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Assessment of Curricular Relevance in Pre-Nursing
and Nursing Microbiology Education

by

Randie Vanorden

A thesis

submitted in partial fulfilment

of the requirements for the degree of

Masters of Science in the Department of Medical Laboratory Science

Idaho State University

May 2020

To the Graduate Faculty:

The members of the committee appointed to examine the thesis of Randie Van Orden find it satisfactory and recommend that it be accepted.

Rachel Hulse, Major Advisor

Marjorie Montanus, Committee Member

Cynthia Blanton, Graduate Faculty Representative

Human Subject Committee Approval Page for Idaho State University

December 2, 2019

Randie Van Orden
Medical Laboratory Science
MS 8288

RE: Study Number IRB-FY2020-131: nursing alumni microbiology survey

Dear Ms. Van Orden:

This message is your official notification that your project/survey IRB-FY2020-131: nursing alumni microbiology survey does not meet the definition of research under the Code of Federal Regulations Title 45 Part 46.102(d); therefore is not subject to review by the Institutional Review Board. You are free to conduct your study as submitted.

Sincerely,

Ralph Baergen, PhD, MPH, CIP
Human Subjects Chair

Human Subjects Committee Modification Letter of Approval from Idaho State University

January 29, 2020

Randie Van Orden
Medical Laboratory Science

RE: Study Number IRB-FY2020-131: nursing alumni microbiology survey

Dear Ms. Van Orden:

I have reviewed your application for revision of the study listed above. The requested revision involves:

- Change in test subjects includes all nurses, rather than only BYU-I graduate nurses.
- Change in survey questions to encompass population change.
- Change in survey cover letter to be more personal.

You are granted permission to conduct your study as revised effective immediately. This study is not subject to renewal.

Please note that any further changes to the study must be promptly reported and approved. Contact Tom Bailey (208-828-2179; email humsbj@isu.edu) if you have any questions or require further information.

Sincerely,

Ralph Baergen, PhD, MPH, CIP
Human Subjects Chair

Human Subjects Committee Modification Letter of Approval for Idaho State University

February 12, 2020

Randie Van Orden
Medical Laboratory Science

RE: Study Number IRB-FY2020-131: nursing alumni microbiology survey

Dear Ms. Van Orden:

I have reviewed your application for revision of the study listed above. The requested revision involves:

- 1st question changed to avoid participant confusion.
- Two options added to question 4 to assist in participant selection.

You are granted permission to conduct your study as revised effective immediately. This study is not subject to renewal.

Please note that any further changes to the study must be promptly reported and approved. Contact Tom Bailey (208-828-2179; email humsbj@isu.edu if you have any questions or require further information.

Sincerely,

Ralph Baergen, PhD, MPH, CIP
Human Subjects Chair

Human Subject Committee Approval Page for Idaho State University

Date: 2-12-2020

IRB #: IRB-FY2020-131

Title: nursing alumni microbiology survey

Creation Date: 11-13-2019

End Date:

Status: **Approved**

Principal Investigator: Randie Van Orden

Review Board: Human Subjects Committee

Sponsor:

Study History

Submission Type	Initial	Review Type	Exempt	Decision	No Human Subjects Research
Submission Type	Modification	Review Type	Expedited	Decision	Approved
Submission Type	Modification	Review Type	Expedited	Decision	Approved

Key Study Contacts

Member	Randie Van Orden	Role	Principal Investigator	Contact	nelsrand@isu.edu
Member	Randie Van Orden	Role	Primary Contact	Contact	nelsrand@isu.edu
Member	Rachel Hulse	Role	Investigator	Contact	hulsrach@isu.edu

Human Subject Committee Approval Page for Brigham Young University- Idaho



Faculty Development & Mentored Research

December 4, 2019

Dear Randie,

Your study entitled, "Microbiology and Nursing Alumni Study", IRB #: F19-011, has been received, reviewed as an expedited review project (category 7) and approved. It has met the expectations of IRB protocols and is approved for one year from the date of this letter. We request that you update us on any changes to the project for our records. Should a change in your research approach or methodology change, please contact our office for assistance or re-evaluation. Please feel free to proceed with your project.

Best Regards,

A handwritten signature in black ink that reads "Sidney L. Palmer".

Sidney L. Palmer,
IRB Director

Acknowledgements

I would like to thank those who have assisted me the last few years as I have worked my way through this degree in Medical Laboratory Science. There are so many people who helped to make this study a possibility. A big thank you to my family and their support, particularly my mom, husband, and others who put in countless of hours of babysitting for me so that I could find the time to complete this program. Thank you to the professors in this program who have supported me and offered their assistance. Rachel Hulse for your invested time, guidance, and feedback. I would not be completing this master's program if it were not for you. Marj Montanus, you have been supportive, encouraging, and someone I always felt comfortable going to when I needed to reach out. None of this would have be possible without this support. A huge thank you to Peter Denner, who helped me analyze my data and helped me understand the various statistical tests. He was so patient and supportive as I asked my endless amount of questions. Without his support and assistance, I would not have been able to determine the statistical significance results in my data.

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Assessment of Curricular Relevance in Pre-Nursing and Nursing Microbiology Education

Thesis Abstract- Idaho State University (2020)

The purpose of this study was to evaluate curricular relevance of existing pre-nursing microbiology education curricula as it related to working nursing professionals, with the intent of revising the Brigham Young University-Idaho pre-nursing microbiology coursework to be more clinically relevant for pre-professional nursing students. University graduate nursing professionals participated in a survey asking about various microbiology topics. Topics were rated on workforce relevance. Study results showed the three most relevant microbiology topics included: (a) healthcare-associated infections and disease transmission; (b) infection control and epidemiology; and (c) vaccinations. The three least relevant microbiology topics included: (a) gram stains; (b) dilutions and serial dilutions; and (c) microscope operations. This survey provided valuable information to help shape course design and collegiate curriculum objectives in relation to professional nursing relevance. In depth presentation and hands-on application of these topics can be used to help students visualize the impact of microbiology as a nurse and both patient care and personal safety.

Key Words: Nurse, nursing, education, curriculum, microbiology.

Assessment of Curricular Relevance in Pre-Nursing and Nursing Microbiology Education

Chapter I: Introduction

There are many issues currently presenting in the healthcare industry. Some of these issues include, but are not limited to; healthcare acquired infections, multi-drug resistant bacteria, incorrect patient sampling techniques, billions of preventable expenses, lack of disease containment, and the lack of compliance of preventative measures (Centers for Disease Control and Prevention [CDC], 2018; Cox and Simpson, 2018; La Fauci et al., 2019; Stone, 2009; Mamhidir et al., 2011). According to the CDC (2018), on an average day, one in 31 hospital patients will acquire one or more healthcare-acquired infections (CDC, 2018). Each year, according to Stone (2009), 2 million healthcare-associated infections are acquired by patients, resulting in nearly 90,000 patient deaths. This makes healthcare-acquired infections the fifth leading cause of death in the United States, and costs hospitals 45 billion dollars in preventable expense (Stone, 2009). So where do these problems stem from? What measures can be implemented to repeal the trend?

Previous research (Buffer et al., 2012; Kelcikova et al., 2012; La Fauci et al., 2019; Mamhidir et al., 2011; Riley, 2019;) has shown that healthcare workers do not possess adequate comprehension of microbiology principles, which may be contributing to the spread of healthcare-associated infections, and the infection of drug and multi-drug resistant bacteria. Consequently, this lack of critical knowledge, contributes to morbidity and mortality among patients, as well as prolonging pathogen exposure to healthcare workers. More specific research has been done regarding nurses (Buffer et al., 2012; Cox and Simpson, 2018; Durrant et al., 2017; Mamhidir et al., 2011; Wilson, 2019) and the level of microbiology knowledge and education obtained. This research shows that nurses are deficient in microbiology principles

which may limit them in providing a higher standard of healthcare to patients, as well as education to patients and their families relating to microbiology topics. These issues could potentially be addressed if revised pre-nursing microbiology education was required of nurses to better meet clinical standards before graduation with a nursing degree.

Norman-McKay and the Committee for Microbiology in Nursing and Allied Health (2018) emphasize how important microbiology laboratories are for nurses to gain hands-on experience and skills before graduation. Norman-McKay et al. (2018) also explain that unfortunately, many nursing programs in the United States do not require hands-on microbiology education and in fact, some colleges are eliminating microbiology requirements entirely from their nursing degree requirements to make room for other classes and credits.

At Brigham Young University- Idaho (BYU-I) (2019), nursing students are required to take only one prerequisite microbiology course with its accompanying laboratory course before entry into the official nursing program. To better educate nurses who are attempting to go through the nursing program at BYU-I, a re-evaluation of the course needs to be investigated. The purpose of this study is to evaluate curricular relevance of existing pre-nursing microbiology education curricula as it relates to working nursing professionals, with the intent of revising the BYU-I pre-nursing microbiology coursework to be more clinically relevant for pre-professional nursing students.

This study aims to survey nurses about their microbiology education and to gather information as it pertains to the nursing field. Surveying nurses will allow for data that may be used to revise and create a more effective undergraduate microbiology laboratory course in relation to the nursing profession. Survey questions about demographics and various topics include but are not limited to, disease transmission, hand hygiene, gram stain procedures,

microbe identification processes, microbial susceptibility testing, and food microbiology. Nurses were asked which topics were the most relevant and the least relevant pertaining to their field, and what topics would be the most beneficial to emphasize in nursing and pre-nursing undergraduate coursework.

This research is important because of the determined need for nurses to have a better understanding of microbiology. Redesigning the curriculum in the required microbiology laboratory course for nursing students at BYU-I will help to fulfil that need. This research will help shape the course design and curriculum objectives in relation to professional relevance in hopes to help combat some of the previously mentioned issues seen in the healthcare field, such as the spread of drug-resistant bacteria and healthcare-associated infections.

By conducting this survey, specific topic areas of improvement can be identified, and topics with little to no relevance to the nursing field can be decreased in emphasis or eliminated from the course. The survey will also help identify any possible gaps that may be present in the curriculum to help students gain a better foundational knowledge in microbiology principles.

The remainder of this paper illuminates a review of the literature relevant to the importance of microbiology and microbiology education to nurses and other healthcare workers. Methods on survey distribution will also be covered as well as a discussion of the findings for their application and future use.

Chapter II- Review of Literature

The purpose of this literature review is to evaluate the history and assess previous studies relevant to microbiology and nursing education to provide background information pertaining to this topic of this study. This study aimed to survey nurses about their microbiology education and to gather information as it pertains to the nursing field. As nurses contribute to the health care workforce in patient care, part of their responsibility is to understand the conditions in which microbes live, and the ability that microbes possess to either be transmitted and contracted, or to be regulated to prevent infection. This thorough understanding ensures that nurses will be able to correctly perform and respond in practice requirements for their profession. These practices include collecting and preparing sample specimens, educating patients and their families, administering antibiotics, and being able to effectively communicate with other healthcare professionals. This literature review will evaluate the importance of microbiology education relevant to the nursing profession, as well as studies that have been performed on nursing professionals and graduates. This will help to determine the value and depth of education that nursing professionals have received in microbiology, disease transmission, infection control, antimicrobial stewardship, infectious pathogens, and other similarly related topics pertaining to microbiology.

The History and Significance of Microbiology

Historically, microbiology has played a major role in healthcare. Before the concept of microbes, people failed to understand how diseases occurred, and did not have the ability to prevent the spread. This caused detrimental consequences, as seen with the Black Death epidemic. The Black Death, spread by flea-carrying rats in 1347-1350, killed one third of the population in England and resulted in approximately 25 million total mortalities. In France, because microbes and disease were not properly understood, Jews were blamed for the spread of

the disease and were pulled from their homes and burned in attempts to control the spread (Ratnikas, n.d.).

For hundreds of years, there remained a general misunderstanding of disease and microbes. It wasn't until the mid-1800's when select people began to realize that microbes may be the cause of certain disease and began to investigate further. Doctor's and their assistants did not understand the importance of a sterile environment, or even washing their hands in between patients. Hand washing practices weren't even considered until the 1840's, when Ignaz Semmelweis, a Hungarian physician, realized that women delivering babies in the maternity ward utilizing doctors had higher mortality rates from childbed fever, better known as puerperal sepsis, than women delivering babies utilizing midwives. After realizing that doctors would often deliver babies after previously performing autopsies, he postulated that contagious particles, what we now know as microorganisms, were being transferred from the corpses to the women via the doctors' hands. Midwives, however, did not perform autopsies and therefore were not transferring these microorganisms to the women during childbirth. He began mandating that all doctors wash their hands with a chlorine mixture before assisting in childbirth in the maternity ward. Results showed a dramatic decline in the mortality rates in women delivering babies in his maternity ward. Unfortunately, his idea of these particles being spread to different patients was not well received since it implied that doctors were responsible for the deaths in the maternity ward. He had little success in persuading any of the European hospitals of handwashing benefits for patients and was ultimately rejected by the medical community (Nuland, 2004).

Throughout the later 1800s, more people began to search for the understanding of disease transmission and the discoveries began to develop at a rapid pace. John Snow documented the spread of cholera in London through water transmission. Louis Pasteur confirmed the germ

theory and formulated vaccines for rabies and other diseases. Robert Koch was able to isolate the bacteria responsible for cholera, and Joseph Lister formulated processes for aseptic and sterile techniques (Ratnikas, n.d.).

The cause of many diseases, such as tuberculosis, typhoid fever, the bubonic plague, and tetanus were also not attributed to microorganisms until the late 1800s, roughly 40 years after Semmelweis had died. Around this same time, modes of transmission were being discovered, such as the transmission of Yellow Fever through mosquitos (“The Early History”, 2018).

In the 1900s, the study of microorganisms continued (Buchholz et al., 2013). In 1940, antimicrobial susceptibility had been studied enough that clinical trials for penicillin were launched for the use of antimicrobial therapy. This early antibiotic use paved the way for the healthcare system to be able to assist in fighting off and controlling disease. At this time, research was continued for other antibiotics such as actinomycin and streptomycin that would later assist in combating infections alongside penicillin.

Even though clinical research in microorganisms has been extensive, application of the processes used to prevent the spread and transmission of disease has been slow. According to The Global Handwashing Partnership (2017), hand washing was not even implemented as a main prevention for the spread of disease until the 1980’s, after the concern of healthcare-associated infections began.

The Problem in Healthcare Workers and Nurses

Implementation of these processes, such as hand washing, how far the healthcare field has come in understanding microbiology, and the acceptance of the presence of microbes, has been beneficial. However, the abilities of microbes continue to be underestimated and various problems remain. Presently, infections and the spread of microorganisms continue to be

devastating in part due to the lack of understanding by healthcare professionals. Stone (2009) declared that there are 2 million healthcare-acquired infections each year, with associated deaths reaching nearly 90,000. The two main causes have been pneumonia and septic blood stream infections with 35,967 and 30,665 deaths, respectively. With healthcare-associated infection being the fifth leading cause of death in the United States, these infections cost hospitals up to 45 billion dollars in preventable expense. The CDC (2018) stated that 1 in every 31 hospital patients have one or more healthcare-associated infections on any given day.

Consequentially, in attempts to combat infections and disease, healthcare providers have turned to the reliance of antibiotics. Lack of education brings a false sense of safety in the use of antibiotics in the healthcare field. Consequences are rising in recent years due to the significant amount of over-use and inappropriate use of antimicrobial therapy. Stone (2009) stated that in healthcare-associated infections, over 70% of the offending bacteria are resistant to one or more antimicrobial drugs. Additionally, according to the CDC (2020), 2.5 million people every year acquire antibiotic-resistant microbe infections resulting in over 35,000 deaths a year. This threat poses one of the largest public health threats of our time and it has been commonly caused by antimicrobial therapy misuse in the health field.

These statistics are alarming since patient welfare is dependent on the healthcare workers' understanding of microbes and the antimicrobials that they are resistant to. However, studies show (Buffer et al., 2012; Mamhidir et al., 2011) that healthcare personnel are deficient in knowledge about antimicrobial therapy and drug-resistant bacteria, and this lack of understanding contributes to therapy misuse. Mamhidir et al. (2011) found that primary healthcare personnel in Sweden lacked knowledge both in multidrug resistant bacteria, and in the preventative hygiene measures needed to prevent the spread of these resistant bacteria.

Physicians, nurses, and nursing assistants were included in the study, and their knowledge concerning multidrug resistant bacteria, preventative hygiene measures, and at-risk patients were evaluated. The researchers found that deficiencies in comprehension were severe in several aspects regarding multidrug resistant bacteria, especially in bacteria producing Extended-Spectrum-Beta-Lactamase (EBL), which is an enzyme produced by bacteria that hydrolyzes extended spectrum in beta-lactam antibiotics. It was determined that the deficiencies in preventative hygiene measures had no significant differences between the groups. However, in knowledge of multidrug-resistant bacteria physicians overall scored higher than nurses and assistant nurses. The researchers concluded that based on the results of the study, implementing education for responsibilities and attitudes related to multidrug-resistant bacteria and the at-risk patients should become a priority (Mamhidir et al., 2011).

Sweden is not the only place demonstrating an increase in antibiotic-resistant microbes. This worldwide issue is even present in the United States. Riley (2019) explains that inappropriate use and overuse of antimicrobial drugs have led to microorganisms becoming increasingly resistant, and this raises a concern for patients in the intensive care unit (ICU). Statistics show that 19% of critical care patients will acquire a multidrug-resistant infection if their stay in the ICU is greater than 24 hours. This makes it essential that critical care nurses implement preventative measures towards these susceptible patients, especially when multidrug resistance can leave no options for patient drug treatment. Riley (2019) offers different factors that contribute to the risk in the ICU: host factors and patient vulnerability; hospital environmental factors include inadequate room and surface disinfection procedures, especially in areas of high drug resistant organism frequencies; human factors such as inadequate hand hygiene, undereducated staff, improper training, and low compliance of infection control

procedures; and patient skin integrity factors, such as the use of invasive devices like catheters and tubes, can also contribute to the rise in drug-resistant organisms. Precautions by healthcare workers can be taken within all these areas to lower the risk. These precautions include good hand hygiene, antimicrobial stewardship, the use of personal protective equipment, education, and proper disinfection and sterilization of the patient's environment. Riley (2019) concludes with a warning that the use of antibiotics will be of little benefit in the future against microbes if action is not taken to educate personnel and use antimicrobials appropriately.

