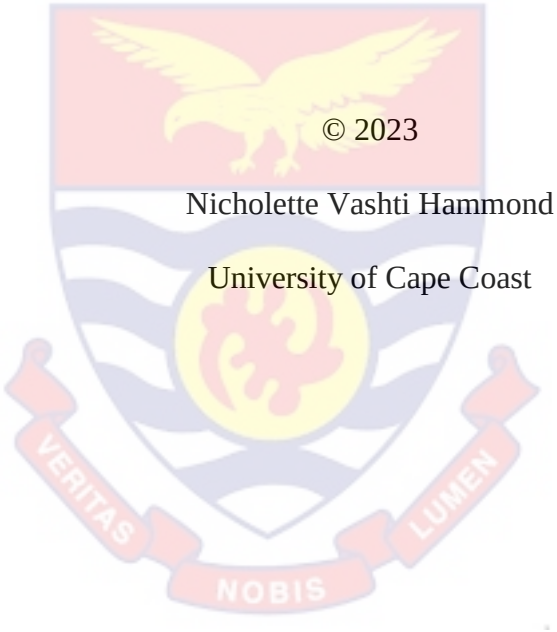
UNIVERSITY OF CAPE COAST

MICROBIAL LOAD OF BED LINENS: THE CASE OF UNIVERSITY OF CAPE COAST STUDENTS

NICHOLETTE VASHTI HAMMOND

2023



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MICROBIAL LOAD OF BED LINENS: THE CASE OF UNIVERSITY OF CAPE COAST STUDENTS

BY

NICHOLETTE VASHTI HAMMOND

Thesis submitted to the Department of Vocational and Technical Education of the Faculty of Science and Technology Education, College of Education Studies, University of Cape Coast, in partial fulfilment of the requirements for the award of Master of Philosophy Degree in Home Economics

OCTOBER 2023

DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original work and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature: …… Date: ……..

Name: …….

Supervisor's Declaration

I hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Supervisor's Signature: ……. Date……..

Name: ……...

ABSTRACT

The study assessed the microbial load of bed linens used by students at the University of Cape Coast. The quantitative research approach was employed and was in two phases. The first phase of the study used survey design to describe the hygienic practices of the population that can bring about microbial existence and served as an exploratory study to assist with the design for phase two. The second phase of the study employed the experimental study with the use of laboratory testing for the assessment of microbial load of bed linens used by students. 32 pieces of 100% cotton and 32 pieces of 35% cotton and 65% polyester blend were used for the study. The statistical software that was used in the analysis of the data collected was the Statistical Package and Service Solution (SPSS) for Windows version 26. The results showed that new bed linens can contain microorganisms, student's bed linens can serve as a reservoir for microorganisms and female students washed their bed linens often more than male students. The study found no difference in microbial load in terms of duration and gender of the user. The results also showed more bacteria load on 100% cotton bed linen than on cotton and polyester blend. It is recommended that new bedlinens should be washed before usage and household linens such as beddings should be washed at least every week in order to help curb the spread of microbes through beddings.

KEY WORDS

Bedlinen

Household Setting

Hygiene

Microbes

Microbial Load

Textiles

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DEDICATION

To Thomas Botchway, Ezekiel De-graft Tetteh, Zara Botchway, Mr. and Mrs Ezekiel Hammond and my niece Jada Janielle Azasu.

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LIST OF ACRONYMS

CDCP	Center for disease Control and Prevention
DNA	Deoxyribonucleic Acid
IPSOS	Institut Public de Sondage d'Opinion Secteur
IFH	International Scientific Forum on Home Hygiene
NASEM	National Academies of Sciences, Engineering, and Medicine
NIAID	National Institute of Allergy and Infectious Diseases
PHLS	Public Health and Laboratory Service
RNA	Rebonucleic Acid
USDHHS	U.S. Department of Health and Human Services
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

Background to the Study

Microbes are the organisms that emphasize the One Health Concept which is an integrating, unifying approach that aims to sustainably balance and optimize the health of the ecosystem connections between man, mammal, and community quality (Trinh, Zaneveld, Safranek & Rabinowitz, 2016). The spread of infections from animals and the environment to people has been largely studied in One Health Concept. As opined by Salla and Scott (2020) microbes thrive in hybrid settings that are frequently shaped in part by human preferences. Kumar and Chordia (2016) added that the term "microbes" refers to the many trillions of bacteria, viruses, fungi, and other tiny organisms that have made the human body their home. They posited that the term "microbiome" refers to the aggregate of all microorganisms from various populations. Since the human microbiome is a source of genetic variability and no two separate microbiomes are measured to be the same, the microbiome is a crucial component of immunity as well as a functional unit that regulates metabolism and manages medication interactions. Microorganisms in the human body have long been recognized as essential to preserving human health and as Dethlefsen, McFall-Ngai and Relman (2013) discoursed, the physical environment and the biological community that makes up people are interdependent and the microbial life that inhabits them includes an organ crucial to human health, like our liver or kidneys. Kumar

and Chordia (2016) also added that microorganisms dwell in various sites on the human body, including the digestive tract, skin, nose, and mouth.

The earliest forms of life on earth which are microbes have existed for more than 3.5 billion years (Dethlefsen, McFall-Ngai & Relman, 2007). Since six million years ago, bacteria and humans have coexisted, although this has evolved throughout time as a result of the complex relationships that have developed between them. Bacteria are necessary for people to be healthy, and many microbes require the same environment that the human body provides to survive (Barton & Northup, 2011). These interactions are essential for the development and health of microorganisms as well as people. Different microbe species inhabit various locations on and in the human body, adapting to their environment (Dethlefsen, McFall-Ngai & Relman, 2007). A complex ecosystem made up of the human population and its microflora exists, and its balance is a prime example of shared adaptation.

Globally, public health has significantly influenced how germs are seen, propagated, and eliminated. According to the germ hypothesis of sickness, microorganisms are the enemy of the human body. As suggested by Binns and Low (2014) the necessity to control infectious illness gave rise to epidemiology and public health. They continued that since infections continue to pose a danger to global health and although chronic diseases now account for a greater proportion of fatalities, infectious diseases might at any time overtake them as the leading cause of death. The struggle between people and the germs that bring about disease and death is the tale of the human race. As indicated by Bloomfield et al (2016), the immune system is a learning instrument, at birth it looks like an empty computer with just the most basic

hardware and software. They went on to say that throughout a person's first few years of existence, more information must be delivered by contact with environmental microbes and other people. When these inputs are insufficient or unsuitable, the immune system's regulatory systems may not function properly. As a result, the immune system fights off not just dangerous pathogens that cause infections but also benign enemies like pollen, household dust, and food allergens that cause allergy illnesses. Allergy-related diseases including asthma, hay fever, eczema, and food allergies have substantially risen in the last century, primarily in high-income countries but now occurring globally. Pandemic risks from infectious diseases, antibiotic resistance, and an increase in the number of people with weakened immune systems have all increased; taken together, these illnesses take a heavy toll on health and prosperity (Strachan, 2000). Strachan's hypothesis which stated that there could be a connection between the growth in allergic sickness and the reduction in microbial exposure because of infection-prevention efforts was first advanced in 1688.

According to Scott, Bruning and Ijaz (2020) in terms of age, health, nutritional state, and susceptibility to infectious agents, the house contains a sizable cross-section of the human population. So far as the need for sanitary practices is concerned, the house serves as a model for many other communal contexts. The dynamics between the home and other communal contexts, such as daycare, work, school, travel, leisure, and healthcare, is constant. As indicated by Abney, Khalid Ijaz, McKinney and Gerba (2021) the majority of microorganisms found in clothes come from human skin, physiological fecal matter and discharges. Operations like cooking and eating, being outside and

working can affect where the microbial flora present on the epidermis and in bodily excrements is distributed. Bed linens, sponges, bath towels, as well as kitchen towels, can all contain distinctive microflora. The properties of textiles, such as the fabric type, use, and pollution content, can also affect the presence of pathogens and bacteria that cause odors in washing (Abney, et al 2021; Owen & Laird, 2020). Although both pillowcases and sheets are classified as bedding, they do not have an equivalent impact on the dispersion of microorganisms (Hyde, 2021). Many people tend to wash their faces and heads more frequently than the rest of their bodies, but this does not always mean that there are lesser bacteria there. Human health can be influenced by a variety of ways by microorganisms with pathogen-associated molecular patterns (PAMPs) being the most prevalent microbiological elements linked to health of people (NASEM, 2016). PAMPs include compounds such as endotoxin, lipopolysaccharide (LPS), flagellin (from bacteria), and (1-3)-D glucans (also referred to as triple helical glucan, from fungi wall membranes) according to the National Academies of Sciences, Engineering and Medicine (2016). These chemicals interact with microbial communities (bacteria or fungus) that may stimulate inborn immune reactions in people, interact with irritating receptors on airway epithelial cells, or have noxious effects.

Numerous studies on allergies and respiratory issues published over the past 20 years reveal complicated positive and negative relationships between different PAMPs and allergy and respiratory outcomes. The danger or defensive variables and the strength of relationships with microbially generated compounds like LPS/endotoxin appear to depend on dosage, human bodily compartment, host, and stage of life in the observational epidemiologic

literature (Perzanowski et al., 2006; Sordillo et al., 2010). According to Mohapatra et al. (2016) and O'Dea et al. (2014) present experimental research also offers verifiable data that PAMPs and other fungal components, including chitin, as well as bacteria may "trigger" innate immune responses, which in turn may have an impact on the body's capacity to combat infections and allergic reactions. Even though some studies find an immediate impact of bacteria or fungi components like endotoxin or glucans, more recent statistical large prospective studies indicate that endotoxin and other PAMPs may be signposts for different neighborhoods of ecologic bacteria and fungi, many of which have initially not been linked to disease (Manor, Levy, Borenstein & Mapping, 2014). Kuhn and Ghannoum (2003) and Lambrecht and Hammad (2013, 2014) added that numerous indoor fungus generate compounds that, when inhaled, can cause systemic or respiratory toxicity.

The significance of textile in transferring viral diseases in institutions has been highlighted by epidemiological investigations. Finding epidemiological links between laundry and transfer is challenging since the majority of diseases associated with clothing have several ways of being transmitted. Larson and Duarte's study (2001) is one that highlighted the spread of respiratory illnesses linked to utilizing public laundromats and refraining from using bleach during laundry. Before laundry, a number of microorganisms have been detected in textile materials, and the majority of pathogens linked to human sickness are probably present in garments and several other textiles. Bloomfield, Exner, Nath, Scott and Signorelli (2011) and Bockmühl, Schages and Rehberg (2016) added that most incidents of sickness occurrences have been linked to healthcare personnel and institutions,

and fabrics infected with viruses, germs, and fungus have also been implicated. Most studies such as those conducted by Hyde (2021) and Knight (2022) have found microbes on bed linens during and after usage. Bacteria, including Enterobacter aerogenes, Bacillus cereus, Escherichia coli, Proteus mirabilis, Staphylococcus aureus, and Staphylococcus epidermidis, were the most prevalent microbial species that have been found on bed linens (Pinon, et al, 2013; IFH, 2018; Fallon, 2013; Olowomofe, 2020).

Statement of the Problem

Due to the stress encountered during the busy academic schedule of University students, their beds become their comfort zones. They jump straight into them during and at the end of the day and is the perfect place for a variety of pathogens, including bacteria, fungus, viruses, and even microscopic bugs, to flourish because of the mixture of perspiration, drool, hair flakes, dead skin cells, and even food debris. Mitjà et al, (2015) and Ghinai, (2010) raised the concern that since infections could be able to persist on substrates for times varying from a couple minutes to many hours, it is possible that microorganisms coexist in a biological storage and textiles serve as reservoirs for germs (Neely & Maley, 2000; Neely, 2000). Many studies have shown evidence of hospital acquired infections caused by microorganisms that were transmitted through bed linens (French, Otter, Shannon, Adams, Watling, & Parks 2004; Datta, Platt, Yokoe, & Huang 2011; Drees et al., 2008; Huang, Datta, & Platt; 2006).

Our beds can be the grounds to a vast variety of bacterial species. A study on microbial assessment of bed linens conducted by Olowomofe, Oluyege, Ogunlade and Makinde (2020) in Nigeria proved that bed linens can

serve as a reservoir and route of microbial dissemination in disease outbreak. Also, an analysis of the microbiological and epidemiological data from the International Scientific Forum on Home Hygiene (IFH) and Public Health and Laboratory Service (PHLS) conference (2001) concluded that it is challenging to gauge the severity of the danger due to the absence of quantitative evidence directly connecting contaminated clothes to illness in the household context.

Numerous research concentrates exclusively on looking for bacteria that are significant for Hospital Acquired Infections, primarily Staphylococcus aureus or Enterococci (Andrade, Angerami & Padovani, 2000; Okareh, 2016; Perry, Marshall & Jones, 2000; Schneider, et al 2021; Pinon, Gachet, Alexandre, Decherf & Vialette, 2013). However, the issues with bedding materials and their potential to worsen people's health are not relevant to the hospital environment only but households as well (Fallon, 2013). Hence, the need for this study. Studies on the microbial load on household bed linens especially those used by students have not been given much attention. This study therefore sought to determine the microbial load of bed linens of students from the University of Cape Coast and its species diversity since this can have a huge impact on student’s health.

Purpose of the Study

The purpose of the study was to explore the hygienic practices of students and assess the microbial load of bed linens used by University students.

Objectives of the Study

The specific objectives of the study were to;

1. explore the hygienic practices of male and female students in relation to bed linens
2. determine the microbial load of bed linens used by students
3. establish the difference between the microbial loads of bed linens in relation to the period of usage by students.
4. ascertain the difference between the microbial loads of bed linen in relation to gender of the user.
5. establish the difference between the microbial loads in relation to the different types of fabrics used to produce the bed linens.

Hypotheses

The following research hypothesis were formulated for the study.

Ho_1: There is no statistically significant difference in the microbial loads of bed linens in relation to the period of usage for:

a) a week and

b) two weeks

Ho_2: There is no statistically significant difference in microbial load of bed linens used by male and female students.

Ho_3: There is no statistically significant difference in the microbial loads of bed linens used by students in relation to the type of fabric.

a) 100% cotton and

b) Cotton/polyester blend

Ho_4: Gender, period of usage and fabric type have no influence on the microbial load of bed linens used by students.

Significance of the Study

Understanding how infections take place and how different micro-organisms spread is critical to preventing infection which is everyone's responsibility and not just health workers. It is anticipated that the study would provide information for educating the public on hygiene and how microbes are transferred from one person to another through textiles. Students can practice good bed linen hygiene from the information derived from the study. The Ghana health service can use the information derived from the study to educate individuals on the dangers they are likely to be exposed to using bed linens for a long period without washing. It is intended that by lowering infectious agent exposure, fewer people, particularly students, will require medical attention because of microbial infections and diseases. There is limited documented research on microbial load on bed linens used by students. This study will provide documentation on the variety of microbes likely to be found on students bed linens and finally, the study will provide baseline information for teaching and research.

Delimitation

Though many household types of linen serve as reservoirs for microbes, the scope of the study covered bed linens precisely bed sheets and pillowcases used by students in the University of Cape Coast. The parameter measured was microbial load. There are different types of fabrics in relation to fibre content but 100% cotton and 35% cotton/ 65% polyester blend were used for the study. The duration for usage was one week and two weeks only.

Limitations

The limitation of the study relates to the testing environment under which the test was conducted. Since different environmental conditions may produce different variations in species, the study cannot be generalized for other environmental settings. Only bed sheets and pillowcases were used and this limits the possibility of generalizing the results to all bed linens used in households. Because only two types of fabrics, two period of usage and students of the University of Cape Coast were used, generalization cannot be made to all fabric types, period of usage and students.

Organization of the Study

This study's report has been organised in five chapters. Chapter one, the introduction, comprises the background to the study, statement of the problem, objectives of the study, research questions and hypotheses, significance of the study, delimitations and limitations of the study and the organisation of the report. Chapter two provides related literature on microorganism and textiles. The chapter reviews literature on the theoretical framework and provide the conceptual framework for the study. Chapter three presents the methods employed in conducting the research. Chapter four presents and discusses the results of the study. The last chapter (chapter five) is where the researcher presents the summary, conclusions and recommendations.

CHAPTER TWO

LITERATURE REVIEW

Introduction

This chapter reviews related literature to the topic. The relevance of the review is to survey the pool of knowledge on the subject matter under study, work done by others on similar studies, and more importantly to create a context for analysing the data. The literature is presented under the following headings in the chapter.

