

ABSTRACT

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REASONING ABOUT INFECTIOUS
DISEASE

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Infectious disease has plagued humanity throughout history and the threat from infectious disease is still real. All healthcare providers and medical researchers need training that focuses on all components of infectious disease. Educators must help future healthcare professionals learn the value of comprehensive solutions to infectious disease problems. I have designed a case study based interview prompt to examine and describe the thought processes of novices and experts as they solve infectious disease problems. During the interviews both microbiology students (novices) and infectious disease professionals (experts) demonstrated comprehensive thinking about an infectious disease problem. This research is the first step in developing a methodology to identify comprehensive thinking about infectious disease problems. Further research will help educators to create classroom environments that encourage students to practice thinking comprehensively about infectious disease.

NOVICE AND EXPERT COMPREHENSIVE REASONING ABOUT
INFECTIOUS DISEASE

By

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Chapter 1: Introduction

Overview

As a science education graduate student and part of the teaching team for the general microbiology class at the University of Maryland, College Park, I am curious about the impact of undergraduate microbiology education on future healthcare providers' and medical researchers' approaches to solving infectious disease problems.

I feel that it is important for all healthcare providers and medical researchers to consider the big picture when thinking about infectious disease problems. I would like to develop a research methodology to measure such comprehensive thinking about infectious disease problems. Using this research methodology I would like to improve undergraduate microbiology education to promote comprehensive thinking about infectious disease problems.

In this paper I will describe the importance and complexity of infectious disease problems. Then I will discuss how infectious disease problems need to be approached from a comprehensive perspective. A comprehensive perspective on infectious disease takes into account both the biological and sociocultural factors¹ that contribute to infectious disease while focusing on the “big picture.” For example, a non-

¹ I have personally wrestled with the classification of components of a comprehensive perspective on infectious disease education. In the majority of this paper I will refer to both biological and sociocultural components of a comprehensive perspective on infectious disease. I am not implying that there are not many other factors or components that should be considered part of a comprehensive perspective on infectious disease. I am merely referencing these two major groupings because they have been the best and most prevalent summarizing descriptions of the components of a comprehensive perspective on infectious disease that I have encountered during this research.

comprehensive perspective on infectious disease might focus on the treatment of the infection, but not on how this infection was acquired or how to prevent future infections of this kind. Next I will discuss how not only future infectious disease professionals, but all future healthcare providers and future medical researchers need to be trained to think comprehensively about infectious disease problems.

I have developed the following research question: what is the impact of undergraduate microbiology education on future healthcare providers' and medical researchers' approaches to thinking about infectious disease problems?

I will describe two preliminary studies designed to help address my research question. In the first study, I attended professional infectious disease patient case study conferences to attempt to identify the components of comprehensive thinking about an infectious disease problem. During this study I realized that experts' reasoning about infectious disease problems was contextually situated. This means that the infectious disease professionals approached infectious disease problems differently when the context of the problem was changed. I will discuss the theoretical implications behind contextually driven problem solving.

In an attempt to more thoroughly examine the nature of contextually driven problem solving about infectious disease, I designed a case study based interview prompt. The interview prompt was specifically designed to examine the contextual reasoning of novices and experts and to promote comprehensive thinking about infectious disease.

In the second study, I interviewed infectious disease novices and experts and described their thought processes as they reasoned about infectious disease patient case studies. For this study, I considered undergraduate microbiology students as novices and

infectious disease professionals as experts. All of the novices and experts demonstrated comprehensive reasoning about the cases presented during the interviews. This is exciting and supports the use of case studies to promote comprehensive thinking about infectious disease. Then I will discuss how this research can help with the development of a research methodology to measure comprehensive thinking about infectious disease problems. Last I will discuss how a research methodology designed to measure comprehensive thinking about infectious disease can be used to answer my research question: what is the impact of undergraduate microbiology education on future healthcare providers' and medical researchers' approaches to thinking about infectious disease problems?