Because of the growing rates of drug-resistance bacteria and the expanding threat that they pose, a study was performed by La Fauci et al. (2019) to look for the presence of antibiotic-resistant bacteria on the hands of healthcare workers and in the in-patient areas of hospitals. The results of the study showed many different strains of drug-resistant bacteria on the hands of healthcare workers, on the surface areas of patient locations, and in the air of the environments tested. These results were consistent with the increasing rate of drug-resistant pathogens and are alarming because the once-effective antimicrobial therapy is now becoming more limited. La Fauci et al. (2019) concluded that preventative measures in infection control strategies should be implemented to include better training and education for healthcare workers, better sanitization practices for hospital environments, correct use and over-use prevention of antimicrobials, and increased hand hygiene among healthcare workers.

Handwashing is a simple and effective way to limit the transmission and exposure of microbes, however, many healthcare workers are not participating in hand washing as advised by disease control institutions. Kelcíkova et al. (2012) discussed in their study that even though hand hygiene is among the simplest and cheapest ways to prevent the spread of disease and healthcare acquired infections, there has been a lack of compliance among health care

professionals. The researchers believed that the lack of compliance is derived from a lack of awareness and comprehension of microbiology in scholastic education. For the study, the researchers evaluated hand hygiene in basic nursing education and the hand hygiene attitudes and skills practiced among nursing students in praxis (Kelcíková et al., 2012). It was found that in the basic nursing programs, there was a significant deficit in the quality of information related to hand hygiene and its consequences. This showed that students were obtaining an insufficient amount of knowledge regarding hand hygiene in the program, which resulted in poor compliance when students reached their clinical training. This study showed that hand hygiene education needs to be improved by educational institutions so that nurses will maintain compliance and develop an understanding of their role in the prevention of healthcare-acquired infections and the spread of disease.

When it comes to the varying capabilities of different bacterial species, the implications of multi-drug resistant microbes and effective hand washing are not the only areas of deficient comprehension among nurses and other healthcare workers. A clear knowledge of specific infectious pathogens, precautions, and disease prevention is lacking. This lack is demonstrated in the study performed by Buffer et al. (2012). Researchers conducted a nationwide research survey that targeted health professionals on their knowledge, understanding, and awareness of *Listeria monocytogenes*, a neonate pathogen and potentially fatal pathogen when contracted in immunocompromised patients. The survey specifically targeted health professionals who worked with immunocompromised patients. These individuals were in the position to not only understand necessary precautions for the patient's safety, but to also potentially educate patients on disease prevention. The study data showed gaps in educational knowledge in the comprehension of *Listeria monocytogenes*, including self-admittance to an understanding deficit

by the health professionals, especially in registered nurses. Buffer et al. (2012) concluded that education and training are needed for health professionals for an adequate understanding of various harmful human pathogens, including food-borne pathogens. For those healthcare professionals working with susceptible patient populations, it is especially important for them to take the appropriate preventative measures for their patients, as well as have the knowledge to treat them appropriately.

Potential Limitations with Nursing Education

Nurses are a category of healthcare professionals who are on the front lines of patient care and have the responsibility to ensure patient safety. Nurses should retain sufficient understanding and education to be able to provide a high level of quality and lifesaving functions for the benefit of the patient and the patients families. Unfortunately, research has shown the microbiology education that nurses possess is lacking in many general and specific areas for complete and effective understanding, retention, and clinical application (Buffer et al., 2012; Cox and Simpson, 2018; Durrant et al., 2017; Mamhidir et al., 2011; Wilson, 2019). A lack in microbiology understanding allows healthcare professionals to contribute to medical error and healthcare-acquired disease and infection.

In a study performed by Cox and Simpson (2018), the researchers delivered information on how significant and costly healthcare associated infections have become, and how acquiring these infections increases a patient's risk of death by a factor of three. This study provided evidence that indicates infection control education, knowledge, and practices for health professional graduates is less than optimal. Nurses often make incorrect infection control decisions based on patient factors and risk assessment that are often not fully understood or incorrect rather than making decisions based on an understanding of microbiology and its

principles of disease pathogenicity and transmission methods. The study explained the critical role that microbiology education plays in the understanding of infection control and its practices. The study argued that without correct microbiology application regarding decision making in infection control, there is an increased risk of incorrect infection control practices, which in turn increases the risk for both patients and nurses. With nurses receiving such limited education in microbiology, Cox and Simpson (2018) expressed the need for a reorganization in nurse education so that nurse professionals will gain an increased competency and a stronger understanding. This is especially important to enable nurses to make appropriate decisions surrounding various infectious organism types, transmission modes, and infection control.

Nurses often lack education in the types of microorganisms that are infectious. An example of pathogenicity and lack of microbiology knowledge is shown in a study performed by Mahdi and Ahmed (2018), where a general lack of knowledge in infectious organisms was demonstrated. The researchers evaluated the effectiveness of a nurse educational program at a Baghdad teaching hospital, where the program was examined to determine the nurse's knowledge regarding infection prevention in orthopedic wounds. The study findings concluded that orthopedic nurses lack adequate knowledge in some respects relating to the prevention of orthopedic wound infections. Interestingly, no correlation was found between educational knowledge and years of experience as a nurse, but instead, there was a correlation between nurse's knowledge and the level of education obtained. This showed the need for a better microbiology education in the pathogenicity of microbes for nurses to help prevent infections.

It has also been shown that nurses lack understanding in antimicrobial stewardship. In addition to the studies evaluated above on drug resistance, another study performed by Wilson (2019) explained that the widespread misuse of antibacterial products has led to the development

of drug or antibiotic resistance in bacteria, including multidrug-resistant bacterial species. These drug-resistant and multidrug-resistant bacteria are a cause for concern and can multiply, spread, and are transmitted via healthcare workers to individuals not previously infected. This study explained that because nurses have a variety of roles, and in some cases have the ability to prescribe antibiotic prescriptions, it is vital that they possess an understanding of microbiology, infection control, and antimicrobial stewardship. However, the lack of nursing education in these areas is an issue. In a study by Castro-Sanchez et al. (2016), they determined that only 36% of undergraduate programs in health care adequately addressed antimicrobial stewardship.

Many questions arise surrounding the extent of these knowledge deficiencies. Various studies have been performed to try and determine where the knowledge deficiencies stem from. Some ideas include the perception that nurses have difficulties applying the theory taught in their institutions, the perception that microbiology isn't important in their field, a lack of understanding or remembrance of the principles taught, that the course curriculum needs to be redesigned, or a mixture of various ideas. But the majority of studies have shown that nurses lack a fundamental understanding of microbiology and a compliance to its principles.

While the aforementioned problems seem to stem from a lack of understanding due to curriculum design alone, it may not be the only factor. A lack of desire to retain basic microbiology knowledge may also be caused by nurses who don't understand the role that they play in the prevention of disease, and how fundamental microbiology understanding is so applicable to the field. A change in the perception of the importance of microbiology concepts and to acknowledge its clinical applications may be the possible bridge to help students retain the information. Allowing students to see the importance of their individual role may provide incentive to obtain a better understanding of microbiology. A study by Cox et al., (2015)

explained that despite the increasing rates of healthcare-associated infections worldwide, we continue to see a lack of knowledge and a poor implementation of precautions towards infection prevention and control. To gain better insight to this pressing issue, the researchers studied the alumni of an undergraduate nursing program on their perceptions of science, health behavior beliefs, and applied knowledge of microbiology. The researchers concluded that microbiology and infection control education should provide nursing students the ability to perceive potential risks, maximize self-efficacy, and help students see the application of microbiology as it applies to their role nursing profession. The researchers believe that this, in turn, would enhance the development of graduates who are competent, ready for work, and who are more aware of the real-life implications of hospital acquired infections and improve their own efforts in infection prevention and control in the nursing field.

The lack of development shows that based on the lack of education, the perception that nurses have of microbiology is inaccurate and, unknown to the nurses, leading to potentially dangerous behavior for their own safety and the safety of the patient. In a study performed by Cox et al. (2014), nursing education of microbiology was evaluated and researchers explored the perceptions in infection control professionals. The researchers were interested in the importance of infection control and microbiology education in undergraduate nursing students' education, and the retention of that education for the application in clinical practice. The four main issues that came to light were the understanding of educational theory versus practice, the importance of role modeling, the disjunction between the university curriculum and the real-world application, and learning in context. This study, too, concluded that the nursing education in microbiology needs to be reviewed and redesigned for better retention and clinical application. With such a lack of understanding, there is an urgent need for a better education of

undergraduate microbiology principles, as well as for nurses to understand the importance of microbiology. This may assist in the nurse's ability to transition the appropriate application of that knowledge to healthcare institutions. This conclusion brings up the question of whether a change in perception about microbiology and the roles that they play, would allow nurses to retain microbiology information better and change their behavior.

Trying to Find Solutions

Some studies have tried to provide answers to educational problems by providing workforce training in microbiology for their healthcare professionals. A study performed by Yoon et al. (2016) showed that by implementing an educational session about microbiology, specifically about bacteria and the effects of bacteria in the environment and health care setting, there was a significant decrease in the amount of contaminated cultures collected by the health care workers collected for culture workup. This showed that education is a key factor in helping nurses take responsibility for disease control and prevention. However, it is unrealistic to believe that all healthcare institutions will make up for a lack in microbiology education in their employees. To fully address the issue, changes need to be made before nurses enter their professional fields, thus, reducing the potential risk and ensuring the release of competent professionals. Other studies have been conducted to find and address gaps in educational learning, such as a study performed by Yano et al. (2019). This study introduced real-life application during which nursing students were provided with microbiology education using short, simple practical sessions. After the sessions, the students hand bacteria were cultured. Upon conclusion of the practical, results of this study showed the students gained an increased awareness of bacteria, the contamination of body surfaces, the types of hospital infections, and the physical symptoms caused by bacterial infections. This study is unique because it showed the

increased benefit, even with short term teaching schedules, and that with only a few hours of real-life application, students showed an increase in competency. Though this study is not all-inclusive in microbiology topics, it provides a steppingstone for students to understand infectious disease control and prevention, bacterial dissemination, and antimicrobial stewardship.

A more inclusive study was performed by Durrant et al. (2017). Researchers from the University of Utah believed that the problem with the nurses' lack of knowledge stemmed from microbiology courses failing to cover the topics that are most relevant to nurses and their professional practice. A survey was sent to registered nurses asking about the relevance of certain microbiology topics as they pertained to their profession, in addition to questions on infectious diseases and any nursing duties requiring an understanding in microbiology. Data showed that infection control, healthcare acquired infections, disease transmission, and patient specimen collection and handling were the most relevant topics in nursing practice. The topics that were determined to be the least relevant to the nursing practice were the grams stain procedure and the use of the microscope. Researchers also recognized a potential gap in understanding pertaining to molecular testing methods and the use of these tests in diagnostic procedure. The researchers believed that the nurses would be more engaged in microbiology topics if they understood the importance of these topics as they pertain to their nursing careers and the impact on both patient care and personal and safety. Findings from this study were used to modify the current microbiology course at the University of Utah in an effort to better prepare nursing students for their professional careers. It was also hoped that these findings could contribute to the evolution of national recommendations for nursing microbiology curricula.

Microbiology Curriculum

Cox and Simpson (2018) proposed that infection control competencies would enhance nurses' understanding of microbiology so that sound knowledge and application could take place in healthcare institutions. Although microbiology courses are offered in the workplace and do provide an increase of knowledge, it is felt that a better understanding should be acquired before nurses enter the workforce.

Norman-McKay and the Committee for Microbiology in Nursing and Allied Health (2018) expressed in their article how important microbiology lecture and laboratory courses are for a nursing degree. However, They continue to explain that unfortunately some of the nursing programs in the United States are actually taking microbiology courses out of the required nursing curriculum due to factors such as aligning the curriculum to the learning outcomes, credit hour caps, and course sequencing and associated pre-requisites. Though the extent of the issue is unknown, as of yet, no baccalaureate level nursing programs have reported cutting microbiology courses. This still raises concern since, according to the U.S. Department of Labor and Statistics, there are roughly 3 million registered nurses in the United States, making nurses the largest group in the health professional workforce. Norman-McKay et al. (2018) stated that limiting microbiology education puts a greater risk on the patient for medical errors concerning infection and disease. An essential aspect of a healthcare professionals' training should include microbiology, to help limit the potential spread and transmission of infectious disease and to manage the increasing number of drug-resistant bacteria. The researchers stated how important it is that health care professionals should have an essential educational microbiology class that provides topics such as aseptic technique, infectious disease pathophysiology, epidemiology,

infection control, and antimicrobial drug stewardship. Topics such as these should provide a solid introduction to result in a firm understanding and an appreciation of concepts.

In the same article, the authors presented new guidelines developed by the American Society for Microbiology in response to microbiology courses being eliminated in some nursing programs. The guidelines, entitled *Microbiology in Nursing and Allied Health (MINAH) Undergraduate Curriculum Guidelines*, covered topics for lecture and laboratory courses. Topics included the impact of microorganisms in health and disease, microbial pathogenicity, identifying and managing infectious disease, healthcare associated infections and epidemiology, and controlling microbial growth to limit disease. The guidelines included select laboratory skills in scientific processes and critical thinking skills needed for the nursing practice.

In December of 2019, a comprehensive laboratory curriculum trial course was created for nurses based on the competencies and skills of these guidelines. McCall et al. (2019) formulated the lab to incorporate each recommended section and included suggestions for keeping laboratory costs low. The course was divided up into seven experiments that consisted of the following:

1. The use of microscopy in bacterial and non-bacterial pathogens with the introduction of gram stains.
2. Understanding and practicing aseptic technique which includes plating bacteria on various media and the discussion of pathogen environments and metabolic properties.
3. Vaccines and gaining knowledge on infectious diseases, outbreaks, reemergence, and gaining comprehension on how diseases spread.
4. Functions of antimicrobials, limiting drugs, and fighting resistance.
5. Enumeration of microorganisms.

6. Specimen collection, biochemical testing, molecular testing and unknown identification processes.
7. Enzyme linked immunosorbent assay (ELISA) and how these methods are used to identify pathogens.

This seven-lab curriculum layout provided microbiology course options for colleges with limited time and budgets. Using bacterial cultures for multiple labs, same-type media, and prepared slides that can be used in later semester, would allow universities to offer nursing students an opportunity to gain essential microbiology knowledge at a limited cost to them. Though it may be easy to remove microbiology classes, McCall et al. (2019) stated the following about microbiology courses:

The laboratory also allows for nursing and allied health students to see how (a) specimen sampling is properly collected, (b) diagnostic tests are performed, and (c) how susceptibility to antimicrobial agents is determined. With this knowledge, healthcare workers can better protect themselves and their patients from the spread of disease and the increasing concern of antibiotic resistance. It also allows them to explain to patients what they are doing and understand what test results mean and how proper diagnoses can be determined from those results. The nurse or physician assistant may be the sole knowledgeable person the patient or their family has any meaningful contact with. (p. 1)

With the appropriate curriculum, nurses should be able to apply these skills in the hospital and patient setting to not only benefits patient care, but to enhance their own personal safety. The study previously evaluated in this literature review by Durrant et al. (2017) showed another hopeful example of altering and customizing micro classes for nursing students to better prepare them before entering the healthcare workplace. After surveying nurses about what they

considered most valuable in their working careers, and comparing that data to the microbiology curriculum currently being taught, the researchers were able to alter the required microbiology course and attempt to make it more applicable to nurses in preparation for the workplace.

Nursing Education in the State of Idaho

Typically, there are a variety of courses needed for a nursing student to graduate with a nursing degree, but, schools of higher education have yet to implement the necessary microbiology classes required for graduation. This may be because the importance of a solid microbiology background has not yet been fully embraced. In Idaho, a number of colleges and universities offer bachelor degrees in nursing: Boise State University, Brigham Young University- Idaho, Idaho State University, Lewis-Clark State College, and Northwest Nazarene University. Most of these schools and other community colleges, such as the College of Southern Idaho and the North Idaho College, also offer Associate degree options, as well as licensed practical nursing (LPN) options.

Boise State University (2020) requires one introductory microbiology lecture course before entry into the bachelor nursing program. At Brigham Young University- Idaho (2020), Northwest Nazarene University (2019), and Idaho State University (2019), one introductory microbiology lecture class with an accompanying laboratory class is required as a pre-requisite to the nursing programs. As an introductory class, these classes cover essential microbiology principles, functions, and economic importance, but none of these classes are clinically-based and after entrance into the nursing programs, no other microbiology class is required for program completion (Boise State University, 2020; Brigham Young University- Idaho, 2020; Northwest Nazarene University, 2019; Idaho State University, 2019). Though microbiology topics may be referenced in other classes, such as the introduction to pathobiology course that is required at

Idaho State University (2019), full and complete microbiology principles and objectives are not attained on a clinical level without a complete clinical microbiology class.

Lewis-Clark State College (2019) requires one microbiology for health sciences course with accompanying lab as part of its prerequisite course requirements. This course requires four hours of lecture each week with three hours of laboratory time that emphasizes infectious disease and food contamination. Microorganism function, growth, and control is also addressed as well as antimicrobial stewardship and sterilization processes (Lewis-Clark State College, 2019). Similarly, the North Idaho College (2019b) program requires a general microbiology class as part of its Registered Nurse program requirements. However, this class is more general and includes aspects of food and environmental sciences in addition to applications in the medical field.

The College of Southern Idaho offers both a practical nursing degree (LPN) (College of Southern Idaho, 2019a) and a registered nursing degree (College of Southern Idaho, 2019b). Neither of these degree programs require a microbiology course as part of the program. North Idaho College (2019a) also lacks a prerequisite or required microbiology course for its LPN program.

