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Knowledge and Perceptions of Antibiotic Resistance Stewardship Among Prehealth and Agriculture Students

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Abstract

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Claudia Maria Da Silva Carvalho

MS, Fort Hays State University 2009

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Dissertation Submitted in Partial Fulfillment

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Abstract

The global threat of antibiotic resistant infection has resulted in health organizations to compile an antibiotic stewardship program, in which the education of current/future medical prescribers and farmers is central for the preservation of current and future antimicrobial treatments. The purpose of this study was to assess and compare the knowledge and perceived threat of antibiotic and antibiotic resistance, as well as the perceived benefit of antibiotic stewardship, among undergraduate students in biology and agriculture at a state university in Kansas. Framed by the health belief model, a cross-sectional study was conducted using a structured online survey of 136 undergraduate students. A chi-square analysis was used to assess the differences (if any) between the respondents in their knowledge and perceptions of antibiotics, antibiotic resistance, and antibiotic stewardship. Results showed that, although undergraduates in agriculture perceived antibiotic resistance as less threatening than undergraduates in biology/prehealth, both undergraduate groups are knowledgeable of the problem and would like more academic education on the issue. Knowledge and perceptions of antibiotic resistance and education increase as undergraduate move up in their class classification, suggesting that as students complete their undergraduate academic career, they would like to be better educated on antibiotic usage and risks before starting their professional career. The findings of this study created a good foundation to initiate a conversation on the curriculum development to meet ASP goals and objectives. Education on the role of antibiotics is relevant to further control the dissemination of antibiotic resistance and protect antimicrobial based treatment. This study contributes to an ongoing international effort to educate future prescribers on the importance of antibiotics in medicine and reduce antibiotic resistance.

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Dedication

This dissertation is dedicated to my Grand-Mother “Vovo” who always believed in me and would be the proudest of my accomplishments. I know she is watching over me.

Acknowledgments

I would like to thank my parents, Jose Carvalho and Nina Da Silva, for giving me the foundation necessary to follow my dreams and ambitions. Thank you, Mom and Dad. I would like also to acknowledge my siblings, Italo, Taisa, and Mario, for always giving me the support I needed to keep going. And lastly, I would like to thank all my friends, colleagues, and faculty who have encouraged me and provided all the guidance necessary for me to finish my doctorate.

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Chapter 1: Introduction to the Study

Since the late 1920s, the introduction of antibiotic drugs in medicine and agriculture has had a noteworthy effect on decreasing morbidity and mortality rates and in preventing diseases in humans and livestock (Lobanovska & Pilla, 2017). For more than 50 years, antibiotic-resistant bacteria have started to arise, resulting in many available antibiotics no longer being useful to fight bacterial infections. Currently, with more than 150 antibiotics drugs available commercially, at least 50% of these drugs are no longer effective in treatment due to emerging resistant bacteria (Lobanovska & Pilla, 2017). Consequently, antibiotic resistance has become a menace to public health worldwide.

As antibiotic resistance became an international public health threat, the U.S. government declared a National Action Plan to Combat Antibiotic-Resistant Bacteria in 2014. The National Action Plan called for the improvement of antibiotic prescribing as a key prevention strategy. With the collaboration of the World Health Organization (WHO) and the United Nations (UN), the Centers for Disease Control and Prevention (CDC) launched the antibiotic stewardship programs (ASPs) initiatives. The initiatives aim to invest in national substructure to detect, respond to, contain, and prevent resistant infections across healthcare settings, food, and communities (CDC, 2019). The overall objectives of ASPs are (a) to detect, respond, and contain resistant pathogens; (b) to prevent the spread of the resistant infections; and finally, (c) to boost novelty strategies for drugs and diagnostics (CDC, 2019).

Nonetheless, the introduction of a coordinated antibiotics stewardship initiative suggests that the public understanding of antibiotic stewardship is a prerequisite for enforcing the suitable practice of antibiotics and restraining the spread of antibiotic resistance (Carter, Sun, & Jump, 2016). Past researchers have focused on the role of healthcare providers and patients for excessive use and misuse of antibiotics in the community. Such studies suggest that the rational use of antibiotics drugs is ultimately achieved by modifying the prescribing behaviors and knowledge of the healthcare providers and the behavior of patients (AfzalKhan, Banu, & Reshma, 2013). Moreover, several other studies have focused on the regulation and enforcement of antibiotic use in agriculture in the aim to detect and control antibiotic use in farming. Welsh et al. (2019) suggested that in many unindustrialized countries, the level and rate of antibiotic usage in the farming sector ultimately are influenced by the manner in which most farmers obtain over the counter antibiotics and use these antibiotics in multiple practices. Nonetheless, the prescription and administration of antibiotics to farm animals are eventually supervised by veterinarians (Welsh et al., 2019). Several researchers have found that veterinarians significantly influence the attitude of farmers toward antibiotic use.

Recently, there has been a shift towards the training of medical students on the concept of antibiotic stewardship and appropriate prescribing behaviors and stricter enforcement of antibiotic stewardship in the medical field, but a lower level of antibiotic knowledge and use in agriculture (Martin, Thottathil, & Newman, 2015). With regard to agriculture education, little attention has been given to antibiotics in training prehealth and agriculture undergraduate students, and little is known on the difference in their perceptions and knowledge on this topic or the acceptability of antibiotic stewardship for compliance in the future (Feiring & Walter, 2017). Therefore, the purpose of this study was to examine the difference in the perception of agriculture and prehealth undergraduate students on antibiotics and antibiotic stewardship. The anticipated social change includes a foundation in developing undergraduate engaged learning techniques and outcomes on antibiotic stewardship relevant to the different needs of the prehealth and agriculture students.

In Chapter 1, I highlight the problem of antibiotic resistance, some of the current strategies in healthcare settings and community settings, and the need for reinforcing guidelines and educating future generations on the suitable and rational use of antibiotics. I explore the gap in knowledge and perceptions between undergraduate students and introduce the problem as determined by the literature gap. I present the theoretical framework of the study. I conclude the chapter with the assumptions, scope, and limitations relevant to the study.

Background

Antibiotics are defined as natural products extracted from microorganisms that target only bacteria and, therefore, are intended to treat and prevent bacterial infections (Aslam et al., 2018). Since the discovery of the first antibiotic, penicillin, in 1928 by Alexander Fleming, antibiotics have been the forefront treatment tools for many infectious diseases (Lobanovska & Pilla, 2017). The period between the 1940s and 1970s marked the antibiotic era with not only the purification and the introduction of penicillin in clinical trials but the discovery and introduction of new antibiotics, such as streptomycin, tetracycline, erythromycin, methicillin, gentamicin, and vancomycin (Lobanovska & Pilla, 2017). As one of the greatest milestones in modern medicine, the introduction of antibiotics has changed the course of human history, saving thousands of lives each year since the 20th Century (Lobanovska & Pilla, 2017). Worldwide, the enforcement of antibiotics in the medical field has had a significant impact in treating infectious communicable diseases, resulting in the reduction of morbidity and mortality rates in most countries (Adedeji, 2016). The United States and many other developed countries have recorded a significant shift of leading causes of deaths from communicable infectious diseases, such as sexually transmitted diseases, to noncommunicable diseases, such as cancers and cardiovascular diseases. The improvement of health has ultimately affected the average life expectancy by increasing life expectancy from an average of 47 years to 79 years in most industrialized countries (Adedeji, 2016). In developing countries, despite poverty, inadequate public health measures, poor sanitation, and poor vaccination coverage, a significant improvement has been recorded in the prevalence rate of many infectious diseases, such as tuberculosis and syphilis, positively affecting infant and maternal mortality and morbidity rates (Adedeji, 2016). In the present day, more than 150 antibiotics are now available commercially and have been used in many capacities ranging from medicine to veterinary medicine to agricultural uses as growth promoters and prevention of infection in livestock (Lobanovska & Pilla, 2017).

The 78th anniversary of the first systematic administration of antibiotics in humans was celebrated in 2019, and the discovery and introduction of antibiotics in modern medicine and agriculture is no doubt one of the greatest accomplishments of the humanity. Nonetheless, as Alexander Fleming predicted in early 1945, there will be an era in which antibiotics will no longer be effective due to the supply and demand of the public (Ventola, 2015). Indeed, soon after the administration of penicillin, researchers highlighted the first *Escherichia coli* strain capable of resisting and inactivating penicillin by secreting an enzyme called penicillinase (Ventola, 2015). Years later, in the 1960s, more antibiotic-resistant bacteria started to arise, resulting in many community and hospital antibiotic resistant infections, such as Methicillin-Resistant *Staphylococcus aureus* and Vancomycin-Resistant *Enterococcus* (Ventola, 2015). Currently, with more than 150 antibiotics drugs available, at least 50% of these drugs are no longer effective due to emerging resistant bacteria (Lobanovska & Pilla, 2017). Consequently, with multiple bacterial strains resistant to antibiotics and the appearance of multiresistant bacteria, called "superbugs," antibiotics have declined in effectiveness. One current concern in medicine is the recorded resistance against the carbapenems, a class of highly effective antibiotic agents that possess the broadest spectrum of activity against Gram-positive and Gram-negative bacteria, which are often used as the last resort for treating infections harboring resistant bacteria (Papp-Wallace, Endimiani, Taracila, & Bonomo, 2011). Several reports have indicated that resistance against carbapenems antibiotics is usually facilitated with long term care treatment. Although the prevalence of carbapenems-resistant infections is still low, growing evidence suggests nonactive surveillance and poor detection methods are among the factors explaining this low prevalence (Zaman et al., 2017). Overall, antibiotic resistance is a dynamic problem caused by overpopulation, boosted global migration, increased use of antibiotics in clinics and animal production, wildlife spread, and inadequate sanitation and sewerage disposal system (Zaman et al., 2017).

Causes of Antibiotic Resistances

Due to the emergence, spread, and persistence of multidrug-resistant bacteria, known as superbugs, antibiotic resistance poses a serious global threat of growing concern to humans, animals, and environmental health. More often, in nature, bacteria have the ability to fight off other bacteria through competition (Habboush & Guzman, 2018). It is only natural that those microorganisms have a very distinct process that boosts resistance. In many of its aspects, human behavior is additionally a source of this evolution. There is a direct connection between the consumption of antibiotics and the appearance and diffusion of resistant bacteria strains in both medicine and agricultural fields (Boeckel et al., 2014). Worldwide, antibiotics have been a drug of preference that is often overused and mishandled by patients, medical officers, and farmers. Boeckel et al. (2014) revealed that between 2000 and 2010 globally, the rise of antibiotic consumption, as well as the consumption of last resort antibiotic drugs, has raised serious concerns for public health. The researchers concluded that in order to prevent a striking rise of antibiotic resistance and preserve antibiotic efficacy worldwide, programs that promote rational use through coordinated efforts by all communities should be a priority (Boeckel et al., 2014).

In many rural areas in the United States, the implication of agricultural antibiotics in the rise and spread of clinical antibiotic resistance is a matter of continuous debate and disagreement (Chang, Wang, Regev-Yochay, et al., 2015). Under most current food-animal production practices, the use of antibiotics has a therapeutic use as well as a sub-therapeutic use to promote animal performance and feed efficiency, which thereby contribute to lower cost of meat, eggs, and other animal-based products (Armbruster & Roberts, 2018). The frequent idea that subtherapeutic antibiotic use should be banned completely might not seem feasible for economic value. Based on economic analysis conducted by the Committee on Drug Use in Food Animals, this specific practice has allowed farmers to maintain large numbers of animals in a healthy state at a lower cost per unit (Armbruster & Roberts, 2018). Eliminating this practice would ultimately reduce or lose production advantages affecting higher cost for consumers.

Coordinated Antibiotic Stewardship

There is evidence that increased antibiotic use is directly associated with a higher prevalence of resistant microorganisms. To respond to the crisis, the Infectious Diseases Society of America, the Society for Healthcare Epidemiology of America, and the Pediatric Infectious Diseases Society have defined antibiotic stewardship as “coordinated interventions designed to improve and measure the appropriate use of antibiotic agents by promoting the selection of the optimal antibiotic drug regimen including dosing, duration of therapy, and route of administration” (as cited in Doron & Davidson, 2011, pg.1114). Launched in 2009 by the CDC, antibiotic stewardship is a rational, systematic approach to use antibiotic agents to improve the outcomes (as cited in Doron & Davidson, 2011). The development of the ASP focuses on public awareness, education, global surveillance, and the reduction of antibiotic use in agriculture (Feiring & Walter, 2017). Barlam et al.

(2016) described stewardship intervention programs as strategies to improve patient outcomes, reduce adverse events, such as nosocomial infections, improve rates of antibiotic susceptibilities, and ultimately, optimize resources.

In healthcare settings, ASP is based on quality improvement. Evidence-based guidelines and protocols have been developed to improve patient care in a safe and timely manner. Those strategies require optimal coordination of trained staff and adequate resources (Feiring & Walter, 2017). Many researchers have examined the behavior of health care providers, such as nurses and physicians, employed to address the challenges and impact of the antibiotic stewardship efforts (Feiring & Walter, 2017). As a result, these researchers offered insights on developing a system that provides adequate resources, training, and multidisciplinary efforts for healthcare providers (Feiring & Walter, 2017). In community settings, education and training play important roles in achieving ASP goals and objectives. Previous work noted strategies and passive educational activities should be used to complement other stewardship activities. Furthermore, because of the longitudinal aspect of this particular health issue, many of those education programs must be sustainable (Ashiru-Oredope et al., 2018). Such studies revealed that academic medical centers and teaching hospitals should immediately integrate education on fundamental antibiotic stewardship principles into their preclinical and clinical curricula (Ashiru-Oredope et al., 2018).

Problem Statement

Despite the creation and development of ASP both in healthcare settings and agricultural community settings, the overuse and inappropriate use of antibiotics still affects antibiotic effectiveness. Although the rate of chronic infectious diseases has been falling globally, progress towards the treatment of multidrug-resistant chronic infections is, ultimately, a major challenge (Belard et al., 2014). The frequency with which doctors prescribe antibiotics varies between states within the United States and between other countries (Chem, Anong, & Akoachere, 2018). Currently, the reasons for this disparity are under investigation, and such studies might share light on strategies to improve antibiotic prescribing (Chem, Anong, & Akoachere, 2018). In Kansas alone, since the introduction of ASP, over 90% of individuals of all ages are still prescribed antibiotics (Walle-Hansen & Hoyes, 2018). However, etiology of infection is only recorded in 7.6% of cases of patients hospitalized with a community-acquired infection (Walle-Hansen & Hoyes, 2018). Consequently, treatment indication, choice of the chemotherapeutic agent, or even duration of antibiotic therapy is incorrect in 30% to 50% of the cases (Walle-Hansen & Hoyes, 2018). This evidence suggests that there is still improvement needed in antibiotic prescribing by physicians. In addition to misuse and overuse of antibiotic prescription, Martin et al. (2015) noted that of all the antibiotics available nowadays for medical purposes, 70% are also being used in the preservation of livestock. They revealed that despite the strict enforcement of antibiotic stewardship in the medical field, there is a lower level of knowledge and perceptions of antibiotic use in agriculture (Martin et al., 2015). Many countries have already restricted the use of medical antibiotics in animal agriculture. In 2006, the European Union banned the use of antimicrobial growth promoters in animal food and water (Martin et al., 2015). However, in the United States, progress in restricting antibiotic use in livestock has been slow at the federal level (Martin et al., 2015).

The implementation of a coordinated antibiotics stewardship initiative suggests that the public understanding of antibiotic stewardship is a prerequisite for enforcing the appropriate use of antibiotics and limiting the spread of antibiotic resistance (Carter et al., 2016). Still, the American public's perceptions and knowledge about antibiotic stewardship in agriculture as well as in medicine, specifically in American rural communities, are a matter of ongoing debate (Carter et al., 2016).

In the past, the role of healthcare providers for excessive use of antibiotics in the community has been addressed suggesting that the rational use of antibiotics drugs is ultimately achieved by regulating the prescribing behaviors and knowledge of the healthcare providers (AfzalKhan et al., 2013). There has been a shift towards the training of medical students on the concept of antibiotic stewardship and appropriate prescribing behaviors (Seid & Hussen, 2018). However, this topic has received little attention in training agriculture students. In addition, there is virtually no research on the place of antibiotic stewardship among undergraduate students who want to pursue a health-related career, known as Biology/Prehealth students, or those pursuing a career in agriculture and horticulture, known as Agriculture students. In my study, I aim to fill this gap by examining the differences in knowledge and perceptions of antibiotic stewardship between these two groups of students (see Feiring & Walter, 2017).

Purpose of the Study

The purpose of this study was to assess and compare the knowledge and perceptions (notably perceived threat and benefits) of stewardship of antibiotics among undergraduate biology prehealth and agriculture students in a rural university in Kansas and to determine how students' attitudes, behaviors, and knowledge could influence their antibiotic stewardship decision making in their future professional career. The topic of antibiotic resistance stewardship is not covered in most curriculum for either the biology prehealth students or the agriculture students. However, antibiotic resistance and bacteria evolution is covered in the introduction to biology course and microbiology course, and both groups of students have equal opportunity to enroll in these two courses based on their major curriculum. Thus, students should have a knowledge of bacteria and bacteria resistance mechanisms. At the undergraduate level, relevant training for antibiotic resistance and stewardship are either limited or nonexistent depending on the 4-year institutions.

Given the gap highlighted in the introduction above, a curriculum review is increasingly important for increasing knowledge, and the findings of the study could assist in developing and incorporating undergraduate learning techniques of antibiotic stewardship relevant to the different needs of the prehealth and agriculture students, such as active learning pedagogies including practicums and field experiences. In this study, I quantitatively examined the level of differences in knowledge and perceptions of antibiotic stewardship between health and agriculture undergraduates at Fort Hays State

University, a rural science, technology, engineering, and math (STEM) College in Kansas.

Research Questions and Hypotheses

In this study, I answered the following three research questions:

Research Question 1: Are there differences in the knowledge of antibiotic resistance in prehealth students compared to agriculture students?

$H_0$1: There are no statistically significant differences in the knowledge of antibiotic resistance and antibiotic stewardship between prehealth students and agriculture students.

H_a1: There is a statistically significant difference in the knowledge of antibiotic resistance between prehealth students and agriculture students.

Research Question 2: Are there differences in the perceived threats of antibiotic resistance in prehealth students compared to agriculture students?

$H_0$2: There are no statistically significant differences in the perceived threat of antibiotic resistance between prehealth students and agriculture students.

H_a 2: There is a statistically significant difference in the perceived threat of antibiotic resistance between prehealth students and agriculture students.

Research Question 3: Are there differences in the perceived benefit of antibiotic resistance education in stewardship in prehealth students compared to agriculture students?

*H_0*3: There are no statistically significant differences in the perceived benefit of antibiotic resistance education in stewardship between prehealth students and agriculture students.

*H_a*3: There is a statistically significant difference in the perceived benefit of antibiotic resistance education in stewardship between prehealth students and agriculture students.

Theoretical Foundation

In this study, the theoretical framework was the health belief model (HBM), which attempts to explain and predict behavior change by using six concepts (risk susceptibility, risk severity, benefit to action, barriers to action, self-efficacy, and cues for action. Bishop, Baker, Boyle, & Mackinnon, 2014). First developed in the 1950s by social psychologists Hochbaum, Rosenstock, and Kegels, the HBM is one of the original models which uses behavioral science theories to explain healthy behavior change (Jones et al., 2015). Often, the model is comprehensive and offers to prevention programs an explanation of the correlation between variables, such as beliefs, norms, parental influences, education (for examples), and behavior (Jones et al., 2015). In the present days, researchers have used the HBM model to seek to advance this theory as an explanatory framework for validating communication in research (Jones et al., 2015). For example, in 2009, following the swine flu outbreak, the HBM was used to evaluate the impact of a campaign on the flu vaccine. Researchers eventually determined how the exposure of the campaign was positively related to vaccination behavior (Jones et al., 2015). Statistical evaluations permitted the authors of the study to support the model where the findings showed a direct effect of exposure on behavior through perceived barriers and benefits (Jones et al., 2015).

Heid, Knobloch, Schulz, and Safdar (2016) used the HBM as a framework to develop questions in a semistructured interview to identify themes associated with patients' perceptions of antibiotic use and the role of patients in antimicrobial stewardship. They revealed a vital role of patients in improving antibiotic use in hospitals by suggesting that the likelihood of patient engagement in stewardship practices can be limited by low perceived susceptibility and lack of cues to act (Heid et al., 2016). Likewise, I used the HBM to provide a theoretical framework to explain how students' perceptions and knowledge affect their role and involvement in antibiotic stewardship in the future during their career. The use of the HBM to assess student perceptions and knowledge while still attending university can represent a theoretically grounded approach describing the potential role of premed and agriculture students as engaged and active participants in antibiotics stewardship in their careers, hence adding a possible successful strategy in the academic curriculum to promote correct antibiotic use. A study questionnaire was developed based on the HBM constructs to assess perceived threat and severity of antibiotic resistance and perceived benefits of antibiotic stewardship between two groups of undergraduate students.

Nature of the Study

I used a structured survey to collect data. The survey was distributed online via Survey Monkey and was organized in four sections: demographic data (age, gender, race, college classification, household income, and first-generation college student), questions assessing knowledge about antibiotic resistance and stewardship, questions assessing perceived threat of antibiotic resistance, and questions assessing the perceived benefit of antibiotic resistance education. The online survey was distributed to biology/prehealth, and agriculture students enrolled during the 2019-2020 academic year at Fort Hays State University. By using a quantitative approach design to assess the knowledge and perceptions of antibiotic resistance stewardship between prehealth and agriculture students, the study was consistent with the literature in helping understand how both groups of students might differ in their perception and knowledge of antibiotic resistance and stewardship, while possibly identifying a correlation between students' perceptions of antibiotic use and their role in antimicrobial stewardship. While more reliable and less resource extensive than qualitative research approach, using quantitative research approach for this study generated statistics to test the hypotheses and to generalize a finding between two variables within a setting (see Salazar, Crosby, & DiClemente, 2015). Ultimately, the numerical data generated in this study were assessed for cause and effect relationships allowing a prediction to be made (see Salazar et al., 2015).

The recruitment of participants can sometimes be a major challenge in research studies involving human subjects. For this study, students ranging from the age of 18 to 25 years old were recruited randomly based on their majors (biology/prehealth and agriculture). An invitational email including a link to the survey was sent to all biology/prehealth and agriculture students enrolled in an Introductory Biology course and Introductory Microbiology course. The data were analyzed using International Business Machines (IBM) Statistical Package for Social Sciences (SPSS) Version 25 analytic tools to assess the statistical differences in perceptions and knowledge between two groups. A Chi-square test was performed to compare the categorical variables between the two groups, emphasizing on the *p* value. The lower the *p* value, the greater evidence the two groups' means are different. Mersha (2018) used a cross-sectional institutional based survey to assess the attitude and perception of medical interns about antimicrobial resistance. The data of the study were analyzed on SPSS Version 25 statistical software with statistical significance set at a *p* value of less than 0.05. The analytical data demonstrated a desire for medial interns for further education on antimicrobial stewardship (see Mersha, 2018). Mersha (2018) concluded that a comprehensive, regular, and up-to-date educational training in all medical institutions should be required for all future prescribers (Mersha, 2018). This latest study reinforces the recommendation for medical institutions and stakeholders to advocate curriculums and policies that build up antimicrobial stewardship programs (Mersha, 2018). In my study, an ordinal logistic regression analysis was performed as a sensitivity test to adjust any potential confounders.