1. The theoretical framework
2. Conceptual framework
3. Hygienic practices of humans
4. Textiles (Fibres)
    a. Staple fibres
    b. Filament fibres
    c. Natural fibres
    d. Cotton
    e. Properties and characteristics of cotton
    f. Manmade fibres
    g. Polyester
    h. Properties and characteristics of Polyester
    i. Fabric blends
5. Fabric types and its interaction with microbes
6. Transmission of microbes through textiles
7. Chapter summary

Theoretical Framework

Microbial Ecology

According to Panikov (2010) ecology as a word comes from the Greek oikos which means household, home or place. Oikos was coined by the German zoologist Ernst Haeckel who put the term oekologie into practical use and related it to an animal's biological as well as inert environment. Based on the above, ecology can be said to deal with organisms and their environs. Microorganisms do not just strive in the physical and chemical changes in their surrounding but also their biological process of changing to suit their environment helps them make use of nutrients available to support their growth (Barton & Northup, 2011). They stated further that the growth, reproduction and development of microbes is dependent on the microbial metabolism with its goal of providing the organism with enough biosynthetic material in a well calculated fashion which helps them to reproduce. Barton and Northup added that microbes adapt and respond to environmental stimuli through physiological processes which enable them to strive within the conditions they find themselves. When these conditions whether physical or chemical are high, it favors the cell having a hereditary content that makes the cell to grow at low pH, high temperature, extreme salt content and other lasting changes. These adaptation can result in the creation of new species with special traits. Kumar and Chordia (2016) explained that there are trillions of microorganisms which find the human body as their home and these organisms known as microbes include bacteria, viruses, fungi and other tiny organisms.

Microbial diversity and classification

As stated by Dunlap (2001) diversification of microorganisms is the range of various kinds of organisms that have single cell and make every effort to survive in the atmosphere creating conditions favorable of other living beings. Various microbes are recognized based on their different features of cells metabolism, physiology, structure, shape and size. He added that the diverse groups of microbes currently present on earth is known to be high and massive yet the factual magnitude of microbial diversification is not known. Nevertheless, they can be grouped into five major types: Viruses, Fungi, Bacteria, Archea and Protists. As opined by IFH & PHLS, most microbes are there to help to shield humans from pathogenic intruders and support the immune system to maintain delicate balance between protection and damaging inflammation. Infectious agents that have the potential to spread via clothing and other fabric items, including cleaning cloths, include enteric bacteria such as Salmonella, Shigella, Campylobacter, E. coli (including E. coli O157 and O104) and C. difficile, and enteric viral strains such as norovirus, rotavirus, adenovirus and astrovirus. It also includes respiratory (cold and flu) viruses such as rhinovirus and respiratory syncytial virus. Risks from skin pathogens are mainly associated with Staphylococcus aureus (including meticillin resistant S. aureus, MRSA), yeasts (such as Candida albicans) together with dermatophyte fungal strains such as Trichophyton rubrum (responsible for athletes foot), and viral strains such as herpes (IFH & PHLS, 2001; Bloomfield, Exner, Signorelli & Scott, 2013; Olowomofe, et al., 2020; Andrade, Angerami & Padovani, 2000; Okareh, 2016; Perry, Marshall & Jones, 2000; Schneider, et al 2021; Pinon, Gachet, Alexandre, Decherf &

Vialette, 2013). For the purpose of the study, only bacteria, fungi and virus will be discussed since these are the main microorganism examined under the study.

Bacteria

As confirmed by Cohan and Perry (2007) bacteria can be categorized and known from another organism by standards of importance to microbiologist and other scientists. They may be the most relevant group of organisms on earth and are responsible for greatly the decomposition of dead organisms. They added that bacterium is responsible for the conversion of nitrogen for plants and may aid in animal food digestion, produce oxygen in the early biosphere and are used in the production of foods such as cheese and yogurt. According to Smith, Venter and Glass (2009), bacteria can be classified according to their shape and colony morphology, their gram reaction and their requirement of oxygen for survival. A large number of bacteria belong to three main shapes. The rod shaped bacteria, spiral bacteria and sphere bacteria. Rod shaped bacteria are called bacilli, spiral shaped bacteria are called spirilla, and sphere shaped bacteria are called cocci.

Smith et al., (2005) added that colony morphology can also be used in presuming bacteria identification since they show different features of growth on solid media under appropriate cultural conditions. They stated further that colonies can differ in size and diameter. They can be circular, wavy or rhizoid in terms of their outline. They can be flat, raised, or convex in terms of their elevation and transparent, opaque and translucent in terms of their translucency. Dunlap (2001) asserted that bacteria can be ‘gram negative or gram positive based on their results of gram staining method. The gram

staining method involves the binding of an agent to the cell wall of a bacterium and was named after Christian Gram in 1884. Finally, classification based on oxygen survival produces Aerobic and Anaerobic bacteria. These are bacteria that need oxygen to survive and those that may die in oxygenated surroundings respectively (Dunlap, 2001).

Viruses

As opined by Panikov (2010) the tiniest of all bacteria are viruses. Their genome is contained inside a capsid, a protein shell, and is formed of either Deoxyribonucleic Acid (DNA) or Rebonucleic Acid (RNA) but not both. They are not composed of cells, are unable to produce their own proteins, and do not expand. He added further that as an alternative, they must infect a host cell and commandeer its machinery to put together fresh viruses. Salla and Scott (2020) indicated that the shape, size, chemical make-up, and mode of replication of viruses are used to classify them and often only have a small range of species that they can infect. The viruses known as bacteriophages infect bacteria. Due to the worrisome rise in diseases that are resistant to antibiotics, they are employed to treat bacterial infections in some countries, and interest in phage therapy has returned. Numerous respiratory and enteric viruses, such as the rotavirus, hepatitis A and B viruses, herpes simplex virus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), influenza virus, HIV, and papilloma virus, have been found in household linens (Abney, Khalid Ijaz, McKinney & Gerba 2021; Bloomfield, Exner, Nath, Scott & Signorelli, 2011). Household linens have also been demonstrated to spread the vaccinia virus (smallpox virus) and the hepatitis A virus (Abney, Khalid Ijaz, McKinney & Gerba 2021; Bloomfield, Exner,

Nath, Scott & Signorelli, 2011). The rotavirus is commonly noted for diarrhea as indicated by Center for disease Control and Prevention (CDCP), 2018. As Hyde (2021) added, some viruses can steal lipid envelopes from the host cell's membranes to make their own. An example of such virus is the influenza virus. Another illustration is the ongoing Covid-19 outbreak from SARS-CoV-2.

Fungi

Smith, Venter and Glass (2009) observed that the fungal lineage includes other lesser-known creatures as well as mushrooms, rusts, smuts, puffballs, truffles, morels, molds, and yeasts. The fungi kingdom in terms of their ecological and economic contributions, are among the most significant creatures and as Smith et al., (2005) asserted, they maintain the flow of nutrients through habitats by decomposing organic matter. Although more than 70,000 different fungi species have been identified, some estimates place the total number at 1.5 million and this is according to Smith, Venter and Glass (2009). In addition to multicellular creatures made of thin, branching tubular structures known as hyphae, fungi can also exist as single cells (like yeasts). Some fungi have the capacity to alternate between these two forms, which make them dimorphic in reaction to external factors like temperature. The presence of chitin in fungi's cell walls is one of its distinguishing characteristics (Hansen and Freney, 2001). Household linen is likely to host Fungi especially if stored damp because the majority of fungi prefer damp environments, however there are some outliers, such as fungi that thrive on dried grains. Although rusts and mildews can thrive in sunshine, mushrooms often prefer the dark (Farson, 2021; Bloomfield, Exner, Nath, Scott &

Signorelli, 2011). Studies have shown that fungi can live on fabrics from a day to several weeks (Neely & Orloff, 2001).

Diseases and infections likely to be caused by microbes

Tosh (2022) indicated that viral infections are brought on by viruses, whereas bacterial infections are brought on by bacteria. He added that the fact that antibiotics typically kill bacteria but are ineffective against viruses. This may be the most significant distinction between bacteria and viruses. He stated that though bacterial are single-celled microbes, some of its species are not bothered by extreme heat or cold and some even live in people's intestines, where they aid with food digestion. However, Jaliman (2022) asserted that despite Tosh's explanation, there are several exceptions to the rule when bacteria can damage humans. For viruses to reproduce, they must live on hosts like people, plants, or animals. Viruses are even tiny than bacteria and cannot survive without a host. When a virus enters your body, it invades a few of \your cells and seizes control of the cell's internal workings, diverting them to create the virus (National Institute of Allergy and Infectious Diseases - NIAID & U.S. Department of Health and Human Services, 2009).

As stated by Centers for Disease Control and Prevention (CDCP), National Center for Emerging and Zoonotic -Infectious Diseases (NCEZID), and Division of Foodborne, Waterborne, and Environmental Diseases (DFWED) (2019) infections with fungi are widespread in a lot of the natural world and fungal infections in humans happen when an invasive fungus colonizes a part of the body and becomes too powerful for the immune system to handle. They added that fungi can be in both beneficial and hazardous varieties, just as many microorganisms. When dangerous fungi enter the body,

they might be challenging to eradicate since they can persist in the environment and re infect the person who is trying to recover. Some infections and diseases likely to be caused by microbes is indicated in table 1 (NIAID & U.S. Department of Health and Human Services (USDHHS), 2009; Tosh, 2022; Jaliman, 2022; NCEZID & DFWED 2019).

Table 1: Infections and Diseases likely to be caused by Microbes

BACTERIAL	FUNGI	VIRUS
1. Tuberculosis	1. Sinusitis	1. Chicken pox
2. Urinary tract infections	2. Skin disease	2. Common cold
3. pneumonia,	3. Athlete foot	3. Flu
4. wound infections,	4. Pneumonia	4. Diarrhea diseases
5. Bloodstream infections (sepsis)	5. Virginal infection	5. Genital herpes
6. Sexually transmitted diseases	6. Meningitis	6. Shingles
7. Strep throat	7. Skin diseases	7. Pneumonia
8. Diarrheal disease	8. Tinea cruris or Jock ich	
9. Meningitis	9. Tinea corporis or ring worm	
10. Sinusitis	10. cutaneous candidiasis	
11. Skin disease	11. candid infections of the mouth, throat and esophagus	
12. Virginal infection	12. vaginal candidiasis	
	13. fungal nail infections	
	14. fungal eye infections	

Germ theory of Disease

According to the germ theory, certain diseases are brought on by microscopic organisms that can only be seen under a microscope attacking the body. The discovery and acceptance of the hypothesis are mostly credited to the French scientist and microbiologist Louis Pasteur (Britannica Encyclopaedia, 2022). In 1865, Pasteur was invited to assist France's struggling silk industry with its production issues. He found out that there was a microorganism that was affecting the silkworms that span threads to make the silk and the leaves they consumed. The silk business was preserved when he suggested destroying the worms and their sustenance. Pasteur was aware

that some illnesses are contagious. He claimed that "germs," sometimes known as microorganisms, could cause infectious diseases and were quickly transferred by people. The germ theory of disease is predicated on this concept (Kendall, 2012). As Berche (2012) added, the germ theory and the development of biomedicine have altered how we think about health and disease, and there has been a scientific investigation into the relationships between the origins of various diseases. Without initially knowing the root of infections and diseases, humans cannot develop cures.

According to Gillen and Oliver (2009), It is now well acknowledged that bacteria, fungus, viruses, protozoa, and other microorganisms are the cause of a number of illnesses, including influenza, chickenpox, and pneumonia. But before the 19th century, however, nobody was aware that bacteria are what cause sickness. They added that people in ancient Greece believed that disease was spread by infectious seeds in the food and the air. Additionally, they discovered that the seeds may endure infected individuals' bodies long after they had recovered in order to trigger a recurrence in the future. As Ernst (1995) indicated, the germ theory influenced the growth of immunology as a separate field of study. Researchers started looking into historical notions that the body might cure itself. It was widely believed that because microorganisms are so common, the body had a defense mechanism against them. He explained further that through the effective use of rabies, anthrax, and smallpox vaccinations, the science of immunology was formed. However, it was unclear at the time whether immunity was ascribed to cellular agent sources.

The ongoing discussion has emphasized how crucial germ theory is to understanding disease and how to fight it. Understanding bacteria has aided in efforts to stop infections brought on by contact, water, and food. In addition, it is the source of several customs, including hygienic personal cleanliness, sterilization, and disinfections (Casanova & Abel, 2013). Particularly, the understanding that microorganisms can transmit infections from one person to another has given rise to a number of methods for reducing the transmission (Colwell, 2017). For instance, asepsis is a technique that has been estableshed for cleaning surfaces to stop the spread of germs. Similar to this, the knowledge that some gut-based organisms can spread through water has prompted sanitation measures including the treatment of sewage and drinking water. As confirmed by Smith, Venter and Glass (2009), a number of molecular biology approaches are based on germ theory. The identification of target microbial sequences using genetic approaches has increased the effectiveness and speed of infection control as well as numerous fields have developed with roots in the germ theory, including epidemiology (Maloy & Schaechter, 2006). The home contains a sizable cross-section of the human population and in terms of susceptibility to infectious agents, surfaces in the home is known to be a prone area (Scott, Bruning and Ijaz, 2020). As indicated by Abney et al., (2021) the majority of microorganisms have been found to be transmitted through textiles. Operations like cooking and eating, being outside and working can affect where the microbial flora present on the epidermis and in bodily excrements is distributed. Abney, Khalid Ijaz, McKinney and Gerba (2021) indicated that bed linens, sponges, kitchen and bath towels, as well as kitchen towels, can all serve as transmission media.

The properties of textiles, such as the fabric type, use, and pollution content, can also affect the presence of pathogens and bacteria that cause odors in washing (Abney et al., 2020).

Targeted hygiene

The concept of targeted hygiene is important as it shows that the transmissions of harmful microbes in everyday living environments are not through "dirty" places only, but mainly people who are infected and people who are healthy carrying possible pathogenic strains such as Staphylococcus aureus (IFH, 2018). The diagrammatic representation of the concept of targeted hygiene is shown in Figure 1.

The chain of infection

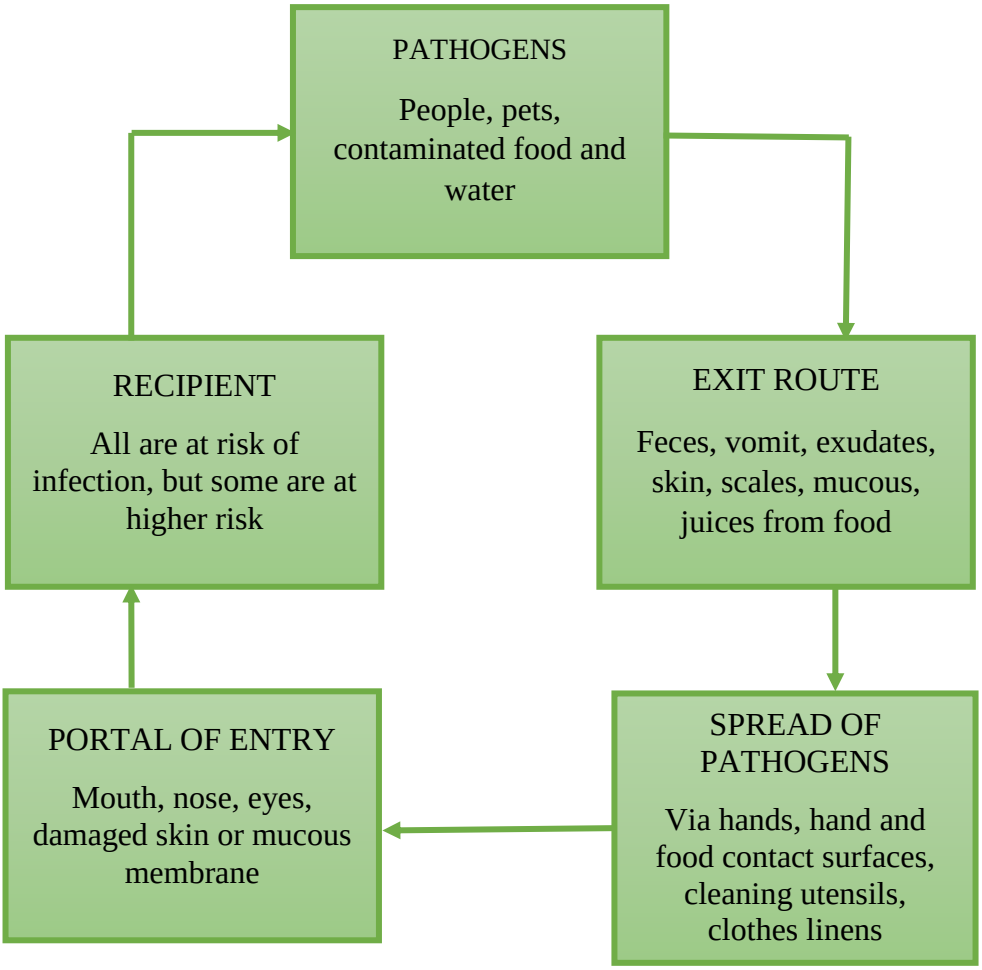

Figure 1: The concept of targeted hygiene. (IFH, 2017, IFH & PHILS, 2001)

This section describes the concept of targeted hygiene bringing out the dimensions of hygiene that the concept provides and indicates its relatedness to the current study. Hygiene is the practices adopted in homes and everyday lives to protect individuals, families, friends and colleague from infectious diseases (IFH, 2018). Before considering the concept of targeted hygiene, there is the need to identify the highest risk factors for transmitting pathogen. The 20th century recorded about 1.7 billion deaths due to infections with 30% being estimation for the total number of worldwide deaths (McCandless, 2014). Evidence obtained in the 2009 IFH review on the global burden of hygiene-related diseases shows that infection eruptions in the home and everyday life settings, particularly gastrointestinal (GI) infections, respiratory infections (RT), and skin, wound and eye infections remain to an extent a heavy toll on the health and prosperity of the global community. Generally, the home continues to exist as a large cross-section of the human population in terms of age, health, nutritional status, and proneness to infectious agents. The home (as stated above represents day care, work, school, travel, leisure, healthcare among others) is therefore paradigmatic of many other public surroundings that are necessary for hygiene practices.