Importance of Infectious Disease

Throughout history, infectious diseases have plagued humanity. No human escapes the wrath of infectious disease. The smallpox virus killed more humans than all wars in history combined. During the middle ages, one-third of the European population was killed by bubonic plague (Whitton, 2002). Infectious diseases infect humans of all ages, but impact particularly on the young and old (Norrby, 2005).

With the advent of antibiotics and vaccinations, drastic reductions in infectious disease mortality were accomplished in the early 20th century. In 1969, US Surgeon General William Stewart went so far as to advise Congress that it was time to “close the book” on infectious disease. Advances such as antibiotics and vaccinations had significantly reduced the threat of infectious disease and it was time for researchers and physicians to focus on the next big threat to health: chronic diseases such as heart disease and cancer.

Surgeon General Stewart could not have been more misguided when he predicted the end of infectious disease. Scientists had been working towards the goal of eliminating infectious agents; however, the increase in antimicrobial use put a new selective pressure on microbes. Common infections began to evolve resistance to antibiotics. Scientists had ignored the ecological and evolutionary implications of fighting infectious disease to the death (Wheeler, 1999).

Epidemiologic Transition Theory

Epidemiologists use the epidemiological transition theory to describe the major changes in human behavior that tipped the balance between humans and infectious disease agents. The first epidemiologic transition occurred when humans shifted from migrating hunter-gatherer bands to stationary agricultural producers. Civilizations began to develop around the agricultural production of food and humans branched out into specializations. The second epidemiological transition occurred when scientific theories and technologies combined with engineering marvels lessened the transmission of infectious diseases. The third transition comprises the evolution of resistant pathogens and the easy spread of diseases across a globally connected population (Barrett et al., 1998). According to the epidemiological transition theory, Surgeon General Stewart was correct that humans had progressed through the second epidemiologic transition and the major threats to public health were by chronic non-infectious diseases. However, he failed to foresee the speed with which humans would progress into the third epidemiologic transition.

Taming Infectious Disease

Over the past century, scientists have discovered many new drugs and therapies to control and prevent infectious disease. These technologies may have dramatically reduced the morbidity and mortality of infectious diseases; but, they also have raised new concerns. Antibiotic resistance is widespread among once susceptible common infectious agents because of the overuse and misuse of antimicrobials. DDT has left long-bearing scars on ecosystems from its successes in reducing the transmission of malaria and yellow fever. As humans develop better ways of preventing and treating infectious diseases then the disease agents will be forced to “outsmart” our weapons and will emerge in another form to infect us. The problem of infectious diseases is not going away and it will never go away. We need to find the best ways to learn to live with infectious agents by taming their morbidity and mortality, while inhibiting the drive of natural selection (Armelagos et al, 2005).

Complexity of Infectious Disease

Emerging and Re-Emerging Infectious Disease

New infectious diseases, such as Legionnaire’s disease, acquired immunodeficiency syndrome (AIDS), hantavirus cardiopulmonary syndrome, and severe acute respiratory syndrome (SARS), have emerged in the human population. Emerging infectious diseases can be defined as those that have “newly appeared in the population, or have existed but are rapidly increasing in incidence or geographic range.” (Morse, 1995) Tuberculosis made a comeback due to antibiotic resistant strains. Newly virulent pathogens such as *Escherichia coli* O157 and the Ebola virus have emerged. Ecological, environmental, and demographic factors can be identified behind the emergence of all of

these new infectious diseases. The changing nature of these factors and the increased selective pressure of medical treatments combine to encourage the emergence of new infectious diseases. (Morse, 1995)

Chronic Diseases with Infectious Origins

Chronic diseases have begun to reveal their infectious origins to scientists. Peptic ulcers, which were long considered to be caused by lifestyle factors such as diet, exercise, and stress, are now known to be caused by a bacterium, *Helicobacter pylori*. Many cancers have been linked to bacterial and viral infections. MALT B-cell lymphoma can be cured by antibiotics (Whitton, 2002). There is now a vaccine against some strains of the human papillomavirus, and it is being advertised as a vaccine to prevent some types of cervical cancer (CDC, 2006).