Definitions

The following key terms were defined according to the Antibiotic Stewardship glossary. In addition, when appropriate, some definitions were provided in accordance with relevant data collection protocols and established scholarly understanding.

Academic major: An academic major is an academic discipline to which an undergraduate student formally commits to qualifying for an undergraduate degree.

Antibiotics: Antibiotics are compounds produced by bacteria that target other bacteria and, thus, can be intended to treat and prevent bacterial infections (Calhoun & Hall, 2019).

Antibiotic resistance: A mechanism that occurs when bacteria evolve to evade the effect of antibiotics through horizontal gene transfer processes (Habboush & Guzman, 2018).

Antibiotic stewardship: Antibiotic stewardship is defined as different strategies that encourage the ideal choice, dosage, and duration of antibiotic treatment to obtain the best clinical outcome for the treatment or prevention of bacterial infections with the lowest toxicity to the patient and the lowest impact on subsequent resistance (Monnier et al., 2018).

Antibiotic therapy: Antibiotic therapy refers to therapy that targets bacterial growth resistance (Monnier et al., 2018).

Antimicrobial: Antimicrobial refers to any agent (including antibiotics) used to kill or inhibit the growth of microorganisms (bacteria, virus, fungi, or parasite) (Calhoun & Hall, 2019). Antimicrobial applies whether the agent is intended for humans, veterinary, or agriculture applications resistance (Monnier, Eisenstein, Hulscher, & Gyssens, 2018).

Antimicrobial resistance: Antimicrobial resistance refers to the ability of infectious microbes (virus, bacteria, fungi, or parasite) to survive exposure to clinically relevant concentrations of antimicrobial drugs that would kill otherwise sensitive organisms of the same strain resistance (Monnier et al., 2018).

Antimicrobial stewardship: Antimicrobial stewardship is defined as the optimal selection, dosage, and duration of antimicrobial treatment that results in the best clinical outcome for the treatment or prevention of infections with minimal toxicity to the patient and minimal impact on subsequent resistance (Doron & Davidson, 2011).

Efficacy of antibiotics: Value approved by the Food and Drug Administration at which antibiotics are deemed effective for treatment or prevention of bacterial growth (Doshi, 2016).

First-generation college students: A first-generation college student is defined as a student whose parent(s)/legal guardian(s) have not completed a bachelor's degree.

Gram-negative bacteria: Gram-negative bacteria refer to the classification of bacteria and imply a certain cell wall composition of the microbe (Monnier et al., 2018).

Gram-positive bacteria: Gram-positive bacteria refer to the classification of bacteria related to the cell wall composition of the organisms (Monnier et al., 2018).

Horizontal gene transfer: Horizontal gene transfer is any mechanisms that allow an organism to incorporate genetic material from other organisms or the environment without being the offspring of that organism resistance (Monnier et al., 2018).

Kansas Academy of Mathematics and Sciences (KAMS) students: High school students who have the opportunity to complete 2 years of college concurrently with the last 2 years of high school in a college environment designed to accelerate a student’s education and personal growth.

Spectrum of activity: An antibiotic effective against a broad number of microorganisms; often applied to one that is active against both Gram-positive and Gram-negative bacteria (Monnier et al., 2018).

Assumptions

For my study, I assumed that all students participating in this study had an equal opportunity to obtain adequate information on antibiotics either through previous education or through a national educative campaign on antibiotic stewardship and course curriculum on how they work and how bacteria become resistant to antibiotics. Courses such as introductory biology and microbiology overlap between the two curriculums, suggesting that both groups have an equal opportunity to learn the general concept of bacteria evolution and antibiotic resistance.

Secondly, I assumed that all student participants are going into a vocation that will require them to use antibiotics in a medical, veterinary, or agriculture context. Third, I assumed that the randomness of my sample and voluntariness of their participation in the study would enable me to depict a true representation of perceptions and knowledge of biology and agriculture students attending Fort Hays State University. Lastly, I assumed that all participants would answer the questions on the survey truthfully and to the best of their ability. I assumed confidentiality and that the intended potential of benefits of the study would reinforce the dependability of the answers provided by the students.

Scope and Delimitations

Due to time and cost limitations as well as the significance of the study, the population sample of the study was limited to biology and agriculture students attending only Fort Hays State University. Because behaviors can be affected by multiple and complex factors, such as norms, education, and beliefs, a study focusing on undergraduate students can initiate a close collaboration between behavioral and social sciences with the aim to develop an educational intervention program curriculum for antibiotic misuse. This principle allowed the selection of the variable presented in this study.

Limitations

In a study where primary data were being collected, several limitations were taken into consideration. First and foremost, this study was conducted in a particular region of Kansas, which could limit the generalizability of the results on a national scale. The nature of the study as a cross-sectional study also added a limitation as the data were only collected at one point in time, creating confounding bias. Hence, the report generated by this study can only be used as a foundation for change. Additionally, administrating a questionnaire has its own limitations that include nonresponse bias, recall bias, and social desirability bias. Moreover, the questions on the survey were not validated. Due to many factors out of my control influencing the dependability of the questions, validating the questions on the survey was not be an easy nor quick task to be performed. Another barrier included the recruitment of participants when gathering primary data. There was a challenge in creating a separation of roles of researcher versus professor during the process, increasing the effect of social desirability bias. Nonetheless, despite those limitations, the findings of the study can provide up-to-date information about undergraduate students' knowledge and perceptions of antibiotic usage and stewardship in rural Kansas.

Significance of the Study

According to health organizations, the rational use of antibiotics is the primary strategy for decreasing antibiotic resistance and the appearance of multidrug resistant "superbugs" bacteria (CDC, 2016). Tackling the issue of antibiotic resistance and understanding antibiotic stewardship by providing training for professionals can increase self-reported knowledge and increase change of self-reported behavior to not only optimize the use of antibiotics but also to decrease the development of new antibiotic drug resistance and the multidrug infections (Chaintarli et al., 2016). Until now, little attention has been given to the education of undergraduate students in prehealth and agriculture on antibiotic stewardship. Therefore, the theoretical framework in this study may facilitate the development of more effective and tailored educational interventions at the undergraduate level as opposed to other settings. By highlighting factors underpinning antibiotic knowledge and behaviors, this study could shape the academic curriculum based on students' needs to correct perceptions and uses of antibiotics among future stakeholders in the hopes to contain antibiotic resistance and preserve antibiotic drugs for the next generation. Because of significant deficiencies found in the rational use of antibiotics in the medical field compared to the agriculture field, the theoretical framework could suggest a potential implication for social change in the investigation of education of future stakeholders in the appropriate future use of antibiotics (Galarraga et al., 2013).

Summary and Transition

There is a lot to be said on the emergent public health issue of antibiotic resistance and how it affects our daily lives. In Chapter 1, I introduced the topic of my study on assessing the perceptions and knowledge of biology and agriculture students on antibiotic resistance and stewardship. I pointed out the significance of the topic and the impact of training future stakeholders on antibiotic stewardship. My research questions and hypotheses were provided with clear definitions of the different variables that were used for my methodology. I presented a framework for the study in addition to some of scopes and limitations.

In Chapter 2, I highlight a general search strategy that led to the identification of the gap addressed in my study. I describe the different search parameters and further discuss the theoretical and study framework and how it appropriately influenced the study research methodology, which is presented in Chapter 3. Chapter 4 is a complete presentation of the results, and lastly, a summary of the study as well as the discussion and conclusions are offered in Chapter 5.

Chapter 2: Literature Review

Introduction

Since the 1940s, the emergence and dissemination of antibiotic resistance have caused an immense problem in population health and the global economy. The adverse effects of the overuse and misuse of antibiotics in both the healthcare system and agriculture have been well documented worldwide, alarming health organizations to take action. According to the CDC database, by the year 2050, about 444 million people will die from minor infections, and birthrates will significantly decline (as cited in Aslam et al., 2018). Recognition of this health issue has been present since the early clinical introduction of antibiotics in the 1940s.

Currently, the use of antibiotics and often the inappropriate use of these have been increasing and show no sign of stopping (Aslam et al., 2018). To respond to this threat, many medical and public health professionals, in addition to health organizations, have collaborated to form and implement strategies to reduce the inappropriate use of antibiotics. Antibiotic stewardship aims to provide guidance for the appropriate use of antibiotics in health care and agriculture settings. Many strategies in the stewardship focus on educational, antimicrobial formulary restrictions, prospective audit and feedback, computer-assisted notifications, molecular testing technology, application of management guidelines, and multidisciplinary strategies (Habboush & Guzman, 2018). Although training of health care providers, health advocates, and medical students has been the forefront of strategies involved in ASPs, little training has been provided to undergraduate students wanting to pursue a medical or agriculture career. In addition, their perceptions and knowledge of the concept of antibiotics and antibiotic stewardship have received little attention.

In Chapter 2, I review the relevant literature on the determinants of antibiotic resistance, the effect of antibiotic resistance in healthcare, agriculture, and the economy, as well as available strategies in place. Finally, I introduce a relevant literature review on the foundation of the theoretical model chosen for this study.

Literature Search Strategy

The literature search was carried out using a diverse number of databases, such as Google Scholar, Walden University Library, the National Center for Biotechnology Information, as well as PubMed databases. The CDC and WHO libraries were also used as search engines. The following terms were used in the search: *determinants of antibiotic resistance, antibiotic resistance health economic impact, epidemiology of antibiotic resistance, educational strategies for antibiotic resistance, antibiotic stewardship programs (ASP), ASP-Clinical, Agriculture, Community,* and *health belief model*. Literature reviews were conducted on the most relevant, peer-reviewed studies limited to the period of 2014 and 2019. However, sources pertaining to the theoretical framework of the study were older than 2014 to provide a historical foundation for the study.

Theoretical Foundation

The HBM is undoubtedly the most difficult theory to trace its historical development (Rosenstock, 1974). Developed by social psychologists Hochbaum, Rosenstock, and Kegels in the late 1950s, the model was formulated originally when public health services were, for the most part, oriented toward the prevention and not the treatment of disease (Rosenstock, 1974). The HBM evolved to posit that health messages will achieve optimal behavior change if those messages successfully target perceived barriers, benefits, self-efficacy, and threats (Jones et al., 2015). According to Glanz and Bishop (2010), HBM is one of the most widely applied theories of health behaviors. The model has provided valuable contributions in explaining the connection between patients' symptoms, their compliance with medical regimens, and/or with physician-patient communications (Jones et al., 2015). One key element of the HBM is that this framework focuses on the individual beliefs about health conditions or health problems, which, in return, can predict the individual health-related behaviors (Jones et al., 2015). This framework proposes that there are key factors that can ultimately influence the health behaviors of an individual. Those key factors are (a) how an individual perceives the threat to the issue (perceived susceptibility), (b) their belief of consequence (perceived severity), (c) if the individual believes the potential benefits on taking action (perceived benefits), (d) if the perceived barriers to action cause limitation to prompt action (cues to action), and (e) if the individual is confident in the ability to achieve the desired goal if action is taken (self-efficacy; Glanz & Bishop, 2010).

To illustrate the valuable impact of HBM in health promotion and intervention, Sharifikia et al. (2019) investigated the effect of the HBM-based educational intervention on the knowledge and perceived belief of women about warning signs of cancer. Despite the implementation of multiple control strategies against cancer, the prevalence of the disease is still rising worldwide. For instance, early detection of cancer depends primarily on the knowledge of warning signs. The authors hypothesized that HBM-based educational intervention has an influence on women's knowledge and their perceived beliefs about cancer warning signs (Sharifikia et al., 2019). The authors concluded that the improvement of women health behaviors promoting cancer prevention was ultimately influenced by an HBM-based educational intervention based on the educational needs of the target groups at the different community levels (Sharifikia et al., 2019).

In a study addressing the public acceptance of information about antibiotic resistance, Rijn, Haverkate, Achterberg, and Timen (2019) found that the public attitudes towards antibiotic resistance provided by public health campaigns are increased by general awareness on antibiotic resistance. Nevertheless, this effect is indeed more profound on individuals who think they are more likely the targets of such information (Rijn et al., 2019). Moreover, this study revealed that, along with the knowledge deficit model, cultural and socioeconomic predispositions affect the approval of information about antibiotic resistance, in return influencing the likelihood to practice antibiotic stewardship (Rijn et al., 2019).

Hence, the HBM theoretical framework has been used to predict health behaviors based on barriers, such as knowledge, and perceived benefits for the appropriate use of antibiotics in both health care providers and patients. To identify themes associated with patient perceptions of antibiotic use and to examine the role of patients in antimicrobial stewardship, Heid et al. (2016) conducted a study using semistructured interviews and the HBM as the framework for questions and analysis. The study provided great insights on the importance of the role of patients in improving antibiotic use in hospitals (Heid et al., 2017). The authors concluded that the low perceived susceptibility and lack of cues to act were factors limiting the likelihood of patient engagement in antibiotic stewardship practices (Heid et al., 2017). In 2018, Ancillotti et al. conducted a study to explore the beliefs and perceptions of the use of antibiotics to identify factors promoting a judicious approach of antibiotics use. The authors used the HBM as a theoretical framework to identify major barriers, such as individual effort and antibiotics overprescribing, as factors for noncompliance (Ancillotti et al., 2018).

In conclusion, knowledge about antibiotic consumption and resistance, as well as values, such as altruism and trust in the health care system, has a significant influence on perceptions of individual responsibility and on behavior (Ancillotti et al., 2018). Ancillotti at al. (2018) made a significant contribution to emphasizing health education and health promotion to increase public awareness of being susceptible to the consequences of antibiotic resistance (Ancillotti et al., 2018). Furthermore, a systematic study on antibiotic prescribing for adult hospital patients drew on the HBM to assess threat perceptions associated with antimicrobial resistance and perceived benefits and barriers associated with antibiotic stewardship (Krockow et al., 2019). This systematic review revealed that although the risk of antimicrobial resistance was generally perceived to be dangerous, the abstract and long-term nature of its consequences has led physicians to doubt personal susceptibility (Krockow et al., 2019). While health care providers believed in the benefits of optimizing prescribing, they also questioned the direct link between overprescribing and antimicrobial resistance (Krockow et al., 2019). Krockow et al. (2019) showed that prescribers' behavior change was frequently considered futile when fighting the complex problem of antimicrobial resistance. Krockow et al. (2019) presents another example of how perceived barriers, susceptibility, and knowledge affect health behaviors.

Subsequent applications of the HBM provide a theoretical framework to explain how students' perceptions and knowledge affect their role and involvement in antibiotic stewardship in the future during their careers. The assumption of the model is that people make decisions about health behaviors according to risk perceptions and personal cost of engaging in the health behavior. According to the model, one must perceive a health problem as a threat and as severe to propose or adopt actions to reduce the risk or severity of the problem (Karimy, Azarpira, & Araban, 2017). The use of the HBM to assess student perceptions and knowledge while still attending a university represents a theoretically grounded approach. The approach has the ability to describe the potential role as engaged and active participants in antibiotic stewardship in their careers, hence adding a possible successful strategy in academic curriculum to promote correct antibiotic use (Heid et al., 2016).

Literature Review

Determinants of Antibiotic Resistances

The threat to human and animal health presented by antimicrobial resistance has remained a challenge for health care systems across the world. This emergent threat has shown the potential to burden population health and the economy of the affected country. Researchers have demonstrated many factors contributing to antimicrobial resistance that demand close collaboration between scientists and citizens (Castro-Sanchez, Moore, Husson, & Holmes, 2016). The public also does not recognize this growing recognition of multifaceted drivers by experts. However, the consequences of antibiotic resistance are not only a laboratory concern but a global threat, responsible for high death tolls (Aslam et al., 2018). In the United States alone, more than 63,000 patients die every year of bacterial infections acquired at the hospital, and about 23,000 of these patients die from multiple drug-resistant bacterial infections, ultimately resulting in extra healthcare costs and productivity losses (Aslam et al., 2018).

Evolutionary mechanisms of antibiotic resistance. Since the discovery and introduction of antibiotics and the first evidence of antibiotic resistance among certain bacteria, the mechanisms of antibiotic resistance have been intensively studied in the field of microbiology. Peterson & Kaur (2018) showed there is evidence of the relationship between resistance determinants of antibiotic producers, environmental bacteria, and clinical pathogens. This relationship suggests antibiotic resistance genes are not only confined in clinic settings. In nature, resistance genes are widely prevalent in bacterial populations. Many microbiological studies identified mechanisms of antibiotic resistance present in soils and the environment, such as antibiotic modification/degradation, antibiotic efflux, antibiotic target bypass, and protection (Shinkawa et al., 1985; Yu et al., 2012; Schmutz et al., 2003; Prija & Prasad, 2017). Processes, such as mutations and horizontal gene recombination, permit bacteria to swap genetic materials to amplify natural selection. But these mechanisms, in which bacteria evolve and become resistant, is not the only mechanism by which resistance progresses (Habboush & Guzman, 2018). Peterson & Kaur (2018) noted although these mechanisms of antibiotic resistance in the soil and the environment do not directly cause a threat to human health, the mobilization of these mechanisms to new bacterial hosts, such as pathogenic bacteria, can indeed translate to a health problem. In the 1970s, Benveniste & Davies (1973) demonstrated the ability of pathogenic bacterial strains to acquired antibiotic resistance genes from antibiotic producers' environmental organisms via a process of Horizontal Gene Transfer. Since then, many observations have explained the evolutionary link between the antibiotic resistance producers and pathogens (Peterson & Kaur, 2018).

Social determinants contributing to antimicrobial resistance. Although the mechanisms explained above are an innate characteristic of the microorganisms, the dissemination of antibiotic resistance in clinical settings is often accelerated by human-driven factors, such as inappropriate use (Peterson & Kaur, 2018). A review of the literature has identified overarching social factors contributing to antimicrobial resistance. Some of those critical determinants are wrongful prescribing behaviors, inadequate public adherence to antibiotic treatments, and overuse of antibiotics in agriculture settings (Castro-Sanchez, et al., 2016). The study of Castro-Sanchez et al. (2016) identified nine factors driving global antimicrobial resistance: a) human antimicrobial misuse and overuse; b) animal antimicrobial misuse and overuse; c) Environmental contamination; d) healthcare transmission; e) lack of quick and accurate test to diagnose infections; f) lack of effective vaccines and reduced intake of existing ones; g) incorrect dosing of antibiotics in humans; h) travel; and finally, i) mass drug administration in human health.

Misuse and overuse of antibiotics. The use of antibiotic varies significantly between geographical regions and between provider settings. This variation is mainly due to the degree of antibiotic consumption, suggesting that regardless of antibiotic policies of a particular country, the more antibiotic is used, the more antibiotic resistances is disseminated (Zanichelli, Monnier, Gyssens, et al., 2018). This considerable variation is still misunderstood and can only be partly explained by different patients' and providers' attitudes on antibiotic and antibiotic resistances (Zanichelli, et al., 2018). Manyi-Loh et al. (2018) identified China as the world's leading producer and consumer of antibiotics in both animals and humans' health. The related antibiotic crisis in the country is often ascribed to the misuse of antibiotics that are, ultimately, discharged into the environment.

In the United States alone, antibiotic use in healthcare settings, measured as outpatient prescribing, has increased by 5% from 2011 to 2014 (Kobayashi, et al., 2016). Out of those antibiotics prescribed in outpatient clinics, about 30% are unnecessary, according to the Center for Disease Control (CDC, 2017). This percentage can be translated to about 47 million unnecessary prescriptions written in doctors 'offices and emergency departments in the U.S (CDC, 2017). In the state of Kansas, in 2015, 91.8% of community prescriptions were given to outpatients (CDC, 2017). The excess prescriptions each year have been shown to put individuals at a higher risk for reactions to drugs and other secondary infections, such as *Clodistrium difficile (C. difficile)* infections. In 2011, 1/3 of *C. difficile* infections were reported as community-associated infections instead of hospital-associated infections (CDC, 2017). In U.S. hospitals, a majority of patients received a type of antibiotic during their hospitalizations (Reddy, Jacob, Varkey, & Gaynes, 2015). A study demonstrated up to half of the antibiotics prescribed to patients during their hospitalization are inappropriate, suggesting the optimization of antibiotic use in healthcare settings is essential to ensure the positive outcome of antibiotic treatments (Reddy et al., 2015).

In agricultural settings, antibiotics can be used in different ways, such as treating sick animals, prophylactic use where there is a higher risk of infections, and for promoting animal growth (Morris, Helliwell, & Raman, 2016). The inclusion of nonessential antibiotics in animal feed for growth promotion purposes remains largely unregulated. On a global scale, the annual consumption of antimicrobial agents in animal feedlots was 45 - 172 mg/kg (Manyi-Loh et al., 2018). The overuse of these agents has a devastating effect on many other animals, such as migratory birds, which are unnecessarily exposed to antibiotics.

The same pattern is also seen in dairy farms. Kumar & Gupta (2018) assessed the use of antibiotics by dairy farmers. In many instances, the judicious use and conservation of antibiotics are often affected by the demand of farmers for antibiotics. The study revealed the frequency of antibiotic with veterinarians improved veterinary-client relationship among dairy farmers. However, the relationship did not affect the judicious use of antibiotics (Kumar & Gupta, 2018). Kumar & Gupta (2018) concluded smaller farmers were faulty injudicious antibiotic usage practices.

The use of antibiotic in food animals a risk for human health, the degree and relative impact on the dissemination of antibiotic resistance on human health have not been well characterized (Chang, et al., 2015). Chang et al. (2015) also found neither the risks to human health nor the benefits to animal production have been well studied leading to a lack of consistency in national and international policies on the use of the antibiotics in agriculture. On the other hand, the consumption of antibiotics in agriculture is routinely described as an important contributor to the public health issue of resistant pathogens in human medicine. Although there are no conclusive data reflecting a plausible link, Chang, et al. (2015) defined potential mechanisms by which agricultural antibiotic use could lead to human diseases. According to the study, there are direct infections with resistant bacteria from animal sources to humans, and a direct transfer of resistance genes from agriculture into human pathogens (Chang, et al., 2015). Many studies show antibiotic use in humans has been shown to select antibiotic-resistant strains. The same has been demonstrated in livestock. Indeed, there have been reports 80% of all antibiotics in the USA annually is been used in the constant sub-therapeutic application for growth promotion and disease prevention in intensively farmed animals (Aslam, et al., 2018). It is with no surprise that antibiotics used in this context have been associated with a high frequency of resistant bacteria in the gut flora of chickens, swine, and other food-producing animals (Aslam, et al., 2018). Consequently, ASPs have not been successfully implemented in agriculture due to non-reliable data about the quantity and patterns of use of antibiotics.