All over the world, the profound effect of infectious diseases on health and prosperity has been recognized by health agencies with the need for investments which emphasizes on infection prevention strategies such as vaccines and hygiene (De Cock, Simone, Davison, & Slukster, 2013; Fonkwo, 2008; Bloomfield et al, 2009). Promoting the health of individuals and populations is an intricate attempt which is dependent upon individuals, families and communities, governments, health professionals, academics,

administrators, development partners, businesses, the media, and others whose activities intersect or interlock. As the Center for Disease Control and Prevention (CDCP) (2018) and World Health Organization (WHO) (2018) stated, it is necessary for the infection control communities and public health agencies worldwide to make efforts toward emphasizing the necessity of basic hygiene practices, at both the individual and community levels for infection control. WHO (2018) indicated that health agencies worldwide recognize the huge impact of infectious diseases on health and prosperity while changes in past years has shown that preventing infection through hygiene in the home and everyday life has become progressively relevant.

In addition, the fundamental part hygiene plays in tackling antibiotic resistance is a current driver. To balance the need for effective hygiene in developing and promoting home and everyday hygiene, a number of concerns which represent an obstacle to change need to be addressed. Clean water, safe disposal of human waste and hygiene became the key to reduce mobility and mortality from infectious diseases in 19th century and early 20th century but in the latter half of the 20th century, vaccines and antibiotics became readily available and therefore investments in hygiene education and promotion dropped and people repudiated in practicing hygiene (Fauci, 2001). Targeted hygiene seeks to address a key issue which is the sustainable use of resources. This include hygiene procedures which targets maximum achievements in the reduction of risk of spread of infection while reducing possible adverse effects which are environmental impacts, toxicity and health issues. It is possible that hygiene and its importance will be left in second place due to the lack of unified voice advocating for hygiene in the home and everyday life. According

to IFH (2019) a 2018 IFH consensus report circles out why hygiene in home and everyday life is such an imperative part of public health, and what needs to be done to change hygiene understanding and hygiene behavior. This serves to tackle some of the key present day health issues such as reducing antibiotic resistance and reducing pressure on our health systems.

For the purpose of this study, only the transmission of microbes through clothing and household linens was examined. As stated by Bloomfield et al., (2011) clothing, household linens and items such as cleaning cloths, just like other surface in the home, can become adulterated with hypothetically harmful microbes (bacteria, viruses and fungi) during normal daily wear or use. They stated further that although most infection risk which is associated with hand or common hand touched surfaces is higher than those associated with clothing and household linens, these risks associated with infections from clothes and household linens need to be managed appropriately according to the level of risk. Clothing and home laundering should also be able to decrease the risk of infectious diseases transmission among family members and moderate the "silent" spread of antibiotic resistant strains such as MRSA (resident skin carriers), or multidrug resistant Gram negative species such as NDM-1, ESBL which may produce strains which is carried easily among families (IFH, 2013).

Bloomfield, Carling and Exner (2017) opined that before microbes spread further, it is equally important to use hygiene procedures (product plus process) to get rid of pathogens from hands and other critical surfaces because data show how insufficient procedures can upsurge infection transmission. Kampf (2018) added that there is the need for more innovative research

approaches to creating effective procedures and evaluating their ability to prevent infection transmission. According to him, the framework for mounting effective hygiene procedures starts from the basic principle that hygienic cleaning of hands, surfaces, fabrics, among others. can be achieved in one of 3 ways. These are i) the physical removal of pathogens using soap or detergent-based cleaning or dry wiping usually referred to as cleaning, ii) disinfecting by using antimicrobial products such as alcohol or sanitizers as well as processes (heat at 60°C or above) that inactivate or kill pathogens and iii) a combined action where laundering and physical removal is combined with heat inactivation.

Although targeted hygiene was adopted as a means to cultivate effective hygiene practice for home and everyday life, it also offers a framework for building hygiene and use of hygiene products sustainably because it meets criteria such as maximizing protection against infection, environmental impacts and safety margins against hazards. The risks of development of antibiotic resistance are also maximized as it sustains the "normal" interaction with the microbial flora of our environment to an extent which is important to build a balanced immune system (Rook, Bäckhed, Levin, McFall-Ngai & McLean, 2017).

Conceptual Base of the Study

This section describes the concept of textile as a reservoir for pathogens as it provides the dimension of the influence of period of usage, fabric type and the gender of the user on microbial diversities found on textiles and its relatedness to the current study.

According to Gao and Cranston (2008), due to the vast surface area and capacity to hold moisture, most fibres are known to be susceptible to the growth of microorganisms. Microbes like bacteria and fungi are almost everywhere and can quickly multiply depending on the amount of moisture, nutrients, and temperature present on the transmission surface. Natural fibres can give microbes nutrients and energy sources in the shape of proteins or carbohydrates (Gao & Cranston, 2008). Because of the hydrophobic character and poor absorbing ability of synthetic fibres, microbial enzymes frequently fail to be able to break the carbon linkages in synthetic fibres, rendering them resistant to microbial attack (Siracusa, 2019; Gao & Cranston, 2008; Pathak, 2017). Additionally, physical deterioration and chemical breakdown brought on by microbial metabolites or enzymatic assaults frequently aid in the biodegradation of synthetic fibres.

In contrast, natural fibres are more susceptible to microbial attack because they frequently have high moisture retention qualities. This is because microbial enzymes can more easily access their polymer linkages, particularly in cases where the fabric's protective layers have been removed during processing (Gupta and Bhaumik, 2007). Also, the characteristics of the cloth, such as its weave, nonwoven content, knit content, thickness, among others can also affect how well the fabric retains heat and moisture (Matusiak, 2006; Premkumar & Thangamani, 2016), which may have an impact on any residing microorganisms. Most research such as those conducted by Sauperl (2016); Siracusa (2019); Szostak-Kotowa (2004); Pathak, 2017; Gupta & Bhaumik (2007) has shown that the various fibres' microbial attractions make fabric mixes made of natural and synthetic fibres more effective at reducing

microbial adhesion. A natural and synthetic fiber mix is less likely to promote microbial development than fabrics composed entirely of natural fibres.

Various bacteria species can endure on textiles for varying lengths of time. The utilization time affects the overall microbial load. The longer one put off changing and cleaning bed linens, the more germs will be lurking in them. Most research have revealed that the amount of time used before doing laundry affects how many bacteria are present. For instance, Staphylococcus aureus can endure two weeks on terry fabric and a week on cotton. Additionally, some fungi (like Candida albicans, which can cause genital yeast infections, urinary tract infections, and oral thrush) can live on textiles for up to a month. Just as influenza viruses can endure on clothing and tissues for 8–12 hours. Other kinds of viruses, like the vaccinia virus, can survive for up to 14 weeks on linen and cotton (Gupta et al., 2017). According to a study by Amerisleep, it can take a week for cushions and bedding to accumulate 3,000,000 and 5,000,000 bacteria, respectively. Additionally, linens will have 24,631 times more bacteria than the restroom doorknob in a week. Likely 17,442 times more bacteria will be present in cushions than on commode seat (Salla & Scott, 2020). It has been shown that the bacterial pollution of nurses' garments is significantly higher after the second shift than after the first (Gupta et al., 2017). As well as 17,000 times as many bacterial colonies were found in laboratory experiments using swabs from cushions that had not been cleaned in a week compared to samples from a toilet seat (Felson, 2021).

The bacterial population may also be influenced by the gender of the textile's user. Even though this topic has not received much study, some studies have found that the microbial burden of each gender on fabrics varies.

According to research by Smith, O' Driscoll, and Lamb (2020), men disseminate bacteria at rates that were greater than those of their female counterparts. Women's feet usually had 1.0106 CFU/cm2 of total microbes, which was not statistically significantly different from men's feet (mean: 1.2105 CFU/cm2) (Smith, O' Driscoll, & Lamb, 2020).

Conceptual Framework

A conceptual framework was developed based on the extent of literature to guide the study. Figure 2 presents a diagrammatic presentation which shows that the amount of microbiological load in bed linens is probably influenced by the user's gender, the kind of fabric in relation to its fiber content, and/or the length of time of usage of the linens.

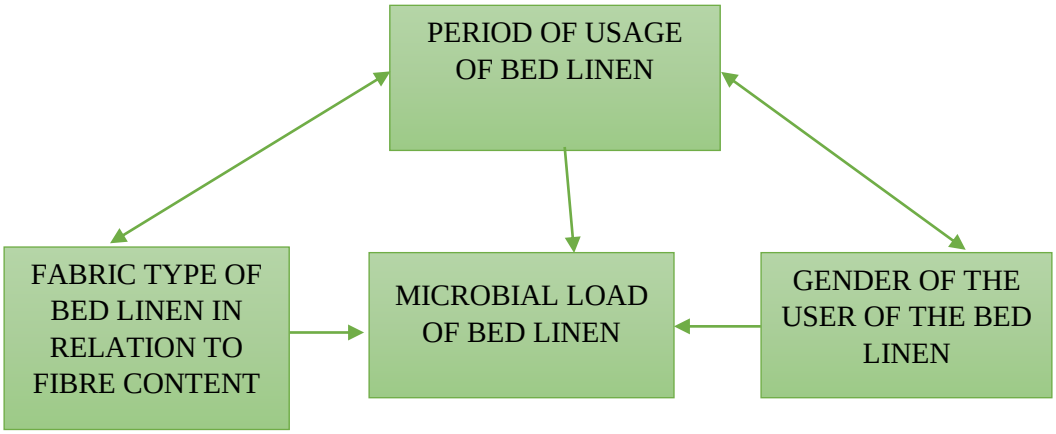

Figure 2: Conceptual framework on the influence of fabric type, gender and period of usage on microbial load of bed linens ((IFH, 2017, IFH & PHILS, 2001)

Hygienic Practices of Humans

One of the strongest defenses against flu, COVID-19, gastroenteritis, and other infectious disorders is practicing good personal cleanliness. Personal hygiene is a behavior that helps one stay healthy and avoid illness, particularly by keeping oneself clean (Nath, 2003). According to the World Health

Organization (2019), hygiene refers to the behaviors and surroundings that lessen the likelihood of disease transmission. The primary advantages of maintaining good personal hygiene are a reduction in the spread of disease and an enhancement in overall health. Germs that can make you sick are removed when you wash your hands with soap and keeping yourself clean can also lessen the likelihood that you may infect others (Satish Kumar et al, 2020). Maintaining good personal and household hygiene can also serve as a preventative measure against impending diseases. Thus, maintaining good hygiene is essential to reducing the spread of infections in daily life. Hand hygiene is another term for hand washing. It involves washing one's hands with soap and water to get rid of any germs, viruses, or other undesirable or dangerous materials that may have adhered to the skin. (Aunger, Greenland, Ploubidis, Schmidt, Oxford & Curtis, 2016). First and foremost, our hands are the ideal place to start when considering personal cleanliness. Humans use their hands all the time for eating, drinking, interacting with others, playing, and typing at work. Thus, hands are the primary sites of infection. One of the most important strategies for preventing the spread of infectious diseases is probably washing your hands with soap (Aunger, Greenland, Ploubidis, Schmidt, Oxford & Curtis, 2016).

The primary method of washing the body outside is taking a bath. The first measure to avoid body odor is to bathe in warm water with soap and water to destroy the bacteria that causes foul odor on the skin. This keeps the body clean and sanitary. Additionally, lice may be avoided by shampooing and conditioning hair at least once a week (Campos, Cardonha, Pinheiro, Ferreira, De Azevedo & Stamford, 2009). In addition, filth and bacteria may

accumulate on the clothing. Taking care of your clothing by washing and changing them on a regular basis is an essential aspect of maintaining good personal hygiene, especially if a family member is ill (Smith, 2008). Using soap after using the toilet, washing hands regularly, covering your nose when you cough or sneeze, washing your hands after touching dogs and other animals, changing your clothes and washing them regularly and bathing your body twice a day are all examples of maintaining proper personal hygiene (WHO, 2019). On the other hand, poor personal hygiene results from a deliberate or inadvertent disregard for ones body's hygiene and health needs. When one ignores all the activities carried out for good personal hygiene, the general well-being is impacted, and the body starts to appear sick which encounters unwelcome health issues (Wilson, 2023).

Textiles (fibres)

Fibres According to Eichhorn, Hearle, Jaffe, and Kikutani (2009), every human is well knowledgeable about textiles as a necessary material since we are constantly associated with it right from birth to death. Every individual uses textiles throughout the life time and clothing is one of the basic human physical needs. The word ‘TEXTILE’ mostly refers to an assemblage of fibres either in semi-finished or finished form which is both pliable and sturdy. In general, textiles refer to all structures having fibres as their smallest component and can further be processed by spinning, weaving, knitting and chemical processes et cetera (Hearle, Jaffe, & Kikutani, 2009).

As stated by Sinclair (2015) the American Society for Testing and Materials (ASTM) defined a ‘fibre’ as a collective term used for any of the various types of matter that form the fundamental element of a textile, and it is

distinguished by having a length of at least 100 times its diameter. Per the description above, Eichhorn, Hearle, Jaffe and Kikutani, (2009) added that fibres are longer, slender units of matter with their component atoms joined into molecules, which accumulate into particular fine structures. Traditional textile uses in clothing, household goods and some technical applications are all made from partially crystalline, partially oriented and linear polymer fibres. Exceptionally, fibres are derived from only six chemical types: cellulosic, protein, polyamide, polyester, polyvinyl (acrylic), and polyolefin (polypropylene). HM-HT polymer fibres are more highly crystalline, oriented and more capricious in chemistry, while the inorganic fibres, glass, ceramic and Carbon fibres are the direct forms of flawed graphitic crystals and are more amorphous or micro-crystallined (Sinclair, 2015).

Besides the differences in chemistry, fiber structures depend on how they are formed. The structure of fibres produced by the fast routes of industrial production is different from the ones produced by the slow growth of natural fibres under genetic control (Eichhorn, Hearle, Jaffe & Kikutani, 2009). The differences within each group, for instance between cotton, wool and silk or between melt and solution spinning, result in assortment of structures. In addition, there are numerical differences that depend on the production parameters within each fundamental form. There are diverse types of fibres around us in everyday use. Fibres can absorb and retain moisture, creating an environment conductive to microbial growth. Certain fibres may facilitate the adhesion of microorganisms, allowing them to colonize and multiply.

Staple Fibres

As Hearle, Jaffe, and Kikutani (2009) stated, Staple fibers are defined as those with a definite length (short/limite). Usually made of natural fibers, they come in different lengths. During yarn manufacturing process, staple fibres have to be twisted together in order to make a continuous length of yarn. The staple length of staple fibres can vary from about 1 cm to many centimetres in length.

Filament fibres

As stated by McIntyre (2004) a filament is a fibre of continuous length. By description, a fibre of very long (infinite) length is known as a filament. A filament can be used directly in weaving and knitting in fabric manufacturing process because it is long enough. Currently, most filaments used are man-made in nature. However, silk is the only naturally occurring fibrous solid in the filament form. Man-made filament yarns which are produced by chemical spinning machines can be many kilometres long in length. Filaments consist of very long, slender cylinders of extruded tough factual, either in on its own (single strand) known as monofilament or grouped in numerous strands known as multifilament. The most imperative difference between a fibre and a filament is in the length (Babu, 2013).

Natural fibres

Fibres which are gained from the natural origin directly or indirectly are referred to as natural fibres. These fibres derieved from the natural origin can further be classified into three categories based on their different natural origins. These are Vegetable Fibres, animal Fibres and mineral Fibres. Eichhorn, Hearle, Jaffe, and Kikutani (2009) stated that each of these fibres

has their unique properties and these characteristics are mostly reliant on their origins. According to Gopalakrishnan (2016) vegetable fibres are conventionally obtained from different parts of the plants such as seeds, bast, leaf, fruit, stalk, etc. He stated further that seed fibres are gotten from seeds and produces fibres such as cotton, kapok, et cetera and cotton fibres are widely used for clothing purpose, medical uses, and other textile applications.