While most of these programs do require a prerequisite for entry into the nursing program, these programs also lack a clinically based microbiology course that is specific and custom to what nurses need to know to be prepared to enter the healthcare field.

Brigham Young University- Idaho microbiology course

Nursing students at Brigham Young University- Idaho (2020) are required to take one general microbiology lecture with accompanying laboratory class before entrance into the

nursing program. The associated laboratory class is generally based on a 13-week schedule but has some variability for semester length.

The first week is an introduction to the operations and functions of the microscope using a prepared slide mixed with bacteria, yeast, and blood. Practice is gained by viewing pre-prepared algae slides.

The second week introduces non-bacterial microorganisms in the Kingdoms Protista and Fungi. Students review pre-made slides under the microscope. The third week continues with the introduction and observance of bacterial microorganisms. During the third week, students learn about aseptic technique and are introduced to bacterial culturing techniques where they get practice in making both traditional streak plates and radiant streak plates. These cultures are the beginning of the bacterial identification process that will continue through the next few labs. Three different types of bacterial cultures are given, a gram-negative rod strain, a *Bacillus* strain, and a gram-positive cocci strain.

Week Four introduces the gram stain procedure where students perform gram stains on the bacterial strains cultured the week before. Students learn the significance of the gram stain and the application in a clinical setting. Week Five allows students to plate their cultures on various biochemical mediums such as MacConkey's agar and mannitol salt agar and the importance of biochemical testing is discussed. Any unfinished gram stains from the previous week are completed. Week Six allows students to collect the results of the biochemical tests, and using their gram stain results, determine their unknown cultures for the completion of the identification process.

The midterm is planned for Week Seven and includes microscopic identification of all of the organisms from Weeks Two and Three, along with questions covering the specifics of the

microorganisms. Week Eight introduces dilutions and serial dilutions. *Escherichia coli* is given in ten milliliter test tubes. Students dilute the sample out to $1/10^8$ and prepare six plates with either 0.1 or 1 milliliter of the dilution. These plates are counted the following week, Week 9, after growth is obtained. In addition to Week 9, students bring in a milk sample which they dilute in a similar fashion utilizing a coliform identification plate. During Week Ten, students can determine the cleanliness of their milk sample by the bacterial and coliform growth. The differences between coliform contamination and udder normal flora is addressed.

The eleventh lab introduces bacterial susceptibility through various techniques. Three species of bacteria are used, a gram-negative rod, an endospore former, and a gram-positive cocci strain. Students test different amounts of time using ultraviolet light, test different disinfectants and antiseptics, and test different antibiotics against the bacterial strains. Following this lab, the remainder of the lab days will address disease transmission, handwashing, food microbiology, and a final.

This laboratory course is a good introductory course for general microbiology topics and principles, but it is not all-inclusive, and is not clinically based. The pre-made slides that are introduced in the first few class periods contain various types of organisms, but few are clinically significant pathogens. Many of these organisms that students are required to study have no significance in the healthcare world and could be replaced by more substantial organisms which are more applicable to the healthcare setting. More emphasis on the differences between bacterial and non-bacterial organisms could be introduced so that students are aware of how bacteria, fungi, viruses, and parasites differ in function and patient treatment.

A large portion of the class is spent developing microscopy skills which, according to findings in Durrant et al. (2017), are irrelevant skills to nursing practice. Instead, more emphasis

should be placed on disease transmission, hand washing, and microbial susceptibility. The food microbiology portion of the lab may also be improved by focusing on food pathogens rather than food production. Results of a study performed by Castro-Sanchez et al. (2016) determined that only 36% of undergraduate programs in healthcare adequately addressed antimicrobial stewardship. Coverage of antimicrobial stewardship in this microbiology course is then warranted.

Though this course has many topics that meet the *Microbiology in Nursing and Allied Health (MINAH) Undergraduate Curriculum Guidelines*, further improvements can be made. Research is required to ascertain the most relevant topics for nursing practice, the depths to which these topics should be covered, and the identification of additional learning gaps.

The purpose of this study is to evaluate curricular relevance of existing pre-nursing microbiology education curricula as it relates to working nursing professionals, with the intent of revising the BYU-I pre-nursing microbiology coursework to be more clinically relevant for pre-professional nursing students. Based on a survey of practicing nurse perceptions, this study will determine the relevant and irrelevant curriculum topics within the pre-nursing General Microbiology laboratory course Bio 222 at Brigham Young University- Idaho. This study will address three things: the gaps in other studies by determining specific importance of various microbiology topics; how nurses feel about the importance of antimicrobial stewardship; and the most and least beneficial aspects of their required microbiology course as it relates to the nursing profession.

Data from this study can help improve the required Bio 222 course by addressing the insufficiencies in microbiology education and the lack of retention among nursing graduates.

These course improvements will be a valuable tool in microbiology education for graduating nursing students.

With a strong foundational knowledge base and an increase in the understanding of the principles of microbiology, nurses would be expected to meet professional requirements more effectively to help prevent the spread of disease. Effective microbiology courses need to be established that will help nurses understand their roles, retain the information, and allow them to apply these principles. Therefore, we believe the improvement of undergraduate coursework will contribute to the increase in understanding of microbiology for graduating nurses. With a better understanding of microbiology, and the importance of personal application, a better retention of knowledge in the workplace may result.

Chapter III: Methodology

Research Purpose and Design

The purpose of this study is to evaluate curricular relevance of existing pre-nursing microbiology education curricula as it relates to working nursing professionals, with the intent of revising the BYU-I pre-nursing microbiology coursework to be more clinically relevant for pre-professional nursing students. Participant nurses who are now graduated from a university and are practicing in their professional nursing careers, were surveyed about various microbiology topics where they rated these topics on workforce relevance based on their perceptions. Participants were also asked about demographic information and about any previous microbiology course. The survey was sent to both Brigham Young University-Idaho nursing graduates, and, with approval, to nurses working at participating Southeastern Idaho hospitals and clinics. The survey was also posted as an ad through social media to reach a wider range of nurses.

The research survey contained multiple choice and optional write-in questions. Some of the questions were based off the syllabus for the BYU-I Bio 222 laboratory curriculum, while other questions were loosely based from ideas and topics from the survey conducted by Durrant et al. (2017). Participation was voluntary, questions could be skipped, and the return of the online survey served as the consent for research participation.

The demographic information that was collected included the highest level of degree obtained, if the participant was a registered nurse, the number of years' experience, the primary place of work, the university that awarded the degree, and if a microbiology course was a degree requirement. This information allowed for a better and more detailed analysis when comparing

microbiology principles to time in the field, degree and classes obtained, and working environment.

Participants were asked about work area specification, their patient population, and the most common infections they came in contact with. Participants were asked to rate the most and the least useful and/or helpful skills used in their profession. This allowed for the determination of trends in the field as it relates to microbiology.

If participants had been required to take a microbiology course in school, they were asked various questions to determine if they felt the class was beneficial to their field. They were asked which aspects helped to prepare them the most for their careers, which aspects helped them understand the clinical microbiology laboratory, and which aspects they felt were unnecessary for the workplace. All participants were asked to rate a list of topics that they felt were the most important and should be given the most emphasis in nursing degrees, and which topics were the least important and should be given the minimum amount of emphasis in microbiology courses for nurse preparation.

Study Approval

Institutional Review Board (IRB) approval was obtained from Idaho State University (ISU) as well as an initial IRB approval from Brigham Young University-Idaho. Approval from the BYU-I nursing department was also obtained, and emailed surveys (Appendix A) were sent to graduate nurses through this department. After the completed surveys by the BYU-I graduates were submitted, a modified survey (Appendix B) was submitted to the ISU IRB. The modified survey included a change from just “BYU-I graduates” to “all nurses” and the additional question asking which university participants attended. There was also a change in questions that

specifically referenced the BIO 222 course to a general microbiology course reference (Appendix B).

Approval from each hospital and clinic was required but before the survey was sent out it was resubmitted for an IRB modification at the request of one of the hospitals. Changes included a specification within the first question referring to level of education and not certification level, as well as the “clinical” and “other” options added to question 4 (Appendix C). After the hospital and clinic-granted approvals, surveys were emailed from the hospitals and clinics directly to their nurse employees. All IRB approvals classified this research survey as exempt.

Participant Criteria

Participants involved in this study were nurses who (a) graduated from Brigham Young University- Idaho within the last four semesters who were located at various regions throughout the United States, or (b) worked as current hospital, clinic, and community nurses in the Southeastern Idaho region, or (c) responded to online advertising and lived throughout the United States. The survey participants needed to be current nurses with workforce experience rather than students in a nursing program. No other restrictions applied.

Sampling Method

Various methods of survey distribution were used to help ensure the largest response rate. First, the survey was distributed to the previous four semesters of recent Brigham Young University- Idaho graduates which totaled 290 nurses. These semesters included the Winter and Spring semesters of 2019, and the Fall and Spring semesters of 2018. These students were required to take the Bio 222 laboratory class before graduation and entrance into the workforce. Surveys were distributed by the BYU-I nursing department using the emails that the department had on file for the graduates.

The second method of distribution was to disseminate the survey to nurses in local hospitals and clinics in the Southeastern Idaho region. These nurses were not specific graduates from Brigham Young University- Idaho, but from multiple universities. Hospitals were contacted and after consent was given for research participation, the survey link was distributed internally via email. Unfortunately, it was not possible to obtain a total for the number of nurses from these hospitals and clinics who were sent the survey.

The last method of distribution was through social media advertisement. A Facebook ad was set up and designed to specifically target nurses. The utilization of Facebook allowed for a larger sample volume and response from nurses across the United States. The ad was posted for two weeks before closing.

Survey Instrumentation

The fifteen or sixteen-question research survey (Appendix A; Appendix B; Appendix C) was created and then inputted online using the Qualtrics survey software. The survey and data output for this paper was generated using Qualtrics survey software, version XM, Copyright © 2020 Qualtrics®. (Qualtrics and all other Qualtrics product or service names are registered trademarks or trademarks of Qualtrics, Provo, UT, USA. <https://www.qualtrics.com>). The survey cover letter (Appendix D) was designed and formatted using a Microsoft Word® document. Utilizing the Qualtrics generated anonymous link, the link was copied and pasted into the cover letter which was then copied and pasted into an email. Email dissemination was from a personal email rather than sent directly from the Qualtrics survey software and used to forward both the cover letter with link to personnel selected for survey dissemination.

Participation Consent and Incentive

A drawing for a \$25 Amazon online gift card was offered as an incentive for survey completion, and aside from the email entry for the drawing, no personal or identification information was collected from the participant. Entry into the drawing was optional and the survey could be submitted without an email entry. Participants who opened the survey, answered questions, but then later closed the survey without submission were classified as a withdrawal rather than a consent and were not included in the data. Consent was explained to the participant on the cover letter as the return of the online survey. No participants reported concerns or contacted that they had been harmed in this research study.

Data Analysis

Data was collected into the password protected online Qualtrics Survey Software and participants who opened the survey and then declined or withdrew by non-completion were excluded leaving a total of n=112 responses. Data was exported into and analyzed using IBM Corp. SPSS Statistics for Microsoft Windows, version 26.0. Armonk, NY: IBM Corp. This software was used to generate frequencies of data for each question result. In addition, SPSS software was used for the generation of cross-tabulation comparison between the questions regarding the level of participants education and if it influenced answer selections in the last question regarding which microbiology topics require more emphasis. Cross-tabulation comparison was also used to compare the nurse's participation in a required microbiology course and if it influenced answer selections on the last question regarding which microbiology topics require more emphasis. The criteria for statistical significance was $.05/16=.003$ based on a Bonferroni adjustment with exact P values and the Fisher's exact test. Using the frequencies

derived in SPSS, tables were generated using a Microsoft Word document for each question data set. Figures were generated utilizing Microsoft Excel.

Limitations and Assumptions

It was hoped that more nurses would participate in this research survey, but the small sample size received limited the cross-tabulation analysis we were able to perform regarding question comparison. Questions should have been formatted in a way that cross-tabulation data analysis could still be performed with a limited sample volume. Lack of email access was also a limitation and it is assumed that lack of direct contact with participants had an effect on the percent returned. In addition, most hospitals and clinics in the Southeastern Idaho Region that were contacted were not able to participate in the survey due to non-solicitation policies or other reasons. Lastly, this study is based off the assumption that all participants were nurses and that all were qualified to participate in the survey, however, there is no way to determine this from the research design.

Method Summary

The purpose of this study is to evaluate curricular relevance of existing pre-nursing microbiology education curricula as it relates to working nursing professionals. Participants were able to classify what microbiology education curriculum topics were relevant and irrelevant in nursing and pre-nursing education programs as they are applied in the nursing field. Information collected included participants' demographics, required microbiology course, and perceptions of application of microbiology topics.

Utilizing the Qualtrics Survey Software, SPSS, Microsoft Word documents, and Microsoft Excel, data was analyzed, and tables and figures were created. Fortunately, though there were limitations, valuable data was collected. This data can be used to revise and create a

more effective undergraduate microbiology laboratory course in relation to the nursing profession.

Chapter IV: Results

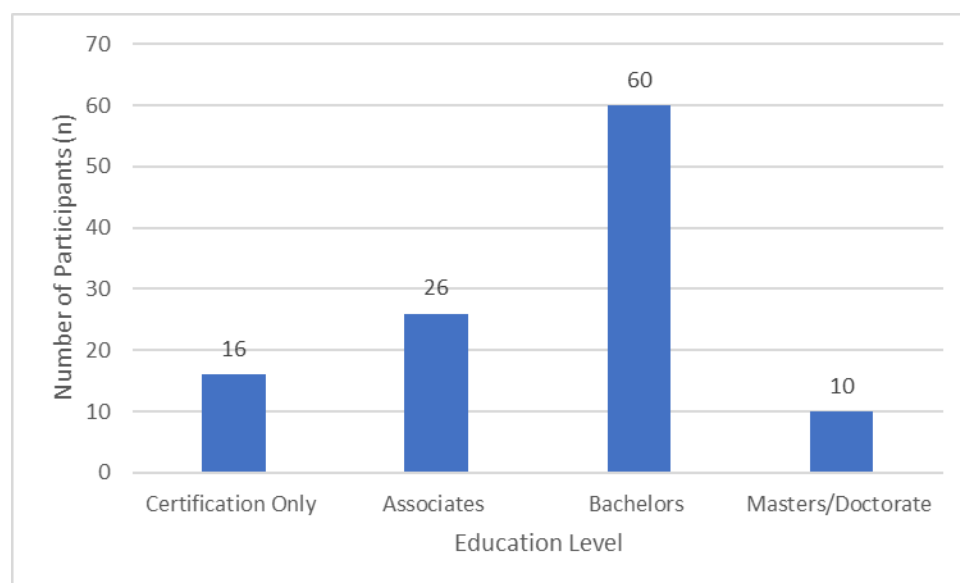
The purpose of this study was to evaluate curricular relevance of existing pre-nursing microbiology education curricula as it relates to working nursing professionals. Participants were able to classify what microbiology education curriculum topics were relevant and irrelevant in nursing and pre-nursing education programs as these topics are applied in the nursing field. Demographic information was collected, information on participants required microbiology course, and application information of microbiology topics as perceived by participants.

Response Rate

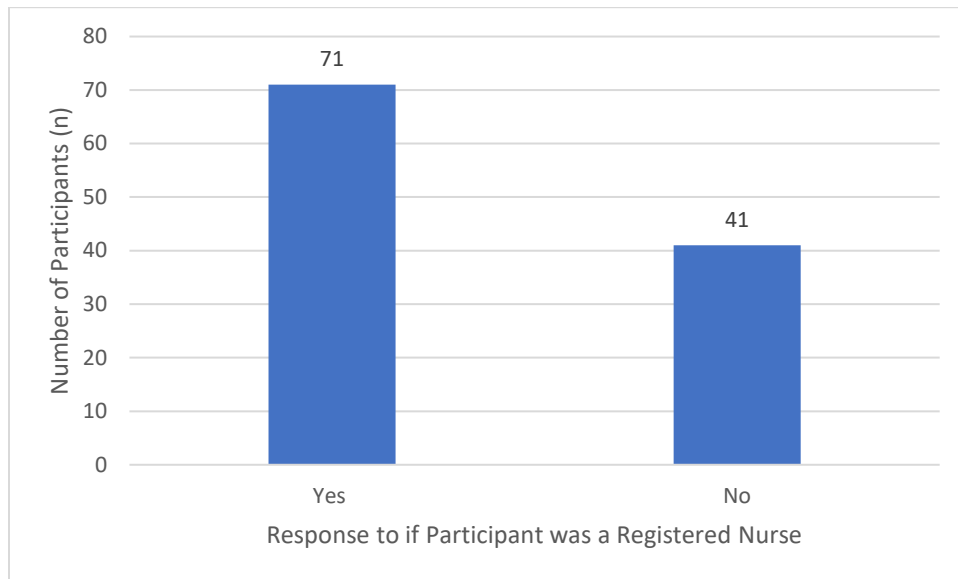
After the close of the survey, n=139 survey responses were collected and n=27 responses were excluded for survey declination or survey withdrawal, leaving a total of n=112 responses for data analysis. The survey was sent to n=290 BYU-I alumni and n=24 nurses responded to the survey for a 12% response rate. Response rates for the hospital and clinic participants and the social media ad could not be obtained.

Participant Demographics

Question one asked about participant's level of nursing education and showed that 14.3% of the participants had obtained a certification only education level, including CNA and LPN certifications, 23.2% had associate degrees, 53.6% had bachelor degrees, and 8.9% had masters/doctorate degrees (Figure 1; Table 1). Question two asked participants if they were a registered nurse. In response, 4% of the participants selected that they were registered nurses and 36.6% answered in that they were not a registered nurse (Figure 2; Table 2).