In conclusion, the relationship between antimicrobial use and resistance has been accepted by the science community for nearly 80 years (Kobayashi, et al., 2016). This literature review shows the intensive use of antibiotics as the dominant factor in the spread of antibiotic resistance and multidrug resistant pathogens.

Antibiotic Stewardship Programs (ASP)

To reduce the dissemination of antibiotic resistance and multi-drug resistant pathogens, a worldwide consensus was to create a set of structures programs that can be implemented globally in medical and agricultural settings. The development of ASPs has been put place to promote the appropriate use of antibiotics and antimicrobials in general, to promote patient outcomes, to reduce the emergence of antibiotic and antimicrobial resistance, and to decrease the spread of infections caused by multi-drug resistance microorganisms (Simoes, Maia, Gregorio, et al., 2018). Overall, ASPs are multidisciplinary quality improvement initiatives that have been proven effective more often to optimize treatment by successfully increasing infection cure rates and reducing infection treatment failures while eliminating undesirable adverse drug reactions. In 2014, President Barack Obama passed an executive order demanding strategic, coordinated, and sustained effort to detect, prevent, and control antibiotic resistance (Jooma, 2015). The executive order, known as "Combatting Antibiotic-Resistant Bacteria," included goals to promote antibiotic stewardship on farms, better surveillance of antibiotic use, and the development of alternatives to antibiotics (Jooma, 2015). In response to the national priority recognized by the executive order, the U.S. government established the U.S. National Strategy for Combatting Antibiotic-Resistant Bacteria and the U.S. National Action Plan for Combatting Antibiotic-Resistant Bacteria (CDC, 2018). Federal agencies goals are to work together to strengthen detection of resistance, to enhance efforts to slow the emergence and spread of resistance, improve antibiotic use and reporting, to advance the development of rapid diagnostics, to enhance infection control measures, and to accelerate research on new antibiotics and antibiotic alternatives (CDC, 2018).

Smith, Quesnell, Glick, et al. (2015) determined two strategies to accomplish federal agencies' goals: reducing the emergence and spread of antibiotic-resistant bacteria by reducing the number of bacterial infections and maximizing antibiotic stewardship. In summary, the ASPs are based on seven core elements: leadership commitment, multi-disciplinary team, situation assessment, and interventions to improve antibiotic use, surveillance, report, and educate (Simoes, Maia, Gregorio, et al., 2018). Both Physicians and the public can practice these strategies, thereby addressing this health concern. Several ASPs exist; however, the HAITooL has been recognized as a combined surveillance and clinical decision support system for antibiotic monitoring and prescription support designed and implemented to adapt to the specific needs of healthcare workers and hospitals (Simoes, et al., 2018). Programs systems, such as HAITooL, are real-time strategies that are often linked with ASP strategy and adapted to local socio-cultural context (Simoes, et al., 2018). Hence, the public health sector is the ideal corporation to promote antimicrobial stewardship across health care institutions. Indeed, education, surveillance, and promoting antimicrobial stewardship align with the goals of public health to prevent disease ultimately, promote population health, and prolong life expectancy (Trivedi & Pollack, 2019). Ideal models of ASP all share common goals to understand better the problem and how to fight it, to thoroughly define the programs and interventions, to educate the implement interventions, and finally to organize a robust national measurement system to track infections (Simoes, et al., 2018).

ASP in clinical settings. Many studies with the collaboration of the CDC have been examining what constitutes a successful ASP implementation in hospitals. To have a better understanding of what it takes to create a successful program, Srinivasan (2018) assessed different successful stewardship programs in a variety of hospital types, including large academic hospitals and small hospitals. The study identified seven common core elements that have been serving as foundations for guiding strategies development. Several systems implementing ASP strategy have been applied across clinical settings by following those general principles, which includes leadership commitment responsible for outcomes, tracking of antibiotic use, regular reporting of antibiotic use and resistance, educating providers on use and resistance, and other specific improvement intervention (Srinivasan, 2018). Most assessments of these strategies implemented at the hospital level saw a reduction of about 50% of infections over the past five years.

Nonetheless, the implementation of stewardship can be harder in some settings. Short stay, critical-access hospitals tend to pose more of a challenge, as only 26% of all implementations have all core elements of the guiding principles (Srinivasan, 2018). This problem urges the collaboration of the CDC with the American Hospital Association and the Pew Charitable Trusts to focus efforts on helping these hospitals. Pollack, Santen, Weiner, et al. (2016) concluded despite a call for action by the National Action Plan to Combat Antibiotic-Resistant Bacteria for all U.S. hospitals to improve antibiotic prescribing as a key prevention strategy, not all hospitals adopt this implementation is not well understood. In Kansas, only 30% of the hospitals are adopting all seven core elements of hospital ASPs compared to Arizona, California, Delaware, Idaho, Maine, Nebraska, Nevada, New York, and Utah where at least 50% of the hospitals are adopting all seven core elements (Pollack, et al., 2019).

Bondarenka & Bosso (2017) evaluated the implementation of an antibiotic stewardship program at an academic medical center. The study provided six steps to a successful program. The first step includes conducting a baseline evaluation and establishes a need for ASP implementation in the hope of gathering administrative support (Bondarenka & Bosso, 2017). The second step is to establish the programs and identify or hire personnel and resources (Bondarenka & Bosso, 2017). The third step involves assessing the needs and selecting initial initiatives to implement (Bondarenka & Bosso, 2017). The fourth step is to collect the data after the program(s) has been initiated (Bondarenka & Bosso, 2017). The fifth and sixth include adjusting the initiatives as needed and using the outcomes data to plan further initiatives and/or expand program personnel (Bondarenka & Bosso, 2017). Overall, most ASP programs have had an impact on defining the daily dose of drugs and on cost consumption, suggesting a multidisciplinary ASP can be successfully deployed in an academic hospital (Bondarenka & Bosso, 2017). Interventions chosen based on the needs of the facility, as well as the availability of resources and content expertise tend to be more highlighted in three categories: broad, pharmacy-driven, and infection and syndrome specific (CDC, 2019). Antibiotic “Time outs” is an example of a board intervention. This strategy prompts a reassessment of the continuing need and choice of antibiotics. In this strategy, all clinicians are to perform a review of the prescribed antibiotic(s) 48 hours after the antibiotic(s) was initiated (CDC, 2019). The assessment consists of answering questions, such as does this patient have an infection that will respond to antibiotics, if so, is the patient on the right antibiotic(s), dose, and route of administration, can a more targeted antibiotic be used to treat the infection, and finally, how long should the patient receive the antibiotics? A second broad intervention is the prior authorization strategy. The strategy requires an external review of antibiotic therapy by an expert in antibiotic use in order to effectively optimize antibiotics in critically ill patients or in cases where broad-spectrum or multiple antibiotics are being used (CDC, 2019).

Although ASP in clinical settings can be proven to be a strong program within a broader context of measurement and improvement interventions, and policy action, as well as a key to improve prescribing to improve patients' outcome, the presence of such programs in clinical settings alone is not enough to adequately address bacteria resistance.

ASP in agriculture settings. As antibiotic resistance becomes a growing threat to human health, international, national, and local antibiotic stewardship have been developing practical strategies to encourage prudent use of antibiotics and limit its unnecessary exposure. Physicians are asked to balance the use of antibiotics to preserve the effectiveness of the mode of action while responding to ethical obligations to treat patients who can benefit from the use of antibiotics. The same ethical debate is considered in veterinary medicine and farming regarding the use of antibiotics in farm animals raised for human consumption (Parsonage, et al., 2017).

In 2005, the United States FDA banned all use of fluoroquinolone in farming animals as a precautionary measure due to the emergence of fluoroquinolone-resistance in clinical settings as a precautionary measure. In 2006, the European Union also banned the use of nonmedicinal antibiotics in animals for the same reason. Despite the ban on antibiotics, it remains unclear if the emergence of resistance was caused using antibiotics in livestock at time (Hoelzer, et al., 2017). Many studies have shown evidence of the use of antibiotics in food animals and antibiotic-resistant infections for several decades now (Hoelzer, et al., 2017). However, it was only recently the epidemiological association of the two had been detected in observational studies.

As the use of antibiotics in agriculture continue to routinely be described as a contributor to the clinical problem of antibiotic resistance in human medicine, the debate about agricultural use of antibiotic is ultimately further complicated by politics and economic issues (Chang, et al., 2015). In recent year, this debate has gained a tremendous amount of attention from the media as the concern and plausible link between antibiotic resistance affecting human health and the use of antibiotics in agriculture is considered unwarranted, suggesting the extent of the problem linking agriculture and human health may be exaggerated (Chang, et al., 2015). Nonetheless, Antibiotic Resistance Stewardship, in any setting, has been focusing on the overabundant use of antibiotics in settings that leads to a major health concern. Although the idea of eliminating the use of antibiotics in agriculture is unparalleled and not supported by farmers, it remains vital, based on the goals of ASPs, to determine what exactly constitutes the “overuse” of antibiotics in agriculture (Chang, et al., 2015). Yet, the complexity of political, economic, and social barriers can put a limit on the quality of the data collected on the use of antibiotics in food animals. Many of the available data are provided on a voluntary basis leading to unstandardized data collection methods and not fully transparent reports (Chang, et al., 2015).

Consequently, the priority in many ASPs strategies for agricultural settings is to put together an effective surveillance scheme on the production and administration of antibiotics by veterinarians and farmers. More importantly, this monitoring of antibiotics should be operated independently of commercial influences to balance out between the public health urgency and economic interests (Manyi-Loh, 2018).

ASP in community settings. The general public, in many instances, is considered a second key component in promoting antibiotic stewardship and slowing down antibiotic resistance, suggesting the problem of antibiotic resistance is no longer just a hospital problem. Often, the general public can engage in specific behaviors, such as receiving recommended vaccines, practicing proper personal hygiene in their daily lives, and also by accepting evidence-based medicine to reduce the unnecessary consumption of antibiotics (Smith, et al., 2016). Still, systematic review repeatedly shows the public's expectation or even over expectation of the efficacy of antibiotic treatment against infections both in humans and animals can lead to the increasing number of antibiotics prescribed (Smith, et al., 2016). There is still evidence of a very serious misleading conception of the actual benefits of antibiotics, such as antibiotics been useful as a cold remedy.

Changing public awareness of antibiotic resistance represents a global health priority ultimately. The study of McParland, Williams, Gozdzielewska, et al. (2018) conducted a systematic review of ASP intervention programs that targeted public awareness on antibiotic resistance and associated behaviors. Despite a diverse number of interventions with different strategies, the standard component present in all interventions is the core mechanisms of action and behavior change techniques (McParland, et al., 2018). The evidence of the effectiveness of those interventions was not always clear. But the findings showed the public continues to show poor knowledge and misperceptions of antibiotic resistance (McParland, et al., 2018). More importantly, the public knowledge on the appropriate use of antibiotics tends to be low, suggesting antibiotic awareness campaigns must be developed as an intervention to improve outpatient antibiotic use (Huttner, et al., 2019). Different countries have conducted numerous campaigns, but, in general, the public communication and key messages are not always supported by evidence, nor do they target conditions for which inappropriate use is highly prevalent (Huttner, et al., 2019). In most low-income and middle-income countries, the global response to antibiotic resistance campaigns is often hindered by the cultural conceptions of healthcare practices (Huttner, et al., 2019). Hence, the authors of the study recommended an extension of the behavioral ASPs to allow room to address context-specific drivers of antimicrobial use and complement education and awareness campaigns (Huttner, et al., 2019).

Educational Interventions

The issue of antibiotic resistance is a multifaceted issue that must be approached with different strategies. Often those strategies simply combine ASPs with educational strategies (Manyi-Loh et al, 2018). Lee, Lee, Kang, et al. (2015) conducted a systematic review of the importance of educating prescribers, antibiotic users and the general public, to assess the effectiveness of programs based on regions. The authors found most education interventions targeted clinicians to reduce antibiotic prescribing, regardless of the regions and the educational programs, though there was a lack of evaluation of educational programs for the public and/or children (Lee, et al., 2015).

The lack of understanding and perceptions of antibiotics has a significant impact on the quality of antibiotic prescribing. By definition, prescribers of antibiotics include all healthcare professionals that have or will have contact with patients. Therefore, according to the general definition of prescribers, those individuals include medical doctors, undergraduate students, nurses, dentists, pharmacists, and veterinarians prescribing antibiotics for animals. Consequently, a continual education about antibiotic resistance as well as prudent antibiotic prescribing is important.

A recent report conducted by the WHO concluded there must be an emphasis on undergraduate students in prudent antibiotic prescribing and other antibiotic stewardship program strategies, such as surveillance and reporting (Silverberg, et al., 2017). In many countries, such as the United Kingdom, education on prudent antibiotic use and prescribing have been included as a component of the undergraduate curriculum for health students, signifying the topic of antibiotics resistance and prudent use and prescribing could eventually be added in the curriculum of biology (Silverberg, et al., 2017). The same is applicable to antibiotic prescriptions for animals and agriculture. Although some antibiotics are specifically used for agricultural purposes and veterinary use, some of those antibiotics belong to the same classes of antibiotics used in human medicine. As recent evidence showed the presence of antibiotic resistance genes in food animals, the use of antibiotics in veterinary and agriculture must be reduced (Economou & Gousia, 2015). Education about antibiotic resistance, use, and prescribing is indeed necessary for agriculture students, farmers, aqua-culturists, and veterinary.

Education of current prescribers. The education of healthcare professionals is an essential element of ASPs. There are considerable efforts put into the education of current prescribers, as seen in the literature to optimize antibiotic therapy and reducing antibiotic resistance (Barlam et al., 2016). The main strategic plans for current prescribers, according to ASPs, are to educate on general medicine, immunological and genetic host factors, and microbial virulence. Nonetheless, conducting passive education alone for current prescribers has had little effect on changing prescribing practices of antibiotics, suggesting changing a pattern of behaviors is more challenging than shaping a behavior. A study on the overuse of antibiotics in acute pancreatitis demonstrated physicians would have a pattern of high prescription rate leading to a high proportion of acute pancreatitis patients receiving antibiotics they did not need (Mourad et al., 2017). Many of those studies suggest intervention approaches about prudent antibiotic use and prescribing should start at the undergraduate level when knowledge, attitudes, and behaviors of future prescribers are being shaped. These approaches can lead to a lesser burden for educating the actual prescribers.

Education of future prescribers. Until now, most educational efforts have been targeting current medical professionals. Silverberg et al. (32017) pointed that educating future prescribers can be viewed as a more effective educational strategy as the approach would focus on shaping the ideal behavior instead of changing the old behaviors.

Previous studies have indeed identified a gap in knowledge of the responsible use of antibiotics by medical students. According to a cross-sectional, medical students feel they still need more education on antibiotic use for their future practices as junior health providers. In South Africa, the conclusions were the same. There was a lack of confidence level with regards to antibiotic prescribing among final year medical students (Wasserman, et al., 2017). The same conclusions were identified in reports evaluating medical students in the United States (Llor & Bjerrum, 2014). 92% of a total of 317 medical students agreed that reliable knowledge of antibiotic prescribing and resistance is essential for their future career, and 90% of the students stated more education about appropriate antibiotic prescribing would be ideal. Many of these studies identified differences existed between the different medical schools in the knowledge of antibiotic use, resistance, and prescribing. Accordingly, the development of a formal and standard curriculum on antimicrobial use and resistance is required. Although many passive educational techniques, such as antibiotic campaigns and traditional course curricula, have been used to increase future providers knowledge on antibiotics use, a study shows active leaning associated with real life specific patient cases or prescribing data has increased influence on prescribing behaviors and, is ultimately longer lived (Hsu, 2018).

The *MedEdPORTAL* has been a good approach that undertake different simulations to tach ASP concepts to infectious diseases to fellow medical students (Hsu, 2018). Other antimicrobial stewardship curriculum consisting of online learning module (interactive lessons paired with logic clinical cases) and workshop sessions that combined both medical students with faculty have demonstrated an increase improvement in knowledge and perceived benefits of appropriate antimicrobial use and collaboration (MacDouglas, et al., 2017)

Limited curricula are currently available for undergraduate pre-health students. Thereby, studies aiming to create modules aiming to engage learning techniques to guide pre-health students through the development of mock ASP intervention relevant to their personal clinical experiences are essential.

Reports for undergraduate students majoring in agriculture are non-existent. However, better knowledge, increased perceived benefits, and practices were associated with farmers who were engaged previously in the efforts to gather more information on antibiotic use and resistance (Llor & Bjerrum, 2014).

Summary and Conclusions

Even with ASPs being implemented across hospitals and farming settings, antibiotic resistance will continue to be our most significant health crisis without education. In chapter 2, the literature review provides a synapse of the problem of antibiotic resistance and its burden in humans' and animals' health as well as economic. I present a few determinants of antibiotic resistances that ultimately became the foundation of many interventions for preserving antibiotics and its effectiveness. Upon a consensus of the health issue, a call for action created a groundwork for the development of an ASP focusing primarily on surveillance, reporting, and education. I describe strategical approaches that are being implemented in clinical settings, agricultures settings, and community settings that have shown potential positive results, most of them emphasizing education of current prescribers to modify certain behaviors, such as antibiotics use and prescribing. Little effects resulted from modifying behavior in current prescribers. More recently, the educational intervention approaches have been aimed to establish appropriate behaviors in future prescribers. Those interventions aim to understand how medical students, especially medical students in their last year, perceive and understand antibiotic use and how it relates to the dissemination of antibiotic-resistance. As seen in the literature review, most gathered information is from medical students. Little attention has been given to undergraduate students in health-related majors, such as biology, and agriculture. This study attempts to assess how biology and agriculture students perceive and understand antibiotic resistance and stewardship and possible establish different patterns between these two groups. A survey was created based on the Health Belief Model. In chapter 3, I provide a rational of a quantitative approach by briefly providing my research questions, variables, and analytic tools, as well as my methodology approach.

Chapter 3: Research Method

Introduction

Antibiotic resistance has become an important public health issue that is known to affect everyone, regardless of age, gender, and nationality. As stated by the CDC (2016), by 2050, antibiotics will no longer be effective if the dissemination of antibiotic resistances continues. To combat the dissemination of antibiotic resistance in humans and animals medicine, a call to action focusing on education to alter and/or shape behavior of future prescribers has been recommended as part of the ASPs. Many researchers have focused on the training of current prescribers, leaving future prescribers untrained and uncertain on how to appropriately use and prescribe antibiotics. The WHO (2014) has recently reported that there is an urgent need for educational trainings of future prescribers at the undergraduate level. To develop a curriculum based on students' needs, the assessment of perception and knowledge of antibiotics use, resistance, and stewardship is recommended. Hence, the purpose of my study was to examine the differences (if any) of knowledge, perceived threat and severity of antibiotic resistance, and perceived benefit of antibiotic stewardship between two groups of undergraduate students: prehealth biology students and agriculture students at a rural university in Western Kansas.

Research Design and Rationale

In my study, I examined three dependents and one independent variable. In this study, the independent variable was the academic major. The participants were undergraduate students majoring in either prehealth/biology students or agriculture students. Demographic data, such as gender, age, race, college major, college classification, household income, and first-generation college students, were collected on the two groups of students.

The three dependent variables were knowledge, perceived threat, and perceived benefit. Knowledge in this study was defined as the level of knowledge/understanding around the appropriate use of antibiotics and the misconception of antibiotic use and antibiotic resistance. In other words, knowledge questions determined if students understood when to use antibiotics, how to use antibiotics, and why to use antibiotics. Perceptions, recorded as perceived threat and perceived benefit, were defined as the level of how students see the value of antibiotic use in humans and animals medicine, how they see the threats of antibiotic resistance and overuse or misuse of antibiotics, and how they view antibiotic resistance education in stewardship.

My study was based on the HBM. A structured, closed-ended survey was developed based on the construct of the HBM. This type of data collection has been used for decades to obtain information from individuals and/or groups to advance knowledge in behavioral sciences. The survey in this study included demographic data as well as questions pertaining to perceptions and knowledge. The questionnaire was set in four sections. The first part consisted of questions related to demographic characteristics. The second part of the questions addressed the field of knowledge. The third part consisted of questions on the HBM (benefits, threat, and severity). The HBM constructs was measured using 5-point semantic differential scales (Likert scale), ranging from 1 (*strongly agree*) to 5 (*strongly disagree*). The Likert scale (mean scores) was converted into three categories on SPSS to run a chi-square. *Strongly agree* and *agree* responses (or equivalent) were combined into one category (0), *undecided* was combined into another category (1), and *disagree* and *strongly disagree* (or equivalent) made the third category (2). The survey was delivered to participants in an electronic format via email providing a link to Survey Monkey, an Internet-based program.

A quantitative cross-sectional study approach was used as a foundation to determine the extent of knowledge and perception of both agriculture students and prehealth biology students. Often, when considering research, the design is frequently determined by the researcher's theoretical perspective. For this study, a cross-sectional design facilitated the description of a specific population, in this example, the undergraduate students, at one point in time (see Allen, 2017). A very common example of a cross-sectional study design is when a specific population is surveyed at one point of time in order to describe the characteristics of population, such as age, income level, and knowledge (Allen, 2017). To illustrate the importance of cross-sectional study design in adding information on knowledge, attitude, and practices of antibiotic use, Jairoun, Hassan, Ali, Jairoun & Shahwan (2019) used a cross-sectional design to conclude the students' knowledge, attitude, and practice regarding antibiotic use, which drive the practice of self-medication and reflect a gap in medical curricula in academic institutes and medical colleges.

Additionally, a quantitative cross-sectional study design permits a descriptive analysis of qualitative variables by quantifying variables summarized using means and standard deviation. An assessment of the difference between the dependent variables between the two groups allowed me to assess a prediction to be made between the two groups and to formulate a foundation for curriculum to be created based on the needs of each groups.

In conclusion, a quantitative cross-sectional study design in this study was the most appropriate to understand the research questions presented at a single point in time. In addition to being cost effective and not being time consuming, the findings and outcomes generated by this approach were, in the end, analyzed to create new studies providing an in-depth research on the topic.

Methodology

Population

The city of Hays is in the state of Kansas and has a county seat in Ellis County. It is the larger city in Ellis County with a population size of 20,852 as of July 2018 according to the U.S. Census. With a population mostly composed of Whites (93%), Black/African Americans, American Indian/ Alaska Natives, Hispanic/Latinos, and Asians are the minorities present less than 2% of the population in Hays (U.S. Census, 2014). Hays is also the home of three major employers in Ellis County: Hays Medical Center, servicing health care for all Western Kansas, Hays Public Secondary School, and Fort Hays State University.

Fort Hays State University is considered the third largest of the six universities governed by the Kansas Board of Regents. The university has an enrollment of approximately 15,000 students, including undergraduate, graduate, and virtual students. The university houses five academic colleges, including the STEM College, known as the

Peter Werth College of Science, Technology, and Mathematics. The STEM College at Fort Hays State University, where this study was conducted, was formed in 2015 by aggregating the departments of agriculture, applied technology, biology, and chemistry. It consists of approximately 1,400 undergraduates and 50 graduate students. STEM departments make significant contributions at innovating technical, classroom, field, and lab experiences to students wanting to pursue an occupation in medical, veterinary, and agriculture fields. The wide range of academic programs is innovative, providing robust scholarship opportunities for the students.