Gopalakrishnan (2016) opined those fibres that are protein-based are normally from animal sources. They are gathered from an animal or removed from a cocoon or web. Mineral fibres are those that are quarried from the earth. As stated by Gopalakrishnan and Karthik (2012) all natural fibres have clusters in their molecules which attract water. Babu, Selvadass and Somashekar (2013) added that the ability to bleach, mercerize, dye and give various finishes to textile materials using chemicals efficaciously depends on the ability of the fiber to absorb moisture. This is known as absorbency. Gopalakrishnan (2016) further explained that absorbency is the capability of a fibre to take up moisture and is uttered as percentage of moisture regain, which is the percentage of moisture that a completely dried fibre will absorb from the air under normal conditions of temperature and humidity. Fibres which absorb moisture are called hygroscopic or hydrophilic fibres. He stated further that moisture absorption of hydrophilic fibres is greater than hydrophobic fibres and hydrophobic fibres are those which do not readily absorb moisture. Examples of fibres from the various categories under natural fibres discussed above include Silk, wool, asbestos, cotton. flax, jute and ramie fibre (Eichhorn, Hearle, Jaffe, & Kikutani, 2009). For the purpose of

this study, only cotton which is a vegetable fiber will be discussed into details since it is one of the fabric types used for the study.

Cotton

According to Eichhorn, Hearle, Jaffe, and Kikutani (2009) cotton which is derived from the cotton plant is a renowned seed fibre and is a widely used natural cellulosic fibre. It is known as the king of textile fibres. Cotton is spoken of as the most important of the natural cellulosic fibres. Though man-made fibres have made substantial inroads into cotton's share during the last three decades, cotton still accounts for about 50% of the total fibre production of the world. Cotton fibres breed in the seed hair pod boll of cotton plants grown and refined in warm climates (Eichhorn, Hearle, Jaffe, & Kikutani, 2009). Cotton has many vital and advantageous fibre properties making it a major fibre for textile applications all over the world. It uniquely combined strength with good absorbency, for example, makes it a comfortable and durable apparel fabric (Gopalakrishnan & Nithiyakumar, 2008).

As Gopalakrishnan and Nithiyakumar (2008) stated, the cotton plant grows best in subtropical countries which have hot, humid summers and cool to mild winters and the best environment condition for cotton cultivation are between 47°N and 35°S. The cotton plant needs six to seven months of warm weather. Chemically, cotton is a polysaccharide or polymeric sugar that is characterized by the chemical formula $(C_6H_{10}O_5)_n$, and because of its combination of strength, durability, and comfort properties, cotton fibre is predominantly appropriate for apparel and home-textiles end uses. Raw cotton fibre contains about 90% or more cellulose and non-cellulosics (Eichhorn, Hearle, Jaffe, & Kikutani, 2009). Thangavel and Duraisamy (2015) added that

the non-cellulosic components of the fibre are located predominantly in the cuticle, the primary cell wall, and in the lumen. Cotton fibres that show a high ration of surface area to linear density in most cases show a higher non-cellulosic content and this content include proteins, amino acids, other nitrogen-containing compounds, wax, pectic substances, organic acids, sugars, inorganic salts, and a very small amount of pigments. Diversities in these constituents arise due to differences in fibre maturity, variety of cotton, and environmental conditions which include soil, climate, farming practices, among others. Gopalakrishnan and Nithiyakumar (2008) added that after removing the naturally occurring non cellulosic materials through treatments, cellulosic content for cotton is over 99%. Raw cotton fibre, after ginning and mechanical cleaning, contains just about 90% or more cellulose and non-cellulosics. This is shown in Table 2.

Table 2: Chemical Compositions of Cotton (Eichhorn, Hearle, Jaffe, & Kikutani, 2009)

Constituent	Typical (%)	Range
Cellulose	95	88.0-96.0
Protein (% Nx6.25)	1.3	1.1-1.9
Pectic substances	0.9	0.7-1.2
Ash	1.2	0.7-1.6
Wax	0.6	0.4-1.4
Total sugars	0.3	0.1-1.0
Organic acids	0.8	0.5-1.0
Pigment	trace	-
Others	1.4	-

Properties and characteristics of cotton

Cotton is noted to have the following properties. Cohesiveness, absorbent, porosity and heat conductivity (Gopalakrishnan, 2016). America's Cotton Producers and Importers (2022) established the cohesive property of cotton by stating that the cellulose chains within cotton fibres are held together by hydrogen bonding. These hydrogen bonds happen between the hydroxyl groups of neighboring molecules and are most dominant between the parallel, tightly packed molecules in the crystalline areas of the fiber. Gopalakrishnan and Nithiyakumar (2008) stated again that absorbency is the ability of a fibre to adapt moisture and the absorbency ability is directly related to washability, dyeing, shrinkage, absorption of aqueous finishes, comfort on humid days, and soiling. Cotton is absorbent and its moisture take up comes from the fibre surface which has a strong attraction for water due to its tiny sponge-like tubes and the hydroxyl (–OH) groups in its molecules (Eichhorn, Hearle, Jaffe, & Kikutani, 2009). Gopalakrishnan added that cottons superior absorbency together with its ability to absorb moisture makes it a good fiber to be used in applications where moisture absorption is important, such as in sheets and towels.

For porosity, Gopalakrishnan (2016) confirmed that the term expresses properties with ability of a textile fibre or yarn to accept and hold a dye, a finish or even resin in order to upsurge the wrinkle resistance of a fabric or to give it a wash and wear finish. Liquids pass quickly when a fabric is porous. In the case of cotton, its porosity is attributed to the hollow centre or lumen in cotton and is usually regarded as the effect of the mechanism capillarity (Gopalakrishnan, 2016).

The heat conductivity of cotton is high nevertheless; cotton fabrics feel cool to be touched. Cotton has exceptional heat characteristics, and its physical properties are unchanged by heating at 120°C for moderate periods (Eichhorn, Hearle, Jaffe, & Kikutani, 2009). The good properties of cotton makes it widely used for household linens such as bed sheets and towels. A household linen like bedsheets is used repeated and therefore its laundry process will be frequent. Cotton is an excellent fibre to be used since it is durable. Despite its qood qualities, cotton has some bad characteristics such as being prone to shrinking and stretching, drying slowly, and is not wrinkle resistant (Gopalakrishnan, 2016).

Man-made fibres

Muthu (2018) stated that man-made fibres can be classified into organic and inorganic types based on the structure of the fibres. Organic man-made fibres are additionally grouped into regenerated and synthetic fibres. Regenerated fibres are manufactured using raw materials available in nature and usual examples of regenerated man-made fibres include viscose rayon, cellulose acetate, cellulose triacetate, cuprammonium rayon and lyocell fibres. Synthetic fibres are made from chemically synthesized polymers that do not occur naturally and are produced wholly in the chemical plant or laboratory, almost always from by-products of petroleum (Thangavel & Duraisamy, 2015).

Fibres that are produced from these polymers include nylon, polyesters, acrylics, the polyurethanes and amongst the most famous are polyester, acrylic and polyamide fibres which have a wide variety of applications in fashion and apparel sectors. Eichhorn, Hearle, Jaffe, and

Kikutani (2009) confirmed that once the polymer is molded, it can be formed into a filament by changing that polymer into liquid form and then the molten or dissolved polymer is forced out through narrow holes to give filaments. To get the fibre from molten polymer it is passed through the spinneret. Synthetic fibres are generally very strong, fine and durable with very low moisture absorbency property and therefore also known as hydrophobic fibres (Muthu, 2018). For the purpose of this study, only polyester as a man-made fabric will be discussed because it is one of the fiber constituents for the fabrics that was used for the study.

Polyester

According to Egan & Salmon, (2021) when the term "polyester" is used, it refers to Polyethylene terephthalate polyester as a generic type. As Vigneswaran, Ananthasubramanian and Kandhavadivu (2014) stated, Polyester in general is a man-made fibre termed as a ‘manufactured’ fibre in which the fibre-forming substance composes of at least 85% by weight of an ester of a dihydric alcohol and terephthalic acid and the most common polyester used for clothing being polyethylene terephthalate (PET). Polyester fibres used in making clothing can be either staple fibres, which are short fibres that are often perverse together to form a yarn, or filament fibres, which are long continuous strands and each of these fibre types has its own unique properties as Grishanov (2011) added. Currently, Polyester filament yarn dominates the polyester market, estimating for 44% of the global polyester production in 2016 (Plastics Insight, 2018).

Polyester properties and characteristics

Polyester from polyethylene terephthalate is an enormously strong fibre with a tenacity of 3-9 g/d (27-81 g/Tex) (Egan & Salmon, 2021). Polyester is quite hydrophobic having a moisture regain of 0.1%-0.4% under standard conditions and 1.0% at 21°C and 100%RH and is non-absorbent without chemical adjustment (Grishanov, 2011). Because of its low regain, polyester dries readily and can be safely ironed or dried at temperatures up to 160°C. Its lack of absorbency limits the comfort of polyester fabrics. Polyester exhibits reasonable heat conductivity and has high resistivity which leads to extensive static charge build-up. On heating, it softens in the 210°-250°C range with fibre shrinkage and melts at 250°-255°C. Polyester is used widely as a staple and filament fibre in apparel and as a staple fibre in blends with cellulosic fibres for all clothing types. This is because polyester lacks good absorbency properties and cotton fibre readily absorbs moisture making it the best fibre to be blended with polyester to increase its absorbency rate. As a preferred fibre in the blending mix for cotton and wool, polyesters are used in home furnishings such as curtains, carpets, draperies, sheets, covers and upholsteries apart from apparel applications.

Blends and its importance

Blended textiles are frequently made and used due to their distinctive qualities. The method of blending involves combining two or more types of staple fibres **(**Sreenivasa, 2015). As McIntyre (2004). stated, combining various complexities gives blended textile materials their intended properties when in use. One major purpose of blending fibres is to exploit the peculiar characteristics of each component of the blended fibres to the fullest. For the

purpose of the study, only cotton and polyester blend will be discussed since this is the specific blend used for the study.

Due to their aesthetic value, user-friendly performance, cheap cost, super performance and complimentary features, polyester and cotton rule the market and are famous in the textile industry. The limitations of both fibres are adequately balanced by blending these two fibres, creating a perfect blend (Akhtar, et al., 2020; Textile Exchange, 2021). According to Gordon and Hsieh (2007) cotton/polyester blends with varying percentages are the most popular on the market. The most frequent combination is 65% cotton and 35% polyester, though the amount differs. As well, 50/50 mixes are widely available. As Haque and Maruf (2016) indicated, since cotton is a completely breathable material, wearing it in humid weather may keep you fresher. However, the ventilation declines as the bulk rises.

Depending on the weave, cotton can rip and wear out quickly. It is an extraordinarily strong and abrasion-resistant cloth, but it is also very dense and weighty. Regarding safety, polyester will melt where cotton fibres that have not been treated for fire protection will typically waste away (Textiles Intelligence Ltd, 2016). Haque and Maruf added that once perspiration starts, polyester does not circulate and tends to adhere to the skin. Polyester tends to be more tear-resistant because it is a stretchy fabric and therefore more durable. It is not typically as abrasion resistant as cotton canvas, though. Polyester is typically much less expensive than 100% cotton because it does not rely on the elements for a good crop (Gordon & Hsieh, 2007). The purpose of the mix of cotton and polyester is to combine the benefits of cotton and polyester fibres into a single cloth (Haque & Maruf, 2016).

The complimentary features of cotton polyester blend make it a great choice for household linens such as bed linens, towels among others (George, Mussone & Bressler, 2014). Given that polyester includes substances like those found in plastic, cotton and polyester sheets are very robust and are less likely to rip or damage than cotton sheets. Due to polyester and cotton's durability, Polyester and cotton is a quite common material option in business settings, including hospitals and residences where bed linens are frequently replaced (Linen bundle, 2019). Additionally, when it comes to washing and drying, bed linens made of polyester and cotton require truly little upkeep. Both kinds of cloth can be dried in the dryer and cleaned in washing machine using standard cycles (Linen bundle, 2019).

Fabric type and its interaction with microbes

Most studies have shown textile surfaces exhibiting a potential role in microbial adhesion and transfer (Bajpai, Dey, Ghosh, Bajpai & Jha, 2011; Banu, Anand, & Nagi, 2012). According to Oh et al (2018) microorganism interaction with textiles is based on various factors like type of microorganism, surface characteristics of microbe and various environmental factors (physical and chemical) while the zeta potential on the surface of bacteria is also dependent on the nature of bacterial species, growth medium, surface architecture, and age of the bacteria.

As Sauperl (2016) stated, fabrics are three-dimensional structures with amorphous and crystalline areas with hydrogen bonds being dominant forces of attraction present in the polymer system in amorphous areas while on the other hand, the construction of textile material is also important. This is because in addition to amorphous areas, there are also free spaces within

fabrics joint by specific position of warp and weft threads in the case of woven fabrics, or fibres' entanglement in the case of nonwoven. Hence, the construction, physical and chemical properties of the textile material/fabric, the surface characteristics together with the shape of microorganism, and the carriers' characteristics give way to the control of transfer of microorganism through textile material (Eichhorn, Hearle, Jaffe, & Kikutani, 2009). Szostak-Kotowa, (2004) confirmed this by asserting that textile microorganisms can bring about staining, fabric deterioration and even physical irritation, such as skin allergies or infections.

As stated by Gao & Cranston (2008), most fibres are known as being susceptible to microorganisms' growth, such as bacteria and fungi, which can be found almost everywhere and can swiftly double, depending on the moisture, nutrients and temperature levels due to their enormous surface area and capability to retain moisture. They further confirmed this by opining those natural fibres such as cotton, hemp, flax, wool, mohair, silk among others provide nutrients and energy sources for microbes in the form of carbohydrates or proteins. The features of the fabric itself be it woven, nonwoven, knitted, thickness, et cetera can also influence moisture and heat retention properties of the fabric (Matusiak, 2006; Premkumar & Thangamani 2016) which may in turn influence resident microorganisms. On the other hand, synthetic fibres are often unaffected by microbial attack because microbial enzymes have a tendency of not being able to break their carbon linkages due to their hydrophobic nature and poor adsorbing capacity (Siracusa, 2019; Gao & Cranston, 2008; Pathak, 2017). Also, biodegradation of synthetic fibres is often assisted by physical damage and chemical

decomposition due to microbial metabolites or enzymatic attacks. By contrast, natural fibres are more prone to microbial attack because they tend to have high moisture retention properties and their polymer linkages can be more easily gained access to by microbial enzymes especially where the protective layers of fabric have been removed during processing (Gupta & Bhaumi, 2007).

At present, it is widely known that natural fibres can be ruined and support the growth of bacteria and fungi as compared to synthetic fibres. Looking at the interrelations between microorganisms and textiles (clothes, sheets, among others), two scenarios could be possible; infections can surface through textile transmission or on the contrary, infections can be prevented because the textile has antimicrobial characteristics (Gupta & Bhaumik, 2007). From the ongoing discussion, it can be said that the absorbency of cotton makes it an excellent material for household fabrics such as sheets. Towels and flannels are estimated to be the largest amount made of cotton used in home furnishings, followed by sheets. Cotton is not affected by most insects but, silverfish will attack cotton in the presence of starch and a major problem faced by cotton is fungi and bacteria being able to grow on them (Siracusa, 2019; Gao & Cranston, 2008).

Mildews can feed on moist cotton fibres, making the fibre weak and rotten at the same time odour and pigment staining of the cotton occurs when mildews attack (Pathak, 2017). Additives capable of protecting cotton are available and commercially applied to cotton fabrics used outdoors. These materials are often metal salts of organic compounds which are capable of inhibiting growth of mildews and similar organisms (Eichhorn, Hearle, Jaffe,

& Kikutani, 2009). The excellent tensile behaviour, resistance to stretch, anti-shrinkage and easy-care properties of polyester makes it the preferred fibre in the blending mix for cotton which is used in a very large number of applications both in apparel and industrial sectors. It is also used in home furnishings such as curtains, carpets, draperies, sheets, covers and upholsteries. As Eichhorn, Hearle, Jaffe, and Kikutani (2009) confirmed, Polyethylene terephthalate polyester is highly unaffected by chemical attack such as acid, bases, oxidizing, or reducing agents and is only attacked by hot concentrated acids and bases. The fibre is not susceptible to biological agents due to lack of absorbency limits or its hydrophobic nature.

Research has shown that fabric blends where natural and synthetic fibre are combined helps reduce the microbial adhersion of microorganisms because of the different fibres attractions to microbes. Fabrics made from 100% natural fibre is likely to aid microbial growth more than a natural and synthetic fibre blend (Sauperl, 2016; Siracusa, 2019; Szostak-Kotowa, 2004; Pathak, 2017; Gupta & Bhaumik, 2007).

Transmission of microbes through textiles

Textiles can serve as a habitat for microbes where they can even multiply. According to Freney and Renaud (2012), the very principal, deliberate, microbiological warfare happened during the Anglo-French wars in North America, when Native American emissaries were given blankets or handkerchiefs contaminated with smallpox in 1763. This caused a small epidemic which extended rapidly, causing significant damage to the rank and file of the Native Americans. Classical piece clothing was the first natural weapon to be used to kill somebody via the transmission of poison. An

example of this was how Hercules was murdered. According to Hansen and Freney (2001) Hercules killed Nessos a centaur and before he did, he gave Deianeira who was Hercules's wife an elixir which will make Hercules very faithful to her. Deianeira gave Hercules a tunic with Nessos, blood on it. Consequently Hercules died of burns and the symptoms he developed were those of anthrax. Also, throughout centuries, black bane was sturdily linked to anthrax. It was called "black bane" because many of the cases were related to or affected the skin in a form of anthrax with a characteristic blackish sore (Hansen & Freney, 2001).