Figure 1*Survey Participants Level of Nursing Education***Table 1***Survey Participants Level of Nursing Education*

	Education Level	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Certification	16	14.3	14.3	14.3
	Associates	26	23.2	23.2	37.5
	Bachelors	60	53.6	53.6	91.1
	Masters/Doctorate	10	8.9	8.9	100.0
	Total	112	100.0	100.0	

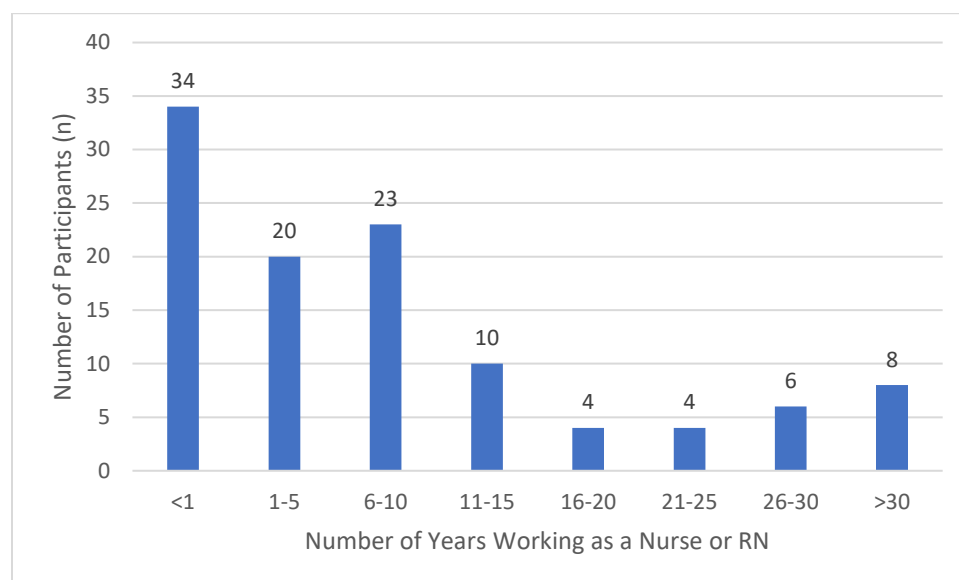
Figure 2*Participant Selection Summary- Registered Nurse Status***Table 2***Participant Selection Summary- Registered Nurse Status*

	Registered Nurse?	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	71	63.4	63.4	63.4
	No	41	36.6	36.6	100.0
	Total	112	100.0	100.0	

Question three asked participants how many years of experience they had working as a nurse or registered nurse. The results showed that 30.4% of the participants had less than one year of experience working as a nurse or registered nurse, 17.9% had 1-5 years of experience, 20.5% had 6-10 years of experience, 8.9% had 11-15 years of experience, 3.6% had 16-20 years of experience, 3.6% had 21-25 years of experience, 5.4% had 26-30 years of experience, and 7.1% had more than 30 years of experience (Figure 3; Table 3).

Figure 3

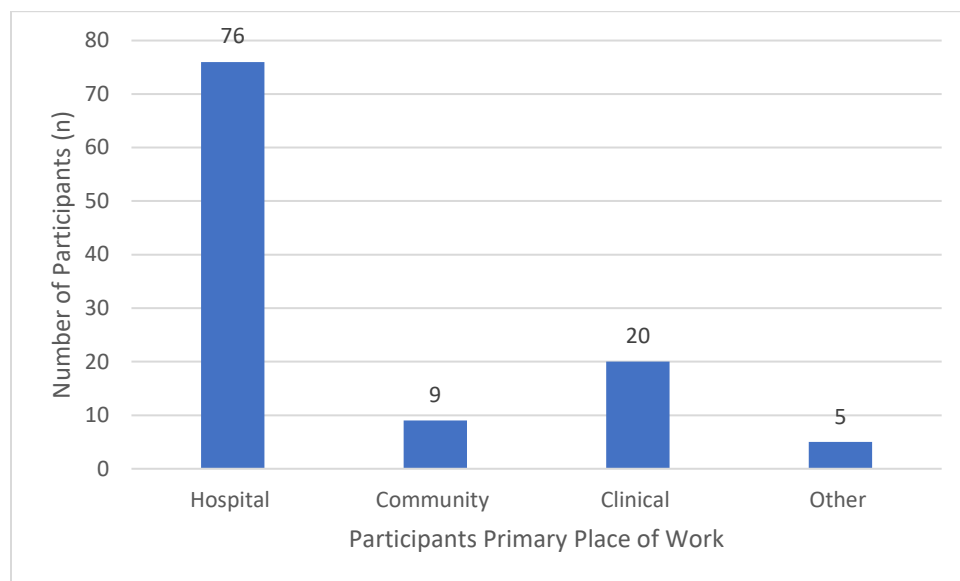
Participants Years of Experience Working as a Nurse or a Registered Nurse

**Table 3**

Participants Years of Experience Working as a Nurse or a Registered Nurse

	Years Working as a Nurse	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	< 1 year	34	30.4	31.2	31.2
	1-5 years	20	17.9	18.3	49.5
	6-10 years	23	20.5	21.1	70.6
	11-15 years	10	8.9	9.2	79.8
	16-20 years	4	3.6	3.7	83.5
	21-25 years	4	3.6	3.7	87.2
	26-30 years	6	5.4	5.5	92.7
	>30 years	8	7.1	7.3	100.0
	Total	109	97.3	100.0	
Missing	System	3	2.7		
Total		112	100.0		

When asked about the location of their primary place of work, 69.1% of participants stated that they worked in a hospital setting, 8.2% worked in a community setting, 18.2% worked in a clinical setting, and 4.5% selected the other option (Figure 4; Table 4).

Figure 4*Participants Primary Place of Work***Table 4***Participants Primary Place of Work*

	Primary Place of Work	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Hospital	76	67.9	69.1	69.1
	Community	9	8.0	8.2	77.3
	Clinical	20	17.9	18.2	95.5
	Other	5	4.5	4.5	100.0
	Total	110	98.2	100.0	
Missing	System	2	1.8		
Total		112	100.0		

Participants were asked which areas of the hospital or clinic they specialized in. This question regarding the areas of specialty allowed for multiple selections. Percent of cases showed that 10.9% of participants worked in the emergency department, 10% worked in labor and delivery, 3.6% worked in psychiatric care, 20.9% worked in surgery, 18.2% worked in critical/intensive care, 7.3% worked in oncology, 14.5% worked in acute care, 15.5% were generalists, 3.6% worked in hospice, 5.5% worked in home health, 10.9% worked in a specialty

clinic, 9.1% were primary care, and 21.8% selected the other option (Table 5). When participants were asked about what patient populations they worked with, multiple selection results showed that 90% of participants worked with adults, 44.5% worked in geriatrics, 28.2% worked with pediatrics, 28.2% worked with adolescents, 12.7% worked with neonates and infants, and 3.6% selected the other option (Table 6).

Table 5

Participants Specialized Area of Work

	Area of Specialization	Responses		
		N	Percent	Percent of Cases
Q5 Specialization ^a	Emergency Department	12	7.2	10.9
	Labor and Delivery	11	6.6	10.0
	Psychiatric	4	2.4	3.6
	Surgery	23	13.8	20.9
	Clinical/Intensive Care	20	12.0	18.2
	Oncology	8	4.8	7.3
	Acute Care	16	9.6	14.5
	General	17	10.2	15.5
	Hospice	4	2.4	3.6
	Home Health	6	3.6	5.5
	Specialty Clinic	12	7.2	10.9
	Primary Care	10	6.0	9.1
	Other	24	14.4	21.8
	Total	167	100.0	151.8

a. Dichotomy group tabulated at value 1.

Table 6*Participants Usual Patient Population*

	Patient Populations	Responses		
		N	Percent	Percent of Cases
Q6 Patient Populations ^a	Adults	99	43.4	90.0
	Geriatrics	49	21.5	44.5
	Pediatrics	31	13.6	28.2
	Adolescents	31	13.6	28.2
	Neonates and Infants	14	6.1	12.7
	Other Patients	4	1.8	3.6
Total		228	100.0	207.3

a. Dichotomy group tabulated at value 1.

Participants were asked which types of infections were the most common in their clinical practice. This question allowed for multiple selections. Percent cases showed that 63% of participants commonly encountered wound infections, 39.8% of participants commonly encountered deep wound infections, 41.7% reported common sepsis infections, 10.2% reported eye infections, 16.7% reported ear infections where skin/nail, joint, and bone infections each were reported at 15.7% encounter rate by participants. Other common infections in participants clinical practice included 38% of participants encountering gastrointestinal infections, 57.4% of participants encountering urinary tract infections, 16.7% reported internal organ infections, 56.5% reported upper respiratory tract infections, 38.9% of participants reported lower respiratory tract infections, 12% reported central nervous system infections, 20.4% reported common encounters with vaginal/sexually transmitted infection, 17.6% reported venous or central line catheter infections, and 9.3% reported perinatal. Types of infections included 62% of participants commonly encountering bacterial infections, 47% of participants commonly encountering viral infections, 29.6% reported fungal infection, and 9.3% reported parasitic/protozoan infections (Table 7). These frequencies show that the top three infections that

participants encounter are superficial wound, urinary tract and upper respiratory tract infections with the leading infectious agent being bacterial.

Table 7

Most Common Infections Participants Come in Contact With

		Responses		
Q7 Infections ^a	Common Infections	N	Percent	Percent of Cases
	Wound, superficial	68	9.9	63.0
	Wound, deep	43	6.3	39.8
	Sepsis	45	6.6	41.7
	Skin/nail	17	2.5	15.7
	Eye	11	1.6	10.2
	Ear	18	2.6	16.7
	Joint	17	2.5	15.7
	Bone	17	2.5	15.7
	Gastrointestinal	41	6.0	38.0
	Urinary tract	62	9.1	57.4
	Internal organ	18	2.6	16.7
	Upper respiratory tract	61	8.9	56.5
	Lower respiratory tract	42	6.1	38.9
	Central nervous system	13	1.9	12.0
	Vaginal/sexually transmitted	22	3.2	20.4
	Venous/central line catheter	19	2.8	17.6
	Perinatal	10	1.5	9.3
	Bacterial	67	9.8	62.0
	Viral	51	7.5	47.2
	Fungal	32	4.7	29.6
	Parasitic/protozoan	10	1.5	9.3
Total		684	100.0	633.3

a. Dichotomy group tabulated at value 1.

Most Helpful Skills

One survey question asked participants to rate options for the most helpful and /or used skill in the nursing profession on a scale of 1 to 5, with 1 being the least helpful and 5 being the most helpful. Handwashing and disease transmission resulted as the most helpful/useful skill according to participants with 89.9% of participants rating the skill at a 5. Only 6.4% of

participants rated handwashing and disease transmission at a 4, 1.8% rated it at a 3, no participants rated it at a 2, and only 1.8% rated it as a 1 (Table 8). Principles of antibiotics and organism susceptibility was the second highest rated for the most helpful/used skill with 40.4% of participants rating the skill at a 5, 33% of participants rated antibiotic principles and organism susceptibility as a 4, 12.8% rated it at a 3, 5.5% rated it at a 2, and 8.3% of participants rated it at a 1 (Table 9). Understanding the differences between bacterial, fungal, viral, and parasitic organisms was the third highest rated topic with 29.4% of participants rating the skill at a 5 and 32.1% of participants rating it at 4. 22% rated it at a 3, 12.8% rated it at a 2, and only 3.7% rated it at a 1 (Table 10). Culturing bacteria and identification processes showed lower levels of importance to participants where the highest rating was 2 at 31.2% and 25.7% rated it at 1. Other ratings included a 3 rating at 21.1%, a 4 rating at 10.1%, and a 5 rating at 11.9% (Table 11).

Table 8*Value of Skill in Workforce- Handwashing and Disease Transmission*

	Rating	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 least helpful/used skill	2	1.8	1.8	1.8
	2	- ^a	-	-	-
	3	2	1.8	1.8	3.7
	4	7	6.3	6.4	10.1
	5 most helpful/used skill	98	87.5	89.9	100.0
	Total	109	97.3	100.0	
Missing	System	3	2.7		
Total		112	100.0		

Note. Hand washing and disease transmission frequencies for the determination of the most helpful/used skills in the nurse participant's career, self-selected and rated on a scale of 1-5 with a rating of 1 being the least helpful skill and a rating of 5 being the most helpful skill as reported on survey by participants.

a. No participants selected 2 as a rating for this skill.

Table 9*Value of Skill in Workforce- Antibiotic Principles and Organism Susceptibility*

	Rating	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 least helpful/used skill	9	8.0	8.3	8.3
	2	6	5.4	5.5	13.8
	3	14	12.5	12.8	26.6
	4	36	32.1	33.0	59.6
	5 most helpful/used skill	44	39.3	40.4	100.0
	Total	109	97.3	100.0	
Missing	System	3	2.7		
Total		112	100.0		

Note. Principles of antibiotics and organism susceptibility frequencies for the determination of the most helpful/used skills in the nurse participant's career, self-selected and rated on a scale of 1-5 with a rating of 1 being the least helpful skill and a rating of 5 being the most helpful skill as reported on survey by participants.

Table 10*Value of Skill in Workforce- Differences Between Microorganism Classes*

	Rating	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 least helpful/used skill	4	3.6	3.7	3.7
	2	14	12.5	12.8	16.5
	3	24	21.4	22.0	38.5
	4	35	31.3	32.1	70.6
	5 most helpful/used skill	32	28.6	29.4	100.0
	Total	109	97.3	100.0	
Missing	System	3	2.7		
Total		112	100.0		

Note. Understanding the differences between bacterial, fungal, viral, and parasitic organism frequencies for the determination of the most helpful/used skills in the nurse participant's career, self-selected and rated on a scale of 1-5 with a rating of 1 being the least helpful skill and a rating of 5 being the most helpful skill as reported on survey by participants.

Table 11*Value of Skill in Workforce- Culturing Bacteria and Identification Processes*

	Rating	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 least helpful/used skill	28	25.0	25.7	25.7
	2	34	30.4	31.2	56.9
	3	23	20.5	21.1	78.0
	4	11	9.8	10.1	88.1
	5 most helpful/used skill	13	11.6	11.9	100.0
	Total	109	97.3	100.0	
Missing	System	3	2.7		
Total		112	100.0		

Note. Culturing bacteria and identification process frequencies for the determination of the most helpful/used skills in the nurse participants career, self-selected and rated on a scale of 1-5 with a rating of 1 being the least helpful skill and a rating of 5 being the most helpful skill as reported on survey by participants.

The survey continued with a question that asked participants to rate microbiology options for the most helpful/used skill used in the nursing profession on a scale of 1 to 5, with 1 being the least helpful and 5 being the most helpful. Performance of dilutions and serial dilutions showed low ratings for being a helpful/used skill in the field according to participants with a rating of 1 rating the highest frequency at 42.6%. Participants rated 2 at 24.1%, 13.9% of participants rated at a 3, 11.1% of participants rated at a 4, and 8.35% of participants rated 5 (Table 12). Performance of gram stains showed 47.7% of participants choosing 1 as the highest frequency and 27.5% choosing a 2 rating. Other ratings included 9.2% selection each for ratings of 3 and 4, and a 6.4% selection on 5 (Table 13). The least valuable skill according to the participants was understanding how to work and operate the microscope which showed 61.7% of participants selecting a 1 rating. Other ratings included a 15.9% participant selection for a rating of 2, 10.3% selection for a rating of 3, 4.7% selection for 4, and 7.5% of participants chose a rating of 5 (Table 14).

Table 12*Value of Skill in Workforce- Dilutions and Serial Dilutions*

	Rating	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 least helpful/used skill	46	41.1	42.6	42.6
	2	26	23.2	24.1	66.7
	3	15	13.4	13.9	80.6
	4	12	10.7	11.1	91.7
	5 most helpful/used skill	9	8.0	8.3	100.0
	Total	108	96.4	100.0	
Missing	System	4	4.6		
Total		112	100.0		

Note. Performance of dilutions and serial dilution frequencies for the determination of the most helpful/used skills in the nurse participants career, self-selected and rated on a scale of 1-5 with a rating of 1 being the least helpful skill and a rating of 5 being the most helpful skill as reported on survey by participants.

Table 13*Value of Skill in Workforce- Gram Stains*

	Rating	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 least helpful/used skill	52	46.4	47.7	47.7
	2	30	26.8	27.5	75.2
	3	10	8.9	9.2	84.4
	4	10	8.9	9.2	93.6
	5 most helpful/used skill	7	6.3	6.4	100.0
	Total	109	97.3	100.0	
Missing	System	3	2.7		
Total		112	100.0		

Note. Performance of gram stain frequencies for the determination of the most helpful/used skills in the nurse participants career, self-selected and rated on a scale of 1-5 with a rating of 1 being the least helpful skill and a rating of 5 being the most helpful skill as reported on survey by participants.

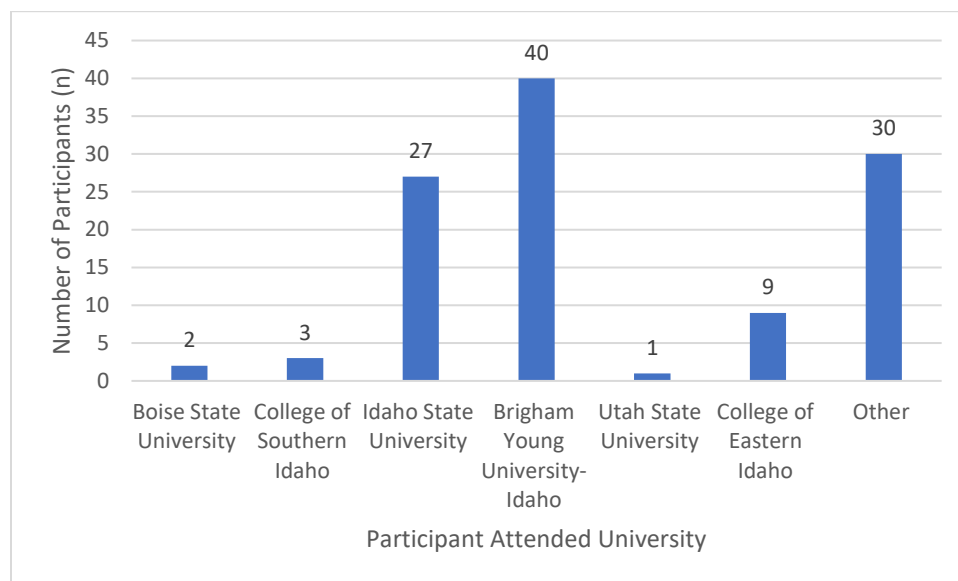
Table 14*Value of Skill in Workforce- Microscope Operations*

	Rating	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 least helpful/used skill	66	58.9	61.7	61.7
	2	17	15.2	15.9	77.6
	3	11	9.8	10.3	87.9
	4	5	4.5	4.7	92.5
	5 most helpful/used skill	8	7.1	7.5	100.0
	Total	107	95.5	100.0	
Missing	System	5	4.5		
Total		112	100.0		

Note. Understanding of how to work and operate the microscope frequencies for the determination of the most helpful/used skills in the nurse participants career, self-selected and rated on a scale of 1-5 with a rating of 1 being the least helpful skill and a rating of 5 being the most helpful skill as reported on survey by participants.