Human Microbial Ecology

Microbial ecology is an important component in the balance between harmless colonization of the human body by microorganisms and infectious disease. Microorganisms have evolved with the human host. They utilize the human body as a nutrient rich environment. Most of these organisms are commensal, meaning they benefit from living in the human body, but have no effect on their host. Some microorganisms are endosymbionts, meaning both the host and the organism benefit from the relationship. Humans are not harmed by most relationships with microorganisms, but occasionally a microorganism causes disease in the human body (Blaser, 1997). The relationship between a given microorganism and its host is proving to be more complicated than previously understood. Carrier states and commensal relationships between microbes and

hosts blur the lines between microorganisms that colonize the host and pathogenic microorganisms that cause disease in a host. (Casadevall & Pirofski, 2000).

The human body contains 10 times more microorganisms than body cells. Complex microbial ecosystems have developed in mouth, upper respiratory tract, digestive tract, skin and vagina of the human body in the form of biofilms (Bengmark, 1998; Rastall et al., 2005; Alvarez-Olmos and Oberhelman, 2001). Biofilms are highly complex formations of microorganisms that account for over 99% of natural bacterial populations (Ehrlich et al., 2005). Many of the infectious diseases in humans are caused by biofilms.

Biofilms

Bacterial cells growing in a biofilm exhibit phenotypic changes that make them 1000 to 1500 times more resistant to antimicrobial therapy (Reid, 1999; Costerton, 1999). Immune phagocytes and antibodies have difficulty attacking bacteria through the complex structure of a biofilm (Kobayashi, 2001). Often multiple species of bacteria preferentially live in a biofilm structure instead of as individual planktonic cells (Costerton, 1999). Biofilms in lung tissue can cause chronic inflammation and as planktonic bacteria are released from the biofilm, they frequently cause acute infections in surrounding tissue (Kobayashi, 2001).

Biofilms have been implicated in infectious diseases such as: endocarditis, cystitis, osteomyelitis, cystic fibrosis pneumonia, prostatitis, dental plaque, upper respiratory infections, peritonitis, urogenital infections, otitis media, and forms of kidney stones, (Costerton, 1999; Parsek and Singh, 2003; Reid, 1999). Biofilms often

form on implantable medical devices such as artificial heart valves, veins, and joints (Reid, 1999).

Microbial Ecology and Disease

Many infectious diseases do not fit Koch's postulates and new research shows that some of these diseases may be multi-organismal and result from a change in the microbial ecology of the host. Both dental caries and periodontal disease result from changes in the oral microbial ecology (Li et al., 2004). The changes in the plaque microbial ecology generate a mineral imbalance between the plaque and the tooth. Slowly, minerals from the tooth leech out into the plaque weakening the tooth and causing cavities (Fejerskov, 2004).

The relationships between microorganisms and the human body are very complex. Many infectious diseases previously thought to be caused by a single infectious agent are proving to be more complex. Multiple microorganisms can interact in complex ways to cause disease in humans. It is important for healthcare providers and medical researchers to understand and appreciate the complex relationship between microbial ecology and infectious disease.

Normal Flora, Prebiotics, and Probiotics

Humans are continually exposed to bacteria from the moment of birth and some of these are able to colonize the body and become normal flora. A majority of the normal flora associated with the human body is acquired from the ingestion of microorganisms in food and water, but some come from contact with the mother during birth. These normal flora gather nutrients from the human body and ingested food, compete with each other

for nutrients and space, and if successful at colonizing the body, adhere to tissues and form biofilms (Reid et al., 2007).

Prebiotics are “A nondigestible food ingredient that beneficially affects the host by selectively stimulating the growth and/or activity of one or a limited number of bacteria that can improve the host health” (Rastall et al., 2005). Carbohydrate supplements are often used as prebiotics to boost levels of nonpathogenic normal flora. Prebiotics can have antimicrobial effects directly or via the stimulation of normal flora that produce antimicrobials (Rastall et al., 2005).

Probiotics are “live microorganisms, which when administered in adequate amounts confer a health benefit on the host” (Rastall et al., 2005). Probiotics help to reduce the presence of potentially pathogenic microorganisms in the natural flora. This lowers the likelihood of infectious disease by opportunistic pathogens during times of host stress (Bengmark, 1998). Probiotics may help to treat and prevent diarrheal diseases, vaginitis, urinary tract infections, and food allergies.