As part of the newest academic college found at Fort Hays State University, the college offers eight major academic programs, such as agriculture and biology. At the beginning of the 2019 academic year, the biology department claimed about 300 students. Sixty percent of those students were following a prehealth professional curriculum designed for students wanting to pursue a health profession career, such as medicine, dentistry, pharmacy, optometry, and veterinary. The agriculture department offered several degree options, such as Agronomy, Animal Science and Preveterinary Medicine. The total enrollment of students in the department is currently unknown.

Sampling and Sampling Procedures

A cross-sectional study is, by definition, a type of observational study design that in this particular study was used to measure the outcomes and the exposures in the study participants at a given time. Unlike other study designs, such as case control studies, or even cohort studies, where participants are often selected based on the outcomes or on the exposure status, the participants of this study were selected based on the inclusion and exclusion criteria for the study. Criteria for inclusion for this study was determined to be prehealth biology students and agriculture students enrolled in courses, such as principles of biology, microbiology, human biology, zoology, and immunology. The classification of these students felt between freshman years (1^{st} year undergraduate) to senior year (4^{th} year of undergraduate). The ages of the participants felt between the ages of 18 and 54 years old. Criteria for exclusion was determined to be nonprehealth biology majors or agriculture majors. All individuals who met the inclusion criteria had the same chance to be part of the sample and be involved in the study (see Garg, 2016).

As one of the most fundamental steps and statistical principles in designing quantitative study to answer the research question(s), sample size is an important factor in approving or rejecting research hypotheses within a specific population, as it is naturally neither practical nor feasible to sample a whole population (Gupta, Attri, Singh, Kaur, & Kaur, 2016). In this study, the sample size was calculated based on the G*Power 3.1 software. As a free power analysis software for statistical tests, such as the *z* test for logistic regression, the G*Power 3.1 was designed for social and behavioral research (Faul, Erdfelder, Lang, & Buchner, 2007).

The minimal sample size for this study was determined to be a minimum of 134 participants for a chi-square test for Goodness of Fit. As this sample size represented a total number of participants for this study, the study groups were divided based on the ratio of the total number of students each department holds to reflect the target population. Assuming the proportion of Population 2 (P2 - agriculture students) answering “strongly knowledgeable/high treat/high benefit” and assuming the knowledgeable/moderate threat/moderate benefit was at a rate of 0.52 (52%), the proportion inequality, two independent groups statistical test was run to estimate the expected number of participants in each group based on the assumption of the ordinal logistic *OR*. Table 1indicates how the sample size for each group is affected.

Table 1

Sample Size Based on Population Ratio

Ratio	# of prehealth biology student participants	# of agriculture student participants	Total sample size
1:1	52	52	104
2:1	75	38	113
3:1	99	33	132
4:1	122	31	153

The degree of freedom was determined to be 4. The degree of freedom was calculated by subtracting the number of categories (5) minus 1. The effect size was selected as 0.3, which is a medium effect size convention that represented the difference between the two groups. The effect size was estimated by assuming that the expected portions of knowledge, perceived threats and perceived benefits, was equal for all two groups of students (H_0). With two groups of students, the expected proportions were equaled to 0.5. The observed proportions for H_1 were estimated for the two groups. The minimal difference that could be detected between the two study groups was medium. The larger the effect size determines a stronger relationship between the two variables. Effect size can be observed when comparing any two groups to see how substantially different they are. The alpha level (*P* value) was set at 0.05, as in the study a *P* value of less than 0.05 was significant. Finally, the power level was set at 0.8 (80%).

This power level is usually considered in behavioral studies, which is the minimum power required to accept the null hypothesis (Gupta et al., 2016).

Procedures for Recruitment, Participation, and Data Collection (Primary Data)

Participants were recruited based on the inclusion and exclusion criteria determined above, as presented to the Institute Review Board (IRB). All participants for this study were classified as undergraduate students between the ages of 18 and 54 years old. Therefore, participants did not belong to a vulnerable population, according to IRB vulnerable population criteria. A list of email addresses of pre-health Biology students and agriculture students were obtained through the main biology and agriculture offices after IRB approval for the study from Fort Hays State University and Walden University. A mass email was sent to undergraduate students based on the inclusion and exclusion criteria. The email contained information about the study, such as background information, significance of the study, and the objectives of the study. The email also contained the Survey Monkey link for the survey. When participants accessed the link provided on the invitation email, they were directed to the Survey Monkey survey website where they were asked to consent to the study (using the Consent Form in Appendix C) prior to starting the survey. The survey was open for three consecutive weeks.

Data Analysis Plan

Survey data cleaning was done prior to exporting the data to IBM SPSS Version 25 software licensed by Walden University. The survey data cleaning involved identifying and removing participants who either do not match my target sample criteria or did not have completed the entire survey or provided inconsistent responses. The survey data cleaning was essential to improve the effect of responses for better analysis and preserve the integrity of the results. The survey data cleaning process also included a descriptive analysis of demographic factors, such as age, gender, race, first-generation college students, and class classification. Descriptive statistics were used to describe the study population and show the balance of demographic variables between the two groups. A sample mean was used for continuous variables. A contingency table was provided to calculate the frequencies for categorical variables.

Research Question 1: Are there differences in the knowledge of antibiotic resistance in prehealth students compared to agriculture students?

$H_0$1: There are no statistically significant differences in the knowledge of antibiotic resistance and antibiotic stewardship between prehealth students and agriculture students.

H_a1: There is a statistically significant difference in the knowledge of antibiotic resistance between prehealth students and agriculture students.

Research Question 2: Are there differences in the perceived threats of antibiotic resistance in prehealth students compared to agriculture students?

$H_0$2: There are no statistically significant differences in the perceived threat of antibiotic resistance between prehealth students and agriculture students.

H_a 2: There is a statistically significant difference in the perceived threat of antibiotic resistance between prehealth students and agriculture students.

Research Question 3: Are there differences in the perceived benefit of antibiotic resistance education in stewardship in prehealth students compared to agriculture students?

$H_0$3: There are no statistically significant differences in the perceived benefit of antibiotic resistance education in stewardship between prehealth students and agriculture students.

H_a3: There is a statistically significant difference in the perceived benefit of antibiotic resistance education in stewardship between prehealth students and agriculture students.

The dependent variables were identified as the knowledge of antibiotic resistance and perception, best described as perceived threat of antibiotic resistance and perceived benefits of antibiotic education stewardship. Appropriately defining knowledge and perception in the study was needed to influence the questions asked in the survey.

The Chi-square analytical test was used to test the hypothesis for all three research questions. A Chi-square was performed on the data. Known as the Pearson Chi-square test, the Chi-square test has been the most useful analytical test for testing hypotheses when both independent and dependent variables are categorical (McHugh, 2013). As this particular study involved dichotomous independent variables, the analytical test provided detailed information accounting for differences found on the categories of dependent variables among the subject groups (Labi et al., 2018). Moreover, knowing the study sample size of the two groups was most probably unequal (more pre-health Biology students than agriculture students), the Chi-square test was the one of the tests that permits an unequal size distribution of the study groups, assuming the data will be obtained through random selection (Labi et al., 2018). The study used an alpha level of 0.05 to assess each research question, the effect is statistically significant if *P* value is <0.05 and the null hypothesis for the given research question was rejected.

When conducting the data analysis, an examination of potential confounding variables was considered. In relation to knowledge and perception, studies showed those two variables can be influenced by confounding variables (Lippold, Coffman, & Greenberg, 2014)., It could be difficult to conclude, without a doubt, that the academic major of the students has a direct correlation or causal effect on the perception and knowledge of antibiotic resistance and antibiotic stewardship. Moreover, the academic year of the participants can influence the knowledge, and perhaps, the perception of antibiotic resistance and education is stewardship. A chi square analysis does not typically consider confounding variables, such as academic level or other confounding that may exist in this study. Consequently, an ordinal logistic regression was used as a sensitivity test to adjust for the potential confounders, such as the academic level of student participants.

Running a chi square alone provided a crude odd ratio because the effects of any possible confounders have not been controlled for. This was not a realistic situation as there are factors that exist that could be associated with the dependent variable. As confounding variable, such as academic level, was identified as a factor that could influence the outcomes of the study, an ordinal logistic regression was used with adjusted odd ratio (*OR*) at a confidence interval of 95% (95% CI) to estimate any possible association (Scaioli, et al., 2015). The analytic tool allowed to adjust the model. The odd ratio was used to determine whether academic level, for instance, is a factor for the outcome of knowledge and perception. Ultimately, an *OR* value equivalent to 1 suggested the exposure, defined as the academic level, does not affect the odds of the outcome. An *OR* value greater than 1 was interpreted as the exposure being associated with higher odds of the outcome and a value of lesser than 1 will be associated with a lower odd of the outcome. In the instance, the *OR* is not equivalent to 0, the academic level of the students participating the study regardless of their academic majors should be considered when assessing knowledge and perception of antibiotic resistance and stewardship in future research. The descriptive analysis providing frequencies of sub questions on the survey were used to support the research questions of the study after adjusting for potential confounders.

A power analysis for ordinal logistic regression was used to determine the sample size for the ordinal logistic regression. With an alpha value of 0.05, and a power of 0.80, the minimal sample size to run an ordinal logistic regression for each research questions was estimated to be 45 participants per research questions, totaling a minimum of 135 participants for the study (Walters, 2004). Since the study is planned to have a minimum of 133 participants, it is reasonable to conduct ordinal logistic regression.

Threats to Validity

In a quality research, validity of the research is an important step to be considered too close of the gap of knowledge and influence social change. Most importantly, in primary data, the validity of the data collection measurement properties of a survey or questionnaires must be ensured. Any potential lack of appropriate consideration of validity can increase the potential threats to the study, and hence, affecting the social change of the study.

External Validity

Confusion around the generalizability of a study has frequently been questioned. Is this study externally valid? Can the results of this study likely to apply in other study settings and/or samples? The question of external validity usually tends to reflect on the statistical concept of sampling strategies. The notion of assessing the entire members of a population has remained an issue of considerable argument in the 20^{th} century (Khorsan & Crawford, 2014). The reality is many socio-behavioral studies tend to focus on a probability sample of a specific population to create more feasible studies (Khorsan & Crawford, 2014).

In this study, potential threats to external validity may be present through the potential limitations of the study, resulting on recall bias and non-response bias from both incomplete or non-existent data, and social desirability bias. Additionally, the definition of the concept of the study can pose an external validity threat as the population sample has been assessed only at one point in time. The generalization of results can be threatened by time, the population characteristics, and response rate. Despite those limitation and threats to external validity, mitigating those potential threats can be accomplished by calculating the appropriate minimal sample size.

Internal Validity

Throughout the study design, the choice of data collection and the appropriate statistical analysis are the fundamental factors of any internal validity of the study (Khorsan & Crawford, 2014). Unfortunately, the survey itself used as the data collection has not been previously validated through case studies. However, the design of the survey questions is consistent with the literature review of similar studies. Confounding bias can also threaten the internal validity of the study. Consequently, the meticulous thoughts put towards the design of the survey, the sample size calculation, and ultimately, the choice of statistical analysis based on the research questions and the aim of the proposed study. In many instances, the internal validity of a study is a prerequisite for the external validity of the study.

Construct Validity

The construct validity of a research is often related to the methodological measures of the study (Danielsen et al., 2015). The quality of the chosen variables, as well of the appropriateness of the instrument of measurements for the study was evaluated to optimize the validity of the construct. In this proposed study, perhaps, the only anticipated threat to the validity of the construct is the survey not having been validated previously. By definition, a validated questionnaire has been previously developed to be administrated among the intended respondents (Tsang, Royse, & Terkawi, 2017). To minimize the validity and reliability of the administrated survey in this study, all survey questions were derived from literature review. Despite the survey not been validity through previous studies, all variables and analytic tests was conducted based on the outcomes of the study.

Ethical Procedures

When designing a quantitative research for social change, a powerful and influential role is given to the researcher in shaping decisions and services that aim to make a difference to everyone (Yip, Han, & Sng, 2016). When research designs and methodology is based on the public, ethics need to be considered (Yip, Han, & Sng, 2016). Ethical issues, such as the amount of information is needed to conduct the study, the target population will be used as the cohorts, the questionnaire designs, and the risk involved in the study, must be considered when designing any type of research (Yip, Han, & Sng, 2016). One of the responsibilities of the Institutional Review Board (IRB) is to ensure that, for any human subject research, the study proposal, which include study designs and methodology, is not conflicting ethically and does not pose any conflict of interest (Grady, 2015). The IRB evaluation considers all the aspect of the research designed from consent form to methodology and results collection (Grady, 2015).

For the proposed study, an IRB approval from Fort Hays State University (FHSU) was sought. For this type of study where there is no risk to the participants, the IRB application was considered to be exempt for FHSU, and therefore, relatively easy to obtain. Once FHSU IRB was approved, an IRB approval from Walden University was acquired. Walden University’s approval number for this study is 06-11-20-0656434.

As a principal investigator for this study, I sought the permission from the department chair of biology as well as from the department chair of agriculture to obtain the list of email of students from the university directory. I used the templates from Walden University for the invitational email to be sent to the students, as well as the template for consenting to the study. The consent form was uploaded on the Survey Monkey link for the study. All the information acquired from the survey was acquired lawfully and solely used for the purpose of the study. Moreover, the information of the participants was kept anonymously and confidential. No information was shared with unauthorized personnel in any way.

Summary

In Chapter 3, I describe the relevant research strategy and methodology that was applicable to the proposed study. An in-depth justification of the quantitative cross-section design for this study was provided. A detailed outlined on the methodology indicating the sampling framework, instrumental measurement, the validity of the study, as well as the ethical concerns of the study were provided.

Chapter 4: Results

Introduction

The purpose of this study was to explore the difference in knowledge of antibiotic resistance, the difference in perceived threat of antibiotic resistance, and the difference in perceived benefit of antibiotic resistance education among biology/prehealth and agriculture undergraduate students. An online survey assessing the three dependent variables was sent to undergraduate students in the departments of biology and agriculture. In this chapter, I report the procedure for data collection and the results of the study. A descriptive statistics analysis presented in frequencies and percentages of the study population demographics is reported and summarized in tables and figures. A descriptive statistics analysis of the dependent variables and supporting questions presented in means and percentage is reported as well and summarized in tables and figures. A Chi-square analysis between the variables was performed for each research question. The Pearson Chi-square value and *P*-value were evaluated and reported for each research question. An ordinal logistic regression was conducted to determine if class classification could be a predicted factor for knowledge of antibiotic and antibiotic resistance, perceived threat of antibiotic resistance, and perceived benefit of antibiotic resistance education. The *OR* as well as the *CI* are summarized and reported in the ordinal logistic parameter tables. The statistical findings for this research study are organized and presented in relation to each research question and hypothesis.

This study included three research questions, represented below along with their corresponding hypotheses:

Research Question 1: Are there differences in the knowledge of antibiotic resistance in prehealth students compared to agriculture students?

$H_0$1: There are no statistically significant differences in the knowledge of antibiotic resistance and antibiotic stewardship between prehealth students and agriculture students.

H_a1: There is a statistically significant difference in the knowledge of antibiotic resistance between prehealth students and agriculture students.

Research Question 2: Are there differences in the perceived threats of antibiotic resistance in prehealth students compared to agriculture students?

$H_0$2: There are no statistically significant differences in the perceived threat of antibiotic resistance between prehealth students and agriculture students.

H_a 2: There is a statistically significant difference in the perceived threat of antibiotic resistance between prehealth students and agriculture students.

Research Question 3: Are there differences in the perceived benefit of antibiotic resistance education in stewardship in prehealth students compared to agriculture students?

$H_0$3: There are no statistically significant differences in the perceived benefit of antibiotic resistance education in stewardship between prehealth students and agriculture students.

H_a3: There is a statistically significant difference in the perceived benefit of antibiotic resistance education in stewardship between prehealth students and agriculture students.

Data Collection

A link of an online survey assessing the knowledge of antibiotic resistance, the perceived threat of antibiotic resistance, and the perceived benefit of antibiotic resistance education was sent to undergraduate students majoring in biology/prehealth and agriculture enrolled in the 2019-2020 academic year. A total of 600 student emails was obtained through the Instructional Research office at Fort Hays State University. The link for the survey was kept active for 3 consecutive weeks. A total of N = 136 undergraduate students participated in the survey. Once the sample size of the study was reached, the responses of the survey were exported on a Microsoft Excel spreadsheet. Data were initially reviewed, cleaned by removing participants who had not completed the entire survey, and coded before exporting them to SPSS Version 25 software. No answers were modified to ensure the validity of the results. The required sample sized for this study was set at 135 participants. The final number of participants at the end the third week was 136.

Demographic Characteristics of the Sample

The demographic characteristics of the sample population for this study is represented in Table 2. Out the 136 participants (N = 136), 120 (87%) participants were between the ages of 18 and 24. Only 10.1% of the sample population was between the ages of 25 and 34, and only 2.9 % of the participants were older than 34 years old (see Table 2). The majority (67%) of the participants were female undergraduate students. There were 55.8% biology/prehealth undergraduate students and 42.8% agriculture undergraduate students. The descriptive analysis showed that 61% of the students who participated were senior undergraduate students and a smaller percentage of 15% were freshmen undergraduate students (see Table 2). Eighty-one percent of the sample population was White. The second largest race seen in the data was the Hispanic/Latino student group. Finally, only 30% of the participants were first generation college students (see Table 2). Table 2 shows the demographics of the population based on the independent variables. The majority of biology/prehealth majors were women,75.3%, whereas only 55.9% were agriculture majors. Most biology/prehealth majors, 97.4%, were between the ages of 18 and 24, and 72.9% of agriculture major undergraduate students were between the ages of 18 and 24. The majority of the biology/prehealth and agriculture undergraduate students were White (72.7% for biology/prehealth and 93.2% for agriculture). Most biology/prehealth and agriculture undergraduate students who participated in this study were classified as senior (4^{th} year) undergraduate students (40.3% for biology/prehealth and 47.5% for agriculture). Seventy-point one percent of biology/prehealth undergraduate students and 71.2% of agriculture undergraduate students were not first-generation college students.

As the characteristics of the population of undergraduate students majoring in agriculture as well as in biology/prehealth is unknown, there is no evidence that this sample population is representative of the target population. Nonetheless, the demographic questions on the survey used in this study presented key variables and characteristics, such as sex, age, and education of the large population under investigation.

Table 2

Sociodemographic Characteristics of Undergraduate Students Participants

Baseline characteristic		Total		Biology		Agriculture	
		N	%	*N*	%	*N*	%
Sex	Female	91	67.4	58	75.3	33	55.9
	Male	45	32.6	19	24.7	26	44.1
Age	18-24	118	87.0	75	97.4	43	72.9
	25-34	14	10.1	2	2.6	12	20.3
	35-44	0	0.00	0	0.00	0	0.00
	45-54	4	2.9	0	0.00	4	6.8
Race	White	113	81.9	56	72.7	55	93.2
	African American/Black	6	4.3	4	5.2	2	3.4
	Hispanic/Latino	14	10.1	13	16.9	1	1.7
	Asian/Pacifier Islander	3	2.2	3	3.9	0	0.00
	Other	2	1.4	1	1.3	1	1.7
Class classification	Freshmen	15	10.9	12	15.6	3	5.1
	Sophomore	26	18.8	13	16.9	13	22.0
	Junior	36	26.1	21	27.7	15	25.4
	Senior	61	44.2	31	40.3	28	47.5
Are you first-generation college students?	Yes	41	29.7	23	29.9	17	28.8
	No	97	70.3	54	70.1	42	71.2

Study Results

To analyze the survey data, the SPSS Version 25 statistical analysis software was used. For each research question presented below, the Chi-square results are presented first, followed by original logistic regression. In addition, the detailed questions related to the outcome variable in each research question are tabulated based on the study major and assessed using a Chi-square test.

Results of Research Question 1

To test the hypothesis for the first research question, a descriptive analysis, a chi-square analysis, and ordinal logistic regression analysis were conducted using the variable overall knowledge of antibiotic resistance and the variable academic major. The descriptive analysis of the level of knowledge of antibiotic resistance between biology/prehealth and agriculture undergraduate students is shown in Table 3.

Table 3

Knowledge of Antibiotic Resistance by Academic Major

Academic major	Level of overall knowledge							
	Strongly knowledgeable/ knowledgeable	Somewhat knowledgeable	Undecided	Not knowledgeable	Total	X^2	*df*	*p*
Biology/prehealth	42	30	1	4	77	5.519	3	0.138
Agriculture	25	27	5	2	59			
Total	70	57	6	6	136			

Note. $\chi^2(3, N = 136) = 5.519, p > .05$

The results of the Chi-square analysis revealed a nonsignificant association between academic major and the level of overall knowledge of antibiotic resistance. Thus, there is not a statistically significant association between academic major and the level of knowledge of antibiotic resistance, and the null hypothesis that there is no significant difference in knowledge about antibiotic resistance between biology/prehealth students and agriculture students cannot be rejected.

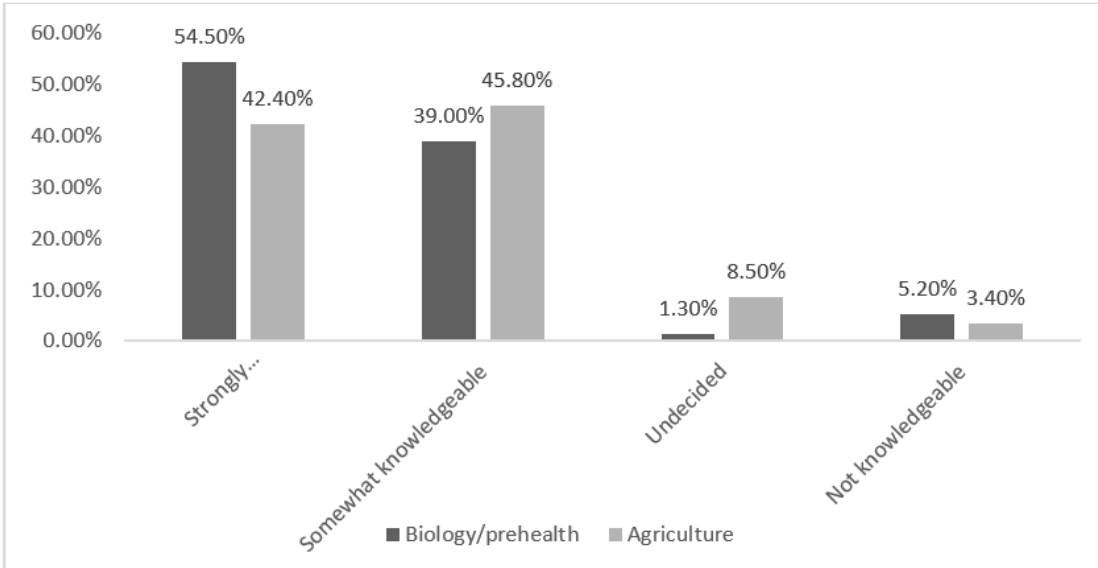

Figure 1. A comparison of frequency of responses assessing the level of knowledge of antibiotic resistance between biology/prehealth and agriculture undergraduates.