As cited by Wattiau et al (2008) more than 60–80,000 people, who worked with the wool industry such as shepherds, wool merchants and wool workers died of anthrax during the seventeenth and eighteenth centuries. Accordingly industrial anthrax which was also known as woolsorter's disease was a severe hazard in the nineteenth and early twentieth centuries, when the wool industry was booming. Another example is one cited by Fenn (2000) which discussions the wars between the French and the British in North America in the eighteenth century. An observation carried out in the London prisons by Sir John Pringle, who was one of the most prominent physicians of the eighteenth century and also invented antiseptics demonstrated that typhus was able to spread from the prisoners to the lawyers and judges (Selwyn, 1966). As he stated, Sir John Pringle ordered the burning of the prisoners' clothes and this stopped the transmission of typhus. After one hundred and fifty years later, Nobel Prize winner Charles Nicolle established that the responsible agent for the sick that were covered in lice was the louse. A comparable case was also detected during the Moscow retreat where countless

number of Napoleon's soldiers died of typhus. Also another case can be reported during the war in Rhodesia between 1976 and 1980 where biological weapons were possibly used. As Guerillas claimed, uniforms and boots had been poisoned by Rhodesian agents where specific areas had anthrax and cholera introduced to them (White, 2004).

Textiles can modify the skin and its microhabitat as well as form a microhabitat in and of itself. The concept of a fibre providing habitat to microbes and their effects has long been known (Gest, 2004). Debatably, characteristics of this effect have been understood before microbes had even been discovered. For instance, the awareness that diseases can emerge from the clothes of sick people was understood before the elaboration of germ theory (Gest, 2004; Sherman, 2017). As cited by Sanders, Grunden, and Dunn (2021) the relationship between textiles and diseases was first scientifically demonstrated by Joseph Lister in 1867 where treating bandages with an antiseptic could prevent the infection of wounds.

Many studies have shown that in cases of infections, pathogens were often found on the clothing of both healthcare workers and patients and bed linens as well with Staphylococcus aureus, multi-resistant S. aureus (MRSA) or Clostridium difficile being the most common (Bloomfield, Exner, Signorelli & Scott, 2013; Srinivasan, Uma, Vinodhkumaradithyaa, Gomathi & Thirumalaikolundusubramanian, 2007). Other diversities such as Pseudomonas aeruginosa or trichophyton mentagrophytes (athlete's foot) from textiles were also allied to infected patients as well (Bloomfield, Exner, Nath, Scott & Signorelli, 2011; Bloomfield, Exner, Signorelli & Scott, 2013; Srinivasan, et al, 2007; Treakle, Thom, Furuno, Strauss, Harris, &

Perencevich, 2009). Sehulster (2015) posited that epidemics in clinical settings ascribed to textiles were frequently caused by Bacillus cereus and also by Acinetobacter spp. or Aspergillus flavus. Another study conducted by Pinon, Gachet, Alexandre, Decherfm and Vialette (2013) in microbiological contamination of textiles in hospitals confirmed that staff hospital uniforms presented the highest contamination rates in the study.

Other studies have found pathogens on medical staff uniforms or on bed linen in patients' rooms (Perry, Marshall, & Jones, 2001; Mahida, Prescott, Yates, Spencer, Weston, & Boswell, 2018). It can be said that textiles may definitely be responsible for transmission of pathogenic microorganisms to patients as many studies have described transmission of microorganisms from uniforms to patient and bed linen and from dirty bed linen to staff uniforms (Wilson, Loveday, Hoffman, & Pratt, 2007; Das, Lambert, Hill, Noy, Bion & Elliott, 2001; Hosein et al., 2013). One particular study conducted by Olowomofe, Oluyege, Ogunlade & Makinde in Nigeria in 2020 assessed the microbial content and its antimicrobial susceptibility test of student bed linens. Their study confirmed that Staphylococcus aureus, Staphylococcus epidermidis, Proteus mirabilis, Enterobacter aerogenes, Bacillus cereus, Escherichia coli and Klebsiella aerogenes were the main bacterial isolates commonly associated with student's bed linens but did not specify the fibre content of linens used.

According to Situ Biosciences (2023) in a given system, acceptable microbial concentrations can range from <10 colony forming units per ml (CFU/ml) to as high as 10^4 CFU/ml (that's the equivalent of 10,000 bacteria in a gram of water). The concentration of microorganisms is likely to cause

either a safety problem when the results is 10^5 CFU/ml or higher. This is deemed out of control and in need of an antimicrobial solution on an average. Whereas a stable system with less than 10^3 CFU/ml is deemed in control. Again, the original quantitative standard stated that ACC on hand-touch sites should not exceed 5 cfu/cm2 but this has since been reduced to 2.5 cfu/cm. (Mulvey, Redding, Robertson, Woodall, Kingsmore, Bedwell & Dancer, 2011)

Influence of gender and period of usage on the growth and survival of microbes on textiles

According to Kampf (2020), for weeks, contaminated linens or materials could serve as a source of transmission. Microbes may cause infections in a domestic environment by spreading from one individual to another while living on textiles for one to ninety days (Gupta et al., 2017).

The total microbial burden is influenced by the usage period. Bed linens will contain more gems the longer the period of usage. Wood, Choi, Wendling, Rogers and Chappie (2013) stated that over time, fungus and bacteria grow in bedding. In addition to causing allergic responses, they can harm your epidermis, eyes, and immune system. These microbes can make your asthma worse and disrupt your slumber.

Various bacteria species can endure on textiles for varying lengths of time. For instance, Staphylococcus aureus can endure two weeks on terry fabric and a week on cotton. Additionally, some fungi (like Candida albicans, which can cause genital yeast infections, urinary tract infections, and oral thrush) can live on textiles for up to a month. Just as influenza viruses can endure on clothing and tissues for 8–12 hours. Other kinds of viruses, like the

vaccinia virus, can survive for up to 14 weeks on linen and cotton (The conversation, 2021). A week can pass before linens and pillows amass 5,000,000 and 3,000,000 bacteria, respectively, according to an Amerisleep research. Additionally, linens will have 24,631 times more bacteria than the restroom doorknob in a week. Likely 17,442 times more bacteria will be present in cushions than on commode seat (Thompson & Bennett, 2017).

Most studies have shown that microbes increase depending on the period of usage before laundry. The bacterial contamination of nurses' clothing has been demonstrated to be considerably greater after the second shift than after the first (Gupta et al., 2017). According to Felson (2021) laboratory studies using swabs from pillows that had not been cleaned for a week contained 17,000 times as many bacterial colonies as samples from a toilet seat. Additionally, bedsheets had more germs after one week than a restroom doorknob and that amount increased to have more germs than a pet toy in just two weeks (Oxford, et al, 2014).).

The sex of the user of a textile might influence the bacterial count as well. Though there has not been much research in this area, some studies have shown some differences in microbial load of gender on textiles. Such study is one conducted by Smith, O’ Driscoll and Lamb (2020) which is the first concrete proof that gender is a major factor in the bacterial pollution of cloth surfaces. Their study revealed that male rates of bacterial spread are higher than those of female peers. In contrast, another study which analyzed the microbiological biodiversity of human foot skin with respect to gender revealed women's feet typically had 1.0106 CFU/cm2 of total microbes, which was not statistically substantially different from men's feet (mean: 1.2105

CFU/cm2) (Steglinska, et al., 2019). According to Ying et al. (2015), Males spread of bacteria or load is higher because they have greater sebum secretion that remains stable with ageing.

Chapter Summary

From the preceding information, both humans and microbes depend on their interactions to grow and stay healthy. However, some potentially harmful bacteria come into intimate contact with the host and cause opportunistic infections in hosts with compromised immune systems, despite the fact that microbes are responsible for resistance to colonization by foreign pathogenic microorganisms. Given that diseases may be able to survive on such surfaces for periods varying from a few minutes to several hours; it is possible that bacteria reside in a natural reservoir and that textiles serve as reservoirs for microorganisms (Neely & Maley, 2000; Neely, 2000; Olowomofe, Oluyege, Ogunlade & Makinde, 2020).

Current research works in the area of clothing and microbes have overlooked the study of microbes found on textiles especially in the household setting specifically those used by students, the influence of their sex and the period of usage. Much attention has been given to research focusing on searching Hospital Acquired Infections-relevant pathogens, mostly Staphylococcus aureus or Enterococci. Additionally, these study on microbes and clothing did not specify the fibre content of the linens or the gender influence on microbial dispersion. This study will therefore examine the different fibre content of bed linens and also compare the microbial load of the gender as well as the period of usage of household linens and its influence on the growth of microorganism on bed linens used by students.

CHAPTER THREE

RESEARCH METHODS

Introduction

This chapter describes the design employed for the study, sample and sampling procedures, instruments employed for data collection, data collection procedures as well as the methods used in the analysis of the data collected. The study was in two phases. The first phase investigated a sample of the population to describe their attitude, behavior, and hygienic practices in relation to household linens and helped to shape the second phase of the study. The second phase assessed the microbial load of bed linens used by the university students.

Research Design

The study employed the use of both quantitative and experimental research designs. According to Akhtar (2016), quantitative research involves analyzing and collecting numerical data in order to find patterns, compute averages, assess correlations, and produce broad conclusions. One major characteristic of quantitative design is its ability to present the findings in numerical form and is suitable for collecting information from a large number of people. Experimental design on the other hand determines the relationship between a situation's cause and effect. It is a causal study strategy in which the impact of the independent variable on the dependent variable is noted (Blaikie, 2000). The cross-sectional survey design was used for the first phase of the study because the researcher intended to describe the hygienic practices of the

population in relation to bed linens. In survey design, researchers use questionnaires to collect quantitative, numerical data which is statistically analyzed to characterize trends in response patterns and to evaluate research hypotheses (Tanny, 2016). Phase two of the study employed the quasi-experimental design with the use of laboratory testing for the assessment of microbial load on bed linens used by students. In quasi- experimental design, although an independent variable is manipulated, participants of the group are not chosen at random. This type of experimental design was used because volunteers of the study were selected purposively and therefore random assignment was not required.

A 2×2×2 factorial design was employed for the study which included two categories of gender (male, female), two different fabric types (100% cotton and cotton/ polyester blend) and two different periods of usage (one week and two weeks). According to Amedahe (2002), when two or more independent variables are included in a study, whether true experiment or a quasi-experiment, a factorial design is necessary. A factorial design is an experimental layout that looks at several independent variables simultaneously to examine their impact on each other or independently (Collins, Dziak & Li, 2008). They went on to say that in a factorial design, the researcher manipulates two or more variables simultaneously in order to explore both the independent effects of each variable on the dependent variables and the interactions between the various variables. The three independent variables in this study were gender, period of usage and type of fabric the bed linen is produced from.

The study was conducted in two phases because there are predetermined theories that influence the presence of microbial activities. The quantitative approach used in phase one helped the researcher to collect data from a representative sample which allowed for comparison, generalization and replication (Creswell, 2008) and was used as a confirmatory study for the phase two of the study which assessed the microbial load of bed linens used by students. It was the researchers believe that the nature of the variables involved in the study will best be examined by the use of both experimental and survey designs explained.

Phase one of the study: Hygienic Practices of students

Phase one of the study was carried out to establish the hygienic practices of students. This was used as a confirmatory study for phase two.

Population and Sample for Phase One

The population of the study was all regular undergraduate students at the University of Cape Coast staying at the halls. The total number of regular undergraduate student is 16,848 (University of Cape Coast, 2021).

Eligibility Criteria for Phase One

1. Respondents should be undergraduate regular students of the University of Cape Coast.
2. Respondents should be residing in any of the two gender-based halls of the University of Cape Coast which are Casley Hayford and Adehye Hall.

Sample and Sampling Procedure for Phase One

The total number of sample size for the study was 364. Krejcie and Morgan (1664) (as cited in Nizzati, 2016) was used to select 364 participants/

volunteers out of a population of 16,848. According to Pourhoseingholi, Vahedi and Rahimzadeh (2013), for ethical reasons, the number of patients or investigated units which is the same as the sample size used in clinical or medical studies is limited due to practicalities such as cost, patient or volunteer inconvenience and decisions not to proceed with an investigation. Therefore, Kane's Sample Size Calculator for clinical tests (2019) was used for the estimation of the sample size for phase two. Kane's Sample Size Calculator for clinical tests works by keying in the total sample size for the entire study and it generates the number suitable for clinical tests. This generated a size of 64 for the phase two leaving the remaining sample size of 300 to be used for phase one. The researcher selected 150 male participants and 150 female participants from the male and female halls respectively for the study.

The multi-stage sampling method was used in phase one to select participants for the study. Both simple random sampling and purposive sampling methods were used. The first stage of sampling used purposive sampling to select one male and one female hall since gender represents a cross-section of the population and a variable examined in the study. The simple random sampling procedure specifically the lottery method was employed for the second stage of the study to select rooms in the halls that were part of the study. There were about 261 rooms in each hall with four students occupying a room. Since only 150 participants were needed from each room, the researcher decided to select one person from each room to be part of the study. Each room in the halls was numbered systematically starting from 1 to 261 and the numbers written on separate pieces of papers, these

pieces of papers were mixed and put into a box then numbers drawn out in a random manner to select 150 rooms. Again, the lottery method was used in selecting individual participants from the 150 rooms. The 150 rooms selected was multiplied by 4 to get 600. This was numbered on pieces of papers starting from 1 to 600 and put into a box then numbers drawn out in a random manner to select 150 participants. In the case where a room or participant that has already been selected for the study is selected during the process of the lottery, it was thrown back into the box and the process repeated.

Data Collection Instrument for Phase One

The first phase of the study used questionnaire. This was administered to respondents from purposively selected halls to collect information regarding their hygiene practices. As McLeod (2016) opined, questionnaires provide a relatively cheap, quick and efficient way of obtaining information from a large sample of people. The questionnaire had two sections; section one covered the demographic information of the participants and section two looked at the hygienic practices of the participants.

Data Collection Procedure for Phase One

Questionnaire was administered to the sampled respondents from the two gender-based halls of the University. The questionnaires were administered in person to respondents and taken immediately after completion which gave a 100% collection rate. A month was used in the administration and collection of questionnaires.

Phase two of the study: Experiment

Population for Phase Two

The population of the study was all regular undergraduate students at the University of Cape Coast staying at the diaspora. The total number of regular undergraduate student is 16,848 (University of Cape Coast, 2021).

Eligibility Criteria for Phase two

1. Volunteers for the second Phase of the study should be an undergraduate student of the University of Cape Coast and staying alone. (Single occupancy).
2. A volunteer should ensure that he/she sleeps on the bed linen alone throughout the study period.

Sample and Sampling Procedure for Phase Two

As stated by Pourhoseingholi, Vahedi and Rahimzadeh (2013) in medical research, the sample size is the number of patients or other investigated units that will be involved in a study and is essential to answer the research hypothesis in the study. They posited further that for ethical reasons, the number of patients or investigated units used in clinical or medical studies is limited due to practicalities such as cost, patient or volunteer inconvenience and decisions not to proceed with an investigation. Kane's Sample Size Calculator for clinical tests (2019) was used for the estimation of the sample size for phase two. Kane's Sample Size Calculator for clinical tests works by keying in the total sample size for the entire study and it generates the number suitable for clinical tests. A sample size of 64 was generated from the calculator, therefore, 64 volunteers (32 males and 32 females) was used for the

phase two of the study which is the generated number derived from the calculator out of the total 364 sample size for the entire study.

Purposive sampling was used to select volunteers (32 males and 32 females) staying alone for the second phase of the study. According to Michael (2011), in a purposive selection process, the researcher selects the sample based on who they believe would be suited for the study. Purposive sampling (single student occupants) was used to reduce or eliminate any statistical mistakes that could alter the conclusions of the study's results and findings such as cross contamination of the bed linen by roommates which can give wrong conclusions.

The 64 volunteers were classified into two based on gender. Each gender used one type of fabric for a week and two respectively. Thus, males used 100% cotton for a week and two weeks respectively as well as the cotton/polyester blend. Female volunteers also used cotton for a week and two weeks respectively as well as the cotton /polyester blend. Volunteers had a week break after every usage. This was done to reduce boredom and loss of interest in the experimental process.

Materials used for Phase Two

Sixty-four (64) pieces of bed linens (bed sheets 55'' by 92'' and pillowcases 27'' by 18'') in two distinct fabric kinds (32 pieces of 100% cotton and 32 pieces of cotton and polyester blend 65% polyester / 35% cotton) were bought from the market. These two kinds of bedding were chosen because they are widely available and mostly utilized by homes on the Ghanaian market. Nutrient agar (NA), Eosin Methylene Blue (EMB), Plate

Count Agar (PCA) and Potato Dextrose agar (PDA) were used to cultivate and enumerate the microorganism from swab sticks.

Data Collection Instrument for Phase two

Test tube was used to store water for sterilization.

Colony counter was used to estimate the liquid culture's density of microorganisms by counting individual colonies on the agar plate.

Incubator was used to support the growth and maintain microbiological cultures or cell cultures.