Participant Education

Participants were asked which university they attended to acquire their nursing degrees. Results showed that 35.7% of participants graduated from Brigham Young University- Idaho, 24.1% of participants graduated from Idaho State University, 8% graduated from the College of Eastern Idaho, formerly known as Eastern Idaho Technical College, 2.7% graduated from the College of Southern Idaho, 1.8% graduated from Boise State University, and 36.8% reported other colleges (Figure 5; Table 15) including but not limited to The North Idaho College, Lewis and Clark state College, the University of Utah, Dixie State University, Chamberlain College, and Grand Canyon University (Table 16).

Figure 5*Participant Attended Universities***Table 15***Participant Attended Universities*

	University	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Boise State University	2	1.8	1.8	1.8
	College of Southern Idaho	3	2.7	2.7	4.5
	Idaho State University	27	24.1	24.1	28.6
	Brigham Young University- Idaho	40	35.7	35.7	64.3
	Utah State University	1	0.9	0.9	65.2
	Other	30	26.8	26.8	92
	College of Eastern Idaho (Eastern Idaho Technical College)	9	8.0	8.0	100.0
	Total	112	100.0	100.0	

Table 16*Other Responses for Participant Attended Universities*

Universities	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	93	83.0	83.0	83.0
California State University- Chico	1	0.9	0.9	83.9
Chamberlain College	1	0.9	0.9	84.8
Chico State University	1	0.9	0.9	85.7
Dixie State University	1	0.9	0.9	86.6
George Fox University	1	0.9	0.9	87.5
Grand Canyon University	1	0.9	0.9	88.4
IAHCSMM	1	0.9	0.9	89.3
Idaho State University College of Pharmacy	1	0.9	0.9	90.2
Lewis Clark State College	1	0.9	0.9	91.1
Lewis-Clark State College	1	0.9	0.9	92.0
Musc	1	0.9	0.9	92.9
North Idaho College	1	0.9	0.9	93.8
Ricks College	2	1.8	1.8	95.5
University of Detroit Mercy	2	0.9	0.9	96.4
University of Utah	2	0.9	0.9	97.3
Vanderbilt University	2	0.9	0.9	98.2
Westminster College	2	0.9	0.9	99.1
WGU	2	0.9	0.9	100.0
Total	112	100.0	100.0	

Note. Frequencies of nurse participants self-declared nursing education locations as reported on survey by participants who chose the “other” selection to question 9 rather than a provided option.

Participants were asked if they were required to take a microbiology course while they were attending school. Results showed that 85.7% of the participants were required to take a microbiology course and 14.3% of the participants reported that they did not have to take a required course (Figure 6; Table 17). If participants answered that they had taken a microbiology

course, the participant was then asked if the course had been helpful in preparing them for their career in nursing. Of these participants, 76.8% said that the course was helpful in preparing them for their career in nursing and 23.2% of the participants said that it was not beneficial (Figure 7; Table 18).

Figure 6

Participants Indication of Taking a Required Microbiology Course for Graduation

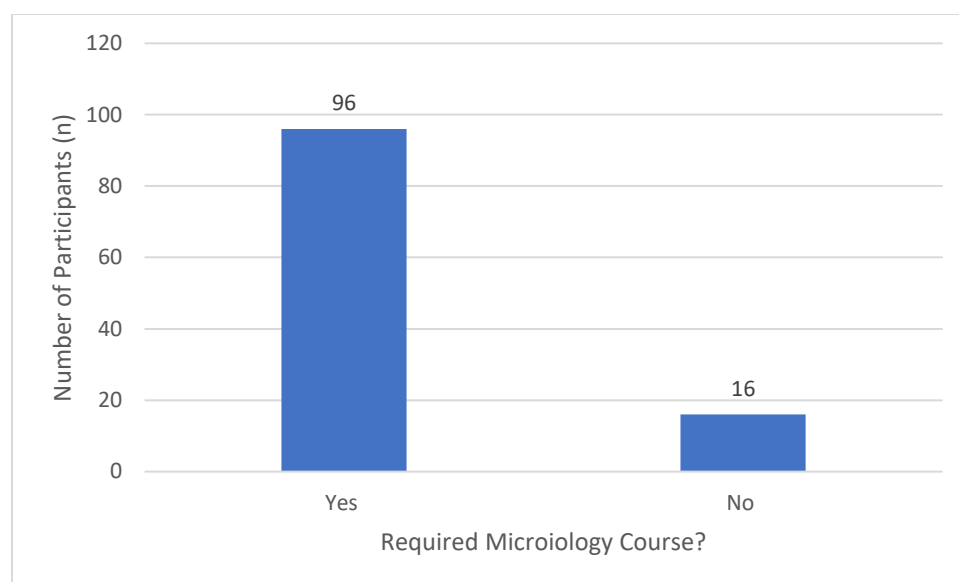


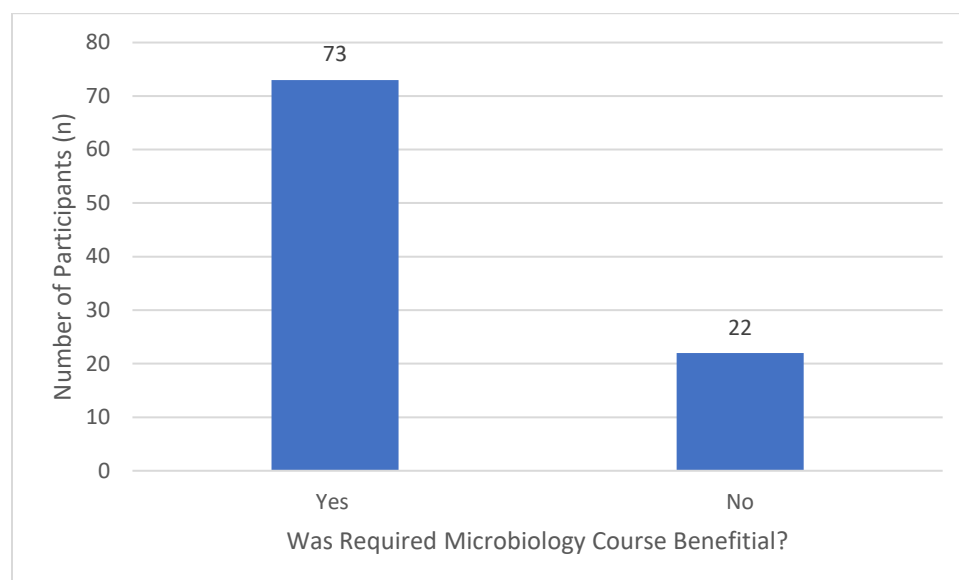
Table 17

Participants Indication of Taking a Required Microbiology Course for Graduation

	Required Microbiology Course?	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	96	85.7	85.7	85.7
	No	16	14.3	14.3	100.0
	Total	112	100.0	100.0	

Figure 7

Participants Indication if Microbiology Course was Beneficial to Career

**Table 18**

Participants Indication if Microbiology Course was Beneficial to Career

	Required Microbiology Course Beneficial?	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	73	65.2	76.8	76.8
	No	22	19.6	23.2	100.0
	Total	95	84.8	100.0	
Missing	System	17	15.2		
Total		112	100.0		

The participants who answered that they had been required to take a microbiology course, were then asked which aspects of the course helped to prepare them the most for their professional careers in nursing. Participants chose from various options and declared at a 46.3% that handwashing and disease transmission was the most beneficial. The second most beneficial at 30.5% was knowledge of antibiotics, antiseptics, and disinfectants. Knowing the differences between bacterial, fungal, and parasitic species was selected at 16.8%, culturing organisms and bacterial identification processes was 2.1%, microscope operations knowledge was 2.1%, and

gram stain knowledge was 1.1% as well as 1.1% for the other selection option. No participants selected the topic options for food microbiology or dilutions and serial dilutions (Table 19).

Table 19

Most Helpful Aspects of Microbiology Course for Workforce Preparation

	Course Topic Options	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Microscope operations	2	1.8	2.1	2.1
	Knowledge of different microorganism groups	16	14.3	16.8	18.9
	Handwashing and disease transmission	44	39.3	46.3	65.3
	Gram stain procedure	1	0.9	1.1	66.3
	Bacterial Culturing and identification	2	1.8	2.1	68.4
	Dilutions and Serial Dilutions	- ^a	-	-	-
	Food microbiology	-	-	-	-
	Antibiotics, antiseptics, and disinfectants	29	25.9	30.5	98.9
	Other	1	0.9	1.1	100.0
	Total	95	84.8	100.0	
Missing	System	17	15.2		
	Total	112	100.0		

a. No participants selected these topic options.

The participants who answered that they had been required to take a microbiology course, were also asked which aspects of the course helped them the most to understand the clinical microbiology laboratory. According to participants the most helpful aspect in helping them to understand the processes of the clinical microbiology laboratory resulted in a 34% selection for culturing organisms and bacterial identification processes. The second most helpful was selected at 27.7% for knowing of the differences between microorganism groups such as bacterial, fungal, and parasitic organisms. Knowledge of antibiotics, antiseptics, and disinfectants resulted in a 20.2% selection rate. Aspects that had low selections included handwashing and disease transmission at 10.6%, microscope operations knowledge at 4.3% and gram stain knowledge at

3.2%. No participants selected the topic options for food microbiology or dilutions and serial dilutions (Table 20).

Table 20

Most Helpful Aspects of Course for Understanding the Clinical Microbiology Laboratory

	Course Topic Options	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Microscope operations	4	3.6	4.3	4.3
	Knowledge of different microorganism groups	26	23.2	27.7	31.9
	Handwashing and disease transmission	10	8.9	10.6	42.6
	Gram stain procedure	3	2.7	3.2	45.7
	Bacterial culturing and identification	32	28.6	34.0	79.8
	Antibiotics, antiseptics, and disinfectants	19	17.0	20.2	100.0
	Dilutions and serial dilutions	- ^a	-	-	-
	Food microbiology	-	-	-	-
	Total	94	83.9	100.0	
Missing	System	18	16.1		
	Total	112	100.0		

a. No participants selected these topic options.

The participants who had answered that they had been required to take a microbiology course, were also asked which aspects of the course helped them the least for workforce preparation. The aspect of participants microbiology course that helped to prepare them the least, according to participants, was microscope operations knowledge with a 56.4% selection rate.

The second least helpful selected was dilutions and serial dilutions at 23.4%, gram stain knowledge was selected at 8.5%, food microbiology was 6.4%, culturing organisms and bacterial identification processes w*as 4.3%, and hand washing and disease transmission resulted at 1.1%.

/No participants selected the topic options for antibiotics, antiseptics, and disinfectants, or knowledge about the different microorganism groups (Table 21).

Table 21*Least Helpful Aspects of Microbiology Course for Workforce Preparation*

	Course Topic Options	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Microscope operations	53	47.3	56.4	56.4
	Handwashing and disease transmission	1	0.9	1.1	57.4
	Gram stain procedure	8	7.1	8.5	66.0
	Bacterial Culturing and identification	4	3.6	4.3	70.2
	Dilutions and Serial Dilutions	22	19.6	23.4	93.6
	Food microbiology	6	5.4	6.4	100.0
	Knowledge of different microorganism groups	- ^a	-	-	-
	Antibiotics, antiseptics, and disinfectants	-	-	-	-
	Total	94	83.9	100.0	
Missing	System	18	16.1		
	Total	112	100.0		

a. No participants selected these topic options.

Most Relevant and Irrelevant Microbiology Topics

All participants were asked their opinion of which microbiology topics should be given more emphasis in pre-nursing and nursing microbiology courses to help better prepare students for careers in nursing by rating on a scale of 1 to 5, with 1 being the least helpful and 5 being the most helpful. These topics included the following: (a) antimicrobial therapy, both oral and intravenous; (b) organism genetics and molecular testing methods; (c) bio-terrorism agents; (d) vaccinations; (e) infection control and the epidemiology of infectious organisms; (f) healthcare acquired infections and disease transmission; (g) performance of dilutions and serial dilutions; (h) specimen collection and handling; (i) gram staining procedures; (j) knowledge of how to work and operate the microscope; (k) emphasis on the differences between bacterial, parasitic, viral, and fungal infections; (l) interpretation of the different culture results from blood, urine,

stool, sputum, and wounds; (m) knowledge of the differentiation of human normal flora and the various body parts vs. pathogens; (n) knowledge of the different groups of medically important pathogens such as gram negative vs. gram positive, anaerobic vs. aerobic, staphylococcus vs, streptococcus, and other pathogens; (o) understanding antibiotic susceptibility results and the interpretation; (p) other.

Healthcare acquired infections and disease transmission was the top-rated topic requiring more emphasis according to participants with 77.6% of participants rating this topic of as a 5. Other ratings for healthcare acquired infections include 17.8% of participants rating at a 4, 3.7% of participants rating at a 3, no participants selected 2 as a rating, and only 0.9% of participants selected a rating of 1 for the least amount of emphasis needed (Table 22).

Table 22

Emphasis Recommended for Nursing Students- Healthcare Associated Infections and Disease Transmission

	Rating Options	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 least emphasis needed	1	0.9	0.9	0.9
	2	- ^a	-	-	-
	3	4	3.6	3.7	4.7
	4	19	17.0	17.8	22.4
	5 most emphasis needed	83	74.1	77.6	100.0
	Total	107	95.5	100.0	
Missing	System	5	4.7		
Total		112	100.0		

Note. Frequencies for the needed emphasis of healthcare associated infections and disease transmission in pre-nursing and nursing degrees to better prepare students for professional nursing careers rated 1-5 with a rating of 1 being the least helpful skill and a rating of 5 being the most helpful skill as reported on survey by participants.

a. No participants selected this rating option.

Infection control and epidemiology of infectious organisms was the second highest rated topic which resulted in 65.4% of participants rating it at a 5. Other ratings include 25.2% for a rating of 4, 7.5% rated it at a 3, and ratings of 2 and 1 both got a rating of 0.9% (Table 23). In the topic of vaccinations, 63.6% of participants rated it at a 5 for the third highest rated topic. Other ratings include 24.3% for a rating of 4, 24.3% for a rating of 3, and ratings of 2 and 1 each received a 0.9% selection (Table 24).

Table 23

Emphasis Recommended for Nursing Students- Infection Control and Infectious Organisms

	Rating Options	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 least emphasis needed	1	0.9	0.9	0.9
	2	1	0.9	0.9	1.9
	3	8	7.1	7.5	9.3
	4	27	24.1	25.2	34.6
	5 most emphasis needed	70	62.5	65.4	100.0
	Total	107	95.5	100.0	
Missing	System	5	4.5		
Total		112	100.0		

Note. Frequencies for the needed emphasis of infection control and the epidemiology of infectious organisms in pre-nursing and nursing degrees to better prepare students for professional nursing careers rated 1-5 with a rating of 1 being the least helpful skill and a rating of 5 being the most helpful skill as reported on survey by participants.

Table 24*Emphasis Recommended for Nursing Students- Vaccinations*

	Rating Options	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 least emphasis needed	1	0.9	0.9	0.9
	2	1	0.9	0.9	1.9
	3	11	9.8	10.3	12.1
	4	226	23.2	24.3	36.4
	5 most emphasis needed	68	60.7	63.6	100.0
	Total	107	95.5	100.0	
Missing	System	5	4.5		
Total		112	100.0		

Note. Frequencies for the needed emphasis of vaccinations in pre-nursing and nursing degrees to better prepare students for professional nursing careers rated 1-5 with a rating of 1 being the least helpful skill and a rating of 5 being the most helpful skill as reported on survey by participants.

Another topic that had high ratings included antimicrobial therapy with both oral and intravenous administration with 62% of participants selecting 5 rating, 25% rated it at a 4, 10.2% rated it at 3, 0.9% rated it at 2, and 1.9% of participants rated it at a 1 (Table 25). In the topic of understanding antibiotic susceptibility results and the interpretation thereof was the next highest with 53.7% of participants rated it at 5, 33.3% rated it at 4, 10.2% rated it at a 3, 1.9% rated it at a 2, and only 0.9% rated it at a 1 (Table 26).

Table 25*Emphasis Recommended for Nursing Students- Antimicrobial Therapy*

	Rating Options	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 least emphasis needed	2	1.8	1.9	1.9
	2	1	0.9	0.9	2.8
	3	11	9.8	10.2	13.0
	4	27	24.1	25.0	38.0
	5 most emphasis needed	67	59.8	62.0	100.0
	Total	108	96.4	100.0	
Missing	System	4	3.6		
Total		112	100.0		

Note. Frequencies for the needed emphasis of antimicrobial therapy, both oral and intravenous administration, in pre-nursing and nursing degrees to better prepare students for professional nursing careers rated 1-5 with a rating of 1 being the least helpful skill and a rating of 5 being the most helpful skill as reported on survey by participants.