However, as mentioned in Chapter 3, the Chi-square analysis does not consider any confounding or predictor factor. Hence, an ordinal logistic regression was performed to adjust to the potential predictor, such as class classification.

Table 4

Proportional Odds Assumption Test for the Overall Level of Knowledge Between Academic Major

Model	-2 Likelihood	Chi-square	df	Sig
Null Hypothesis	36.532			
General	29.158	7.374	6	p>0.05

The assumptions of ordinal logistic regression were evaluated first before running the analysis and are presented in Table 4. Logistic regression analysis assumes that there is a proportional odds assumption, suggesting that the coefficients that describe the relationship between response variables are the same. As shown in Table 4, the proportional odd assumption was not violated ($p > .05$). The null hypothesis states that the location parameters (slope coefficients) are the same across responses categories.

Table 5

Model Fitting Information for the Ordinal Logistic Regression for RQ1

Model	-2 log likelihood	Chi-square	*df*	Sig.
Intercept only	60.562			
Final	36.532	24.030	3	.000

The model fitting information of the -2-log likelihood for a null model and the full model containing the predictor factor is shown in Table 5. The table also provided the likelihood ratio chi-square test to test whether there is a significant improvement in fit of the final model relative to the null model. As shown in Table 5, there is a significant improvement of the final model with the predictor over the null model (X^2 (3) = 24.030, p < .001). A goodness fit analysis was conducted to evaluate whether the final model with the predictor over the null model exhibits good fit to the data. The Pearson's Chi-squared test assesses whether the observed frequency distribution differs from a theoretical distribution, whereas the deviance test is often used in statistical hypothesis testing. The results of the goodness fit showed both Pearson Chi-square test (X^2 (6) = 5.295, p > .05) and the deviance test (X^2 (6) = 7.406, p > .05) were both non-significant. These results suggest good model fit.

Table 6

Results of Ordinal Logistic Regression for the Effect of Class Classification on Knowledge of Antibiotic Resistance

	Estimate	Std. Error	Wald	*df*	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Strong/ Knowledge = 0	.792	.275	8.298	1	.004	.253	1.332
Somewhat Knowledge = 2	3.451	.424	66.225	1	.000	2.620	4.283
Not Knowledge = 3	4.219	.515	67.014	1	.000	3.209	5.229
	2.170						
Freshmen = 1	1.895	.595	13.288	1	.000	1.003	3.336
Sophomore = 2	.824	.487	15.154	1	.000	.941	2.849
Junior = 3	0[a]	.425	3.749	1	.053	-.010	1.657
Senior = 4		.	.	0	.	.	.

Note. This parameter is set to zero because it is redundant.

The results of the ordinal logistics regression analysis to investigate if there is a potential relationship between class classification, defined as freshman, sophomore, junior, and senior year, (additional potential predictor/factor variable) and the level of knowledge between biology/pre-health and agriculture undergraduate students is shown in Table 6. The Estimate of knowledge of antibiotic resistance for freshmen students majoring in is 2.170, $p < .05$; whereas the estimate knowledge of a senior undergraduate student is 0, indication the knowledge of antibiotic resistance is seniors will be the baseline for the analysis. As shown in Table 6, the Estimate value of knowledge increases as students move up to class classification. In this instance, senior undergraduate students are more likely to be knowledgeable of antibiotic resistance than freshman undergraduate students. An odd ratio above 1 suggests an increase odd of being in a less knowledgeable on the dependent variables as the values on the independent variables increases. The results of this analysis suggest there is a higher odds ratio juniors and seniors are more knowledgeable than freshman and sophomore undergraduate students. In this instance where the value of a strong knowledge is estimated at 0, freshman undergraduate students have about 7 times of odd being less knowledgeable than sophomore undergraduate students. The odds of sophomore undergraduate students to be less knowledgeable than senior undergraduate students' counterparts are 6.556. Juniors had 2.3-time odds being less knowledgeable than seniors. So, knowledge of antibiotics resistance increases with classes levels. These results suggest class classification must be considered as a predicted factor for the level of knowledge of antibiotic resistance.

A comparison of knowledge of antibiotic resistance based on academic major as well as class classification is shown in Table 7.

Table 7

Knowledge of Antibiotic Resistance by Academic Major and Class Classification

Knowledge level	Undergrads academic major							
	Biology/prehealth				Agriculture			
	Freshmen	Sophomore	Junior	Senior	Freshmen	Sophomore	Junior	Senior
Strongly knowledgeable/ Knowledgeable	8.3	38.5	47.6	83.9	33.3	15.4	53.3	50.0
Somewhat knowledgeable	75.0	53.8	42.9	16.1	66.7	53.8	40.0	42.9

Table 7 (Continued)

Undecided	0.00	0.00	4.8	0.00	0.00	15.4	6.7	7.1
Not knowledgeable	16.7	7.7	4.8	0.00	0.00	15.4	0.00	0.00

The frequency of responses of questions assessing how biology/pre-health and agriculture undergraduate students view the concept of antibiotic resistance are shown in Table 8. The questions are all related to assessing the knowledge as well as the impact of antibiotic resistance based on the academic major.

Table 8

Assessment of Antibiotic Resistance Knowledge Between Biology/Prehealth and Agriculture Students

Antibiotics are powerful medicines to kill viruses	Academic Major			
	Biology/prehealth Undergrads		Agriculture Undergrads	
	N	%	*N*	%
Strongly agree/ Agree	24	31.2	23	39.0
Undecided	8	10.4	5	8.5
Strongly disagree	45	58.4	31	52.5
P value from X^2 test >.05				
Frequent use of antibiotics in medicine and agriculture decrease the efficacy of antibiotics	Academic Major			
	Biology/prehealth Undergrads		Agriculture Undergrads	
	N	%	*N*	%
Strongly agree/ Agree	66	85.7	43	72.9
Undecided	8	10.4	8	13.6
Strongly disagree	3	3.9	8	13.6

Table 8 (Continued)

P value from X^2 test >.05

Frequent use of antibiotics put patients at risk	Academic Major			
	Biology/prehealth Undergrads		Agriculture Undergrads	
	N	%	*N*	%
Strongly agree/ Agree	55	71.4	26	44.1
Undecided	17	22.1	19	32.2
Strongly disagree	5	6.5	14	23.7

P value from X^2 test < .05

There is no connection between taking antibiotics and the development of resistant Bacteria.	Academic Major			
	Biology/prehealth Undergrads		Agriculture Undergrads	
	N	%	*N*	%
Strongly agree/ Agree	1	1.3	2	3.4
Undecided	10	13.0	16	27.1
Strongly disagree	66	85.7	41	69.5

P value from X^2 test >.05

Antibiotics speed up the recovery from common cold or flu.	Academic Major			
	Biology/prehealth Undergrads		Agriculture Undergrads	
	N	%	*N*	%
Strongly agree/ Agree	25	32.5	22	37.3
Undecided	11	14.3	5	8.5
Strongly disagree	41	53.2	32	54.2

Note. P value from X^2 test >.05.

The Chi-square analysis of the questions assessing the knowledge and impact of antibiotic resistance among undergraduate students majoring in biology/prehealth agriculture are all not statistically significant (p > .05), except for the question assessing the risk/impact of frequent use of antibiotics on patients' risk. The *P* value for this specific question was below 0.05, suggesting the difference of perception between the two undergraduate academic major is statistically significant.

Results of Research Question 2

To test the hypothesis for the second research question, a descriptive analysis, a chi-square analysis and ordinal logistic regression analysis were conducted using the variable "Rate your level of perceived threat of antibiotic resistance" and the variable "Academic Major". Table 9 reports the descriptive analysis of the level of perceived threat of antibiotic resistance between biology/prehealth and agriculture undergraduate students.

Table 9

Level of Perceived Threat of Antibiotic Resistance by Academic Major

Academic Major	Level of perceived threat of antibiotic resistance						X^2	*df*	*p*
	High threat	Moderate threat	Low threat	No threat	Unknown/Don't know	Total			
Biology/prehealth	29	28	12	0	8	77	15.067	4	.005
Agriculture	7	25	16	3	8	59			
Total	36	53	28	3	16	136			

Note. $\chi^2(4, N = 136) = 15.067, p < .01$.

The results of the Chi-square analysis revealed a significant association between academic major and the level of perceived threat of antibiotic resistance. Thus, we can conclude that there is a statistically significant association between academic major and the level of perceived threat of antibiotic resistance, and the null hypothesis that there was no significant difference in perceived threat about antibiotic resistance between biology/prehealth students and agriculture students can be rejected.

A comparison bar chart of the frequency of responses assessing the level of perceived threat of antibiotic resistance between academic major is shown in Figure 2.

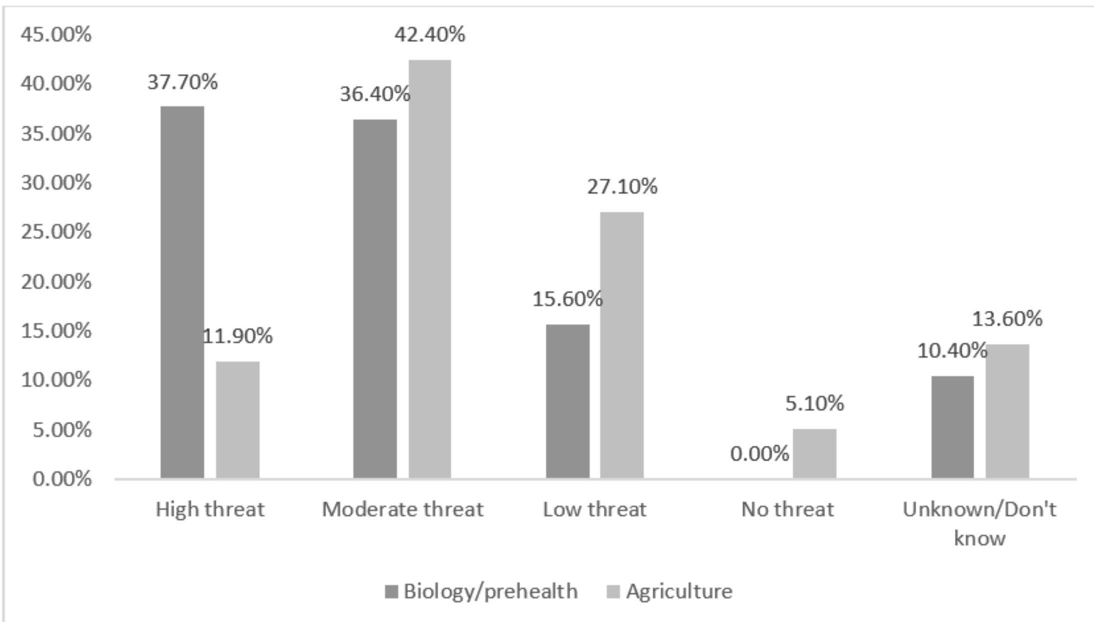

Figure 2. A comparison of frequency of responses assessing the level of perceived threat of antibiotic resistance between biology/prehealth and agriculture undergraduates.

An ordinal logistic regression was performed to adjust to potential predictor, such as class classification. The assumptions of ordinal logistic regression were evaluated first before running the analysis and presented in Table 10. As shown in Table 10, the proportional odd assumption was not violated because the null hypothesis of this chi-square test shows there is no significant difference in the coefficients between models ($p>.05$). The null hypothesis states the location parameters (slope coefficients) are the same across responses categories.

Table 10

Proportional Odds Assumption Test for the Level of Perceived Threat of Antibiotic Resistance Between Academic Majors

Model	-2 Likelihood	Chi-square	df	Sig
Null Hypothesis	57.481			
General	48.760	8.720	9	.463

The Model Fitting information provided the -2-log likelihood for a null model and the full model containing the predictor factor is shown in Table 11. Reported in Table 11 is the likelihood ratio chi-square test to test whether there is a significant improvement in fit of the final model relative to the null model. There is a significant improvement of the final model with the predictor over the null model (X^2 (3) = 12.059, p < .05). The goodness fit test evaluates whether the model exhibits good fit to the data. The results showed both Pearson chi-square test (X^2 (9) = 14.036, p > .05) and the deviance test (X^2 (9) = 14.886, p > .05) were both non-significant. These results suggest good model fit

Table 11

Model Fitting Information for the Ordinal Logistic Regression for RQ2

Model	-2 Log Likelihood	Chi- Square	df	Sig.
Intercept Only	69.540			
Final	57.481	12.059	3	.007

The results of the ordinal logistics regression analysis to investigate if there is a potential relationship between class classification (additional potential predictor variable) and the level of perceived threat of antibiotic resistance between biology/pre-health and agriculture undergraduate students are shown in Table 12.

Table 12

Results of Ordinal Logistic Regression for the Effect of Class Classification on Perceived Threat of Antibiotic Resistance

						95% Confidence Interval	
	Estimate	Std. Error	Wald	df	Sig.	Lower Bound	Upper Bound
High Threat = 0	-.563	.251	5.038	1	.025	-1.055	-.071
Moderate Threat =1	1.257	.273	21.238	1	.000	.722	1.791
Threat = 2	2.493	.334	55.578	1	.000	1.837	3.148
Threat = 3	2.696	.350	59.433	1	.000	2.011	3.382
Freshmen = 1	.862	.530	2.650	1	.104	-.176	1.901
Sophomore = 2	1.389	.439	9.994	1	.002	.528	2.250
Junior = 3	.804	.390	4.251	1	.039	.040	1.568
Senior = 4	0[a]	.		0	.	.	.

a. Set to zero because this parameter is redundant.

The Estimate perceived threat of antibiotic resistance for freshmen students majoring in is .862, $p > .05$; whereas the Estimate perceived threat of a senior undergraduate student is 0, indicating that perceived threat of senior will be the baseline for this analysis. The Estimate value of perceived threat increases as students move up to class classification as it is assumed in this study a high threat has a value of 0. As shown in Table 12, juniors (.804, $p < .05$) perceived antibiotic resistance more as a threat than sophomore students (1.389, $p < .05$). However, there is a gap between freshmen and sophomore where in this instance, freshmen view antibiotic resistance more as a threat than sophomores (.862, $p > .05$). This result is not statistically significant. An odd ratio above 1 suggests an increase probability of being in a higher level (high threat=0) on the dependent variables as values on the independent variables increases. The results of the table suggest there is a higher probability juniors and seniors have a higher perception of threat of antibiotic resistance than freshman and sophomore students, and the results are statically significant as the p-value is less than 0.05. In this instance, freshmen students have an increase of about 3.5 times to less likely perceived antibiotic resistance as a threat than seniors. Juniors are nearly 2.4 times less likely to considered antibiotic resistance as a threat than seniors. Consequently, class classification is indeed a possible predictor for evaluating the level of perceived threat of antibiotic resistance between biology/prehealth and agriculture undergraduate students as shown in Table 12.

A comparison of perceived threat of antibiotic resistance based on academic major as well as class classification is shown in Table 13.

Table 13

Perceived Threat of Antibiotic Resistance by Academic Major and Class Classification

Perceived threat	Undergrads academic major							
	Biology/prehealth				Agriculture			
	Freshmen	Sophomore	Junior	Senior	Freshmen	Sophomore	Junior	Senior
High threat	16.7	15.4	42.9	51.6	33.3	0.00	13.3	14.3
Moderate threat	33.3	38.5	23.8	45.2	33.3	46.2	26.7	50.0
Low threat	41.7	23.1	14.3	3.2	33.3	30.8	33.3	21.4
No threat	0.00	0.00	0.00	0.00	0.00	0.00	6.7	7.1
Unknown/Don't know	8.3	23.1	19.0	0.00	0.00	23.1	20.0	7.1

The frequency of responses of questions assessing how biology/pre-health and agriculture undergraduate students perceived antibiotic resistance as a threat is shown in Table 14. The questions are all related to assessing the level of perceived threat as well as the impact of antibiotic resistance based on the academic major.

Table 14

Assessment of Perceived Threat of Antibiotic Resistance Between Biology/Prehealth and Agriculture Students

Antibiotics resistance will affect you and your family's health	Academic Major			
	Biology/prehealth Undergrads		Agriculture Undergrads	
	N	%	*N*	%
Strongly agree/ Agree	56	72.7	33	55.9
Undecided	13	16.9	16	27.1
Strongly disagree	8	10.4	10	16.9
P value from X^2 test > .05				

The use of antibiotics in farming is a danger to human health	Academic Major			
	Biology/prehealth Undergrads		Agriculture Undergrads	
	N	%	*N*	%
Strongly agree/ Agree	21	27.3	9	15.3
Undecided	26	33.8	12	20.3
Strongly disagree	30	39.0	38	64.4
P value from X^2 test < .05				

If taken too often, antibiotics are less likely to work in the future	Academic Major			
	Biology/prehealth Undergrads		Agriculture Undergrads	
	N	%	*N*	%
Strongly agree/ Agree	70	90.9	46	78.0

Table 14 (Continued)

Undecided	5	6.5	10	16.9
Strongly disagree	2	2.6	3	5.1
P value from X^2 test >.05				
Currently, antibiotic resistance is a major problem in the United States as well as in the rest of the world	Academic Major			
	Biology/prehealth Undergrads		Agriculture Undergrads	
	N	%	*N*	%
Strongly agree/ Agree	59	76.6	20	33.9
Undecided	13	16.9	28	47.5
Strongly disagree	5	6.5	11	18.6

P value from X^2 test < .05

The results of the analysis suggest when it comes to the danger of antibiotic use globally and in farming, the perception of threat between the two groups of students differ statistically ($p < .05$) as shown in Table 14. However, the perception of threat of antibiotic resistance in term of efficacy in treatment and how it will affect their families are not statistically different between the two majors.

Results of Research Question 3

To test the hypothesis for the third and final research question, a descriptive analysis, a chi-square analysis and ordinal logistic regression analysis were conducted using the variable “Rate your level of perceived benefit of antibiotic education in stewardship” and the variable “Academic Major”. The descriptive analysis of the level of perceived benefit of antibiotic education between biology/prehealth and agriculture undergraduate students is shown in Table 15.

The results of the Chi-square analysis revealed a non-significant association between academic major and the level of perceived benefit of antibiotic resistance education. Thus, we can conclude that there is a non-statistically significant association between academic major and the level of perceived benefit of antibiotic resistance education, and the null hypothesis that there was no significant difference in perceived benefit of antibiotic resistance education between biology/prehealth students and agriculture students cannot be rejected.

Table 15

Level of Perceived Benefit of Antibiotic Resistance Education by Academic Major

Academic Major	Level of perceived benefit of antibiotic resistance education								
	High benefit	Moderate benefit	Low benefit	No benefit	Unknown/Don't know	Total	X^2	*df*	*p*
Biology/prehealth	47	20	2	1	7	77	4.356	4	.360
Agriculture	28	18	4	3	6	59			
Total	75	38	6	4	13	136			

$\chi^2(4, N = 136) = 4.356, p > .05$.

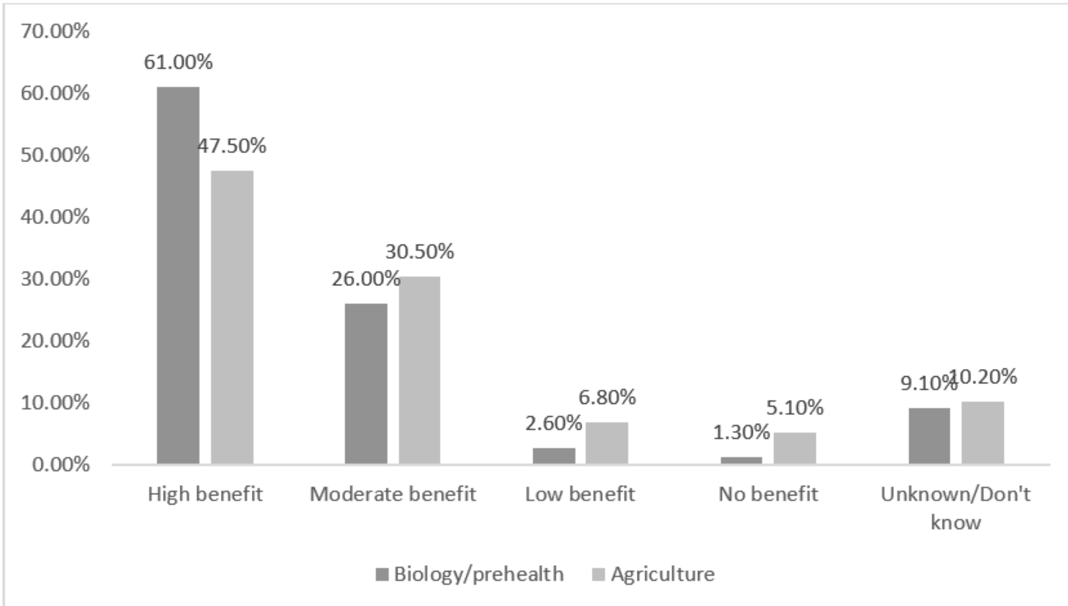

Figure 3. A comparison of frequency of responses assessing the level of perceived benefit of antibiotic resistance between biology/prehealth and agriculture undergraduates.

An ordinal logistic regression was performed to adjust to potential predictor, such as class classification. The results for the proportional odds assumption for the ordinal logistic regression are shown in Table 16.

Table 16

Proportional Odds Assumption Test for the Level of Perceived Benefit of Antibiotic Resistance Education Between Academic Majors

Model	-2 Likelihood	Chi-square	df	Sig
Null Hypothesis	49.797			
General	39.004	10.793	9	.290

The results above showed the null hypothesis states the location parameters (slope coefficient) are the same across response categories. As stated for first and second research questions, the assumption was not violated. However, the results showed a statistically significant difference as the $p > .05$, suggesting the validity of the test.

Table 17

Model Fitting Information for the Ordinal Logistic Regression for RQ3

Model	-2 Log Likelihood	Chi-square	df	Sig.
Intercept Only	52.919			
Final	49.797	3.122	3	p > .05

Model Fitting information provided the -2-log likelihood for a null model and the full model containing the predictor factor is shown in Table 17. The table also provided the likelihood ratio chi-square test to test whether there is a significant improvement in fit of the final model relative to the null model. Table 17 showed there is no statistically significant improvement of the final model with the predictor over the null model (X^2 (3) = 3.122, $p > .05$). In addition, the model exhibits good fit to the data. The results of the goodness fit showed both Pearson chi-square test (X^2 (9) = 9.081, $p > .05$) and the deviance test (X^2 (9) = 10.793, $p > .05$) were both non-significant. These results suggest good model fit.

Table 18

Results of Ordinal Logistic Regression for the Effect of Class Classification on Perceived Benefit of Antibiotic Education

	Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
High Benefit = 0	.545	.262	4.344	1	.037	.032	1.058

Table 18 (Continued)

Moderate Benefit = 1	1.937	.312	38.602	1	.000	1.326	2.548
Low Benefit = 2	2.296	.336	46.661	1	.000	1.637	2.955
No Benefit = 3	2.604	.363	51.538	1	.000	1.893	3.315
Freshmen	.511	.553	.856	1	.355	-.572	1.595
Sophomore	.725	.448	2.616	1	.106	-.154	1.604
Junior	.477	.409	1.360	1	.243	-.325	1.279
Senior	0[a]	.		0	.	.	.

a. Set to zero because this parameter is redundant.