Microbial interference therapy (MIT) involves the maintenance and supplementation of the normal flora with probiotics to help treat and prevent infections. As antibiotic resistance continues to increase and the development of new antibiotics cannot keep pace, MIT has the potential to become the preferred method for treatment and prevention of infectious disease (Bengmark, 1998). Probiotics block the adherence of pathogenic microorganisms to human body cells. There is some evidence that probiotics produce antimicrobial agents that help defend the host against pathogens. Probiotic microorganisms prime the immune system to be ready to fight off pathogenic invaders (Rastall et al., 2005).

Infectious Disease Education

Epistemology of Infectious Disease

Farmer touches upon the epistemology of the study of emerging infectious diseases. He raises the idea that many of today's emerging infections are only considered "emerging" or new because of human alteration of both the social and physical environment, which tips the balance between man and microbe. He discusses some of the flaws with viewing infectious disease as "tropical medicine," through epidemiologic transitions, and studying nations as homogeneous populations. He proposes that only through interdisciplinary research can emerging infectious diseases be understood and controlled. He outlines the need for a critical examination of the epistemology of the study of infectious diseases (Farmer, 1996).

Farmer neatly supports my desire to link undergraduate microbiology education to controlling infectious disease. He also supports my view that a comprehensive perspective is necessary to understanding and controlling infectious disease.

Problems with a Non-Comprehensive Approach to Infectious Disease

Kirby proposes a conceptual map to model the mortality of infectious diseases in human populations. His model consists of three interactive factors: exposure, resistance, and recovery. The idea is that different populations can have the same mortality rate via different combinations of the three factors. He tested this model using cholera as the test disease. Independent variables that contribute to any of the three factors were measured across populations. The dependent variable of mortality was also measured and then the relationships between the independent variables and the dependent variable and the three

factors could be calibrated. This model could then be used to determine the effectiveness of different independent variables in reducing the mortality of cholera (Kirby, 2001).

I find this conceptual map interesting and potentially useful for studying control measures for infectious diseases. However, I think that it is a gross oversimplification of the complexity of infectious disease problems. It may not apply to all infectious diseases or accurately predict helpful strategies to prevent or cure infectious diseases in all populations. This is an example of how too narrow of a perspective on infectious disease might lead us astray in our search for solutions.

Education and a Comprehensive Approach to Infectious Disease

I would like to propose that educators support a comprehensive approach to infectious disease by helping all of the future healthcare professionals and medical researchers to see the comprehensive nature of infectious disease and how important it is for professionals in the different fields of infectious disease to communicate effectively with each other. Manderson identifies some of the inherent difficulties with the multi-disciplinary nature of infectious disease research (Manderson, 1998). My hope is that educators can help smooth out some of these difficulties by helping future healthcare professionals and medical researchers to better understand the comprehensive nature of infectious disease and the value of multi-disciplinary research and problem solving.

Porter et al. highlight the need to restructure public health to focus not on the elimination of disease, but instead of the creation of health. They define public health as “fulfilling society’s interest in assuring the conditions in which people are healthy.” They also define the purpose of public health to “generate organized community effort to address the public interest in health by applying scientific and technical knowledge to

prevent disease and promote health.” This emphasizes that effective infectious disease policies will not be purely derived from the biomedical community, but from the community as a whole (Porter et al., 1999). Educators are trained to include the community as a whole in the development of new and improved educational programs. The potential positive impact that educators could have on global public health is immense.

Infectious Disease Educational Standards in the Literature

The American Society for Microbiology has published core curriculum guidelines for undergraduate level microbiology education. It is recommended that introductory courses in microbiology cover the following core concepts relating to infectious disease: host defense mechanisms, microbial pathogenicity mechanisms, disease transmission, and antibiotics and chemotherapy (ASM, 1997). All of these concepts are important biological components of a comprehensive perspective on infectious disease. However, the sociocultural components of a comprehensive perspective on infectious disease are not included in the undergraduate introductory microbiology curriculum. I am curious about the impact of an introductory microbiology class on the development of a comprehensive perspective on infectious disease. Does the class contribute only to the biological components of a comprehensive perspective on infectious disease? What effect does this have on the sociocultural components of a comprehensive perspective on infectious disease?