Petri dish was used to grow the microorganisms in the sample.

Sterilized swab sticks with tubes were used to pick specimen from mattress and the bed linens samples for testing.

Autoclave was used to sterilize water in the test tube for culturing.

Data Collection Procedure for Phase Two

Labelling of samples

Labels for mattresses and Bed linens

The mattresses and bed linens of the volunteers were tested for any microbial load before assigning treatment. The purpose of testing the mattresses and bed linens was to find out if there were any microbes before treatment.

Three levels were used for the labeling of the bed linens and mattresses. The first level was used to label the mattresses. The alphabets M was used to represent males and F for females. The mattresses were labelled M1 to M 32 for the 32 male volunteers and F1 to F32 for the 32 females volunteers. The fabric type was labelled at the second level where the alphabet C represented 100% cotton and C/P represented cotton/polyester blend. The

last level was used to label the number of weeks of usage of the bed linen. The alphabet A was used for samples to be used for a week and B for samples to be used for two weeks. All samples labelled C used 100% cotton and those labeled C/P used cotton/ polyester blend. All samples labelled A were used for a week while those labelled B were used for two weeks.

Labels for Petri Dishes

The labelling of the petri dishes followed the same procedure for the labelling of the mattresses and bed linens as indicated above.

Media and Media Preparation

Media used were Nutrient -Agar (NA), Potato Dextrose Agar (PDA) and Plate Count Agar and Eosin Methylene Blue (EMB) Agar.

Nutrient Agar (NA)

11. 2g of dehydrated Nutrient Agar was suspended in 400mL of distilled water in a 500ml conical flask. The agar was melted in a microwave in order to dissolve in the solution. The conical flask was then corked tightly with cotton and wrapped with aluminum foil. (This quantity was prepared for each treatment).

Eosin Methylene Blue (EMB) Agar

14.38 g of dehydrated EMB Agar was weighed on a balance and suspended in 400 ml of distilled water in a 500ml conical flask. The agar was melted in a microwave in order to dissolve in the solution. The conical flask was then corked tightly with cotton plug and wrapped with aluminum foil. (This quantity was prepared for each treatment).

Plate Count Agar (PCA)

9.4 g of the Plate Count Agar was weighed and suspended in 400ml of distilled water in a 500 ml conical flask. The agar was melted in a microwave

to dissolve completely in the Solution. The conical flask was then corked tightly with cotton plug and wrapped with aluminum foil. (This quantity was prepared for each treatment).

Potato Dextrose Agar (PDA)

15.6g of the dehydrated PDA war weighed on a balance and suspended in 400ml of distilled water in a 500ml conical flask. The agar was melted in a microwave to dissolve in the solution. The conical flask was then corked tightly with cotton plug and wrapped with aluminum foil. (This quantity was prepared for each treatment).

Specimen Collection and Testing Procedures

Isolation and Culturing

Mattresses and Bedlinens

For testing the mattresses, and bedlinens, sterile swab sticks moistened in normal saline were used to pick specimens from the mattresses and bedlinen. The swab sticks were immediately transported in a refrigerated box to the laboratory for microbial analysis. The bed linen were swapped after a week and two usage.

The pour plate method was used for isolation and culturing of the samples. Three hundred and eighty-four (384) test tubes were filled with 9 ml of distilled water each. The test tubes were then corked tightly with cotton plug and wrapped with aluminum foil. The media prepared, the 384 test tubes containing the distilled water and a pipette rack containing pipet tips were autoclaved in a YX- 24LM Eoral pressure steam autoclave for 15 minutes at 121°C. One sterile culturing swap stick was dipped in one of the sterile distilled water and swapped on the bed linen. The swab stick was dipped back

into the sterile distilled water and swapped again on the bed linen. This process was repeated about 4 times on each bed linen (Swaps were taken from different portions of the bed linen). Specimens were taken from the rest of the bed linens using the same process. The Petri dishes were labeled with the names of the media and the labels on the bed linens. 1 mL each of the specimen was pipetted into the various dishes according to the labels. The various media were soft melted and poured into the Petri dishes and swirled to mix properly with the specimen. After solidifying, the Petri plates were packed and incubated for twenty four to seventy two hours. After incubation, developed colonies on the plates were counted and recorded. Colonies were recorded as total bacteria count (CFU/ml). This was done for the mattresses as well. After specimen had been taken from the bed linens, those with microbes were disinfected with Clorox's hydrogen peroxide cleaner and disinfectant to ensure they were free from microbes before assigning treatment. The labeled samples were given to each volunteer in each group (male/ female) to be used for a period based on the groupings (1 week/ 2 weeks), and each packaged sample was kept in a disinfected sack and transferred to the lab for testing. The duration for data collection was eight weeks and volunteers were to use the bed linen alone and package them in their packaging bags they came in after usage to make collection easy and also avoid any cross contaminations.

Data Analysis

Responses were gathered on hygienic practices of respondents. Readings were recorded for microbial load and species identification. The statistical software that was used in the analysis of the data collected was the Statistical Package and Service Solution (SPSS) for Windows version 26.

Means and standard deviations of microbial load of new and used bed linens were determined. Additionally, means and standard deviations were determined if differences exist in microbial species between new and used bed linens. Inferential statistics (independent samples t-test and analysis of variance were employed in testing the hypotheses). These are statistical tools used in measuring differences, and the purpose of testing the hypotheses was to establish if any differences existed between and among the groups identified in the study.

To analyse data for objective one, frequencies and percentages were used, and descriptive statistics (means and standard deviations) were used in analysing objective two. In analysing hypothesis 1, 2 and 3, independent sample t test was used where period of usage which is 1 and 2 weeks were taken against the dependent variable (microbial load), gender taken against the dependent variable (microbial load) and fabric type (cotton and cotton and polyester blend) was taken against the dependent variable (microbial load) respectively.

In testing hypotheses 4, 3-way analysis of variance was employed to determine if there was any influence of the independent variables (gender, period of usage and fabric type) on the dependent variable (microbial load). Post hoc analysis was performed to establish if any difference exists between and among the groups involved in the study.

Ethical Considerations

Before commencing with this study, ethical approval was sought from the Institutional Review Board, University of Cape Coast (UCC, IRB). The researcher sought the consent of the participants; informed them about the

nature and purpose of the study and guarantee the confidentiality and anonymity of the information acquired. Participation in the research was, therefore, voluntary. Those who were purposively or randomly selected but were not willing to participate in the study were allowed to withdraw.

CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

In this chapter, the results acquired from the analysis of the data for the study are presented and discussed. The chapter is structured under two parts with two phases. Part one will discuss the analysis from the study and part two will discuss the results of the study. The phase one which defined the attitudes, opinions, actions, or features of the students about hygienic practices for household linens and laundry hygiene is presented under the following headings:

a. Personal Hygiene practices of respondents
b. Laundry hygienic practices of respondents

Phase two is also structured under:

a. Microbial load of bed linens used by students.
b. Testing of Hypotheses 1 and 2
c. Testing of Hypothesis 3 and 4

Hygienic Practices of Students

To explore the hygienic practices of male and female students in relation to bed linens which answers objective 1 of the study, 300 questionnaires (150 males,150 females) were given out. Percentages and frequencies were employed for the analysis. Hygienic practices were measured using 26 items on a five-point Likert scale with 1 representing not at all, 2 representing rarely, 3 representing moderately, 4 representing often and 5

representing very often. Table 3, page 66- 67 present results for percentages and frequencies in relation to personal hygienic practices of male and female students.

Again, exploring the laundry hygiene practices of students, 26 items on a five-point Likert scale was used with 1 representing not at all, 2 representing rarely, 3 representing moderately, 4 representing often and 5 representing very often. Table 4, page 70- 71 present results for percentages and frequencies in laundry hygienic practices of male and female students. The test results for number of times students wash their bedlinens is shown in Table 5 on page 71.

Table 3: Personal Hygienic Practices of Respondents

Personal Hygienic practices	Gender	Not at all Frequency (%)	Rarely Frequency (%)	Moderately Frequency (%)	Often Frequency (%)	Very often Frequency (%)
Bath twice a day (morning and evening)	Male	0 (0)	16 (10.6)	23 (22.0)	49 (32.7)	52 (34.7)
	Female	0 (0)	15 (10.0)	26 (17.4)	47 (31.3)	62 (41.3)
Bath with sponge, soap, and water in the morning	Male	0 (0)	0 (0.0)	16 (10.7)	41 (27.3)	93 (62.0)
	Female	0 (0)	1 (0.7)	12 (8.0)	36 (24.0)	101 (67.3)
Bath with just soap and water in the morning	Male	24 (16.0)	22 (14.7)	1 (0.7)	14 (9.3)	89 (59.3)
	Female	21 (14.0)	15 (10.5)	1 (0.7)	10 (6.7)	103 (68.1)
Bath with just water in the morning	Male	8 (5.3)	8 (5.3)	7 (4.7)	20 (13.3)	107 (71.4)
	Female	13 (8.7)	8 (5.4)	2 (1.3)	11 (7.3)	116 (77.3)
Bath with sponge, soap and water in the evening	Male	11 (7.3)	29 (19.3)	6 (4.0)	26 (17.3)	78 (52.1)
	Female	9 (6.6)	19 (12.7)	8 (5.3)	17 (11.3)	97 (64.1)
Bath with just soap and water in the evening	Male	77(51.3)	42 (28.0)	9 (6.0)	10 (6.7)	12 (8.0)
	Female	97 (64.7)	25 (16.7)	15 (10.0)	8 (5.3)	5 (3.3)
Bath with just water in the evening	Male	76 (50.7)	39 (26.0)	25 (16.1)	10 (6.7)	0 (0.0)
	Female	91 (60.7)	27 (18.0)	23 (15.3)	8 (5.3)	1 (0.7)
Eat on bed	Male	21(14.0)	37 (24.7)	29 (19.3)	37 (24.7)	26 (17.3)
	Female	20 (13.1)	32 (22.0)	34 (22.3)	32 (21.3)	32 (21.3)
Wash hair every day	Male	58 (38.6)	40 (26.7)	42 (28.0)	10 (6.7)	0 (0.0)
	Female	62 (41.3)	47 (31.3)	33 (22.0)	6 (4.0)	2 (1.4)
Wash hands frequently during the day with soap and water	Male	6 (4.0)	26 (17.3)	55 (36.7)	41 (27.3)	22 (14.7)
	Female	4 (2.7)	20 (13.3)	54 (36.0)	40 (26.7)	33 (21. 3)
Cough/ sneeze into tissue and dispose	Male	1 (0.7)	16 (10.7)	16 (10.7)	74 (49.3)	43 (28.6)
	Female	0 (0.0)	19 (12.7)	24 (16.0)	65 (43.3)	42 (28.0)

Table 3: Continued

Wash hands with soap and water after using tissue	Male	14 (9.3)	33 (22.0)	37 (24.7)	44 (29.3)	22 (14.7)
	Female	9 (6.0)	36 (24.0)	37 (24.7)	42 (28.0)	26 (17.3)
Wash hands with soap and water every time after using washroom	Male	6 (4.0)	18 (12.0)	11 (7.3)	45 (30.0)	70 (46.7)
	Female	4 (2.7)	13 (8.7)	13 (8.6)	42 (28.0)	78 (52.0)
Use hand sanitizer frequently	Male	7 (4.7)	24 (16.0)	53 (35.3)	27 (18.0)	39 (26.0)
	Female	4 (2.7)	26 (17.3)	51 (39.0)	31 (20.4)	38 (20.6)
Keep Toes and fingernails are short	Male	8 (5.3)	18 (12.0)	24 (16.0)	47 (31.3)	53 (35.4)
	female	8 (5.3)	21 (14.0)	23 (15.3)	40 (26.7)	58 (38.7)

Personal Hygiene in Relation to Bathing

Table 3 indicates that for personal hygiene in relation to bathing, majority of female students bath twice in a day very often with a percentage of 62% as compared to male students with a percentage of 52%. There was no frequency and percentage recorded on not at all for both male and female students. However, there was a high frequency and percentage recorded for bathing very often with just water in the morning with female students being the majority 116 (77.3%) and male students being in the minority 107 (71.3%).

This is followed by not at all with females still leading with 91 (60.7%) and males in the minority with 79 (50.7%). The least recorded frequency and percentage for bathing with just water in the evening was for very often with 0 (0.0%) for males and 1 (0.7%) for females (Table 3).

For coughing and sneezing into tissue and disposing, the highest recorded was for very often with males having the highest frequency and percentage of 43 (28.7%) as compared to females with 42 (28.0%). Again, for the use of hand sanitizers, males had the highest recorded frequency and percentage for which is 53 (35.3%) compared to females who had 51 (34.0%).

Washing of hands frequently with soap and water during the day and after using washroom

Results from Table 3 shows that for personal hygiene in relation to Washing of hands frequently with soap and water during the day, the highest recorded was for moderately with males having the highest frequency and percentage of 55(36.7%) as compared to females with 54 (36.6%). The least frequency and percentage were for not at all with males having the highest

record of 6 (4.0%) compared to females 4 (2.7%). Results in Table 3 shows that female students 78(52.0%) wash their hands very often after every washroom visit compared to males 70(46.7%). The least record was for not at all with males 6 (4.0%) being in the majority compared to females 4(2.7%) (Table 3).

Table 4: Laundry Hygienic Practices of Respondents

Laundry Hygienic practices	Gender Male/ female	Not at all Frequency (%)	Rarely Frequency (%)	Moderately Frequency (%)	Often Frequency (%)	Very often Frequency (%)
Use of detergents in washing bed linens	Male	9 (6.0)	29 (19.3)	22 (14.7)	36 (24.0)	54 (36.0)
	Female	10 (6.7)	32 (21.3)	29 (19.3)	34 (22.7)	45 (30.0)
Use of bleach in washing bed linens	Male	50 (33.4)	33 (22.0)	44 (29.3)	14 (9.3)	9 (6.0)
	Female	53 (35.3)	34 (22.7)	39 (26.0)	17 (11.3)	7 (4.7)
Boil bed linens before washing	Male	71 (47.3)	42 (28.0)	7 (4.7)	20 (13.3)	10 (6.7)
	Female	59 (39.3)	41 (27.0)	17 (11.3)	22 (14.7)	11 (7.3)
Rinse bed linens two to three times after washing	Male	31 (20.7)	22 (14.7)	33 (22.0)	40 (26.7)	24 (16.0)
	Female	20 (13.3)	38 (25.3)	39 (26.0)	33 (22.0)	20 (13.5)
Air bed linen under sunlight two to three times in a week	Male	34 (22.7)	31 (22.0)	30 (22.7)	21 (14. 0)	34 (22.7)
	Female	33 (22.0)	35 (23.3)	38 (25.3)	15 (10.0)	29 (19.3)

Table 4: Continued

Use warm water in washing bed linen	Male	38 (25.3)	56 (37.3)	13 (8.7)	12 (8.0)	31 (20.7)
	Female	29 (19.3)	51 (34.0)	22 (14.7)	17 (11.3)	31 (20.7)
Dry bed linen directly under sunlight after washing	Male	34 (22.7)	11 (7.3)	18 (12.0)	10 (6.7)	77 (51.7)
	Female	33 (22.0)	21 (14.0)	15 (10.0)	14 (9.3)	67 (44.7)
Dry bed linen under a shade after washing	Male	87 (58.0)	35 (23.3)	14 (9.3)	4 (2.7)	10 (6.7)
	Female	74 (49.3)	32 (21.3)	20 (13.3)	14 (9.3)	10 (6.7)
Wash bed linen in the evening and drying immediately	Male	47 (31.3)	46 (30.7)	15 (10.0)	22 (14.7)	20 (13.3)
	Female	46 (30.7)	42 (28.0)	19 (12.7)	22 (14.7)	21 (14.0)
Wash bed linen in the morning and drying directly under sunlight	Male	17 (11.3)	20 (13.3)	9 (6.0)	23 (15.3)	81 (54.0)
	Female	17 (11.3)	29 (19.3)	17 (11.3)	20 (13.3)	67 (44.7)
Iron bed linen before usage on mattress	Male	19 (12.7)	46 (30.7)	25 (16.7)	38 (25.3)	22 (14.7)
	Female	19 (12.7)	48 (32.7)	40 (26.7)	31 (20.7)	12 (8.0)

Table 5: Number of times Respondents wash Bedlinens

Gender	Number of times for washing bedlinen			
	Every 3 days Frequency (%)	Every week Frequency (%)	Every two weeks Frequency (%)	Every month Frequency (%)
Male	11 (7.3)	50 (33.3)	33 (22.0)	56 (37.3)
Female	10 (6.7)	64 (42.7)	35 (23.3)	41 (27.3)

Laundry Hygiene Practices of Respondents

Table 4 presents the results for the laundry hygiene of male and female students. For washing with detergent, the highest recorded frequency and percentage for very often with males in the majority 54 (36.0) and females in the minority 45 (30.0). With regard to use of bleach, not at all had the highest records with females in majority 53 (35.3) and males in minority 50 (33.3). Table 5 presents the results for the number of times male and female students wash their bedlinens. As indicated in Table 5, majority of male students (37.3%) wash their bed linens every month. This was the highest recorded frequency for males. For females, majority revealed they wash their bed lines every week (42.7%). This was the highest frequency for females. This informed the decision to use one and two weeks for the study.