Table 26*Emphasis Recommended for Nursing Students- Antibiotic Susceptibility Results and**Interpretation*

	Rating Options	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 least emphasis needed	1	0.9	0.9	0.9
	2	2	1.8	1.9	2.8
	3	11	9.8	10.2	13.0
	4	36	32.1	33.3	46.3
	5 most emphasis needed	58	51.8	53.7	100.0
	Total	108	96.4	100.0	
Missing	System	4	3.6		
Total		112	100.0		

Note. Frequencies for the needed emphasis on the understanding of antibiotic susceptibility results and the interpretation in pre-nursing and nursing degrees to better prepare students for professional nursing careers rated 1-5 with a rating of 1 being the least helpful skill and a rating of 5 being the most helpful skill as reported on survey by participants.

The interpretation of the different culture results from blood, urine, stool, sputum, and wounds showed 48.6% of the participants selecting 5, and other results showing 31.8% rating it at a 4, 15.0% rating it at a 3, 3.7% rating it at a 2, and 0.9% rating it at a 1 (Table 27). Selection for emphasis on the differences between bacterial, parasitic, viral, and fungal infection showed 46.3% participants selecting 5, 30.6% of participants rating it at a 4, 18.5% rating it at a 3, 3.7% rating it at a 2, and 0.9% rating it at a 1 (Table 28).

Table 27

Emphasis Recommended for Nursing Students- Interpretation of Culture Results

	Rating Options	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 least emphasis needed	1	0.9	0.9	0.9
	2	4	3.6	3.7	4.7
	3	16	14.3	15.0	19.6
	4	34	30.4	31.8	51.4
	5 most emphasis needed	52	46.4	48.6	100.0
	Total	107	95.5	100.0	
Missing	System	5	4.5		
Total		112	100.0		

Note. Frequencies for the needed emphasis of the interpretation of different culture results from blood, urine, stool, sputum, and wounds in pre-nursing and nursing degrees to better prepare students for professional nursing careers rated 1-5 with a rating of 1 being the least helpful skill and a rating of 5 being the most helpful skill as reported on survey by participants.

Table 28*Emphasis Recommended for Nursing Students- Different Microorganism Infections*

	Rating Options	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 least emphasis needed	1	0.9	0.9	0.9
	2	4	3.6	3.7	4.6
	3	20	17.9	18.5	23.1
	4	33	29.5	30.6	53.7
	5 most emphasis needed	50	44.6	46.3	100.0
	Total	108	96.4	100.0	
Missing	System	4	3.6		
Total		112	100.0		

Note. Frequencies for the needed emphasis on the difference between bacterial, parasitic, viral, and fungal infections in pre-nursing and nursing degrees to better prepare students for professional nursing careers rated 1-5 with a rating of 1 being the least helpful skill and a rating of 5 being the most helpful skill as reported on survey by participants.

The selection for specimen collection and handling included 37.4% of participants rated it as a 5, 33.6% who rated it as a 4, 19.6% who rated it as a 3, 7.5% who rated it at a 2, and 1.9% of participants rated it as a 1 (Table 29). Knowledge of the different groups of medically important pathogens such as gram negative vs. gram positive, anaerobic vs. aerobic, staphylococcus vs. streptococcus, and other pathogens resulted in 35.2% of participants rating it at a 5, 33.3% rated at a 4, 21.3% rated at a 3, 7.4% rated at a 2, and lastly 2.8% rated it at a 1 (Table 30).

Table 29*Emphasis Recommended for Nursing Students- Specimen Collection and Handling*

	Rating Options	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 least emphasis needed	2	1.8	1.9	1.9
	2	8	7.1	7.5	9.3
	3	21	18.8	19.6	29.0
	4	36	32.1	33.6	62.6
	5 most emphasis needed	40	35.7	37.4	100.0
	Total	107	95.5	100.0	
Missing	System	5	4.5		
Total		112	100.0		

Note. Frequencies for the needed emphasis of specimen collection and handling in pre-nursing and nursing degrees to better prepare students for professional nursing careers rated 1-5 with a rating of 1 being the least helpful skill and a rating of 5 being the most helpful skill as reported on survey by participants.

Table 30*Emphasis Recommended for Nursing Students- Different Microorganism Groups*

	Rating Options	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 least emphasis needed	3	2.7	2.8	2.8
	2	8	7.1	7.4	10.2
	3	23	20.5	21.3	31.5
	4	36	32.1	33.3	64.8
	5 most emphasis needed	38	33.9	35.2	100.0
	Total	108	96.4	100.0	
Missing	System	4	3.6		
Total		112	100.0		

Note. Frequencies for the needed emphasis on the knowledge of the different groups of medically important pathogens such as gram negative vs. gram positive, anaerobic vs. aerobic, staphylococcus vs. streptococcus, and other pathogens in pre-nursing and nursing degrees to better prepare students for professional nursing careers rated 1-5 with a rating of 1 being the least helpful skill and a rating of 5 being the most helpful skill as reported on survey by participants.

Result for knowledge about the differentiation of human normal flora vs. human pathogens, showed that 40.2% of participants rated it at a 4 for the highest frequency. The other results showed 36.4% of participants selected a rating of 5, 17.8% selected a rating of 3, 4.7% selected a rating of 2, and 0.9% selected a rating of 1 (Table 31). Organism genetics and molecular testing methods had a high frequency of a 3-rating that resulted in a 40.7% selection. Other responses included a 10.2% participant selection of 5, a 18.2% participant selection of 4, a 20.4% selection of 3, and 10.2% selection of a 1 rating (Table 32). Bio-terrorism agents showed the highest frequency rated at 3 with a 30.8% selection rate. A selection of 4 was the next highest at a 22.3% selection and a selection of 5 resulted in 15.9%. A rating of 2 was 18.7%, and a rating or 1 was 11.2% (Table 33).

Table 31

Emphasis Recommended for Nursing Students- Normal Flora vs. Pathogens

	Rating Options	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 least emphasis needed	1	0.9	0.9	0.9
	2	5	4.5	4.7	5.6
	3	19	17.0	17.8	23.4
	4	43	38.4	40.2	63.6
	5 most emphasis needed	39	34.8	36.4	100.0
	Total	107	95.5	100.0	
Missing	System	5	4.5		
Total		112	100.0		

Note. Frequencies for the needed emphasis of the differentiation of human normal flora and the various body parts vs. pathogens in pre-nursing and nursing degrees to better prepare students for professional nursing careers rated 1-5 with a rating of 1 being the least helpful skill and a rating of 5 being the most helpful skill as reported on survey by participants.

Table 32*Emphasis Recommended for Nursing Students- Organism Genetics and Molecular Testing**Methods*

	Rating Options	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 least emphasis needed	11	9.8	10.2	10.2
	2	22	19.6	20.4	30.6
	3	44	39.3	40.7	71.3
	4	20	17.9	18.5	89.8
	5 most emphasis needed	11	9.8	10.2	100.0
	Total	108	96.4	100.0	
Missing	System	4	3.6		
Total		112	100.0		

Note. Frequencies for the needed emphasis of organism genetics and molecular testing methods in pre-nursing and nursing degrees to better prepare students for professional nursing careers rated 1-5 with a rating of 1 being the least helpful skill and a rating of 5 being the most helpful skill as reported on survey by participants.

Table 33*Emphasis Recommended for Nursing Students- Bio-Terrorism Agents*

	Rating Options	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 least emphasis needed	12	10.7	11.2	11.2
	2	20	17.9	18.7	29.9
	3	33	29.5	30.8	60.7
	4	25	22.3	23.4	84.1
	5 most emphasis needed	17	15.2	15.9	100.0
	Total	107	95.5	100.0	
Missing	System	5	4.5		
Total		112	100.0		

Note. Frequencies for the needed emphasis on bio-terrorism agents in pre-nursing and nursing degrees to better prepare students for professional nursing careers rated 1-5 with a rating of 1 being the least helpful skill and a rating of 5 being the most helpful skill as reported on survey by participants.

The three lowest rated topics for needed emphasis according to participants included the following: (a) gram staining procedure; (b) performance of dilutions and serial dilutions; (c) knowing how to operate the microscope. Results for the gram stain procedure showed that participants selected a rating of 1 and 2 each at 29.9%, results for a 3-rating showed 23.4%, results for a 4 at 7.5%, and results for a 5 at 9.3% (Table 34). Performance of dilutions and serial dilutions showed 32.3% of participants selected a 1 rating, 25% selected a rating of 2, 22.2% selected a rating of 3, 9.3% selected a rating of 4, and 11.1% selected a rating of 5 (Table 35). Knowledge of how to work and operate the microscope showed results for the least amount of emphasis according to participants with 50.9% of participants selecting a rating of 1. 2 was selected at 19.4%, 3 was selected at 10.2%, 4 was selected at 12.0%, and only 7.4% selected a rating of 5 (Tables 36).

Table 34

Emphasis Recommended for Nursing Students- Gram Staining Procedures

	Rating Options	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 least emphasis needed	32	28.6	29.9	29.9
	2	32	28.6	29.9	59.8
	3	25	22.3	23.4	83.2
	4	8	7.1	7.5	90.7
	5 most emphasis needed	10	8.9	9.3	100.0
	Total	107	95.5	100.0	
Missing	System	5	4.5		
Total		112	100.0		

Note. Frequencies for the needed emphasis of gram staining procedures in pre-nursing and nursing degrees to better prepare students for professional nursing careers rated 1-5 with a rating of 1 being the least helpful skill and a rating of 5 being the most helpful skill as reported on survey by participants.

Table 35*Emphasis Recommended for Nursing Students- Dilutions and Serial Dilutions*

	Rating Options	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 least emphasis needed	35	31.3	32.4	32.4
	2	27	24.1	25.0	57.4
	3	24	21.4	22.2	79.6
	4	10	8.9	9.3	88.9
	5 most emphasis needed	12	10.7	11.1	100.0
	Total	108	96.4	100.0	
Missing	System	4	3.6		
Total		112	100.0		

Note. Frequencies for the needed emphasis of dilutions and serial dilutions in pre-nursing and nursing degrees to better prepare students for professional nursing careers rated 1-5 with a rating of 1 being the least helpful skill and a rating of 5 being the most helpful skill as reported on survey by participants.

Table 36*Emphasis Recommended for Nursing Students- Microscope Operations*

	Rating Options	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 least emphasis needed	55	49.1	50.9	50.9
	2	21	18.8	19.4	70.4
	3	11	9.8	10.2	80.6
	4	13	11.6	12.0	92.6
	5 most emphasis needed	8	7.1	7.4	100.0
	Total	108	96.4	100.0	
Missing	System	4	3.6		
Total		112	100.0		

Note. Frequencies for the needed emphasis of microscope operation knowledge in pre-nursing and nursing degrees to better prepare students for professional nursing careers rated 1-5 with a rating of 1 being the least helpful skill and a rating of 5 being the most helpful skill as reported on survey by participants.

Cross-Tabulation Comparison Analysis

Cross-tabulation comparison of data was done between survey question number one and the last question in the survey. This comparison was to determine any potential correlation between education level and the participants opinion of what microbiology topics should be given more emphasis in pre-nursing and nursing degrees to better prepare students for professional nursing careers.

The microbiology topic that showed statistical significance when compared to education level was antimicrobial therapy, both oral and intravenous. The data showed that n=1 certification only participant and n=1 associate level participant chose to rate antimicrobial therapy at a 1. The n=1 certification only participant was 7.1% of the total certification only group and the n=1 associate level participant amounted to 4% of the associate level participants. Only n=1 participant selected and rated antimicrobial therapy as a 2. This participant had a bachelors level education and amounted to 1.7% of the bachelor participants. Selections for a rating of 3 were chosen by n=4 participants who held certifications, n=5 participants who held associate degrees, n=1 bachelor level participant, and n=1 masters/doctorate level participant. This accounted for 28.6% of the certification participants, 20% of the associate level participants, 1.7% of the bachelor participants, and 10% of the masters/doctorate participants. Participants who selected a rating of 4 for antimicrobial therapy included n=5 certification only participants, n=6 associate degree level participants, and n=16 bachelor level participants. No participants out of the masters/doctorate group selected a rating of 4 for this topic, antimicrobial therapy. This selection accounted for 35.7% of the certification only participants, 24% of the associate level participants, and 27.1% of the bachelor level participants. Selections for a 5 rating were chosen by n=4 certification only participants, n=13 associate level participants, n=41 bachelor level

participants, and n=9 masters/doctorate level participants. This selection accounted for 28.6% of the certification only participants, 52% of the associate level participants, 69.5% of the bachelor level participants, and 90% of the masters/doctorate level participants (Table 37).

Table 37

Cross-Tabulation Comparison- Participants Education Level and Importance of Antimicrobial Therapy

Rating		Certification	Associates	Bachelors	Masters/Doctorate	Total
1	Count	1	1	0	0	2
	% within antimicrobial therapy	50	50	0	0	100
	% within question 1	7.1	4	0	0	1.9
2	Count	0	0	1	0	1
	% within antimicrobial therapy	0	0	100	0	100
	% within question 1	0	0	1.7	0	0.9
3	Count	4	5	1	1	11
	% within antimicrobial therapy	36.4	45.5	9.1	9.1	100
	% within question 1	28.6	20	1.7	10	10.2
4	Count	5	6	16	0	27
	% within antimicrobial therapy	18.5	22.2	59.3	0	100
	% within question 1	35.7	24	27.1	0	25
5	Count	4	13	41	9	67
	% within antimicrobial therapy	6	19.4	61.2	13.4	100
	% within question 1	28.6	52	69.5	90	62
Total	Count	14	25	59	10	108
	% within antimicrobial therapy	13	23.1	54.6	9.3	100
	% within question 1	100	100	100	100	100

This data shows that participants with higher levels of education rated antimicrobial therapy, both oral and intravenous, higher and were more likely to choose a rating of 5 when compared to participants with lower levels of education. In contrast, more certification only and associate level participants chose lower rating numbers when compared to participants with higher educational levels. The correlation between education level and the microbiology topic of antimicrobial therapy, both oral and intravenous, showed statistical significance, Fisher's Exact Test = 26.536, $p = .001$ (Table 38).

Table 38

Statistical Tests for Level of Education and Antimicrobial Therapy Comparison

Statistical Tests	Value
Fisher's Exact Test	26.536
P Value	.001

No other associations between nursing education level and rated microbiology topics in the last question of the survey were found to be statistically significant and included the following statistical test results: (a) Organism genetics and molecular testing methods, Fisher's Exact Test = 6.474, $p = .909$; (b) bio-terrorism agents, Fisher's Exact Test = 3.054, $p = .999$; (c) vaccinations, Fisher's Exact Test = 10.991, $p = .614$; (d) infection control and the epidemiology of infectious organisms, Fisher's Exact Test = 15.871, $p = .141$; (e) Healthcare acquired infections and disease transmission, Fisher's Exact Test = 15.123, $p = .037$; (f) performance of dilutions and serial dilutions, Fisher's Exact Test = 14.383, $p = .217$; (g) Specimen collection and handling, Fisher's Exact Test = 23.616, $p = .007$; (h) gram staining procedures, Fisher's Exact Test = 19.301, $p = .042$; (i) knowledge of how to work and operate the microscope, Fisher's Exact Test = 23.749, $p = .006$; (j) emphasis on the difference between bacterial, parasitic, viral, and fungal infections as the different microorganism groups are classified, Fisher's Exact Test =

10.366, $p = .600$; (k) interpretation of the different culture results from blood, urine, stool, sputum, and wounds, Fisher's Exact Test = 18.521, $p = .052$; (l) knowledge of the differentiation of human normal flora and the various body parts versus pathogens, Fisher's Exact Test = 11.843, $p = .438$; (m) knowledge of the different groups of medically important pathogens such as gram negative vs. gram positive, anaerobic vs. aerobic, staphylococcus vs, streptococcus, and other pathogens, Fisher's Exact Test = 12.496, $p = .324$; Understanding antibiotic susceptibility results and the interpretation, Fisher's Exact Test = 10.995, $p = .537$ (Table 39).

Table 39

Statistical Test Values for Level of Education Compared to Various Microbiology Topics

Microbiology Topics	Fisher's Exact Test Value	P Value
Organism genetics and molecular testing methods	6.474	.909
Bio-terrorism agents	3.054	.999
Vaccinations	10.991	.614
Infection control and epidemiology	15.871	.141
Healthcare acquired infections and disease transmission	15.123	.037
Dilutions/serial dilutions	14.383	.217
Specimen collection and handling	23.616	.007
Gram staining procedures	19.301	.042
Microscope operations	23.749	.006
Knowing difference between microorganism groups	10.366	.600
Interpretation of culture results	18.512	.052
Human flora vs. pathogens	11.843	.438
Knowing groups of pathogens	12.496	.324
Antibiotic susceptibility results	10.995	.537

Cross-tabulation comparison of data was done between the survey question that asked if participants had taken a required microbiology class for graduation, and the last question in the survey. This comparison was to determine any potential correlation between microbiology class requisites and the participants opinion of what microbiology topics should be given more

emphasis in pre-nursing and nursing degrees to better prepare students for professional nursing careers.

The microbiology topic that showed statistical significance when compared to participation in a microbiology course was antimicrobial therapy, both oral and intravenous. The data showed that for rating antimicrobial therapy at a 1, n=2 participants who were not required to take a microbiology course chose this selection, but n=0 participants who had taken a microbiology course chose a rating of 1. These n=2 participants who had selected “no” in response to having taken a microbiology course made up 14.3% of all participants who had selected “no”. Only n=1 participant rated antimicrobial therapy at a 2. This participant had answered “yes” to having taken a microbiology course and made up 1.1% of the total “yes” group. Of the participants who rated antimicrobial as 3, n=6 of them had taken a microbiology course and n=5 had not. This makes up 6.4% of the participants who had selected “yes” to having taken a microbiology class and 35.7% of the participants who had selected “no”. The participants who had rated antimicrobial therapy as 4 included, n=24 participants who had taken a microbiology course and n=3 who had not. This made 25.5% of participants who had taken a microbiology course and 21.4% who had not. The participants who rated antimicrobial therapy as a 5 included, n=63 participants who had taken a microbiology course and n=4 who had not. This selection resulted in 67% of all participants who had taken a microbiology course and 28.6% who did not (Table 40).