The results of the ordinal logistics regression analysis to investigate if there is a potential relationship between class classification (additional potential predictor variable) and the level of perceived benefit of antibiotic education between biology/pre-health and agriculture undergraduate students are shown in Table 18.

The Estimate perceived benefit of antibiotic resistance education for freshmen students majoring in is 0.511, p > .05; when compared to the Estimate for seniors. In this analysis, the perceived benefit of antibiotic resistance education in seniors will be the baseline. Although the p values are not statistically significant as the p-values are above 0.05, the Estimate value of perceived benefit increases as students move up to class classification. Juniors (.477, p > .05) have a higher perception of the benefit of antibiotic resistance education that sophomore students (.725, p > .05). However, freshmen students (.511, p > .05) seems to have a slightly higher perception of benefit of antibiotic resistance education than sophomore students (.725, p > .05) However, the analysis suggests class classification should be considered a predicted factor in level of perceived benefit of antibiotic resistance among biology/prehealth and agriculture undergraduate students. The difference of odd ratios is small between class classifications and not statically significant based on the p-value. Nonetheless, since the odds are above 1, it does suggest in this instance, class classification should be considered.

A comparison of perceived benefit of antibiotic resistance education based on academic major as well as class classification is shown in Table 19.

Table 19

Perceived Benefit of Antibiotic Resistance Education by Academic Major and Class Classification

Perceived threat	Undergrads academic major							
	Biology/prehealth				Agriculture			
	Freshmen	Sophomore	Junior	Senior	Freshmen	Sophomore	Junior	Senior
High benefit	41.7	53.8	47.6	80.6	66.7	46.2	60.0	39.3
Moderate benefit	41.7	23.1	33.3	16.1	33.3	23.1	20.0	39.3
Low benefit	8.3	0.00	4.8	0.00	0.00	0.00	0.00	14.3
No benefit	0.00	7.7	0.00	0.00	0.00	7.7	6.7	3.6
Unknown/Don’t know	8.3	15.4	14.3	3.2	0.00	23.1	13.3	3.6

The frequency of responses of questions assessing how biology/pre-health and agriculture undergraduate students perceived the benefit of antibiotic resistance education is shown in Table 20. The questions are all related to assessing the level of perceived benefit as well as the impact of antibiotic resistance education based on the academic major.

Table 20

Assessment of Perceived Benefit of Antibiotic Resistance Education Between Biology/Prehealth and Agriculture Students

Students can contribute to the work being done to control antibiotic resistance	Academic Major			
	Biology/prehealth Undergrads		Agriculture Undergrads	
	N	%	*N*	%
Strongly agree/ Agree	71	92.2	41	69.5
Undecided	6	7.8	16	27.1
Strongly disagree	0	0.00	2	3.4
P value from X^2 test < .05				

It is necessary to give more education for students about antibiotic resistance.	Academic Major			
	Biology/prehealth Undergrads		Agriculture Undergrads	
	N	%	*N*	%
Strongly agree/ Agree	71	92.2	47	79.7
Undecided	6	7.8	9	15.3
Strongly disagree	0	0.00	3	5.1
P value from X^2 test < .05				

All health and agriculture students should get training on the appropriate use of antibiotics before exiting college.	Academic Major			
	Biology/prehealth Undergrads		Agriculture Undergrads	
	N	%	*N*	%
Strongly agree/ Agree	74	96.1	43	72.9
Undecided	2	2.6	11	18.6
Strongly disagree	1	1.3	5	8.5
P value from X^2 test < .05				

Dispensing antibiotics without prescription should be more closely controlled.	Academic Major	
	Biology/prehealth Undergrads	Agriculture Undergrads

Table 20 (Continued)

	N	%	*N*	%
Strongly agree/ Agree	66	85.7	34	57.6
Undecided	9	11.7	16	27.1
Strongly disagree	2	2.6	9	15.3

P value from X^2 test < .05

The Chi-square analysis of the assessment of perceived benefit of antibiotic resistance education between both groups of students indicated the results were statistically significant as $p < .05$

Summary

I presented the results of the study in Chapter 4. Overall, 136 undergraduate students majoring in either Biology/pre-health or Agriculture participated in this study, reached the overall required sample size of the study. A descriptive analysis using frequencies were used to present the demographic of the sample population been studied. For each research question proposed in the study, I conducted a descriptive analysis of the responses for the research question, a Chi-square analysis to test the hypothesis, and an ordinal logistic regression to adjust to potential predictor in the study by using the variable class classification as a factor variable. The proportional odd assumptions for all three research questions were verified before the ordinal logistics regression analysis was conducted. The results were presented in table formats reported major values, such as the Pearson Chi-square value and the significance level for each response. The results presented in Chapter 4 will be interpreted in Chapter 5. Chapter 5 will also include some of the limitations of the study and recommendations.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

The excessive use of antibiotics and other antimicrobial drugs has become a global concern. Irrational use of these drugs is often related to multiple factors, such as knowledge and attitudes towards antibiotic resistances and stewardship. As education of future antibiotic prescribers at the undergraduate level can potentially show better results, the nature of this study was to assess and compare the knowledge and perceptions of antibiotic resistance and education among undergraduate students majoring in biology/prehealth and agriculture attending a Western Kansas university. Those students in particular are considered future antibiotic prescribers. Consequently, understanding their knowledge and perceptions in relation to the public risk of antibiotic resistance can greatly impact antibiotic-related issues. In Chapter 5, I interpret the results of the study based on the data presented in Chapter 4. I also provide the limitations of the study and a few recommendations for the future.

Interpretation of Findings

In this study, the results revealed that there are no significant differences between these two groups of students in their knowledge of antibiotic resistance and perceived benefit of antibiotic resistance education. However, there was a statistically significant difference between the two groups on perceived threat of antibiotic resistance. The interpretation of the findings for each research question is presented below.

Research Question 1

Research Question 1 was as follows: Are there differences in the knowledge of antibiotic resistance in prehealth students compared to agriculture students? Reducing antibiotics and any other antimicrobial use in livestock has been requested by public health authorities (Carmo et al., 2018). Ideally, this request should be achieved by identifying measures that do not jeopardize production output or animal health and welfare. Carmo et al. (2018) hypothesized that the differences in prescribing and preserving the view of antibiotic resistance among veterinarians could be related to knowledge of disease epidemiology, animal husbandry, and socioeconomic factors. Other studies conducted by Lee et al. (2015) and Manyi-Loh et al. (2018) revealed that among the many factors that influence perception and knowledge, the lack of understanding -- defined as knowledge of the role of antibiotic and the perceived threat of antibiotic resistance -- has contributed the most to the quality of antibiotic prescribing in agriculture. This finding marks an important need to assess the knowledge of future prescribers and users of antibiotics (particularly future farmers and veterinarians) on the role of antibiotics in humans and animal health. The need to educate about the role of antibiotics in medicine, especially in future professional prescribers, is relevant to further control the dissemination of antibiotic resistance and protect antimicrobial based treatment. In this study, I aimed to contribute to an ongoing international effort to educate future prescribers on the importance of antibiotics in medicine and reduce antibiotic resistance.

Based on this study, when it comes to knowledge of antibiotic resistance between biology/prehealth undergraduate students and agriculture undergraduate students, the difference in knowledge between the two groups is a minimal to no significant difference. Both groups of students seem to be knowledgeable as to what antibiotics do and the role of antibiotic resistance.

However, knowledge of antibiotic resistance increases as the undergraduate students (biology/prehealth and agriculture) move up in their class classification, especially among biology/prehealth students who become more knowledgeable than do agriculture students. The curriculum for both of groups is not the same for both groups; for instance, biology students understand more on biological concepts in disease, epidemiology, and disease preventions. Although the agriculture curriculum emphasizes animal health, the main concepts are primarily related to socioeconomic values and mass animal production. In this way, differences appear in how these two groups perceive the frequent use of antibiotics as a risk for patients. Biology students are exposed to, and tend to acknowledge, the link between frequent use of antibiotics and patient health, whereas agriculture students have been less exposed to the risk of the frequent use of antibiotics on an individual’s health. A part of this difference between the two groups may also be attributed to the lack of evidence of the degree and relative impact on the dissemination of antibiotic resistance on human health. Chang et al. (2015) concluded that the benefits and risks to animal production and health have not been well studied, leading to an inconsistency in national policies on the use of antibiotics in agriculture relative to the risk of patient’s health.

Research Question 2

Research Question 2 was as follows: Are there differences in the perceived threats of antibiotic resistance in prehealth students compared to agriculture students? As reported above, there was a statistically significant difference in the perceived threat of antibiotic resistance not only globally but to human health between biology/prehealth and agriculture undergraduate students. The majority of biology/prehealth undergraduate students rated the perceived threat of antibiotic resistance as high or moderate whereas the majority of agriculture undergraduate students rated the threat of antibiotic resistance as moderate or low. This suggests that biology/prehealth students are more aware of the damage antibiotic resistance can cause in disease treatments and individual health, as those concepts are more of a focus in the courses biology/prehealth students take. Agriculture students seem to be less interested in the threat of antibiotic resistance in human health. The perception of threat between both groups of students differs statistically when it comes to the health damage that can be caused by the frequent use of antibiotic in farming. The biology/prehealth undergraduate students tended to *strongly agree* (value of 0 or close) that antibiotic resistance is a threat to their health and their family's health and a major health issue globally. By contrast, agriculture undergraduate students tended to view the threat of antibiotic resistance *moderately*, especially when it comes to the threat of the use of antibiotics in farming in relation to the danger to human health.

The results of the ordinal logistic regression analysis for the second research question were similar to those for the first research question. The results imply that junior and senior undergraduate students majoring in biology/prehealth as well as in agriculture view antibiotic resistance more as a threat than freshmen and sophomore undergraduate students. In addition, junior and senior biology/prehealth undergraduate students perceived antibiotic resistance as a higher threat than junior and senior agriculture students. The gradient of increase perception of risk between the two groups can be related to the difference in curriculum as one curriculum focuses more on human health as opposed to the other that focuses more on livestock productivity.

In conclusion, class classification can also be a predictor of level of perceived threat of antibiotic resistance and should be considered in future analysis testing the level of perceived threat of antibiotic resistance. Once more, the results imply that agriculture students do view the threat differently than in biology/prehealth, especially when it is related to human health in relation to antibiotic usage in farming. The findings reported for this specific research question perhaps highlight the difference in curriculum between the two academic majors. Ample learning active pedagogies on antibiotics and their role in society are emphasized in the curriculum for biology/prehealth. Courses such as immunology, microbiology of pathogens, and virology are courses examples in which lecture topics highlight the importance of antimicrobial properties and functions. With enough repetition on the topic, it is easier for one academic group to be more aware of the importance of antibiotics and the threat of antibiotic resistance relative to a patient’s treatment course. Once more, the findings relate to Aslam et al. (2018), who reported that ASP guidelines have not been successfully implemented in agriculture settings due to the lack of reliable data about the quantity and patterns use of antibiotics in relation to threat.

Hence, most agriculture students do not perceive the notion of antibiotic resistance as a threat. This perception may be attributed to the fact that there is no found direct link between the frequent use of antibiotics and the health of the animal. All antibiotic resistance pathogens are human pathogens, such as *Staphylococcus aureus*, *Klebsiella pneumoniae*, nontyphoid *Salmonella and Mycobacterium tuberculosis*, and, therefore, do not apply to animal health directly.

Research Question 3

Research Question 3 was as follows: Are there differences in the perceived benefit of antibiotic resistance education in stewardship in prehealth students compared to agriculture students? The chi-square analysis for the third research question suggested that there was no statistically significant difference in the perceived benefit of antibiotic resistance education for future prescribers. Both groups of students saw a benefit in the education of antibiotic resistance. When assessing if they perceived a benefit of education on antibiotic resistance at the undergraduate level, both biology/prehealth undergraduate students and agriculture undergraduate students strongly agreed (mean value close to 0) they can contribute to the work being done to control antibiotic resistance. They also strongly agreed that education and training on the appropriate use of antibiotics at the undergraduate level were beneficial. The results for the ordinal logistic regression analysis for the third research question were again not different than the results of the ordinal logistic regression analysis for the first and second research questions.

There were no statistically significant differences between the class classifications. However, because the *OR*s were above 1, class classification should be considered as a potential factor. The desire to learn more about antibiotic resistance can only be assumed as the students complete their undergraduate academic career, signifying that perhaps they would like to be better educated on antibiotic usage and risks before they start their professional career. Stimulatingly, even though agriculture students think they already have a good grasp of knowledge on antibiotic resistance, and even though they do not perceive antibiotic resistance as a threat, they do want to have more information about the topic. Silverberg et al. (2017) indicated the need for educating undergraduate students in prudent antibiotic prescribing and other antibiotic stewardship program strategies, such as surveillance and reporting; the finding that agriculture and biology/prehealth students want to learn more about antibiotic resistance stewardship is a good foundation to initiate a conversation on the curriculum development to meet ASP goals.

Limitations of the Study

The study presents some limitations that ultimately could affect the generalization of the study findings. The study relied primarily on the survey data that was distributed to local biology/pre-health and agriculture undergraduate students. One general limitation attributed to using a survey research approach is the oversimplification of the social reality (Khorsan & Crawford, 2014). As the survey used in this study was constructed with pre-conceived categories and an overly simplified view of the reality, this could represent a bias. This arbitrary bias can lead to a so-called arithmetic manipulation of frequencies, averages, and rates that represent statistics that carry no real significance on its own (Khorsan & Crawford, 2014). Therefore, a qualitative approach may have added a richer impact in the data. The true nature of a cross-sectional survey, in reality, is an interactive and dynamic process. This particular limitation, consequently, leads to the questions of reliability and validity of the results attributed to, what was mentioned previously in chapter 3, a lack of truth and/or consistency in the replies given. Even when questions are well formulated, ultimately, the questions on the survey are influenced by the ideology and value system of the researcher (Tsang, Royse, & Terkawi, 2017). Moreover, the reliability of the responses given bears more often little resemblance to the actual behaviors or thinking due to the omission, imprecision or, perhaps, the deliberate distortion of the responses.

In addition to the limitation presented by using a survey research, there is also the notion of time that favored a rapid assessment (Danielsen et al., 2015). As a result, my survey provides only a quick overview of attitudes and perceptions of the population. A short period of data survey collection may be efficient in this study, but consequently, it runs the risk of the data to be incomplete and possibly presenting a static image of the reality. In terms of generality, as mentioned in previous chapters, the data may not necessarily reflect the opinion of all undergraduate students in biology/pre-health and agriculture. It is worth noted my findings are limited to one institution in western Kansas and do not necessarily reflect the attitudes of others undergraduate students at other universities or colleges.

Recommendations

This study resulted in many interesting findings consistent with the findings of other studies. Several students in biology/prehealth and agriculture had a good overall level of knowledge of antibiotic use and resistance, but overall there was a high rate of incorrect perceptions of threat of antibiotic resistance and benefit of education on antibiotic resistance were noticeable in this study. The current findings of this study can contribute to the current body knowledge regarding the assessment of knowledge and perceptions of agriculture undergraduate students on a very important and global health issue that is antibiotic resistance. Currently, there has been no known studies assessing the knowledge and perception of antibiotic resistance in the agriculture field. This study provides an insightful glance of how future farmers, business Ag, and veterinarians view antibiotic resistance compare to future medical doctors.

Until now, most educational efforts have been targeting medical professionals. However, as explained in Chapter 2, several survey studies on knowledge and attitudes of medical students on antibiotic resistance have found many medical students wanted further education and training on antibiotic stewardship. Therefore, the interesting findings of this study notably suggest education about antibiotic stewardship should be started at the undergraduate training track. Although many academic institutions include antibiotic education in undergraduate curricula leading to medicine, the same type of courses, perhaps, should be extended to nonmedical curricula, such as agriculture, as evidence show in this study.

But the ultimate question is when education of antibiotic and other antimicrobial stewardship should start. As the importance of undergraduate training in prudent prescribing of antibiotics has become increasingly recognized, a robust and transparent framework for curriculum development at all stages of the undergraduate level should be the focus for both agriculture and biology/prehealth. Recommendations on the development of learning outcomes, such as, statements indicating what a student should know, understand and be able to do by the end of each class classification should be re-examined to create a foundation and transfer of basic antibiotic resistance science knowledge through the different class classification. Since the recommendation of education on prudent antibiotic stewardship should start early in the undergraduate level, preferably by the third year (Junior year) for both prehealth and agriculture students, the teaching principles preparing for this stewardship should ultimately be guaranteed by the development of learning outcomes and appropriate evaluation, yet to be developed at the undergraduate level. If training starts early in the curriculum of undergraduates, postgraduate education could then focus on implementation and measurement of practice, with additional supportive and restrictive measures. Still, further studies on the assessment in knowledge and attitudes of agriculture undergraduate students on antibiotic resistance and stewardship should be further carried out to get a clear understanding of the gap that can exit between prehealth student and agriculture students. I also recommend further studies consider the possible correlation between undergraduate training and becoming good stewards of antibiotic prudent practices.

Implications

This is the first study to assess and compare perceptions and knowledge of antibiotic resistance and stewardship among undergraduate students majoring in biology/pre-health and agriculture in Western Kansas. Given the importance of antibiotic and other antimicrobial resistance worldwide and the ambiguous use of antibiotics in both medicinal and agricultural purposes, the evaluation of knowledge and perception of antibiotic resistance can help guide the development of optimal training in antibiotic practices in future prescribers at the undergraduate level. Currently little is known about how knowledgeable agriculture undergraduate students are on the topic of antibiotic resistance and little is known about how they perceived this threat and how they perceived the benefit of antibiotic resistance education. Consequently, this study presents useful data at the undergraduate level. I hope my findings will be used to better understand the magnitude of the problem to plan, or least, propose effective educational interventions that aim at improving knowledge antibiotic resistance and stewardship of antibiotic use among university students who eventually will become future antibiotic prescribers. In addition to assessing undergraduate students, my findings may help researchers to identify challenges through academic research, and possibly, identify a gap in undergraduate biology/per-health and agriculture curricula at the undergraduate level. The reinforcement of appropriate training in curricula can suggest evidence-based policy recommendations to support rational use of antibiotics. The findings of this study can help with the development of an effective and comprehensive antibiotic-stewardship program in undergraduate education.

Conclusions

For many years, public health organizations have been advocating for the implementation of strategies that allow the next generation of antibiotic prescribers - in medicine and in agriculture - to be better prepared for the appropriate use of antibiotics and other antimicrobials and to combat antimicrobial resistance. The undergraduate training track is the time when knowledge, attitudes, and behaviors of future prescribers are shaped. Education about prudent antibiotic prescribing and stewardship could be significantly effective in minimizing antibiotic resistance (Silverberg (2017). At a time when resistance is being acknowledged as a serious public health problem, this small study shows that, although undergraduates in agriculture perceived antibiotic resistance as less threatening than undergraduates in biology/prehealth, both undergraduate groups are knowledgeable of the problem and would like more academic education on the issue. This finding creates a good foundation for initiating a conversation on the curriculum development to meet ASP goals and objectives.

As the demand of antibiotic education increases, focusing on an adapted undergraduate curriculum for pre-health as well as agriculture that teaches all the necessary principles of microbiology and infectious diseases with an important emphasis on the principles of prudent antibiotic stewardship can help the dissemination of antibiotic resistance and advocate for the prudent use of antibiotic both in the medical and agriculture fields. Despite of what we know and understand about antibiotic resistance, there is still a lot to know about educational approached to antibiotic and other antimicrobial resistance stewardship. As Silverberg (2017) stated, there has been no evaluation of the best practice for teaching antibiotic resistance stewardship at the undergraduate level. Still, knowing our undergraduate students, particularly in health and agriculture fields are interesting in knowing more about stewardship, there is perhaps a possibility to develop a novel and optimum learning outcomes and training courses to foster a culture of antibiotic stewardship at the undergraduate level.