Microbial load of Bed linens used by Students

Two types of bed linen fabrics were used. 100% cotton / cotton and polyester blend (65% polyester / 35% cotton). Descriptive statistics (means and standard deviations) were employed to determine the microbial load of bed linens used by students which answers objective two of the study. The

mattresses which the bed linens were used on were tested to find out if there were any presence of microbes before usage. The results revealed that majority of the mattresses did not have any microbes on them (Table 6 and 7). Few of the mattresses such as sample IDs C16, C22, C25, P12, and P14-P17 showed the presence of both E-coli and Klebsiella aerogenes (Table 6 and 7). The results showed that not all the new bedlinens had microbes on them such as sample IDs C15, C16, C22 and C23 for 100% cotton and P4, P7, P11, P12, p14- p17, P21, and P22 for the blend. Most of the unused bedlinens contained microbes. The highest recorded microbes on 100% cotton was on sample ID C32 with mean of 586.33 for E-coli and 740.00 for klebsiella aerogenes; and for cotton and polyester blend the highest was 300.00 for E-coli and 309.00 for klebsiella aerogenes on sample ID P27 (Table 6 and 7). The results revealed high levels of microbial loads on the bed linens after students have used them with the highest mean of 732.00 for E. coli and 553.00 for Klebsiella aerogenes on sample ID C32 for 100% cotton and for the cotton and polyester blend, the highest mean was 435.66 for E-coli and 416.66 for Klebsiella aerogenes for sample ID P30. The result is presented in Table 6 and 7.

Table 6: Descriptive Statistics of microbial load of mattresses, used and unused bedlinens for cotton samples

SAMPLE ID		Mattress				Unused bedlinen				Used bedlinen			
		E.coli		Klebsiella A		E.coli		Klebsiella A		E.coli		Klebsiella A	
		M	S.D	M	S.D	M	S.D	M	S.D	M	S.D	M	S.D
C1	Male Samples	0.33	0.58	0.00	0.00	0.67	1.15	11.00	19.05	73.67	38.79	53.67	2.30
C2		0.47	0.25	0.92	0.54	83.00	22.60	87.33	4.93	68.00	24.33	79.33	24.94
C3		0.26	0.44	0.00	0.00	0.00	0.00	0.00	0.00	61.66	84.21	30.33	43.08
C4		0.32	0.55	0.00	0.00	0.00	0.00	4.66	8.08	81.00	58.79	80.33	14.04
C5		0.26	0.44	0.00	0.00	0.00	0.00	0.00	0.00	61.66	84.21	30.33	43.08
C6		0.00	0.00	0.00	0.00	0.00	0.00	12.66	11.15	117.33	50.21	185.00	54.74
C7		0.00	0.00	0.01	0.01	145.33	137.71	6.00	7.00	184.66	138.01	143.00	198.46
C8		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	86.00	110.17	55.33	72.43
C9		0.00	0.01	0.00	0.01	0.00	0.00	0.33	0.57	305.66	109.40	530.33	109.63
C10		3.66	6.35	0.01	0.02	0.00	0.00	0.33	0.57	94.33	130.48	198.66	135.88
C11		0.01	0.02	0.01	0.02	57.00	62.55	34.33	39.52	104.66	126.08	145.00	123.55
C12		0.33	0.57	0.00	0.00	1.33	2.30	0.00	0.00	30.66	42.82	47.33	61.49
C13		0.00	0.00	0.00	0.00	0.33	0.57	2.66	4.61	153.66	126.75	47.66	82.56
C14		0.00	0.00	0.01	0.02	2.33	4.04	16.66	1.15	208.66	75.00	296.66	5.77
C15		0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	105.66	140.50	59.33	58.82
C16		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	345.00	436.17	36.00	61.53

Table 6: Continued

C17	Female Samples	0.00	0.00	0.00	0.00	3.00	2.64	0.66	0.57	197.33	91.59	66.00	61.53
C18		0.00	0.00	0.03	0.05	0.00	0.00	0.66	1.15	72.66	98.19	133.33	109.57
C19		0.00	0.00	0.00	0.00	73.33	103.00	49.33	78.52	119.66	157.38	100.00	45.29
C20		0.00	0.00	0.00	0.00	1.00	1.73	53.33	73.21	105.66	140.69	28.66	24.84
C21		0.00	0.00	0.00	0.00	2.33	4.04	5.33	3.21	118.33	36.89	517.00	111.07
C22		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.33	11.95	19.66	29.77
C23		0.00	0.00	0.66	0.57	0.00	0.00	0.00	0.00	20.66	26.83	18.66	27.20
C24		0.00	0.00	0.00	0.00	292.00	88.27	426.66	68.06	180.66	52.50	212.00	367.19
C25		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	189.66	52.50	212.00	367.19
C26		0.00	0.00	0.00	0.00	0.33	0.57	0.00	0.00	23.00	23.89	48.66	69.06
C27		0.00	0.00	0.00	0.00	7.33	11.01	2.33	2.51	309.33	100.80	222.33	97.57
C28		0.00	0.00	0.00	0.00	0.00	0.00	2.33	4.04	151..66	99.32	31.00	53.69
C29		0.00	0.00	0.00	0.00	4.33	7.50	1.33	1.52	269.66	87.53	8.33	7.23
C30		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	248.00	61.02	322.33	77.42
C31		0.00	0.00	0.00	0.00	8.66	12.50	6.33	4.93	58.00	44.91	54.66	14.57
C32		0.00	0.00	0.01	0.02	586.33	185.07	740.00	189.19	732.66	102.96	553.66	170.93

Table 7:Descriptive Statistics of microbial load of mattresses, used and unused bedlinens for cotton/ polyester samples.

SAMPLE ID		Mattress				Unused bedlinen				Used bedlinen			
		E.coli		Klebsiella A		E.coli		Klebsiella A		E.coli		Klebsiella A	
		M	S.D	M	S.D	M	S.D	M	S.D	M	S.D	M	S.D
P1	Male Samples	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.00	131.66	726.58	122.00	122.85
P2		0.00	0.0	0.01	0.02	5.66	9.81	0.00	0.00	301.33	521.92	206.66	95.57
P3		0.00	0.00	0.35	0.56	0.00	0.00	42.00	50.47	173.33	714.26	260.00	34.69
P4		0.00	0.00	0.02	0.03	0.00	0.00	0.00	0.00	15.33	21.45	10.66	18.47
P5		0.00	0.00	0.02	0.03	0.33	0.57	0.00	0.00	14.00	20.07	5.33	6.65
P6		0.00	0.00	0.00	0.00	0.00	0.00	2.00	3.46	105.33	116.74	130.00	117.50
P7		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	359.66	49.09	456.66	44.01
P8		0.00	0.00	0.00	0.00	213.66	187.51	172.33	147.50	245.66	95.44	145.00	50.68
P9		0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.73	78.60	115.53	333.00	342.90
P10		0.00	0.00	0.00	0.00	0.00	0.00	6.33	6.02	207.00	90.93	62.33	107.96
P11		0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	45.00	63.78	17.00	17.77
P12		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	43.00	68.50	64.00	107.39
P13		0.00	0.00	0.00	0.00	0.00	0.00	42.00	50.47	143.66	143.30	329.66	26.27
P14		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.66	2.08	26.00	36.59
P15		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	422.66	240.71	228.00	122.97
P16		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	77.66	106.80	86.33	109.66

Table 7: Continued

P17	Female Samples	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	162.33	211.85	132.33	132.29
P18		0.00	0.00	0.00	0.00	0.66	31.15	5.33	3.51	253.33	71.51	105.33	182.44
P19		0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	162.33	211.85	88.66	86.49
P20		0.00	0.00	0.00	0.00	0.00	0.00	1.33	2.30	115.33	101.90	283.33	76.37
P21		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	173.66	214.44	174.00	240.23
P22		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	173.66	214.44	174.00	240.23
P23		0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.57	162.66	278.29	115.00	161.78
P24		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.66	1.15	2.00	2.00
P25		0.00	0.00	0.00	0.00	162.33	124.11	98.66	87.80	396.66	187.53	231.00	59.75
P26		0.00	0.00	0.00	0.00	0.33	0.57	0.33	0.57	54.66	82.61	42.33	37.81
P27		0.16	0.21	0.00	0.00	300.00	100.00	309.33	118.09	275.33	23.18	230.33	34.01
P28		0.00	0.00	0.00	0.00	0.00	0.00	0.66	1.15	36.00	42.75	509.00	30.51
P29		0.00	0.00	0.00	0.00	0.00	0.00	1.33	2.30	376.00	31.00	252.00	128.26
P30		0.00	0.00	0.00	0.00	0.33	0.57	5.00	3.46	435.66	53.71	416.66	76.37
P31		0.00	0.00	0.00	0.00	2.33	4.04	0.00	0.00	163.66	192.81	103.00	94.39
P32		0.00	0.00	0.00	0.00	2.33	4.04	5.33	3.21	259.66	90.50	207.00	358.53

Experimental

Testing of Hypothesis 1, 2 and 3

To determine whether differences existed between microbial load regarding period of usage, gender of user and type of fabric, hypotheses 1, 2 and 3 were tested using inferential statistics (independent sample T test). The results are provided in Tables 8 to 10.

Testing of Hypothesis 4

To test Hypotheses 4 which sought to establish whether gender, period of usage and fabric type have no influence on the microbial load of bed linens used by students, 3-way analysis of variate was employed. The result is presented in Table 11, page 80.

Results for Hypothesis 1

Results in Table 8 indicate that there was no statistically significant difference in microbial load of bed linen used by students in relation to period of usage for one week and two weeks for both E. coli (t= -.202, df= 62, p= .903) and Klebsiella aerogenes (t= .417. df=62, p= .787) respectively.

Table 8: Mean, Standard Deviation, P-value, and T- values for Bacteria load by Period of Usage

Bacteria load	Period of usage	M (c/fu)	S.D	Df	*t*- value	*p*-value
E. coli	1 week	0.6128	1.32999	62	-.202	.903
	2 weeks	0.6784	1.26760			
Klebsiella aerogenes	1 week	1.0563	1.35814	62	.417	.787
	2 weeks	0.9175	1.29976			

Results for Hypothesis 2

With regards to microbial load in relation to gender of the user, the results in Table 9 show that there was no difference in microbial load in relation to gender which is male and female for both E. coli (t= .983, df =62, p= .178) and Klebsiella aerogenes (t= -1.001, df= 62, p= .293)

Table 9: Mean, Standard Deviation, P-value, and T- values for Bacteria load of by Gender of User

Bacteria type	Gender of user	M (c/fu)	S.D	Df	*t*- value	*p*- value
E. coli	Male	0.4872	1.15251	62	.983	.178
	Female	0.8041	1.41343			
Klebsiella	Male	0.8216	1.18086	62	-1.001	.293
aerogenes	Female	1.1522	1.44747			

Results for Hypothesis 3

Table 10 indicates that there was a statistically significant difference in microbial load with regards to fabric type for E. coli (t= 1.309, df =62, p= .004). A comparison of the mean scores presented in the Table revealed that students who used 100% cotton had higher bacteria load (M=3.5556, SD= 0.95795) than students who used cotton and polyester blend (M=2.8784, SD= 0.82400).

The study found that, there was a statistically significant difference in microbial load for Klebsiella aerogenes with regards to fabric type, (t= 1.235, df =62, p= .000). A comparison of the mean scores presented in the descriptive statistics revealed that students who used 100% cotton (M=3.4209, SD=0.92791) had higher bacterial load than students who used cotton and polyester (M=2.8059, SD= 0.76824).

Table 10: Mean, Standard Deviation, P-value, and T- values for Bacteria load by Type of Fabric

Bacteria load	Type of fabric	M (c/fu)	S.D	Df	*t*- value	*p*-value
E. coli	100% cotton	3.5556	.95795	62	1.308	.004
	C/P blend	2.8784	.82400			
Klebsiella aerogenes	100% cotton	3.4209	.92791	62	1.235	.000
	C/P blend	2.8059	.76824			

Results for Hypothesis 4

The result presented in Table 11 shows no significant influence of the three independent variables combined on the dependent variable, microbial load (p= .516).

Table 11: 3-Way Analysis of Variance on the Influence of Gender, period of usage and fabric type on the microbial load of bed linens used by students.

Source	Type III sum of squares	Df	Mean (c/fu)	F	*P*-value
gender * periodofusage	.002	1	.002	.001	.973
gender * typeoffabric	.397	1	.397	.228	.635
periodofusage * typeoffabric	1.501	1	1.501	.861	.357
gender * periodofusage * typeoffabric	.744	1	.744	.427	.516

Discussion of Results

Discussion for Phase One: Personal Hygienic Practices of Students

The results in Table 3 show that for personal hygiene in relation to bathing, majority of female students bath twice in a day with a percentage of 62% as compared to male students with a percentage of 52%. Again, the results shows that female students 78(52.0%) wash their hands very often after every washroom visit compared to males 70(46.7%). Unpredictably, for coughing and sneezing into tissue and use of hand sanitizer, males had the highest record of 43 (28.7%) and 53 (35.3%) respectively as compared to females with 42 (28.0%) and 51 (34.0%) respectively.

The findings in relation to hygienic practices of male and females supported similar studies conducted as an Institut Public de Sondage d'Opinion Secteur (IPSOS) poll in 2018 indicated that women (81%) are more likely to practice hygiene than men (72%) (IPSOS poll, 2018). Mangru-Kumar (2022) also confirmed that women have a better understanding of how to care for their hygiene than men (57% vs. 42%). A recent survey by IPSOS (2018) among American men and women found that marginally fewer men than women rated hand washing as very vital in several key contexts (84% vs. 91% after using the toilet; 68% vs. 72% before a meal; 66% vs. 74% after using public transport). This sex difference in hygiene norms is consistent with behavioral studies of hand washing not only in the united states but also in Egypt, Ghana, Hong Kong, and China (Anderson,Warren, Perez, Louis, Phillips, Wheeler, Et Al., 2008; Elkhawaga & El-Masry, 2017; Mariwah, Hampshire & Kasim, 2012). Generally, the results show that both the male and female students practice good hygiene.

Discussion for laundry Hygienic practices of Students

In relation to laundry hygiene the study discovered that majority of male students (37.3%) wash their bed linens monthly while females wash their bed lines every week (42.7%). This is shown in Table 5. It can be deduced from the finding that females washed their bed linens often as compared to males. These confirmatory results did not influence the difference of microbial load found on bedlinens used by males and females as the results in table 9 showed no difference. Despite this, it can be said that male students maintain some level of good hygiene by washing their bedlinens monthly while female students maintain a higher level of good hygiene by changing their bedlinens weekly.

The findings were consistent with studies conducted by Moore (2016) which showed that 44% of women clean their bed sheets at least once a week, compared to 32% of men with 6% of both men and women cleaning their sheets at minimum every seven weeks. Similar to these studies which supports the current findings include those by Tonic (2022), studyfinds (2018) and Green (2022). Several studies have indicated that general hygiene practices adopted in homes and everyday lives are means to protect individuals, families, friends and colleague from infectious diseases (IFH, 2018; De Cock, Simone, Davison, & Slukster, 2013; Fonkwo, 2008; Bloomfield et al, 2009; Fauci, 2001; Bloomfield, Carling & Exner, 2017; Kampf, 2018; Rook, Bäckhed, Levin, McFall-Ngai & McLean, 2017) however, the hygiene hypothesis proposed by David Strachan does not support these studies as he stated that the problem with particularly clean

environments is that they fail to offer the needed exposure to germs required to “teach” the immune system to defend responses from infectious organisms.

Discussion of results for microbial load of bed linens used by students

Results for microbial load of bed linens used by students in Tables 6 and 7 showed that majority of the mattresses didn’t contain microbes and those that had microbes recorded a low mean. Meanwhile, some of the unused bed linen showed the presence of microbes which increased after usage.

The findings are consistent with most studies as they confirm that textiles can serve as a habitant for microbes where they can even multiply (Bajpai, Dey, Ghosh, Bajpai & Jha, 2011; Banu, Anand, & Nagi, 2012; Hyde, 202). Situations which will aid the spread of microbes through household linens include the use of clothing such as bed linens which are contaminated by potentially harmful microorganisms (IFH, 2013), and the finding from this study is evidence of this. Neely and Maley (2000) and Neely (2000) also opined that pathogens may be able to survive on textile surfaces for periods oscillating from a few minutes to several hours. Theres no doubt the mattresses didn’t contain so much or none since most pathogens cannot survive on some surfaces for a long time. As Zanoaga and Tanasa (2014) cited, under an ideal condition which is 36–40 ″C, pH 5–9, some bacteria populations may double every 20–30 minutes. This means that one single bacteria cell can increase to 1,048,576 cells in just 7 hours, and this is a confirmation of the findings of the study in the increase of microbial load after usage. The increase in microbial load after usage could also be attributed to operations like cooking and eating, being outside and working which can

affect where the microbial flora present on the epidermis and in bodily excrements is distributed (Abney et al., 2021).