The American Society for Microbiology describes an undergraduate microbiology major’s program of study based upon recommended courses. The core courses include: introductory microbiology, microbial physiology, microbial genetics, and microbial

diversity and ecology (Baker, 1997). In theory it is possible for all of these courses to include aspects of infectious disease, but there is no clear inclusion of infectious disease as part of the curricula for any of these courses except for introductory microbiology.

There is a long list of 17 suggested elective courses for undergraduate microbiology majors (Baker, 1997). Some of these courses may be combined into larger, broader courses; however, even combining some of the courses, there are too many elective courses for a single student to complete during their undergraduate education.

The following electives directly relate to infectious disease: immunology, pathogenic microbiology, virology, parasitology, epidemiology, and public health. The remaining electives may incorporate aspects of infectious disease into their curricula; however, there is no stipulation of this in the guidelines. Generally speaking, most of these microbiology electives also focus on the biological components of a comprehensive perspective on infectious disease. However, some electives, such as epidemiology and public health definitely cover the sociocultural components of a comprehensive perspective on infectious disease.

The American Society for Microbiology has also published an outline of important aspects of bioterrorism for inclusion in undergraduate curricula. The outline includes: ancient and modern history of bioterrorism; characteristics of the pathogens or agents; aspects of the outbreak, such as surveillance and detection, response, and prevention; current research; ethical issues; information management; and student perspective (Baker, 2002). Clearly, these types of courses focus on both the biological and sociocultural components of a comprehensive perspective on infectious disease education.

At the 2000 and 2001 American Society for Microbiology Undergraduate Education Conferences, microbiology educators developed outlines for microbiology inclusion in non-majors undergraduate biology curricula. One of the topics recommended for inclusion in a science course for non-science or general education majors was microbes' interrelationships with humans which includes aspects of infectious disease such as: immune responses, epidemiology, and disease transmission.

It is recommended that all students majoring in biotechnology, biology, and allied health complete an introductory microbiology course. For allied health majors, it is recommended that 50% of an introductory microbiology course's curricula focus on infectious disease.

Infectious Disease Educational Content in the Literature

Non-Comprehensive

A majority of the literature on infectious disease education outlines activities to help students learn about one or two infectious disease concepts. Such isolated concepts include: epidemiology, transmission, prevention, pathogen biology, host pathogen interactions, antimicrobial compounds, antimicrobial resistance, biomedical technology, and microbial ecology. In the following sections, I will define some of the common concepts of infectious disease described in the education literature. Then I will discuss some of the common educational activities designed to help students learn about the concept. More detailed descriptions of these activities can be found in Appendix L.

Epidemiology is the study of factors that affect the health and illness of populations. Many activities ask students to investigate outbreaks of a disease in a population (Deutch, 2001; Hammond et al., 2002; Sorensen, 1998).

Transmission refers to the mechanism(s) by which an infectious disease spreads through a population. There are many different simple activities designed to model the transmission of an infectious disease among students (Jones, 1993; Waugh, 2003; Edwards, 1999; Grimes et al., 1998; Howard and Nozicka, 2000; Kelly, 1998; Link and Cardinale, 2007). Others have developed lab activities in which students model the transmission of disease using model systems (Adamo & Gealt, 1996; Coleman, 1995).

Prevention involves acts designed to inhibit the transmission of infectious disease through populations. Prevention learning activities can be approached from many different angles including: learning about vaccination (Goetsch et al., 2002), discussion about proper handling of body fluids (Waechter-Brulla, 2002), or learning about prevention strategies for a specific disease (Kerr & Elwell, 2002).

Pathogen biology is the study of the characteristics of an organism that can cause infectious disease. Pathogen biology can be studied indirectly through modeling (Gillen & Mayor, 1995) or directly via experimental manipulation (Jones et al., 1999).