References

Adedeji, W. A. (2016). The treasure called antibiotics. Annals of Ibadan Postgraduate Medicine, *14*(2), 56–57. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5354621/

AfzalKhan, A. K., Banu, G. M., & Reshma, K. K. (2013). Antibiotic resistance and usage-A survey on the knowledge, attitude, perceptions and practices among the medical students of a southern Indian teaching hospital. *Journal of Clinical and Diagnostic Research, 7 8*, 1613-6. doi:10.7860/JCDR/2013/6290.3230

Allen, M. (2017). *The sage encyclopedia of communication research methods* (Vols. 1-4). Thousand Oaks, CA: SAGE Publications, Inc. doi:10.4135/9781483381411

Ancillotti, M., Erickson, S., Veldwijk, J., Fahlquist, J. N., Anderson, D. I., & Godskesen, T. (2018). Public awareness and individual responsibility needed for judicious use of antibiotics: A qualitative study of public health beliefs and perception. *BMC Public Health*, *18*(1153), 1-9. Doi:10.1186/s12889-018-6047-8

Armbruster, W. J., & Roberts, T. (2018). The Political Economy of US Antibiotic Use in Animal Feed. *Food Safety Economics: Incentives for a Safer Food Supply*, 293–322. Doi:10.1007/978-3-319-92138-9_15

Ashiru-Oredope, D., Doble, A., Akpan, M. R., Hansraj, S., Shebl, N. A., Ahmad, R., & Hopkins, S. (2018). Antimicrobial stewardship programmes in community healthcare organizations in England: A cross-sectional survey to assess implementation of programmes and national toolkits. *Antibiotics* (Basel, Switzerland), *7*(4), 97. doi:10.3390/antibiotics7040097

Aslam, B., Wang, W., Arshad, M. I., Khurshid, M., Muzammil, S., Rasool, M. H., … Baloch, Z. (2018). Antibiotic resistance: A rundown of a global crisis. *Infection and Drug Resistance*, *11*, 1645–1658. doi:10.2147/IDR.S173867

Barlam, T. F., Cosgrove, S. E., Abbo, L. M., MacDougall, C., Schuetz, A. N., Septimus, E. J., … Trivedi, K. K. (2016). Implementing an antibiotic stewardship program: Guidelines by the Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America. *Clinical Infectious Diseases: An Official Publication of the Infectious Diseases Society of America*, *62*(10), e51–e77. doi:10.1093/cid/ciw118

Belard, S., Janssen, S., Osbak, K. K., Adegnika, A. A., Ondounda, M., & Grobusch, M. P. (2014). Perspectives limited access to drug for resistant tuberculosis: A call for action. *Journal of Public Health*, *37*(4), 691-693. doi:10.1093/pubmed/fdu101

Benveniste, R, & Davies, J. (1973). Mechanisms of antibiotic resistance in bacteria. *Annual Review of Biochemistry*, *42*, 471-506. doi:10.1146/annurev.bi.42.070173.002351

Bishop, A. C., Baker, G. R., Boyle, T. A., & MacKinnon, N. J. (2014). Using the health belief model to explain patient involvement in patient safety. *Health Expectations, 18*(6), 3019-3033. https://doi.org/10.1111/hex.12286

Boeckel, T. P., Gandra, S., Ashok, A., Caudron, Q., Grenfell, B. T., Levin, S. A., & Laxminarayan, R. (2014). Global antibiotic consumption 2000 to 2010: An analysis of national pharmaceutical sales data. *The Lancet: Infectious Diseases*, *14*(8), 742-750. doi:10.1016/S1473-3099

Bondarenka, C. M., & Bosso, J. A. (2017). Successful implementation of an antimicrobial stewardship program at an academic medical center. *Hospital Pharmacy*, *52*(7), 508–513. doi:10.1177/0018578717721535

Carmo L. P., Nielsen, L. R., Alban, L., da Costa, P. M., Schüpbach-Regula, G., & Magouras, I. (2018). Veterinary expert opinion on potential drivers and opportunities for changing antimicrobial usage practices in livestock in Denmark, Portugal, and Switzerland. *Front Vet Sci.*, *01March2018*, 5-29. doi:10.3389/fvets.2018.00029

Carter, R. R., Sun, J., & Jump, R. L. P. (2016). A survey and analysis of the American public's perceptions and knowledge about antibiotic resistance. *Open Forum Infectious Diseases*, *3*(3), 1-19. doi:10.1093/ofid/ofw112

Castro-Sanchez, E., Moore, L. S., Husson, F., & Holmes, A. H. (2016). What are the factors driven antimicrobial resistance? Perspectives from a public event in London, England. *BMC Infectious Diseases*, *16*, 465. doi:10.1186/s12879-016-1810-x

Centers for Disease Control and Prevention. (2016). Continuing education and informational resources. *Antibiotic Prescribing and Use in Doctors' Offices*. Retrieved from https://www.cdc.gov/antibiotic-use/community/for-hcp/continuing-education.html

Centers for Disease Control and Prevention. (2017). Antibiotic use in outpatient settings. Retrieved from https://www.cdc.gov/antibiotic-use/stewardship-report/outpatient.html

Centers for Disease Control and Prevention. (2018). U.S. national action plan for combatting antibiotic-resistant bacteria (National Action Plan). Retrieved from https://www.cdc.gov/drugresistance/us-activities/national-action-plan.html

Centers for Disease Control and Prevention. (2019). *What CDC is doing: antibiotic resistance (AR) solutions initiative*. Retrieved from https://www.cdc.gov/drugresistance/solutions-initiative/index.html

Chaintarli, K., Ingle, S. M., Bhattacharya, A., Ashiru-Oredope, D., Oliver, I., & Gobin, M. (2016). Impact of a United Kingdom-wide campaign to tackle antimicrobial resistance on self-reported knowledge and behavior change. *BMC Public Health*, *16*, 393. doi:10.1186/s12889-016-3057-2

Chang, Q., Wang, W., Regev-Yochay, G., Lipsitch, M., & Hanage, W. P. (2015). Antibiotics in agriculture and the risk to human health: How worried should we be? *Evolutionary Applications*, *8*(3), 240–247. doi:10.1111/eva.12185

Chem, E. D., Anong, D. N., & Akoachere, J. (2018). Prescribing patterns and associated factors of antibiotic prescription in primary health care facilities of Kumbo East and Kumbo West Health Districts, North West Cameroon. *PLoS One*, *13*(3), e0193353. doi:10.1371/journal.pone.0193353

Calhoun C, & Hall, G. A. (2019). Antibiotics. In *StatPearls* [Internet]. Treasure Island (FL): StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK535443/

Danielsen A., K., Pommergaard, H.-C., Burcharth, J., Angenete, E., & Rosenberg, J. (2015) Translation of questionnaires measuring health related quality of life is not standardized: A literature-based research study. *PLoS ONE*, *10*(5), e0127050.

https://doi.org/10.1371/journal.pone.0127050

Doron, S., & Davidson, L. E. (2011). Antimicrobial stewardship. *Mayo Clinic Proceedings*, *86*(11), 1113–1123. doi:10.4065/mcp.2011.0358

Doshi, P. (2016). Defining antibiotic effectiveness and resistance: How a private party may soon rule judgments over susceptibility testing. *BMJ*, 352. doi:10.1136/bmj.h6849

Dyar, O. J., Nathwani, D., Monnet, D. L., Gyssens, I. C., Lundborg, C. S., & Pulcini, C. (2018). Do medical students feel prepared to prescribe antibiotics responsibly? Results from a cross-sectional survey in 29 European countries. *Journal of Antimicrobial Chemotherapy*, *73*(8): 2236-2242. doi:10.1093/jac/dky150

Economou, V., & Gousia, P. (2015). Agriculture and food animals as a source of antimicrobial-resistant bacteria. *Infection and drug resistance,* 8, 49–61. doi:10.2147/IDR.S55778

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2): 175-191. doi:10.3758/bf03193146

Feiring, E., & Walter, A. B. (2017). Antimicrobial stewardship: a qualitative study of the development of national guidelines for antibiotic use in hospitals. *BMC Health Services Research*, *17*, 747. doi:10.1186/s12913-017-2683-4

Galárraga, O., Genberg, B. L., Martin, R. A., Barton Laws, M., & Wilson, I. B. (2013). Conditional economic incentives to improve HIV treatment adherence: literature review and theoretical considerations. *AIDS And Behavior*, *17*(7), 2283-2292.

doi:10.1007/s10461-013-0415-2

Garg, R. (2016). Methodology for research I. *Indian journal of anesthesia*, *60*(9), 640–645. doi:10.4103/0019-5049.190619

Glanz, K. & Bishop, D. B. (2010). The role of behavioral science theory in development and implementation of public health interventions. *Annual Review of Public Health*, *31*, 399-418. doi:10.1146/annurev.publhealth.012809.103604

Grady, C. (2015). Institutional Review Boards: Purpose and Challenges. *Chest*, *148*(5), 1148–1155. doi:10.1378/chest.15-0706

Gupta, K. K., Attri, J. P., Singh, A., Kaur, H., & Kaur, G. (2016). Basic concepts for sample size calculation: Critical step for any clinical trials! *Saudi journal of anesthesia*, *10*(3), 328–331. doi:10.4103/1658-354X.174918

Habboush Y, Guzman N. (2018). Antibiotic Resistance. In: *StatPearls* [Internet]. Treasure Island (FL): *StatPearls Publishing*; 2019 Jan. Retrieved from https://www.ncbi.nlm.nih.gov/books/NBK513277/

Heid, C., Knobloch, M. J., Schulz, L. T., & Safdar, N. (2016). Use of the Health Belief Model to Study Patient Perceptions of Antimicrobial Stewardship in the Acute Care Setting. *Infection Control and Hospital Epidemiology*, *37*(5), 576–582. doi:10.1017/ice.2015.342

Hoelzer, K., Wong, N, Thomas, J., Talkington, K., Jungman, E., & Coukell, A. (2017). Antimicrobial drug use in food-producing animals and associated human health risks: What, and how strong, is the evidence. *BMC Veterinary Research*, *13*(211). doi:10.1186/s12917-017-1131-3

Hsu J. L. (2018). Building an Antibiotic Stewardship Program: An Interactive Teaching Module for Medical Students. *MedEdPORTAL: the journal of teaching and learning resources*, *14*, 10726. doi:10.15766/mep_2374-8265.10726

Huttner, B., Saam, M., Moja, L., Mah, K., Sprenger, M., Harbarth, S., & Magrini, N. (2019). How to improve antibiotic awareness campaigns: findings of a WHO global survey. *BMJ global health*, *4*(3), e001239. doi:10.1136/bmjgh-2018-001239

Ilika, F., Jamshidimanesh, M., Hoseini, M., Saffari, M., & Peyravi, H. (2015). An evaluation of high-risk behaviors among female drug users based on Health Belief Model. *Journal of medicine and life*, *8*(Spec Iss 3), 36–43. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5348937/

Jairoun, A., Hassan, N., Ali, A., Jairoun, O., & Shahwan, M. (2019). Knowledge, attitude and practice of antibiotic use among university students: a cross sectional study in UAE. *BMC public health*, *19*(1), 518. doi:10.1186/s12889-019-6878-y

Jones, C. L., Jensen, J. D., Scherr, C. L., Brown, N. R., Christy, K., & Weaver, J. (2015). The Health Belief Model as an explanatory framework in communication research: exploring parallel, serial, and moderated mediation. *Health communication*, *30*(6), 566–576. doi:10.1080/10410236.2013.873363

Jooma S. (2015). Executive action to combat the rise of drug-resistant bacteria: is agricultural antibiotic use sufficiently addressed? *Journal of law and the biosciences*, *2*(1), 129–138. doi:10.1093/jlb/lsv005

Karimy, M., Azarpira, H., & Araban, M. (2017). Using Health Belief Model Constructs to Examine Differences in Adherence to Pap Test Recommendations among Iranian Women. *Asian Pacific journal of cancer prevention: APJCP*, *18*(5), 1389–1394. doi:10.22034/APJCP.2017.18.5.1389

Khorsan, R., & Crawford, C. (2014). How to assess the external validity and model validity of therapeutic trials: a conceptual approach to systematic review methodology. *Evidence-based complementary and alternative medicine: eCAM*, 2014, 694804. doi:10.1155/2014/694804

Kobayashi, M., Shapiro, D. J., Hersh, A. L., Sanchez, G. V., & Hicks, L.A. (2016). Outpatient antibiotic prescribing practices for uncomplicated urinary tract infection in women in the United States, 2002-2011. *Open Forum Infectious Diseases*, *3*(3). Doi: 10.1093/ofid/ofw159

Krockow, E. M., Colman, A. M., Chattoe-Brown, E., Jenkins, D. R., Perera, N., Mehtar, S., & Tarrant, C. (2019). Balancing the risks to individual and society: a systematic review and synthesis of qualitative research on antibiotic prescribing behavior in hospitals. *The Journal of Hospital Infection*, *101*(4): 428-439. doi: 10.1016/j.jhin.2018.08.007

Kumar, V. & Gupta, J. (2018). Prevailing practices in the use of antibiotics by dairy farmers in Eastern Haryana region of India. *Veterinary World*, *11*(3): 274-280. doi:10.14202/vetworld.2018.274-280

Labi, A. K., Obeng-Nkrumah, N., Bjerrum, S., Aryee, N., Ofori-Adjei, Y. A., Yawson, A. E., & Newman, M. J. (2018). Physicians' knowledge, attitudes, and perceptions concerning antibiotic resistance: a survey in a Ghanaian tertiary care hospital. *BMC health services research*, *18*(1), 126. doi:10.1186/s12913-018-2899-y

Lee, C. R., Lee, J. H., Kang, L. W., Jeong, B. C., & Lee, S. H. (2015). Educational effectiveness, target, and content for prudent antibiotic use. *BioMed research international*, *2015*, 214021. doi:10.1155/2015/214021

Lippold, M. A., Coffman, D. L., & Greenberg, M. T. (2014). Investigating the potential causal relationship between parental knowledge and youth risky behavior: a propensity score analysis. *Prevention science: the official journal of the Society for Prevention Research*, *15*(6), 869–878. doi:10.1007/s11121-013-0443-1

Llor, C., & Bjerrum, L. (2014). Antimicrobial resistance: risk associated with antibiotic overuse and initiatives to reduce the problem. *Therapeutic advances in drug safety*, *5*(6), 229–241. doi:10.1177/2042098614554919

Lobanovska, M., & Pilla, G. (2017). Penicillin's Discovery and Antibiotic Resistance: Lessons for the Future? *The Yale journal of biology and medicine*, *90*(1), 135–145. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5369031/

MacDougall, C., Schwartz, B. S., Kim, L., Nanamori, M., Shekarchian, S., & Chin-Hong, P. V. (2017). An Interprofessional Curriculum on Antimicrobial Stewardship Improves Knowledge and Attitudes Toward Appropriate Antimicrobial Use and Collaboration. *Open forum infectious diseases*, *4*(1), ofw225. doi:10.1093/ofid/ofw225

Manyi-Loh, C., Mamphwell, S., Meyer, E., & Okoh, A. (2018). Antibiotic use in agriculture and its consequential resistance in environmental sources: potential public health implications. *Molecules*, *23*(4). doi: 10.3390/molecules23040795

Martin, M. J., Thottathil, S. E., & Newman, T. B. (2015). Antibiotics Overuse in Animal Agriculture: A Call to Action for Health Care Providers. *American journal of public health*, *105*(12), 2409–2410. Doi:10.2105/AJPH.2015.302870

McHugh M. L. (2013). The chi-square test of independence. *Biochemia medica*, *23*(2), 143–149. doi:10.11613/bm.2013.018

McParland, J. L., Williams, L., Gozdzielewska, L., Young, M., Smith, F., MacDonald, J., … Flowers, P. (2018). What are the 'active ingredients' of interventions targeting the public's engagement with antimicrobial resistance and how might they work? *British journal of health psychology*, *23*(4), 804–819. doi:10.1111/bjhp.12317

Mersha A. G. (2018). Attitude and perception of medical interns about antimicrobial resistance: a multi-center cross-sectional study in Ethiopia. Antimicrobial resistance and infection control, *7*, 149. doi:10.1186/s13756-018-0443-9

Monnier, A. A., Eisenstein, B. I., Hulscher, M. E., Gyssens, I. C., & DRIVE-AB WP1 group (2018). Towards a global definition of responsible antibiotic use: results of an international multidisciplinary consensus procedure. *The Journal of antimicrobial chemotherapy*, *73*(suppl_6), vi3–vi16. doi:10.1093/jac/dky114

Morris, C., Helliwell, R. & Raman, S. (2016). Framing the agriculture use of antibiotics and antimicrobial resistance in UK national newspapers and the framing press. *Journal of Rural Studies*, *45*:43-53. doi:10.1016/j.jrurstud.2016.03.003

Mourad, M. M., Evans, R., Kalidindi, V., Navaratnam, R., Dvorkin, L., & Bramhall, S.

R. (2017). Prophylactic antibiotics in acute pancreatitis: endless debate. *Annals of the Royal College of Surgeons of England*, *99*(2), 107–112. doi:10.1308/rcsann.2016.0355

Papp-Wallace, K. M., Endimiani, A., Taracila, M. A., & Bonomo, R. A. (2011). Carbapenems: past, present, and future. *Antimicrobial agents and chemotherapy*, *55*(11), 4943–4960. doi:10.1128/AAC.00296-11

Parsonage, B., Hagglund, P. K., Keogh, L., Wheelhouse, N., Brown, R. E., & Dancer, S. J. (2017). Control of Antimicrobial Resistance Requires an Ethical Approach. *Frontiers in microbiology*, *8*, 2124. doi:10.3389/fmicb.2017.02124

Peterson, E. & Kaur, P. (2018). Antibiotic resistance mechanisms in bacteria: relationship between resistance determinants of antibiotic producers, environmental bacteria, and clinical pathogens. *Frontiers in Microbiology*, *9*:2928. Doi: 10.3389/fmicb.2018.02928. eCollection 2018

Pollack, L. A., van Santen, K. L., Weiner, L. M., Dudeck, M. A., Edwards, J. R., & Srinivasan, A. (2016). Antibiotic Stewardship Programs in U.S. Acute Care Hospitals: Findings From the 2014 National Healthcare Safety Network Annual Hospital Survey. *Clinical infectious diseases: an official publication of the Infectious Diseases Society of America*, *63*(4), 443–449. doi:10.1093/cid/ciw323

Prestinaci F, Pezzotti P, Pantosti A. Antimicrobial resistance: a global multifaceted phenomenon. Pathogen Global Health. 2015;*109*(7):309-18. doi: 10.1179/2047773215Y.0000000030. *Epub* 2015 Sep 7. PMID: 26343252; PMCID: PMC4768623.

Prija F., Prasad R. (2017). DrrC protein of *Streptomyces peucetius* removes daunorubicin from intercalated dnrI promoter. *Microbial Research., 202*:30–35. doi: 10.1016/j.micres.2017.05.002

Reddy, S. C., Jacob, J. T., Varkey, J. B., & Gaynes, R. P. (2015). Antibiotic use in US hospitals: quantification, quality measures and stewardship. *Expert Review of Anti-Infective Therapy*, *13*(7): 843-854. doi:10.1586/14787210.2015.1040766

Rijn, M. V., Haverkate, M., Achterberg, P., & Timen, A. (2019). The public uptake of information about antibiotic resistance in the Netherlands. *Public Understanding of Science*, *28*(4):486-503. doi:10.1177/0963662518823701

Rosenstock, I. M. (1974) Historical Origins of the Health Belief Model. *Health Education Monographs*, *2*, 328-335. doi:10.1177/109019817400200403

Salazar, L. F., Crosby, R. A., & DiClemente, R. J. (2015). *Research Methods in Health Promotion* (2nd ed). San Francisco, CA: Jossey-Bass

Scaioli, G., Gualano, M. R., Gili, R., Masucci, S., Bert, F., & Siliquini, R. (2015). Antibiotic use: a cross-sectional survey assessing the knowledge, attitudes and practices amongst students of a school of medicine in Italy. *PloS one*, *10*(4), e0122476. doi:10.1371/journal.pone.0122476

Schmutz E., Muhlenweg A., Li S. M., Heide L. (2003). Resistance genes of aminocoumarin producers: two type II topoisomerase genes confer resistance against coumermycin A1 and clorobiocin. *Antimicrobial Agents Chemotherapy., 47*:869–877. doi:10.1128/AAC.47.3.869-877.200

Seid, M. A., & Hussen, M. S. (2018). Knowledge and attitude towards antimicrobial resistance among final year undergraduate paramedical students at University of Gondar, Ethiopia. *BMC infectious diseases*, *18*(1), 312. doi:10.1186/s12879-018-3199-1

Sharifikia, I., Rohani, C., Estebsari, F., Matbouei, M., Salmani, F., & Hossein-Nejad, A. (2019). Health Belief Model-based Intervention on Women's Knowledge and Perceived Beliefs about Warning Signs of Cancer. *Asia-Pacific journal of oncology nursing*, *6*(4): 431-439. doi:10.4103/apjon.apjon_32_19

Shinkawa H., Sugiyama M., Nimi O., Nomi R. (1985). Molecular cloning and expression in *Streptomyces lividans* of a streptomycin 6-phosphotransferase gene from a streptomycin-producing microorganism. *FEBS Lett*, *181*:385–389. doi: 10.1016/0014-5793(85)80298-2

Silverberg, S. L., Zannella, V. E., Countryman, D., Ayala, A. P., Lenton, E., Friesen, F., & Law, M. (2017). A review of antimicrobial stewardship training in medical education. *International journal of medical education*, *8*, 353–374. doi:10.5116/ijme.59ba.2d47

Simoes, A.S., Maia, M.R., Gregorio, J., Couto, I., Asfeldt, A.M., Simonsen, G.S., Povoa, P., Viveiros, M., Lapao, L.V. (2018). Participatory implementation of an antibiotic stewardship program supported by an innovative surveillance and clinical decision-support system. *The Journal of Hospital Infection*, 100(3): 257-264. Doi: 10.1016/j.jhin.2018.07.034

Smith, R. A., Quesnell, M., Glick, L., Hackman, N., & M'Ikanatha, N. M. (2015). Preparing for Antibiotic Resistance Campaigns: A Person-Centered Approach to

Audience Segmentation. *Journal of health communication*, *20*(12), 1433–1440. doi:10.1080/10810730.2015.1018652

Srinivasan A. (2018). Antibiotic Stewardship Grows Up. Joint Commission journal on quality and patient safety, *44*(2), 65–67. doi:10.1016/j.jcjq.2017.11.002

Topor, G., Grosu, I. A., Ghiciuc, C. M., Strat, A. L., & Lupuşoru, C. E. (2017). Awareness about antibiotic resistance in a self-medication user group from Eastern Romania: a pilot study. *PeerJ*, *5*, e3803. doi:10.7717/peerj.3803

Trivedi, K. K., & Pollack, L. A. (2014). The role of public health in antimicrobial stewardship in healthcare. *Clinical infectious diseases: an official publication of the Infectious Diseases Society of America*, *59* Suppl 3(Suppl 3), S101–S103. doi:10.1093/cid/ciu544

Tsang, S., Royse, C. F., & Terkawi, A. S. (2017). Guidelines for developing, translating, and validating a questionnaire in perioperative and pain medicine. *Saudi journal of anesthesia*, *11*(Suppl 1), S80–S89. doi:10.4103/sja.SJA_203_17

Ventola C. L. (2015). The antibiotic resistance crisis: part 1: causes and threats. *P & T: a peer-reviewed journal for formulary management*, *40*(4), 277–283.

Walle-Hansen, M. M., & Høye, S. (2018). Geographic Variation in Antibiotic Consumption-Is It Due to Doctors' Prescribing or Patients' Consulting? *Antibiotics* (Basel, Switzerland), *7*(1), 26. doi:10.3390/antibiotics7010026

Walters, S.J. (2004). Sample size and power estimation for studies with health-related quality of life outcomes: a comparison of four methods using the SF-36. Health and Quality of Life Outcomes, *2*(26). doi:10.1186/1477-7525-2-26

Wasserman, S., Potgieter, S., Shoul, E., Constant, D., Stewart, A., Mendelson, M., & Boyles, T.H. (2017). South African medical students' perceptions and knowledge about antibiotic resistance and appropriate prescribing: Are we providing adequate training to future prescribers? *South African Medical Journal*, *107*(5): 405-410. doi:10.7196/SAMJ. 2017.v107i5.12370

Welsh, J. A., Braun, H., Brown, N., Um, C., Ehret, K., Figueroa, J., & Boyd Barr, D. (2019). Production-related contaminants (pesticides, antibiotics and hormones) in organic and conventionally produced milk samples sold in the USA. *Public health nutrition*, *22*(16), 2972–2980. doi:10.1017/S136898001900106X

Yip, C., Han, N. R., & Sng, B. L. (2016). Legal and ethical issues in research. *Indian journal of anesthesia*, *60*(9), 684–688. doi:10.4103/0019-5049.190627

Yu L., Yan X., Wang L., Chu J., Zhuang Y., Zhang S., et al. (2012). Molecular cloning and functional characterization of an ATP-binding cassette transporter OtrC from *Streptomyces rimosus*. *BMC Biotechnology., 12*:52. doi:10.1186/1472-6750-12-52

Zaman, S. B., Hussain, M. A., Nye, R., Mehta, V., Mamun, K. T., & Hossain, N. (2017). A Review on Antibiotic Resistance: Alarm Bells are Ringing. *Cureus, 9*(6), e1403. doi:10.7759/cureus.1403

Appendix A: Research Questions

Research Question 1: Are there differences in knowledge of antibiotic resistance in pre-health students compared to agriculture students?

$H_0$1: There are no statistically significant differences in knowledge of antibiotic resistance and antibiotic stewardship between pre-health students and agriculture students.

H_a1: There is a statistically significant difference in knowledge of antibiotic resistance between pre-health students and agriculture students.