Again the results showed higher load on cotton compared to the blend of polyester and cotton. This result is consistent with studies which have shown that the properties of textiles, such as the fabric type, use, and pollution content, can also affect the presence of pathogens and bacteria that cause grow on textile surfaces (Abney et al., 2020). Natural fibres based on their high moisture retention qualities can give microbes nutrients and energy sources in the shape of proteins or carbohydrates whereas the hydrophobic character and poor adsorbing ability of synthetic fibres makes it difficult for microbial enzymes to be able to break the carbon linkages in synthetic fibres, rendering them resistant to microbial attack (Gao & Cranston, 2008; Siracusa, 2019; Gao & Cranston, 2008; Pathak, 2017). Sauperl (2016); Siracusa (2019); Szostak-Kotowa (2004); Pathak, 2017; Gupta & Bhaumik (2007) have shown that the various fibres' microbial attractions make fabric mixes made of natural and synthetic fibres more effective at reducing microbial adhesion. A natural and synthetic fiber mix is less likely to promote microbial development than fabrics composed entirely of natural fibres and the findings from this study confirms this.

The results reveals that there is a reason to be worried since majority of the load found on the used bed linen contained more than 10^5 CFU/ml or 2.5 cfu/cm as indicated to be high and could cause health related issues (Mulvey, Redding, Robertson, Woodall, Kingsmore, Bedwell & Dancer, 2011; Situ Biosciences, 2023)

Discussion of results for hypothesis one

The independent sample T test in Table 8 showed no significant difference in the period of usage (one week and two weeks) on the microbial load of bed linens used by students. The null hypotheses which state that there is no statistically significant difference in the microbial loads of bed linens in relation to the period of usage were retained. The results is dissimilar to Hales (2022). He observed that over time, fungus and bacteria grow in bedding and linens will have 24,631 times more bacteria than the restroom doorknob in a week.

The findings are contrary to Hyde (2021) who found a significant difference. His findings showed that after one week, pillowcases and sheets contained between three million and five million CFUs (colony-forming units) per square inch and by the fourth week, both areas of bed linen had almost 12 million CFUs. Additionally, bedsheets had more germs after one week than a restroom doorknob and that amount increased to have more germs than a pet toy in just two weeks (Knight, 2022). The significant difference in the finding could be as a result of the different participants used since the sample for these studies might be households with children and probably an animal as a pet. Again, the difference could be as a result of the good personal and laundry hygiene activities practiced by students as shown in Tables 3,4 and 5 and confirmed by studies from Aunger, Greenland, Ploubidis, Schmidt, Oxford and Curtis, (2016), Smith (2008), WHO (2019) and Wilson (2023). This study's finding therefore might be the first to establish no difference exists in microbial load found on bed linens in the school setting in terms of duration of usage for a week and two.

Discussion for hypothesis 2

The independent samples t test results in Table 9 showed no significant difference in the microbial loads of bed linens used by male and female students. The findings does not support studies conducted such as those by Smith, O' Driscoll, & Lamb (2020) which showed bacterial levels on garments worn by male operators being almost always in excess of those worn by females at all sites tested and that of Ying et al. (2015) which confirmed that males have bacteria load which is higher because they have greater sebum secretion that remains stable as they age. This study's finding might be the first to establish no difference in existence in microbial load found on bed linens in terms of gender and this could be as a result of the population used. They were tertiary students who had greater knowledge of personal hygiene and its effects.

Discussion of hypothesis 3

The difference in microbial load for the two types of fabric used was compared for both E. coli and Klebsiella aerogenes (Table 10). The study found a statistically significant difference in both E. coli and Klebsiella aerogenes for both 100% cotton and cotton and polyester blend. A comparison of the mean scores presented in Table 10 revealed that students who used 100% cotton had higher E. coli and Klebsiella aerogenes than students who used cotton and polyester. This shows that there were more bacteria load in the bed linen of students who used4 100% cotton fabric than in cotton and polyester blend.

The study confirms the findings of Gao and Cranston (2008) which showed that natural fibres can provide nutrients and energy sources for

microbes in the form of carbohydrates or proteins. This is because they tend to have high moisture retention properties and their polymer linkages can be more easily gained access to by microbial enzymes as Gupta and Bhaumik (2007) asserted. Cotton had a higher microbial load because it is a vegetable fiber which can serve as nutrient source for microbes. The cotton and polyester blend had lower bacteria load as compared to the 100% cotton because the blend has some presence of synthetic fibre which is the polyester and microbial enzymes have a tendency of not being able to break synthetic carbon linkages due to their hydrophobic nature and poor adsorbing capacity (Siracusa, 2019; Gao & Cranston, 2008; Pathak, 2017).

The findings again confirm studies by Gopalakrishnan and Nithiyakumar (2008), Gopalakrishnan (2016), and Eichhorn, Hearle, Jaffe, and Kikutani (2009) which showed that cotton has properties such as porosity, absorbency and high heat conductivity. Most studies have shown textile surface exhibiting a potential role in microbial adhesion and transfer (Bajpai, Dey, Ghosh, Bajpai & Jha, 2011; Banu, Anand, & Nagi, 2012) and cotton is one of them. Cotton's absorbency and moisture take up comes from the fibre surface which has a strong attraction for water. According to Oh et al (2018) microorganism interaction with textiles is based on various factors like type of microorganism, surface characteristics of textile and various environmental factors (physical and chemical). The higher microbial load on cotton can be attributed to these properties since microbes need to adhere to a surface and grow on some nutrient, moisture and temperature.

Discussion of hypothesis 4

The 3-way analysis of variance results (Table 11) show that the three independent variables (period of usage, gender and type of fabric) combined had no significant influence on microbial load of bedlinens used by students. The finding was consistent with the null hypotheses and therefore the researcher failed to reject the null hypotheses.

None of the reviewed works examined the interaction of gender, period of usage and fabric type on the microbial load of bed linens. Therefore, no comparison could be made with the reviewed literature and this study could be the first to determine no significance in the influence of period of usage, gender and fabric type on the microbial load of bed linens used by students.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Overview

This chapter presents the summary of the processes involved in conducting the study, and the conclusions drawn by the researcher. It also makes recommendations and suggests areas for further studies.

Summary of the Study

The study assessed the microbial load of bed linens used by students of the University of Cape Coast. It employed the quantitative research approach and was in two phases. The first phase of the study used survey design to describe the hygienic practices of the population that can bring about microbial existence and served as an exploratory study to assist with the design for phase two. The second phase of the study employed the experimental study with the use of laboratory testing for the assessment of microbial load of bed linens used by students with a 2×2×2 factorial design which included the two categories of gender, two different fabric types (100% cotton and cotton and polyester blend) and two different periods of usage (one week and two weeks). Sixty four samples of new bed linens were used for the study (32 pieces of 100% cotton and 32 pieces of cotton and polyester blend). The instruments used in the collection of data included Test tube, Colony counter, Incubator, Petri dish, Sterilized swab sticks with tubes and Autoclave (see appendix). The study was carried out at the Molecular Biology and Biotechnology Department's laboratory of the University of Cape Coast.

Summary of the Findings

Phase one findings

1. The study showed that relatively female students maintain better hygiene practices compared to male students.
2. The study revealed majority of females wash their bed lines often (42.7%) compared to male students (37.3%).

Phase two findings

1. Some investigated student mattresses contained microbes.
2. Unused bed linens had microbes and the microbes increased after usage.
3. No statistically significant difference was found between period of usage in terms of microbial load.
4. Statistical analysis showed no significant difference between gender of the user in terms of microbial load.
5. Statistically significant difference was observed in microbial load based on the type of fabric in terms of fibre content used for bed linen. More bacterial load was noted for 100% cotton bed linen than on cotton/polyester blend.
6. Period of usage, gender and type of fabric were found not to have significant influence on microbial load.

Conclusions

The study revealed that relatively female students maintain better hygiene practices compared to male students, however, female students washed their bed linens frequently as compared to males. Mattresses of students can harbor microbes but not for a long time. Also, new bed linens can

contain varying microorganisms and will increase after usage. There was no statistically significant difference in microbial load of bed linens used by students in terms of period of usage as well as gender of the user. Conversely, there was a statistically significant differences in microbial load based on the type of fabric used for the bed linen. There was more bacteria load on 100% cotton bed linen than on cotton and polyester blend. However, the interaction of the period of usage, the gender of the user and the type of fabric have no influence on the microbial load of bed linens used by students. The microbial load found on used bed linens contained more than 10^5 CFU/ml or 2.5 cfu/cm of microbes which is deemed too high to cause health issues and this raises a concern.

Linking findings to the conceptual framework

The conceptual framework that guided the study provided an understanding of the interaction of the variables under study in assessing the microbial load of bed linens used by students. The findings of the study have confirmed that the extent of microbial load in household linens (bed linens) is likely to be dependent singly on the interaction of either of the three independent variables (gender of the user, fabric type in relation to fibre content and period of usage of the bed linen) employed in the study in aiding microbial adhesion, growth and transfer on household bed linens.

Limitations of the study

The study did not examine all types of household linens used by students. Studying a wider range of linens used by students will give a broader view for generalization of the presence of microbes on household linens.

Again, for microbial diversity only Escherichia coli (E-coli) and Klebsiella aerogenes were measured and no fungi diversities were examined.

Recommendations

Based on the findings and the conclusions of the current study, the following have been suggested.

1. New bed linens can contain microbes; therefore, they should be washed before usage.
2. Household linens such as beddings can be grounds for microbial growth, therefore, students should wash their beddings at least every week in order to help curb the spread of microbes through beddings.
3. Since cotton and polyester blend was noted to carry less microbial load because of their characteristics, students should opt for 35% cotton and 65% polyester fabric blends when purchasing bed linens.

Suggestions for Further Study

In order to further extend the literature on the assessment of microbial load on household linens used by students, the following recommendations for future studies are being made.

1. Further study can be conducted to assess the fungal species that could be found on student's bed linens.
2. Household linens does not only comprise bed linens. Other household linens such as kitchen napkins and towels used by students could also be studied to assess their microbial load and diversities.
3. Bed linens made from other types of fibre content used by students could also be examined to assess their growth and susceptibility of microorganisms.
4. Secondhand bed linens could be examined to assess their microbial load since most people prefer them to new bed linens.

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APPENDICES

APPENDIX A

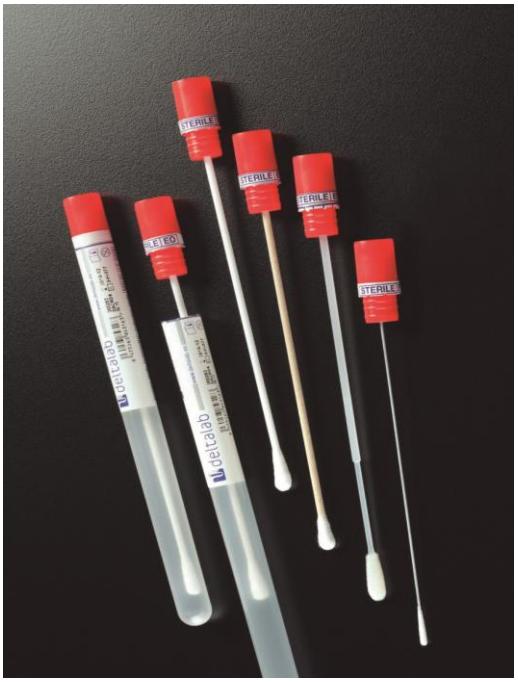
PICTURES OF SOME OF THE INSTRUMENTS USED FOR THE EXAMINATION

Incubator

Test tube

Colony counter

Petri dish



Sterilized swab sticks

Autoclave

APPENDIX B

UNIVERSITY OF CAPE COAST

DEPARTMENT OF VOCATIONAL AND TECHNICAL EDUCATION

QUESTIONNAIRE

The study seeks to assess the microbial load and diversity of bed linens (bed sheets and pillow cases) used by University students. The exercise is strictly for academic purposes and any information given shall be used for only academic purpose and will be treated with the necessary confidentiality. Your anonymity will be ensured and your honest participation in facilitating this study will be highly appreciated. Kindly tick in the space provided with the correct answer.

SECTION A

DEMOGRAPHIC CHARACTERISTICS OF RESPONDENT

1. Gender

   Male [ ] female [ ]

2. Age of Respondents

   18-25 [ ] 26-35[ ]

Programme of study

…….

3. Level

100[ ] 200[ ] 300[ ] 400[ ] 800[ ]

ITEMS		Not at all	Rarely	Moderately	Often	Very often
	PERSONAL HYGENE					
1.	I bath two times in a day (morning and evening)					
2.	I bath with sponge, soap and water in the morning					
3.	I bath with just soap and water in the morning					
4.	I bath with just water in the morning					
5.	I bath with sponge, soap and water in the evening					
6.	I bath with just soap and water in the evening					
7.	I bath with just water in the evening					
8.	I eat on my bed					
9.	I wash my hair everyday					
10.	I wash my hands frequently during the day with soap and water					
11.	I always cough or sneeze into a tissue and dispose it					
12.	I wash my hands after sneezing, coughing or using tissue with soap and water					
13.	I wash my hands with soap and water every time after visiting the washroom					
14.	I use hand sanitizer frequently					
15.	My finger and toe nails are kept short.					

SECTION B:

HYGIENIC PRACTICES OF RESPONDENTS

This section seeks to identify the hygienic practices of respondents. Tick the statement that best applies to you.

LAUNDRY HYGIENE

16. How many times do you wash your bed linens (bed sheets and pillow cases)?

Every three days [ ] every week [ ] every two weeks [ ] every month [ ]

ITEMS		Not at all	Rarely	Moderately	Often	Very often
17.	I use detergents to wash my bed sheets and pillow cases					
18.	I use bleach in washing my bed sheets and pillow cases					
19.	I boil my bed sheets and pillow cases before washing them					
20.	I rinse my bed sheets and pillow cases two to three times after washing					
21.	I air my bed sheets in the direct sunlight two to three times in the week					
22.	I use warm water to wash my bed sheets and pillow cases					
23.	I dry my bed sheets in the direct sunlight after washing					

24.	I dry my bed sheets and pillow cases under a shade after washing					
25.	I wash my bed sheets and pillow cases in the evening and dry them immediately after washing					
26.	I wash my bed sheets and pillow cases in the morning and dry them directly in the sunlight immediately after washing					
27.	I iron my bed sheets and pillow cases before placing it on my mattress					

APPENDIX C

INTRODUCTORY LETTER

UNIVERSITY OF CAPE COAST
COLLEGE OF EDUCATION STUDIES
FACULTY OF SCIENCE AND TECHNOLOGY EDUCATION
DEPARTMENT OF VOCATIONAL AND TECHNICAL EDUCATION

Direct: 03320-91097
Telegrams & Cables: University, Cape Coast

University of Cape Coast
Cape Coast

Our Ref: VTE/IAP/V.4/263

22nd March, 2022

The Chairman
Institutional Review Board
UCC

Dear Sir,

REQUEST FOR ETHICAL CLEARANCE

We have the pleasure of introducing to you **Nicholette Vashti Hammond** who is an M.Phil. Home Economics student of this Department and working on the research topic **"Microbial content of bed linens: The case of University of Cape Coast Students".**

Currently, she is at the data collection stage of her research work and we would be most grateful if you could give her the necessary assistance from your outfit to enable her progress with the collection of data.

Thank you.

Yours faithfully,

Dr. Augustina Araba Amissah
HEAD OF DEPARTMENT

APPENDIX D

ETHICAL CLEARANCE

UNIVERSITY OF CAPE COAST
INSTITUTIONAL REVIEW BOARD SECRETARIAT
TEL: 0558093143 / 0508878309
E-MAIL: irb@ucc.edu.gh
OUR REF: UCC/IRB/A/2016/1461
YOUR REF:
OMB NO: 0990-0279
IORG #: IORG0009096

2ND AUGUST, 2022

Ms. Nicholette Vashti Hammond
Department of Vocational and Technical Education
University of Cape Coast

Dear Ms. Hammond,

ETHICAL CLEARANCE – ID (UCCIRB/CES/2022/49)

The University of Cape Coast Institutional Review Board (UCCIRB) has granted Provisional Approval for the implementation of your research **Microbial Load Of Bed Linens: The Case Of University Of Cape Coast Students.** This approval is valid from 2nd August, 2022 to 3rd August, 2023. You may apply for a renewal subject to submission of all the required documents that will be prescribed by the UCCIRB.

Please note that any modification to the project must be submitted to the UCCIRB for review and approval before its implementation. You are required to submit periodic review of the protocol to the Board and a final full review to the UCCIRB on completion of the research. The UCCIRB may observe or cause to be observed procedures and records of the research during and after implementation.

You are also required to report all serious adverse events related to this study to the UCCIRB within seven days verbally and fourteen days in writing.

Always quote the protocol identification number in all future correspondence with us in relation to this protocol.

Yours faithfully,

Samuel Asiedu Owusu, PhD
UCCIRB Administrator

ADMINISTRATOR
INSTITUTIONAL REVIEW BOARD
UNIVERSITY OF CAPE COAST