Table 40

Cross-Tabulation Comparison- If Participant took a Microbiology Course and Importance of Antimicrobial Therapy

		Microbiology Course Required?		
Rating		Yes	No	Total
1	Count	0	2	2
	% within antimicrobial therapy	0	100	100
	% within question 1	0	14.3	1.9
2	Count	1	0	1
	% within antimicrobial therapy	100	0	100
	% within question 1	1.1	0	0.9
3	Count	6	5	11
	% within antimicrobial therapy	54.5	45.5	100
	% within question 1	6.4	35.7	10.2
4	Count	24	3	27
	% within antimicrobial therapy	88.9	11.1	100
	% within question 1	25.5	21.4	25
5	Count	63	4	67
	% within antimicrobial therapy	94	6	100
	% within question 1	67	28.4	62
Total	Count	94	14	108
	% within antimicrobial therapy	87	13	100
	% within question 1	100	100	100

This data shows that participants who had been required to take a microbiology course as part of their education rated antimicrobial therapy, both oral and intravenous, higher and were more likely to choose a rating of 5 when compared to participants who had not been required to take a microbiology course. In contrast, participants who had not taken a course chose lower rating numbers when compared to participants who had taken a course. The correlation between participants taking a required microbiology course and the microbiology topic of antimicrobial therapy, both oral and intravenous, showed statistical significance, Fisher's Exact Test = 19.091, $p = .000$ (Table 41)

Table 41

Statistical Tests for Microbiology Course History and Antimicrobial Therapy

Statistical Tests	Value
Fisher's Exact Test	19.091
P Value	.000

No other associations between participants history in taking a microbiology course and rated microbiology topics in the last question of the survey were found to be statistically significant and included the following statistical test results: (a) Organism genetics and molecular testing methods, Fisher's Exact Test = 4.698, $p = .282$; (b) bio-terrorism agents, Fisher's Exact Test = .665, $p = .992$; (c) vaccinations, Fisher's Exact Test = 8.310, $p = .070$; (d) infection control and the epidemiology of infectious organisms, Fisher's Exact Test = 6.507, $p = .179$; (e) Healthcare acquired infections and disease transmission, Fisher's Exact Test = 6.049, $p = .096$; (f) performance of dilutions and serial dilutions, Fisher's Exact Test = 7.535, $p = .078$; (g) Specimen collection and handling, Fisher's Exact Test = 8.524, $p = .051$; (h) gram staining procedures, Fisher's Exact Test = 7.228, $p = .081$; (i) knowledge of how to work and operate the microscope, Fisher's Exact Test = 9.856, $p = .021$; (j) emphasis on the difference between

bacterial, parasitic, viral, and fungal infections as the different microorganism groups are classified, Fisher's Exact Test = 7.548, $p = .085$; (k) interpretation of the different culture results from blood, urine, stool, sputum, and wounds, Fisher's Exact Test = 5.019, $p = .292$; (l) knowledge of the differentiation of human normal flora and the various body parts versus pathogens, Fisher's Exact Test = 8.193, $p = .068$; (m) knowledge of the different groups of medically important pathogens such as gram negative vs. gram positive, anaerobic vs. aerobic, staphylococcus vs. streptococcus, and other pathogens, Fisher's Exact Test = 3.000, $p = .512$; Understanding antibiotic susceptibility results and the interpretation, Fisher's Exact Test = 7.069, $p = .117$ (Table 42).

Table 42

Statistical Test Values for Microbiology Course History and Various Microbiology Topics

Microbiology Topics	Fisher's Exact Test Value	P Value
Organism genetics and molecular testing methods	4.698	.282
Bio-terrorism agents	.665	.992
Vaccinations	8.310	.070
Infection control and epidemiology	6.507	.179
Healthcare acquired infections and disease transmission	6.049	.096
Dilutions/serial dilutions	7.535	.078
Specimen collection and handling	8.524	.051
Gram staining procedures	7.228	.081
Microscope operations	9.856	.021
Knowing difference between microorganism groups	7.548	.085
Interpretation of culture results	5.019	.292
Human flora vs. pathogens	8.193	.068
Knowing groups of pathogens	3.000	.512
Antibiotic susceptibility results	7.069	.117

Chapter V: Discussion and Conclusion

Discussion

The purpose of this study was to evaluate curricular relevance of existing pre-nursing microbiology education curricula as it relates to working nursing professionals. Participants were able to classify, based on their opinion, what microbiology education curriculum topics were relevant and irrelevant in nursing and pre-nursing education programs as these topics are applied in the nursing field. Demographic information was collected, information on participants required microbiology course, and application information of microbiology topics as perceived by participants. Because nurses were asked in the survey about their microbiology education and how it applies to their professional fields, the question can be answered: What microbiology topics, according to nurses who are working professionals, are relevant and irrelevant in application to nursing and pre-nursing education programs?

The first few questions of the survey provide demographic information to give an idea about which level of education pre-nurses are more inclined to obtain before becoming a nurse. In addition, information was gathered on registered nurse status and years spent in the field. The data shows that the majority of the nurses who took the survey had been working in the field for less than ten years. A factor for this result is because the survey was intentionally sent to recent Brigham Young University- Idaho graduates, but other potential factors would include populations who are more likely to participate in the study or indication of an unequal balance between younger nurses and older nurses.

Though most of the nurses surveyed worked in a hospital setting (69.1%), the spread of data between the different areas of specialization, types of infections, and different patient populations was fairly consistent and without trend, with the exception that more nurses worked

with adults as their main patient population. This data however does provide information on which topics and areas are more common above others and provides additional awareness when emphasizing topics in educational courses.

Regardless of the participants demographic information and background, trends were clear in Tables 9-14 that showed which microbiology topics were applicable and stood as a valued skill in the workforce. The microbiology topics selected were general microbiology topics that are commonly covered in general microbiology courses (Boise State University, 2020; Idaho State University, 2019; Northwest Nazarene University, 2019). This information helps to determine which of these topics in the current curricula are most applicable to nurses and which ones are not, at a general level. Principles of antibiotics and organism susceptibility and understanding the differences between bacterial, fungal, viral, and parasitic organisms were the two top rated topics according to participants, whereas skills in bacterial culturing and identification techniques, dilutions, gram stains, and microscope operations resulted in overall lower frequencies of importance (Tables 8-14).

The question regarding which university the participant attended was to attain a general idea of where most of the nurses in the specific Southeastern Idaho region were originating from as it pertains to local curricula. At the termination of the survey, it was determined that this question was very limited in the ability to provide valuable information because of the addition of the social media advertisement and recruitment that brought in participants from universities across the United States. Overall, however, a large percentage of participants originated from Idaho State University (24.1%), which was an unexpected result since many BYU-I nursing graduates were specifically targeted for the survey. This information may provide useful if future

attempts are made to re-evaluate curriculum at other influential universities in the Southeastern Idaho area.

In continuation with the questions pertaining to education, only the nurses who answered “yes” to having taken a required microbiology course were asked about the benefit of the course. In addition, they were asked questions regarding microbiology topics as they pertained to career benefit, workforce preparation, and if the course helped the participant gain an understanding of the clinical microbiology laboratory. These microbiology topics were based off the syllabus outline for the BYU-I Bio 222 general microbiology laboratory course that BYU-I’s pre-nursing students are required to take. The answers provide information of not only what is more relevant, but also which aspects of topics would help connect separate areas of the hospital as far as understanding job function. By understanding what happens to the patient’s samples and processes performed on them after collection, nurses would be able to perform their job function to the standard needed, as well as understand how patient results were obtained and the meaning of those results. Topics of handwashing and disease transmission and understanding principles of antibiotics, antiseptics, and disinfectants were rated the highest by participants as topics more relevant to their job, and understanding different microorganism groups and bacterial culturing and identification processes were rated the highest for nurses to understand the microbiology laboratory as it pertains to nurses.

In the last question of the survey, all nurses were asked about fifteen different microbiology topics that would be rated according to the opinion of the participant on what topics should be emphasized in nursing and pre-nursing courses. This helped provide information on topics that are currently both included and not included in the BIO 222 curriculum, as well as topics from the *Microbiology in Nursing and Allied Health (MINAH)*

Undergraduate Curriculum Guidelines as provided by Norman-McKay and the Committee for Microbiology in Nursing and Allied Health (2018). This allowed for a more accurate and complete comparison between various topic options.

Unsurprisingly, the topics of healthcare-acquired infection and disease transmission; infection control and epidemiology of infectious organisms; and vaccines were rated the highest of importance according to participants. These results were similar in findings to the survey performed by Durrant et al. (2017) where results deemed most important consisted of hospital-acquired infections, disease transmission, infectious control, and patient specimen collection and handling. The topics that nurses rated the least important for emphasis included gram staining procedure, dilutions, and knowledge on how to operate the microscope. These results, again, correlated with the findings of Durrant et al. (2017) where surveyed nurses also found gram staining and microscope operations of minimal relevance.

It was anticipated that the level of education, time spent working in the field, and completion of a microbiology course would be three factors that would influence the importance of microbiology topics and affect the data as viewed by nurse participants. It was anticipated that nurses who had used microbiology skills through longer work experience or who were able to see the application of microbiology topics through education may have seen more value in certain topics as compared to nurses who did not have this experience. It was found that this was true in the cross-tabulation analysis of education level against the various microbiology topics in the last question of the survey. Participants with a higher education level viewed antibiotic therapy with more importance than did participants who only had certifications or associate degrees. This was also true if participants had taken a microbiology class as part of their nursing education. Participants who had been required to take a course viewed antimicrobial therapy with

more importance than the participants who had not taken a course. Another factor that may have an influence on these results is workplace position. Nurses who maintain a lower ranked position may not see the importance of these topics because they do not have to utilize this knowledge when compared to a nurse who has more authority, who is in positions of superiority, or a nurse who provides prescription ability.

Survey Importance

Every nursing student preparing to enter the nursing program at BYU-I is required to take the Bio 222 laboratory course, and it is the only microbiology laboratory course that they will take before graduation. No study or evaluation of the course has been previously performed to determine topic relevance to the nursing field. For ease of study comparison in this next section, this current study will be referred to as the Vanorden (2020) study.

The Vanorden (2020) survey questions were based off the BYU-I Bio 222 General Microbiology Laboratory course curriculum and some questions loosely based from ideas and topics from the survey conducted by Durrant et al. (2017). Select demographic questions were similar between the surveys, such as those asking if the participant was a registered nurse, the number of years of working experience, the participants main patient population, and if the participant had taken a microbiology course. However, since Durrant et al. (2017) was specific only to the microbiology course at the University of Utah, there were additional topics that could be covered in the Vanorden (2020) survey. The Vanorden (2020) survey sought to determine the significant topics from the Bio 222 curriculum as it relates to a nursing career.

Twenty different topics were presented in the Durrant et al. (2017) survey. Some topics such as, microbiology cell biology, host defense mechanisms and immune reactions, infection in the immunocompromised host, and epidemics and pandemics were not specifically mentioned in

the Vanorden (2020) survey. Some of these topics were covered within larger topics in the Vanorden (2020) survey. Because the Vanorden (2020) survey was based off the BYU-I course curriculum, it also included additional topics that the Durrant et al. (2017) survey did not. Some of these topics included dilutions and serial dilutions, food microbiology, and knowledge of the differences between bacterial, parasitic, viral, and fungal infections. It was felt that all topics within the BYU-I curriculum should be presented in the survey to receive more specific feedback on specific course topics.

Limitations

This survey provided valuable information to contribute towards redesigning nursing and pre-nursing collegiate curriculum, but this study is not without its limitations. First, because of the nature of how this survey was dispersed, a complete response rate was not obtained, and the total number of survey responses was low. Because old emails were used when dispersing the survey to the BYU-I graduates, there was a very low rate of return (n=24). With a low number of hospitals and clinics participating, along with the busy workloads of nurses, the surveys disbursed directly to nurses through the hospitals and clinics also contributed to the low response rate.

In addition to a low response rate, there was the possibility of multiple submissions by participants. Though this would be unlikely because nurses are busy and the survey specifically asked that only one survey be submitted per participants, we cannot dismiss it as a possibility. The survey allowed multiple attempts on the same computer to compensate for computer sharing within hospitals. It was hoped that this function would allow for a greater return rate and be of more value than to limit one survey response per IP address.

Another limitation might be that nurses did not remember taking a microbiology course or details of the curriculum. The survey was set up to compensate for a lack of remembering certain details or topics about the required courses, however if participants didn't remember taking a class at all, it would have had an impact on question 10 which asked participants if they had taken a required microbiology course. In addition, survey questions can easily be misread or interpreted and therefore lead to selection of unintentional option choices. This situation does not seem to have been an issue within the survey but remains a possibility. Lastly, there was also the assumption that all participants were qualified to take the survey and were indeed nurses, however, there is no way to determine this from the research design.

Curriculum Recommendations

Microbiology topics in this survey represent relevant and irrelevant microbiology material as perceived by nurse participants. Recommendation for curricular revision based on these study results include greater emphasis on the following: (a) healthcare-associated infections; (b) disease transmission; (c) infection control; (d) infectious organisms; (e) vaccinations; (f) antimicrobial therapy; (g) antibiotic susceptibility; (h) interpretation of culture results; (i) differences between microorganism groups and the associated infections; (j) specimen collection and handling; (k) the differences between normal flora and pathogens. Topics requiring lower emphasis according to participants included the following: (a) organism genetics and molecular testing methods, bio-terrorism agents; (b) gram staining; (c) dilutions and serial dilutions; (d) microscope operations.

Many of these topics can be covered simultaneously such as microorganism groups, infectious organisms, and normal flora species. In addition, other topics that appear to have a lesser importance for emphasis can be incorporated and viewed as a contributing factor for

importance. The redesign of the course curriculum for the BYU-I Bio 222 laboratory course would include the following class periods:

1. A discussion of the different types of microorganisms, the human interaction of these microorganisms, and their pathogenicity will be held. Different classes of microorganisms would be emphasized, including the differences between bacteria, protozoans, fungi, viruses, and parasites. A hands-on portion would include microscopy use to view premade slides of clinically significant microorganisms, with slides being limited to non-bacterial organisms. Specific and significant pathogens would be selected, and characteristics of each species discussed with the students as they viewed each with the microscope.
2. The second lab would focus on bacterial microorganisms. This class would allow the students to gain a foundation in normal flora, pathogens, opportunistic pathogens, and patient factors. Because bacteria are more extensive, this second period would focus on bacterial pathogenicity and their differentiation when compared to Eukaryotes. Students would again perform hands-on microscopy techniques to view premade slides of significant bacterial organisms. Specific clinically significant pathogens would be selected, and characteristics of each species discussed with the students as they viewed each with the microscope.
3. Next would be an introduction of hands-on bacterial culturing with an emphasis on aseptic technique, and processes in the medical laboratory. This lab period would help students understand what happens to patient samples after collection and allow for an understanding of their role as a nurse when collecting those patient samples. In addition, students will learn about the environmental factors that microbes require.

4. Building from the previous class period, students will perform biochemical characteristic testing and learn about the key identification processes for the detection of pathogens. The effectiveness and usefulness of molecular identification processes would also be discussed.
5. During this lab, the significance of the gram stain would be emphasized to provide a firm understanding for students on how bacteria are classified, and the implication behind that classification regarding cell wall content and species characteristics. Students would perform hands-on gram staining procedures to visualize the mechanism of the gram stain principle. Gram staining will be tied into the material from the previous weeks so that students can comprehend the whole identification process.
6. Following the classes on culturing and gram staining, antibiotic susceptibility and antimicrobial stewardship would be introduced. Because students would have an understanding at this point on cell wall and classification characteristics, antibiotic function can be more thoroughly understood. Differences between gram-negative and gram-positive bacteria susceptibility characteristics can be highlighted. Emphasis on when to appropriately use bactericidal versus bacteriostatic antibiotics would be addressed. Current factors for antibiotic over-use and misuse would be covered with thorough emphasis on the consequences of antibiotic use for any infection other than bacterial.
7. Because the class period covering antimicrobial stewardship would be extensive, two class periods would be required. The first class period would allow students to set up the antibiotic susceptibility plates with different species of bacteria, the second class

- period would allow for interpretation of the results. Hands-on results and interpretation would help students visualize the mechanism of the principle. Functions of different antibiotics towards gram-positive and gram-negative bacteria could be addressed and would allow students to visualize the mechanism of different antibiotics towards different species and discussion of the affects within the patient. This second week would also serve to solidify principles in the week previous about the consequences of inappropriate antibiotic use, and help students gain an understanding of the mutation abilities that microbes have in becoming resistant to drugs. Steps to fight and prevent drug resistance would also be covered.
8. This next lab would be the hand washing lab. Students will culture their own hand bacteria before and after washing their hands using various methods such as hand sanitizer, water, and soap and water. Discussions on the importance of hand hygiene in both clinical and personal settings will be held. This would be a good lab to introduce food preparation and contamination, if needed, as well as discuss different methods of hand hygiene and when certain methods may be preferred over other methods for cleanliness. Importance of hand hygiene in a clinical setting will be stressed as it relates to hospital-associated infections and to patient transmission.
 9. An infectious disease simulation lab will build off the previous hand washing lab. The disease simulation lab will allow students to participate in the spread of a simulated disease throughout the classroom as students make contact with each other. Methods of disease control, vaccinations, epidemiology, nosocomial infection prevention, and transmission methods will all be addressed.
 10. Enumeration of microorganisms

A midterm could still be provided in the middle of the semester if desired, as well as a final at the end of the semester, creating a total of twelve class periods, one a week, throughout the semester. Dilutions, serial dilutions, and gram staining would be taught for one day rather than two, to allow for a more in-depth study of other clinical microbiology topics, such as antimicrobial stewardship. In depth presentation, cause and effect, patient factors, and hands-on application of these topics can be used to help students understand microorganisms and disease, and has the potential to help students see the role that they will play in disease contamination and prevention as a nurse.