Research Question 2: Are there differences in perceived threats of antibiotic resistance in pre-health students compared to agriculture students?

$H_0$2: There are no statistically significant differences in perceived threat of antibiotic resistance between pre-health students and agriculture students.

H_a2: There is a statistically difference in perceived threat of antibiotic resistance between pre-health students and agriculture students

Research Question 3: Are there differences in perceived benefit of antibiotic resistance education in stewardship in pre-health students compared to agriculture students?

$H_0$3: There are no statistically significant differences in perceived benefit of antibiotic resistance education in stewardship between pre-health students and agriculture students.

H_a3: There is a statistically difference in perceived benefit of antibiotic resistance education in stewardship between pre-health students and agriculture students

Appendix B: Survey Questions

Section I: Demographic data

Age: Under 18   18-24 years old   25-34 years old   35 or above
Sex: Male   Female
Major: Biology/pre-health   Agriculture
Class Classification: KAMS   Freshman   Sophomore   Junior   Senior
Race: White African American/black Hispanic/Latino Native American/American Indian Asian/Pacific Islander Other
Are you a first-generation College Student?   Yes   No

Section II: Questions to assess participants' Knowledge about antimicrobial resistance

Rate your overall level of knowledge of antibiotic resistance

Strongly knowledgeable
Knowledgeable
Somewhat knowledgeable
Undecided
Not knowledgeable

Antibiotics are powerful medicines to kill viruses

Strongly Agree
Agree
Undecided
Disagree
Strongly Disagree

Frequent use of antibiotics in medicine and agriculture decrease the efficacy of antibiotics

Strongly Agree
Agree
Undecided
Disagree
Strongly Disagree

Frequent use of antibiotics put patients at risk

Strongly Agree
Agree
Undecided
Disagree
Strongly Disagree

There is no connection between taking antibiotics and the development of resistant bacteria.

Strongly Agree
Agree
Undecided
Disagree

Strongly Disagree

Antibiotics speed up the recovery from common cold or flu

Strongly Agree
Agree
Undecided
Disagree
Strongly Disagree

Section III: Questions to assess participants' perceived threat of antibiotic resistance

Rate your level of perceived threat of antibiotic resistance.

High threat
Moderate threat
Low threat
None
Unknown/don't' know

Antibiotics resistance will affect you and your family's health

Strongly Agree
Agree
Undecided
Disagree
Strongly Disagree

The use of antibiotics in farming is a danger to human health

Strongly Agree
Agree
Undecided
Disagree
Strongly Disagree

If taken too often, antibiotics are less likely to work in the future

Strongly Agree
Agree
Undecided
Disagree
Strongly Disagree

Currently, antibiotic resistance is a major problem in the United States as well as in the rest of the world

Strongly Agree
Agree
Undecided
Disagree
Strongly Disagree

Section IV: Questions to assess participants' perceived benefit of antibiotic education in stewardship.

Rate your level of perceived benefit of antibiotic education in stewardship for futire prescribers

High benefit
Moderate benefit
Low benefit
None
Unknown/Don't know

Students can contribute to the work being done to control antibiotic resistances

Strongly Agree
Agree
Undecided
Disagree
Strongly Disagree

It is necessary to give more education for students about antibiotic resistance.

Strongly Agree
Agree
Undecided
Disagree
Strongly Disagree

All health and agriculture students should get training on the appropriate use of antibiotics before exiting college.

Strongly Agree
Agree
Undecided
Disagree
Strongly Disagree

Dispensing antibiotics without prescription should be more closely controlled.

Strongly Agree
Agree
Undecided
Disagree
Strongly Disagree

Appendix C: Fort Hays State University IRB Application

FORT HAYS STATE UNIVERSITY

Forward thinking. World ready.

Proposals for review by the IRB may be submitted at any time. With the exception of expedited reviews, complete proposals submitted no later than ten (10) business days prior to a scheduled meeting will be reviewed at meeting. Late proposals will be reviewed at the next scheduled meeting. The IRB meeting schedule is posted on the website. Incomplete proposals will not be reviewed until the researcher supplies the missing information. Be sure to respond to all sections.

Type of Request:

Full Review

Complete Application and Relevant Forms

Expedited Review

Complete Application and Expedited Review Attachment

X Exempt from Review

Complete Application and Exempt Review Attachment

All materials related to this study must be uploaded into your IRBNet study workspace. Instructions for using IRBNet are located at the FHSU IRB website.

Required materials include:

Completed application (including relevant parts of section IX if a vulnerable population is involved)

A completed form requesting Exemption, Expedited or Full Review.

Copies of all recruiting materials, including scripts, emails, letters, posters, advertising, etc.

Copies of all measurements, instruments, surveys, interview questions being used, etc.

All consent forms and assent forms or scripts (for children).

Debriefing materials.

I. Certifications:

I am familiar with the policies and procedures of Fort Hays State University regarding human subjects in research. I subscribe to the university standards and applicable state and federal standards and will adhere to the policies and procedures of the Institutional Review Board for the Protection of Human Subjects. I will comply with all instructions from the IRB at the beginning and during the project or will stop the project.

AND

I am familiar with the published guidelines for the ethical treatment of human subjects associated with my particular field of study.

Statement of Agreement:

By electronically signing and submitting this application package, I certify I am willing to conduct and /or supervise these activities in accordance with the guidelines for human subjects in research. Further, I certify any changes in procedures from those outlined above or in the attached proposal will be cleared through the IRB.

If the Principal Investigator is a student, the electronic signature of the Faculty Advisor certifies:

1) Agreement to supervise the student research; and, 2) This application is ready for IRB review. The Student is the "Principal Investigator". The Faculty Research Advisor is the "Advisor". Designees may not sign the package. It is the student's responsibility to contact their Faculty Research Advisor when the study is ready for his/her signature.

I certify the information provided in this application is complete and correct

I understand I have ultimate responsibility for the conduct of the study, the ethical performance of the project, the protection of the rights and welfare of human subjects and strict adherence to any stipulations imposed by the IRB.

I agree to comply with all FHSU policies, as well as all federal, state and local laws on the protection of human subjects in research, including:

Ensuring all study personnel satisfactorily complete human subjects in research training

Performing the study according to the approved protocol

Implementing no changes in the approved study without IRB approval

Obtaining informed consent from subjects using only the currently approved consent form

Protecting identifiable health information in accordance with HIPAA Privacy rule

Promptly reporting significant or untoward adverse effects to the IRB

Application Information:

II. Activity or Project Title:

Time period for activity**If longer than 1-year, annual review will be needed*

III. List all people involved in research project:

Name & Title	Institution & Department	Phone	Email
*Ms. Claudia Da Silva Carvalho	Fort Hays State University-Department of Biological Sciences Walden University-Public Health Program	785-628-5665 254-424-3144	cmdasilvacarvalho@fhsu.edu claudia.dasilvacarvalho@waldenu.edu

*Principal Investigator

**Faculty Research Advisor (if student is Principal Investigator)

If there are additional investigators, please attach their information to the application.

IV. Type of investigator and nature of the activity: (Check all the appropriate categories)

A. Faculty/Staff at FHSU:

Submitted for extramural funding to:
Submitted for intramural funding to:
Project unfunded
Quality improvement/program evaluation
Quality assurance
Other (PhD completion- dissertation requirement)

B. Student at FHSU: Graduate Undergraduate Special
Thesis Graduate Research Paper
Specialist Field Study Independent Study
Class Project (Course Number and Course Title):
Other (Please Explain):
C. Other than faculty, staff, or student at FHSU (Unaffiliated with FHSU).

V. Human Subjects Research Ethics Training: The IRB will not review submissions without verification of appropriate CITI training. The Principal Investigator and all members of the research team must complete the appropriate CITI training modules. Faculty Research Advisors, when listed above, must also complete CITI training. If the PI is not affiliated with FHSU, documentation of CITI or other comparable training must be provided.

Date completed FHSU CITI training:

Claudia Da Silva Carvalho - December 02, 2019

VI. Description of Project

Completely describe the research project below. Provide sufficient information for effective review and define abbreviations and technical terms. Do NOT attach a thesis, prospectus, grant proposal, etc. If an item is not applicable, please provide justification.

Project purpose(s):

The global threat of antibiotic resistant infections and dissemination has urged health organizations to compile an Antibiotic Stewardship Program (ASP) provides strategical solutions to slow down the dissemination of antibiotic resistant infections and other antimicrobial resistance in medical, veterinary and agricultural settings. Education has been the forefront of ASP, suggesting the public's and current/future prescribers' knowledge and perception of antibiotic use and antibiotic resistance is necessary for the preservation of current and future antimicrobial treatments. The purpose of this study is to assess and compare the knowledge and perceived threat of antibiotic and antibiotic resistance, as well as the perceived benefit of antibiotic stewardship among undergraduate students at Fort Hays State University. Using the theoretical framework of the Health Belief Model (HBM), a structured electronic survey will be sent to biology and agriculture undergraduate students. A Factor Analysis (FA) will be applied to test the hypothesis of a possible relationship between undergraduate major and the underlying constructs of knowledge, perceived threat and benefits. A Chi-square analysis will also be used to assess the differences (if any) between the respondents in their knowledge and perception toward antibiotic, antibiotic resistance, and antibiotic stewardship. By highlighting factors underpinning antibiotics knowledge and behaviors, this study could shape the academic curriculum based on students' needs to correct perceptions and use of antibiotics among

future stakeholders in the hopes to contain antibiotic resistance and preserving antibiotic drugs for the next generation.

B. Describe the proposed participants (number, age, gender, ethnicity, etc)

Primarily undergraduate students from Fort Hays State University will be asked to participate in this study. Participants in this study must be between 18 and 30 years of age.

C. What are the criteria for including or excluding subjects? Are any criteria based on age, gender, race, ethnicity, sexual orientation, or origin? If so, justify.

Participants have to be between 18-30 years of age in order to avoid sampling protected populations.

D. Population from which the participants will be obtained:

General Populations:

_X_Adult students (18-65 years) on-campus

___Adults (18-65 years) off-campus

*See Section IX for additional information

Protected or Vulnerable Populations*:

____Elderly (65+ Years)

____Prisoners

____Wards of the State

____Pregnant Women

____Fetuses

____Mentally disabled

____Children (under the age of 18)

Other vulnerable groups:

____Vulnerable to influence or coercion (may include FHSU students or employees)

____Economically disadvantaged

____Educationally disadvantaged

____Decisionally impaired

____Non-English speakers

____International researcher

E. Recruitment Procedures: Describe in detail the process to be used to recruit participants. Upload scripts, emails, letters, advertising and all marketing materials with your application. Provide a step-by-step description of how potential participants will be recruited for the study.

An email will be sent to biology and agricultures professors to obtain permission to recruit students enrolled in their classes. If professors agree, the link of survey monkey will be sent to professors to distribute the link to the students.

F. Describe the benefits to the participants, discipline/field, and/or society for completing the research project. This description is necessary for determining if the risks are reasonable in relationship to anticipated benefits. Research provides no benefit or potential for benefit will not be approved.

By participating in this study, participants will gain general knowledge of antibiotic resistance and a better understanding of antibiotic stewardship. The grades of students will not be impacted by participating or not participating in this study.

Antibiotic resistance is an emerging public health issue is threatening the health of the population. The results of this study could serve as a platform for future research on the investigation of education future stakeholders in the appropriate future use of antibiotic.

G. Describe the potential risks to participants for completing the research project. **A risk is a potential harm a reasonable person would consider important in deciding whether to participate in research. Risk categories include physical, psychological, social, economic and legal, and include pain, stress, and invasion of privacy, embarrassment, or exposure of sensitive or confidential information. All potential risks and discomforts must be minimized to the greatest extent possible by using appropriate monitoring, safety devices and withdrawal of a subject if there is evidence of a specific adverse event.**

_X_ Minimal Risk: the probability and magnitude of harm or discomfort anticipated in the research are not greater in and of themselves than those ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests.

___More than minimal risk

H. Describe the follow up efforts will be made to detect any harm to subjects, and how the IRB will be kept informed. Serious adverse or unexpected reactions or injuries must be reported to the IRB within 48 hours. Other adverse events should be reported within 10 days.

Participants are given a consent form providing the contact information for the principle investigator. Participants will be instructed of the no risk and their voluntary participation.

I. Describe <u>in detail</u> the procedures to be used in the research project. What will all participants experience during the research project?

The participants are invited to take part in a research study about the assessment of the knowledge and the perception (perceived threat and benefit) of undergraduate students on the topic of antibiotic resistance and antibiotic

stewardship. The researcher is inviting undergraduate students majoring in biology/prehealth and agriculture to be in the study. This form is part of a process called "informed consent" to allow you to understand this study before deciding whether to take part. If the participants agree to be in this study, they will be asked to complete a short demographics questionnaire and a few questions regarding your knowledge and perception of antibiotic resistance and antibiotic stewardship online. The questionnaire will take approximately 30 minutes.

J. List all measures/instruments to be used in the project, include citations and permission to use (if measure/instrument is copyrighted) if needed or if it will be changed for this study. Attach copies of all measures, such as surveys, interview questions, instruments, etc. to the package.

Informed Consent form
Survey form
Debriefing form
Statistical application

K. Describe in detail how confidentiality will be protected or how anonymity will be ensured before, during, and after information has been collected? Please note the difference between confidentiality (researcher knows identity of subjects and keeps information secret) and anonymity (researcher does not know identity of participants).

Reports coming out of this study will not share the identities of individual participants. Details might identify participants will not be shared. The researcher will not use your personal information for any purpose outside of this research project. All information obtained from the study will be kept confidential and utilized only for this study on a password protected laptop. Only authorized personnel for the study will have access to names and other identifiable data. Data will be kept for a period of at least 5 years, as required by Walden University.

L. Data Management: How will the data be stored? When will the data be destroyed? Who will have access to the data? If audio or video recordings are used, how will they be kept confidential?

ID alphanumeric code encryptions will be used for the identification of participants and the privacy of information. Only authorized personnel for the study will have access to names and other identifiable data. Data will be kept for a period of at least 5 years, as required by Walden University.

M. Informed Consent: Describe in detail the process for obtaining consent. *If non-English speaking subjects are involved, describe how consent will be obtained.*

Consent form will be available online. Participants must agree to the consent form to have access the questions on the survey.

N. If informed consent is to be waived or altered, complete Supplemental: Consent Waiver Form

N/A

O. If written documentation of consent is to be waived, complete Supplemental: Documentation Waiver Form

N/A

P. Explain Debriefing procedures/end of study information will be given to all participants.

When participants have finished with the survey, a short debriefing message will appear:

You may ask any questions you have now. Or if you have questions later, you may contact the researcher via email claudia.dasilvacarvalho@waldenu.edu. If you want to talk privately about your rights as a participant, you can call the Research Participant Advocate at my university at 612-312-1210. Walden University's approval number for this study is IRB will enter approval number here and it expires on IRB will enter expiration date.

Q. Emergencies. How will emergencies or unanticipated adverse events related to the research be handled if they arise? Please note this refers to an emergency situation associated with the research activity, not an emergency such as a fire alarm.

No unforeseen emergencies should arise.

R. Will information about the research purpose and design be held from subjects? If yes, justify the deception.

No deception will be used in the current study.

VII. If the research involves protected health information, it must comply with the HIPAA Privacy Rule.

Select one:

__**X**_ The research does not involve protected health information

____Do you plan to use or disclose identifiable health information outside FHSU? *If yes, the consent form must include a release of protected health information.*

The IRB may make a waiver of authorization for disclosure if criteria are met under the HIPAA Privacy Rule. *If a waiver of authorization is being requested, the researcher must contact the IRB chair prior to submitting this application.*

____ Will the protected health information to be used or disclosed be de identified or will a limited data set be used or disclosed? *Please describe*:

VIII. Conflict of Interest: Each individual with a personal financial interest or relationship in the individual's judgment could reasonably appear to affect or be affected by the proposed study involving human subjects is required to disclose the existence of financial interests. It is unnecessary to report any financial interests or relationships do not reasonably appear to affect or be affected by the proposed study.

Definitions:

"Conflict of interest" occurs when an independent observer may reasonably question whether an individual's professional actions or decisions are influenced by considerations of the individual's private interests, financial or otherwise.

Conflicting financial interests do <u>not</u> include:
Salary and benefits from Fort Hays State University;
Income from seminars, lectures, teaching engagements, or publishing sponsored by federal, state, or local entities, or from non-profit academic institutions, when the funds do not originate from corporate sources;
Income from service on advisory committees or review panels for governmental or non-profit entities;
Investments in publicly-traded mutual funds;
Gifts and promotional items of nominal value; and
Meals and lodging for participation in professional meetings.

"Principal investigator or other key personnel" means the principal investigator and any other person, including students, who are responsible for the design, conduct, analysis, or reporting of research involving human subjects.
Select one:

__X_ There is no conflict of interest

____ I need to disclose financial interests in any external entity is related to the work to be conducted under the proposed project or is interested in the results of the project. *(If this is checked, you will be contacted by the Office of Scholarship and Sponsored Projects and asked to complete a disclosure form).*

IX. Special Considerations for Vulnerable Participants

Vulnerable participants are generally regarded as those who are relatively or absolutely unable to protect their own interests. The National Bioethics Advisory Committee describes the following factors to consider would impair prospective subjects' ability to protect themselves:
Cognitive or communicative (unable to comprehend, think, or make decisions)
Institutional (students, prisoners)
Deferential (patient/doctor, student/teacher)
Medical (desire for a cure)
Economic
Social

Studies involve protected or vulnerable populations will need to explicitly address the strategies will be used to provide protection for these groups. Studies involving vulnerable populations will receive a Full Review, and there must be considerable justification provided if there is more than minimal risk involved.

When using a vulnerable population, additional consents and debriefings need to be conducted. The researcher must recruit a site or location; consent from the head of these locations must give permission to use the facilities. In addition, the guardians, parents, etc. of young, elderly, or cognitively impaired participants must also give permission. Finally, the actual participant must give assent to participate.

Additional considerations include:

How will the research location/site, parent/guardian/etc., participant be contacted? Attach copies of the 1) recruitment letter and consent for each location/site will be used during this research project; 2) recruitment letters and consent forms for parent/guardians/etc.; and 3) participant assent forms and/or process used to obtain and document assent.

Upon completion of the research project, how will the site/location, parents/guardians/etc., and participants be debriefed and notified of the termination of the project.

Complete and include with the application package.

Vulnerable populations are listed below. Those with * have additional information or may require the Principal Investigator to answer additional questions. Click on the links to go to those sections:

Elderly (65+ Years)
Prisoners
Wards of the State
Pregnant Women
Fetuses
Mentally disabled
Children (under the age of 18) *
Researchers also should describe safeguards for populations are:
Vulnerable to influence or coercion (includes FHSU students or employees) *
Economically disadvantaged
Educationally disadvantaged (includes illiterate) *
Decisionally impaired*Non-English speakers
International research*

Appendix D: Data Coding

Section I: Demographic data

1. Age: Under 18 **0** 18-24 years old 1 25-34 years old 2 45-54 years old **3**
2. Sex: Male **0** Female **1**
3. Major: Biology/pre-health **1** Agriculture **2**
4. Class Classification: KAMS **0** Freshman **1** Sophomore **2** Junior **3** Senior **4**
5. Race: White **0** African American/black **1** Hispanic/Latino **2** Native American/American Indian **3** Asian/Pacific Islander **4** Other **5**
6. Are you a first-generation College Student? Yes **0** No **1**

Section II: Questions to assess participants' Knowledge about antimicrobial resistance

1. **Rate your overall level of knowledge of antibiotic resistance**
   A. Strongly knowledgeable **0**
   B. Knowledgeable **0**
   C. Somewhat knowledgeable **2**
   D. Undecided **3**
   E. Not knowledgeable **4**
2. **Antibiotics are powerful medicines to kill viruses**
   A. Strongly Agree **0**
   B. Agree **0**
   C. Undecided **1**
   D. Disagree **2**
   E. Strongly Disagree **2**
3. **Frequent use of antibiotics in medicine and agriculture decrease the efficacy of antibiotics**
   A. Strongly Agree **0**
   B. Agree **0**

C. Undecided **1**
D. Disagree **2**
E. Strongly Disagree **2**

4. **Frequent use of antibiotics put patients at risk**
   A. Strongly Agree **0**
   B. Agree **0**
   C. Undecided **1**
   D. Disagree **2**
   E. Strongly Disagree **2**
5. **There is no connection between taking antibiotics and the development of resistant**
   Bacteria.
   A. Strongly Agree **0**
   B. Agree **0**
   C. Undecided **1**
   D. Disagree **2**
   E. Strongly Disagree **2**
6. **Antibiotics speed up the recovery from common cold or flu**
   A. Strongly Agree **0**
   B. Agree **0**
   C. Undecided **1**
   D. Disagree **2**
   E. Strongly Disagree **2**

Section III: Questions to assess participants' perceived threat of antibiotic resistance

1. **Rate your level of perceived threat of antibiotic resistance.**
   A. High threat **0**
   B. Moderate threat **1**
   C. Low threat **2**
   D. None **3**

E. Unknown/don’t’ know **4**

2. **Antibiotics resistance will affect you and your family’s health**

A. Strongly Agree **0**

B. Agree **0**

C. Undecided **1**

D. Disagree **2**

E. Strongly Disagree **2**

3. **The use of antibiotics in farming is a danger to human health**

A. Strongly Agree **0**

B. Agree **0**

C. Undecided **1**

D. Disagree **2**

E. Strongly Disagree **2**

4. **If taken too often, antibiotics are less likely to work in the future**

A. Strongly Agree **0**

B. Agree **0**

C. Undecided **1**

D. Disagree **2**

E. Strongly Disagree **2**

5. **Currently, antibiotic resistance is a major problem in the United States as well as in the rest of the world**

A. Strongly Agree **0**

B. Agree **0**

C. Undecided **1**

D. Disagree **2**

E. Strongly Disagree **2**

Section IV: Questions to assess participants' perceived benefit of antibiotic education in stewardship.

1. **Rate your level of perceived benefit of antibiotic education in stewardship for futire prescribers**

   A. High benefit **0**

   B. Moderate benefit **1**

   C. Low benefit **2**

   D. None **3**

   E. Unknown/Don't know **4**

2. **Students can contribute to the work being done to control antibiotic resistances**

   A. Strongly Agree **0**

   B. Agree **0**

   C. Undecided **1**

   D. Disagree **2**

   E. Strongly Disagree **2**

3. **It is necessary to give more education for students about antibiotic resistance.**

   A. Strongly Agree **0**

   B. Agree **0**

   C. Undecided **1**

   D. Disagree **2**

   E. Strongly Disagree **2**

4. **All health and agriculture students should get training on the appropriate use of antibiotics before exiting college.**

   A. Strongly Agree **0**

   B. Agree **0**

   C. Undecided **1**

   D. Disagree **2**

   E. Strongly Disagree **2**

5. **Dispensing antibiotics without prescription should be more closely controlled.**

   A. Strongly Agree **0**

   B. Agree **0**

   C. Undecided **1**

   D. Disagree **2**

   E. Strongly Disagree **2**