicable and non-communicable health concerns, the problem should be kept in context as **a** concern and perhaps compare Disability Adjusted Life Years (DALYs) from other diseases.

c. The study population should be indicated as all patients attending the hospital while the study sample is all patients presenting FBD related symptoms/diagnosis.

*The **negligible risk application** was expedited and provisionally approved by the UNISACAES Health Research Ethics Committee on 09 February 2022 in compliance with the Unisa Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment. The application will serve at the next committee meeting on 10 February 2022 for ratification.*

The proposed research may now commence with the provisions that:

1. The researcher will ensure that the research project adheres to the relevant guidelines set out in the Unisa Covid-19 position statement on research ethics attached.
2. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.
3. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the Committee.
4. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.
5. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing, accompanied by a progress report.
6. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.
7. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are similar to those of the original research. Secondary use of identifiable human research data requires additional ethics clearance.
8. No field work activities may continue after the expiry date. Submission of a completed research ethics progress report will constitute an application for renewal of Ethics Research Committee approval.

Note:

*The reference number **2022/CAES_HREC/047** should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.*

Yours sincerely,

Prof MA Antwi

Chair of UNISA-CAES Health REC
E-mail: antwima@unisa.ac.za
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Prof SR Magano

Executive Dean : CAES
E-mail: magansr@unisa.ac.za
Tel: (011) 471-3649

Annexure 7: Approval letter from the hospital that provided the data

Province of the

EASTERN CAPE

HEALTH Enquiries: Yvonne Gixela Tel no: 079 0740859

Email: Yvonne. gixela@echeaith. gov.za / ygixela@gmail.com

Date: 24 March 2022

Occurrence of food-borne diseases among residents of Mhlontlo local municipality, OR. Tambo district, Eastern Cape Province, South Africa.

(EC_202203_020)

Dear Ms N. Ndlame

The department would like to inform you that your application for the abovementioned research topic has been approved based on the following conditions:

1. During your study, you will follow the submitted protocol with ethical approval and can only deviate from it after having a written approval from the Department of Health in writing.
2. You are advised to ensure, observe and respect the rights and culture of your research participants and maintain confidentiality of their identities and shall remove or not collect any information which can be used to link the participants.
3. The Department of Health expects you to provide a progress update on your study every 3 months (from date you received this letter) in writing.
4. At the end of your study, you will be expected to send a full written report with your findings and implementable recommendations to the Eastern Cape Health Research Committee secretariat. You may also be invited to the department to come and present your research findings with your implementable recommendations.
5. Your results on the Eastern Cape will not be presented anywhere unless you have shared them with the Department of Health as indicated above.

Your compliance in this regard will be highly appreciated.

SECRETARIAT: EASTERNN CAPE H APE HEALTH RESEARCH COMMITTE

TOGETHER, MOVING HEALTH SYSTEM FORWARD