Though it is true that many topics will not be used by nurses in their professional careers, certain topics such as understanding gram stain procedures and bacterial culturing are foundational aspects to microbiology and microorganism concepts and can help nurses be aware of proper aseptic techniques, sampling techniques for specimens, and bacterial classification. In addition, knowledge in these areas will help to address potential communication gaps between healthcare microbiology laboratories and nurses, especially in bacterial classification and offending organism workups. Explanation of these topics during student education on how these topics may relate, has the potential to change the perspective for level of importance. Further education may in turn, help increase knowledge retention.

Tying these topics into educational course-work may help in multiple ways: to help increase understanding of their relevance; fill in learning gaps to provide more emphasis on the clinical areas deemed important in this study; and to help create the design and reconstruction of required microbiology courses for nurses. Recommendations from this study will be used in the redesign of the microbiology course in attempts to create more work-ready and microbiology-learned graduates.

Future Research Possibilities

Study replication has the potential to change or provide deeper results if a wider range of nurses participate in the study. A higher response rate may influence the study in one of two ways: increase the statistical significance of microbiology topics when compared to education level, or show no statistical significance if more seasoned nurses participate. Comparison of the number of years that participants have worked in the field could also be compared to the sixteen microbiology topics to determine statistical significance.

Future studies have the potential to base curriculum off more specified nurse recommendations, compare graduate nurses against nurses who were taught general curriculum, or compare to nurses who were not required to take a microbiology course. Results of these further studies would show the benefit to the redesign of nursing microbiology courses. Additionally, in an effort to create more value in currently required microbiology courses, this study could be used as a foundational reference, along with others, for other universities to enrich microbiology course content for their nursing students.

Conclusion

With a strong foundational knowledge base and an increase in the understanding of microbiology principles, nurses would have the ability to meet professional requirements more effectively, to help prevent the spread of disease, help to prevent drug-resistance in microorganisms, and understand the importance of microbiology at it pertains to their work. Redesigning microbiology courses have the potential to help nurses understand their roles as they pertain to microbiology, retain important microbiology information, and allow them to apply these microbiology principles in the workforce. It is believed that the improvement of undergraduate coursework using the results of this study will contribute to the increase in

understanding of microbiology for graduating nurses. With a better understanding of microbiology, and the importance of personal application, a better retention of knowledge in the workplace may result, and nurses will be able to understand the importance of these topics as they pertain to the nursing careers and the impact on both patient care and personal and safety.

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Appendix A

BYU-I Participant Survey

1. Did you complete an Associates of Nursing or a Bachelor of Nursing at BYU-I?

- Associates
- Bachelors

2. Are you a Registered Nurse (RN)?

- Yes
- No

3. How many years of experience do you have working as a nurse or RN?

- Less than 1 yr.
- 1-5 yrs.
- 6-10 yrs.
- 11-15 yrs.
- 16-20 yrs.
- 20-25 yrs.
- 25-30 yrs.
- More than 30 yrs.

4. What is your primary place of work?

- Hospital
- Community

5. In what areas do you specialize?

- Emergency Department
- Labor and Delivery
- Psychiatric
- Surgery
- Critical or intensive care
- Oncology
- Acute care
- General
- Hospice
- Home health
- Specialty clinic
- Primary care
- Other

6. What kind of patient population do you normally work with? (mark all that apply)

- Adult
- Geriatric
- Pediatrics
- Adolescents
- Neonates and infants
- Other

7. Which type of infections are most common in your clinical practice? (mark all that apply)

- Wound, superficial
- Wound, deep
- Sepsis
- Skin/nail
- Eye
- Ear
- Joint
- Bone
- Gastrointestinal
- Urinary tract
- Internal organ
- Upper respiratory tract
- Lower respiratory tract
- Central nervous system
- Vaginal/sexually transmitted infections
- Venous or central line catheter
- Perinatal
- Bacterial
- Viral
- Fungal
- Parasitic/ protozoans

8. Please rate the following from 1-5, 5 being the most helpful/used skill in your professional career and 1 being the least helpful/used skill.

- Knowing how to work and operate the microscope.
- Knowing the differences between bacterial, fungal, and parasitic organisms.
- Hand washing and disease transmission.
- Performance of gram stains.
- Culturing bacteria and identification processes.
- Performance of dilutions and serial dilutions.
- Principles of antibiotics and organism susceptibility.

- Hand washing technique and disease transmission.

9. While attending school at BYU-I, did you take the class titled “General Microbiology Lab” course BIO 222?

- Yes
- No

10. Do you feel as if this class helped to prepare you for your professional career in nursing?

- Yes
- No

11. Which aspect of Bio 222 helped to prepare you the **most** for your professional career in nursing?

- Microscope knowledge
- Differences between bacterial, fungal, and parasitic species
- Hand washing and disease transmission
- Gram stain knowledge
- Culturing organisms and bacterial identification processes
- Dilutions and serial dilutions
- Food microbiology
- Antibiotic, antiseptic, and disinfectant knowledge
- I did not take/do not remember taking this class

12. Which aspect of Bio 222 helped you the most to understand the processes in the clinical microbiology laboratory?

- Microscope knowledge
- Differences between bacterial, fungal, and parasitic species
- Hand washing and disease transmission
- Gram stain knowledge
- Culturing organisms and bacterial identification processes
- Dilutions and serial dilutions
- Food microbiology
- Antibiotic, antiseptic, and disinfectant knowledge
- I did not take/do not remember taking this class

13. Which aspect of Bio 222 was **least** beneficial in preparing you for your professional career in nursing?

- Microscope knowledge
- Differences between bacterial, fungal, and parasitic species
- Hand washing and disease transmission
- Gram stain knowledge

- Culturing organisms and bacterial identification processes
- Dilutions and serial dilutions
- Food microbiology
- Antibiotic, antiseptic, and disinfectant knowledge
- I did not take/do not remember taking this class

14. Which of the following should be given more emphasis in pre-nursing degrees to better prepare students for professional nursing careers? Please rate 1-5, with 5 requiring the most amount of emphasis and 1 requiring the least amount of emphasis.

- Antimicrobial therapy, both oral and intravenous.
- Organism genetics and molecular testing methods (such as PCR).
- Bioterrorism agents.
- Vaccinations.
- Infection control and the epidemiology of infectious organisms.
- Healthcare acquired infections and disease transmission.
- Performance of dilutions and serial dilutions.
- Specimen collection and handling.
- Gram staining procedures.
- Knowledge of how to work and operate the microscope.
- Emphasis on the differences between bacterial, parasitic, and fungal infections.
- Interpretation of the different culture results from blood, urine, stool, sputum, and wounds.
- Knowledge of the differentiation of human normal flora and the various body parts vs. pathogens.
- Knowledge of the different groups of medically important pathogens such as gram negative vs. gram positive, anaerobic vs. aerobic, staphylococcus vs. streptococcus, and other pathogens.
- Understanding antibiotic susceptibility results and the interpretation.

15. If you would like to enter to win a \$25 Amazon gift card as a “thank you” for completing this survey, please enter an email address below.

Please submit only one survey and email address per person.

Email submission is optional.

Appendix B
Undistributed Survey with First Modification

1. What level of nursing education do you poses?

- CNA
- Associates
- Bachelors
- Masters
- Doctorate
- Other

2. Are you a Registered Nurse (RN)?

- Yes
- No

3. How many years of experience do you have working as a nurse or RN?

- Less than 1 yr.
- 1-5 yrs.
- 6-10 yrs.
- 11-15 yrs.
- 16-20 yrs.
- 20-25 yrs.
- 25-30 yrs.
- More than 30 yrs.

4. What is your primary place of work?

- Hospital
- Community

5. In what areas do you specialize?

- Emergency Department
- Labor and Delivery
- Psychiatric
- Surgery
- Critical or intensive care
- Oncology
- Acute care
- General
- Hospice
- Home health
- Specialty clinic

- Primary care
- Other

6. What kind of patient population do you normally work with? (mark all that apply)

- Adult
- Geriatric
- Pediatrics
- Adolescents
- Neonates and infants
- Other

7. Which type of infections are most common in your clinical practice? (mark all that apply)

- Wound, superficial
- Wound, deep
- Sepsis
- Skin/nail
- Eye
- Ear
- Joint
- Bone
- Gastrointestinal
- Urinary tract
- Internal organ
- Upper respiratory tract
- Lower respiratory tract
- Central nervous system
- Vaginal/sexually transmitted infections
- Venous or central line catheter
- Perinatal
- Bacterial
- Viral
- Fungal
- Parasitic/ protozoans

8. Please rate the following from 1-5, 5 being the most helpful/used skill in your professional career and 1 being the least helpful/used skill.

- Knowing how to work and operate the microscope.
- Knowing the differences between bacterial, fungal, and parasitic organisms.
- Hand washing and disease transmission.
- Performance of gram stains.
- Culturing bacteria and identification processes.

- Performance of dilutions and serial dilutions.
- Principles of antibiotics and organism susceptibility.
- Hand washing technique and disease transmission.

9. Which university did you attend to acquire your nursing degree?

- Boise State University
- College of Southern Idaho
- Idaho State University
- College of Eastern Idaho (Eastern Idaho Technical College)
- Brigham Young University-Idaho
- Utah State University
- Brigham Young University- Provo
- Other

10. While attending school, did you take a required microbiology course?

- Yes
- No

Condition: If “No” is selected, skip to: Question 15.

11. Do you feel as if your microbiology course helped to prepare you for your professional career in nursing?

- Yes
- No

12. Which aspect of your course helped to prepare you the **most** for your professional career in nursing?

- Microscope knowledge
- Differences between bacterial, fungal, and parasitic species
- Hand washing and disease transmission
- Gram stain knowledge
- Culturing organisms and bacterial identification processes
- Dilutions and serial dilutions
- Food microbiology
- Antibiotic, antiseptic, and disinfectant knowledge
- I did not take/do not remember taking this class

13. Which aspect of your course helped you the **most** to understand the processes in the clinical microbiology laboratory?

- Microscope knowledge
- Differences between bacterial, fungal, and parasitic species
- Hand washing and disease transmission

- Gram stain knowledge
- Culturing organisms and bacterial identification processes
- Dilutions and serial dilutions
- Food microbiology
- Antibiotic, antiseptic, and disinfectant knowledge
- I did not take/do not remember taking this class

14. Which aspect of your course helped to prepare you the **least** for your professional career in nursing?

- Microscope knowledge
- Differences between bacterial, fungal, and parasitic species
- Hand washing and disease transmission
- Gram stain knowledge
- Culturing organisms and bacterial identification processes
- Dilutions and serial dilutions
- Food microbiology
- Antibiotic, antiseptic, and disinfectant knowledge
- I did not take/do not remember taking this class

15. Which of the following should be given more emphasis in pre-nursing degrees to better prepare students for professional nursing careers? Please rate 1-5, with 5 requiring the most amount of emphasis and 1 requiring the least amount of emphasis.

- Antimicrobial therapy, both oral and intravenous.
- Organism genetics and molecular testing methods (such as PCR).
- Bioterrorism agents.
- Vaccinations.
- Infection control and the epidemiology of infectious organisms.
- Healthcare acquired infections and disease transmission.
- Performance of dilutions and serial dilutions.
- Specimen collection and handling.
- Gram staining procedures.
- Knowledge of how to work and operate the microscope.
- Emphasis on the differences between bacterial, parasitic, and fungal infections.
- Interpretation of the different culture results from blood, urine, stool, sputum, and wounds.
- Knowledge of the differentiation of human normal flora and the various body parts vs. pathogens.
- Knowledge of the different groups of medically important pathogens such as gram negative vs. gram positive, anaerobic vs. aerobic, staphylococcus vs. streptococcus, and other pathogens.
- Understanding antibiotic susceptibility results and the interpretation.

16. If you would like to enter to win a \$25 Amazon gift card as a “thank you” for completing this survey, please enter an email address below.

Please submit only one survey and email address per person.

Email submission is optional.

Appendix C

Hospital/Clinic and Social Media Survey

1. What is your **highest** level of nursing education? (Please focus on college education rather than licenses obtained for this question unless no college diploma was acquired)

- Certification only (Ex: CAN)
- Associates
- Bachelors
- Masters
- Doctorate

2. Are you a Registered Nurse (RN)?

- Yes
- No

3. How many years of experience do you have working as a nurse or RN?

- Less than 1 yr.
- 1-5 yrs.
- 6-10 yrs.
- 11-15 yrs.
- 16-20 yrs.
- 20-25 yrs.
- 25-30 yrs.
- More than 30 yrs.

4. What is your primary place of work?

- Hospital
- Community
- Clinical
- Other

5. In what areas do you specialize?

- Emergency Department
- Labor and Delivery
- Psychiatric
- Surgery
- Critical or intensive care
- Oncology
- Acute care
- General

- Hospice
- Home health
- Specialty clinic
- Primary care
- Other

6. What kind of patient population do you normally work with? (mark all that apply)

- Adult
- Geriatric
- Pediatrics
- Adolescents
- Neonates and infants
- Other

7. Which type of infections are most common in your clinical practice? (mark all that apply)

- Wound, superficial
- Wound, deep
- Sepsis
- Skin/nail
- Eye
- Ear
- Joint
- Bone
- Gastrointestinal
- Urinary tract
- Internal organ
- Upper respiratory tract
- Lower respiratory tract
- Central nervous system
- Vaginal/sexually transmitted infections
- Venous or central line catheter
- Perinatal
- Bacterial
- Viral
- Fungal
- Parasitic/ protozoans

8. Please rate the following from 1-5, 5 being the most helpful/used skill in your professional career and 1 being the least helpful/used skill.

- Knowing how to work and operate the microscope.
- Knowing the differences between bacterial, fungal, and parasitic organisms.

- Hand washing and disease transmission.
- Performance of gram stains.
- Culturing bacteria and identification processes.
- Performance of dilutions and serial dilutions.
- Principles of antibiotics and organism susceptibility.
- Hand washing technique and disease transmission.

9. Which university did you attend to acquire your nursing degree?

- Boise State University
- College of Southern Idaho
- Idaho State University
- College of Eastern Idaho (Eastern Idaho Technical College)
- Brigham Young University-Idaho
- Utah State University
- Brigham Young University- Provo
- Other

10. While attending school, did you take a required microbiology course?

- Yes
- No

Condition: If “No” is selected, skip to: Question 15.

11. Do you feel as if your microbiology course helped to prepare you for your professional career in nursing?

- Yes
- No

12. Which aspect of your course helped to prepare you the **most** for your professional career in nursing?

- Microscope knowledge
- Differences between bacterial, fungal, and parasitic species
- Hand washing and disease transmission
- Gram stain knowledge
- Culturing organisms and bacterial identification processes
- Dilutions and serial dilutions
- Food microbiology
- Antibiotic, antiseptic, and disinfectant knowledge
- I did not take/do not remember taking this class

13. Which aspect of your course helped you the **most** to understand the processes in the clinical microbiology laboratory?

- Microscope knowledge
- Differences between bacterial, fungal, and parasitic species
- Hand washing and disease transmission
- Gram stain knowledge
- Culturing organisms and bacterial identification processes
- Dilutions and serial dilutions
- Food microbiology
- Antibiotic, antiseptic, and disinfectant knowledge
- I did not take/do not remember taking this class

14. Which aspect of your course helped to prepare you the **least** for your professional career in nursing?

- Microscope knowledge
- Differences between bacterial, fungal, and parasitic species
- Hand washing and disease transmission
- Gram stain knowledge
- Culturing organisms and bacterial identification processes
- Dilutions and serial dilutions
- Food microbiology
- Antibiotic, antiseptic, and disinfectant knowledge
- I did not take/do not remember taking this class

15. Which of the following should be given more emphasis in pre-nursing degrees to better prepare students for professional nursing careers? Please rate 1-5, with 5 requiring the most amount of emphasis and 1 requiring the least amount of emphasis.

- Antimicrobial therapy, both oral and intravenous.
- Organism genetics and molecular testing methods (such as PCR).
- Bioterrorism agents.
- Vaccinations.
- Infection control and the epidemiology of infectious organisms.
- Healthcare acquired infections and disease transmission.
- Performance of dilutions and serial dilutions.
- Specimen collection and handling.
- Gram staining procedures.
- Knowledge of how to work and operate the microscope.
- Emphasis on the differences between bacterial, parasitic, and fungal infections.
- Interpretation of the different culture results from blood, urine, stool, sputum, and wounds.
- Knowledge of the differentiation of human normal flora and the various body parts vs. pathogens.

- Knowledge of the different groups of medically important pathogens such as gram negative vs. gram positive, anaerobic vs. aerobic, staphylococcus vs, streptococcus, and other pathogens.
- Understanding antibiotic susceptibility results and the interpretation.

16. If you would like to enter to win a \$25 Amazon gift card as a “thank you” for completing this survey, please enter an email address below.

Please submit only one survey and email address per person.

Email submission is optional.

Appendix D

Survey Cover Letter

Greetings,

My name is Randie Van Orden, and I am a graduate student with Idaho State University. The purpose of this email is to disseminate a survey to gather information about participants microbiology education, particularly in nursing students. We hope that the findings of this survey will serve to better shape the microbiology course objectives, curriculum design, and professional relevance of microbiology coursework for pre-professional healthcare students. The survey is brief and should only take five to ten minutes of your time.

Participation in the survey is voluntary and responses are anonymous. Participants have the right to decline to answer questions or withdraw/terminate participation at any time. An optional email entry for a drawing to win a \$25 Amazon gift card will be available as a thank you for your participation in this survey. Only complete and submitted surveys will be entered in the drawing. If you have questions, concerns, or feel as if you have been harmed in this research study, please contact Randie Van Orden at (email inserted here). If you have a question or concern and do not feel comfortable speaking with the primary investigator, or if you have questions regarding your rights as a research participant, please contact the institutional review board (IRB) at Idaho State University at (208) 282-2179.

The return of this online survey is your consent to participate in this research project.

Please follow the link below to begin the survey, and again, we greatly appreciate your time.

(Survey link inserted here)

Randie Van Orden, MLS (ASCP)^{cm}

(email inserted here)