Host pathogen interactions consist of the study of the effects a pathogen has on a host and the effects a host has on a pathogen. There are many activities that focus on helping students understand how pathogens attempt to evade the immune system and how the immune system attempts to eliminate pathogens (Houston et al., 2002; Shupp et al., 2005; Merkel, 2003)

Antimicrobial compounds are chemicals that inhibit the growth of or kill microorganisms. Instead of studying traditional antimicrobial compounds, students can test natural plant extracts for antimicrobial activity (Finer, 1997; de Castro-Ontengco and Capal, 2004). There are also activities in which students test the antimicrobial activity of

environmental microorganisms (Benathen et al., 2004; Gallo, 2001). Many activities test the effectiveness of antimicrobial cleaners on bacteria (Cooper, 2001; Anglehart et al., 2005; Gaydos, 2005). Some activities help students to understand the mechanism by which various antimicrobial chemicals affect microorganisms (Merkel, 2001; Hampikian, 1999).

Antimicrobial resistance occurs when a pathogen has been repeatedly exposed to an antimicrobial chemical. Sometimes the pathogen is able to acquire genes from the environment or mutations in their own genome are selected for. These new genes or mutated genes change the characteristics of the pathogen so that the antimicrobial chemical is no longer effective on the pathogen.

When studying antibiotic-resistant bacteria, students are often surprised and intrigued that such bacteria are common in their everyday environment. Several lab activities guide students through isolating antimicrobial resistant bacteria from the environment (Omoto & Malm, 2003; Brock et al., 2004; Woolverton & Hawkins, 1999). Some other activities help students understand the mechanisms behind microorganisms acquiring antimicrobial resistance (Welden & Hessler, 2003; Snow, 2004).

Biomedical technology is laboratory tests or assays that aid in the identification of infectious diseases and help to characterize pathogens. There are lots of lab activities in which students learn how to perform laboratory tests that aid in the identification of pathogens (Verran, 2005; Stuart & Cox, 2000; Ogden, 2000; Pommerville et al., 2001; Katz & Leyva, 2007; Mitchell & Carter, 2000; Lehman, 2005; Buxton, 2005; Allen, 2005; Hanson, 2006; Shields and Tsang, 2006; Fan, 2006; Lal and Cheeptham, 2007; Suchman and Blair, 2007).

Microbial ecology is the study of the distribution of microbial life and the interactions of microbial life with their environment. Activities can help students to understand the role of microbial ecology in infectious disease (Williams & Gillen, 1991; Boomer, 2006).

Comprehensive

A small minority of the literature details projects or curricula that attempt to help students learn about multiple infectious disease concepts and the comprehensive nature of infectious disease problems. I am defining a comprehensive infectious disease activity or curriculum as one that covers at least three different infectious disease concepts. In the following section, I will discuss some activities, projects, and courses that attempt to teach infectious disease from a comprehensive perspective. Following this I will separately discuss the use of case studies to help teach infectious disease from a comprehensive perspective.

Activities, Projects, and Courses

There is some evidence that the accused witches during the Salem witch hunts were suffering from rye ergot poisoning. Students research *Claviceps purpurea* as a plant pathogen and learn about the resulting human disease caused by ingestion of the organism. The students also research the Salem witch trials and read Arthur Miller's *The Crucible*. Students then write a critique of a *Science* paper exploring the possibility of ergotism's involvement in the Salem witch trials (Chapman, 2003).

Richard Fluck (2001) designed a first-year multidisciplinary seminar around tuberculosis. In this course, students read public health books such as *The White Plague: Tuberculosis, Man, and Society* by Rene and Jean Dubos (1987). Students also read

scientific reviews of tuberculosis. From this background information, student groups chose topics of interest concerning tuberculosis and researched them. Topics chosen by the students varied from the biochemical aspects of drug resistance to links between tuberculosis and HIV or tuberculosis and poverty. By having students specialize in different aspects of the disease and share their knowledge with the class, the whole class is able to gain a comprehensive perspective on tuberculosis.

Students are shown pictures of a family eating in an open air market. Each picture is captioned with information about the individuals, their food, and the environment. Students then answer questions designed to help them learn about the risk factors for food-borne illness, how to identify sources of food-borne infection, common pathogens that cause food-borne illness, prevention strategies and public health practices (Buxton, 2003).

Verran (2004) has designed an activity for students to explore dental plaque as a biofilm. Students sample the biofilm directly and using toothbrushes. Comparisons are made between the two different sampling methods. Students also comment on the toothbrush as a fomite.

Furlong (2007) describes an activity in which students observe the spread of influenza through two different populations. Students analyze their observations in terms of: prevalence, mortality, recovery, and vaccination rate.

Case Studies

Instead of a final exam in Caccavo's (2001) course in Microbes in Human Disease, the students complete an infectious disease case study analysis. In this case study analysis, students draw upon all of the topics they have learned in the course to:

“identify patient symptoms, suggest appropriate specimens, order appropriate tests, interpret test results, identify the etiological agent, and prescribe therapy.”

At the beginning of each lecture, small groups of Anderson’s (2001) microbiology students present an infectious disease to the whole class. They are tasked with creatively presenting the “etiology, transmission, pathogenesis, clinical features, diagnosis, treatment and prevention” of each infectious disease to the class.

In 1998, Gibbins wrote a history of “Typhoid Mary” for the *Journal of Biological Education*. It was hoped that teachers would use the history as a case study to address current problems surrounding infectious diseases. Included in the history were “epidemiological, ethical, judicial, publicity, and individual and societal rights issues.”

Malaria is an infectious disease that affects millions of people in developing nations every year. Dinan and Bieron (2001) wrote a case study about the issues surrounding the use of DDT to control malaria-spreading mosquitoes. Students are asked to perform a risk/benefit analysis of the impact of this scientific technology on society. In order for students to perform this analysis, they need to understand malaria from a comprehensive perspective.

Cody (2001) describes a series of three medical microbiology case studies that can be used to teach students aspects of infectious disease. The first case study asks students to use biochemical tests to identify the cause of an outbreak of foodborne illness. The students also analyze some epidemiological data to identify the source of the outbreak. The second case study gives a description of a patient with an infectious disease. Students are asked to answer questions about several different aspects of the infectious disease. The third case study also gives a description of a patient with an

infectious disease. Students are asked to interpret biochemical tests and relate the results to the patient's illness.

Merkel et al. (2005) describe a series of three case studies designed to help students improve their microscopy skills. In the first case study, students investigate an outbreak of *Legionella* on a cruise ship that can be traced to a biofilm in the water system. Students investigate the best treatments to control the biofilm to prevent future outbreaks of disease. In the second case study, students investigate *Cryptosporidium* in the New York City watershed. Students research *Cryptosporidium* and its likely sources in the watershed. Students then decide if New York City should filter its drinking water and defend their decision based upon evidence. In the third case study, students investigate an outbreak of severe acute respiratory syndrome (SARS). The students perform tests to characterize the causative agent and then discuss the implications. Students relate the pathogen's characteristics to public health policy.

Jacobs and Visschers-Pleijers (2005) use a case study about a peer student returning from Africa to teach students about malaria. Students learn about the transmission of the parasite, the lifecycle of the pathogen, the role of the vector in transmission of the disease, and the effects of malaria upon the health of the local population.

Cundell (2000) has gathered a collection of bacterial, viral, fungal and protozoal mini-case history studies for supplementing the instruction of medical microbiology. These case studies ask students to consider laboratory data, patient medical and lifestyle history, pathogen characteristics and their virulence, treatment, and prevention of further spread of the infection.

Case Studies and Comprehensive Curricula

There is an interesting link between utilizing case studies and comprehensive curricula on infectious disease. The use of case studies appears to promote comprehensive approaches to infectious disease problems.

Teaching with a case study involves the presentation of background information about a problem that must be solved. Students are guided through the analysis of the facts of the problem and must pose possible solutions, considering the consequences of their actions (Herreid, 1994).

Surveyed faculty think that students' critical thinking and understanding are increased by the use of case studies. They also noted that students are better able to view a problem from a comprehensive perspective. However, there is very little empirical research on the use of case studies in teaching and their impact on student learning (Lundeberg & Yadav, 2006).

Problem

I have just described several projects, activities, courses, and case studies in which infectious disease education is approached from a comprehensive perspective. But just prior I described many more activities from the literature in which infectious disease education is not approached from a comprehensive perspective, but as individual concepts relating to infectious disease. I have been unable to find any literature that has examined the frequency of use of non-comprehensive vs. comprehensive activities and curricula in undergraduate microbiology classrooms. If the comprehensive activities and curricula are not prevalent in use, I fear that students may not learn about all aspects of infectious disease in their studies or alternatively; students may learn about all of the

individual components of infectious disease problems, but not synthesize these individual concepts into a comprehensive perspective.

Microbiology Education at the University of Maryland, College Park

A group of faculty with similar research and teaching interests has spent the past several years significantly modifying the microbiology curricula at the University of Maryland, College Park. One of their goals was to design curricula that help students who complete the program to deeply understand major concepts in host pathogen interactions. As I defined earlier, host pathogen interactions is just one concept of infectious disease consisting of the study of the effects a pathogen has on a host and the effects a host has on a pathogen.

Another goal of the faculty group was to develop a host pathogen concept inventory to measure the success of the curricula on student understanding of important host pathogen concepts. I have been working with this faculty team on this project and have often found myself wondering what impact this project has on the students' development of a comprehensive perspective on infectious disease. How does the focus on host pathogen concepts affect the students' development of a comprehensive perspective on infectious disease?

One of the major modifications to the microbiology curricula at the University of Maryland was the addition of case studies to several courses. The use of case studies was added to the following courses: general microbiology, pathogenic microbiology, immunology, and epidemiology and public health. The faculty team is currently using their host pathogen concept inventory to assess the impact of using case studies on student learning of host pathogen concepts.

I would like to develop a research methodology that can help the researchers at the University of Maryland to measure the impact of case studies on student learning. My research methodology would help to measure students' progress towards the development of a comprehensive perspective on infectious disease.

Chapter 2: Preliminary Research

Overview

In the Fall of 2006, as a part of a Medical Anthropology course, I conducted a field study of infectious disease fellows and specialists and the factors they considered while treating patients with various infectious diseases. I attended clinical case management conferences of the Greater Washington Area Infectious Diseases Society. These meetings were conducted on a weekly basis by infectious disease fellows (specialists in training) at the National Naval Medical Center. Each week two to three different patient cases were presented to the audience and discussed in terms of clinical guidelines, relevant literature, and previous experience. The audience consisted of a variety of infectious disease experts, including: infectious disease fellows, specialists, and researchers. The presenter provided the patient history to the audience who was then asked to discuss possible diagnoses. The presenter then described the treatment and diagnosis of the patient and discussed literature relevant to the case. At the end of each case presentation, the audience was invited to share personal experiences with similar cases.

Theory

Prior to beginning this study, I defined a comprehensive approach to infectious disease education as focusing on the biological, ecological, and sociocultural aspects of infectious disease. This definition of comprehensive infectious disease education was

informed by the field of medical anthropology (Inhorn, 1990). I defined these factors as follows: 1. Biological Factors – relate to the interactions between infectious disease agents and hosts; 2. Ecological Factors – relate to the interactions between biological factors and their physical environment; 3. Sociocultural Factors – relate to the interactions between biological and ecological factors and human systems. I developed two different conceptual maps to organize the relationship between all of the factors.

In the first concept map (Figure 1), the factors are organized so that biological factors are at the core. Ecological factors are then a ring surrounding biological factors. And finally, sociocultural factors are a ring surrounding both biological and ecological factors. Outward pointing arrows demonstrate how biological factors' influence expands outwards to affect ecological and sociocultural factors. Inward pointing arrows demonstrate how sociocultural factors' influence trickles down to affect ecological and biological factors. This means that any contributing factor also affects factors from all three of the categories in a hierarchically organized pattern. This map helps to show how ecological factors build off biological factors and how sociocultural factors build off both biological and ecological factors.

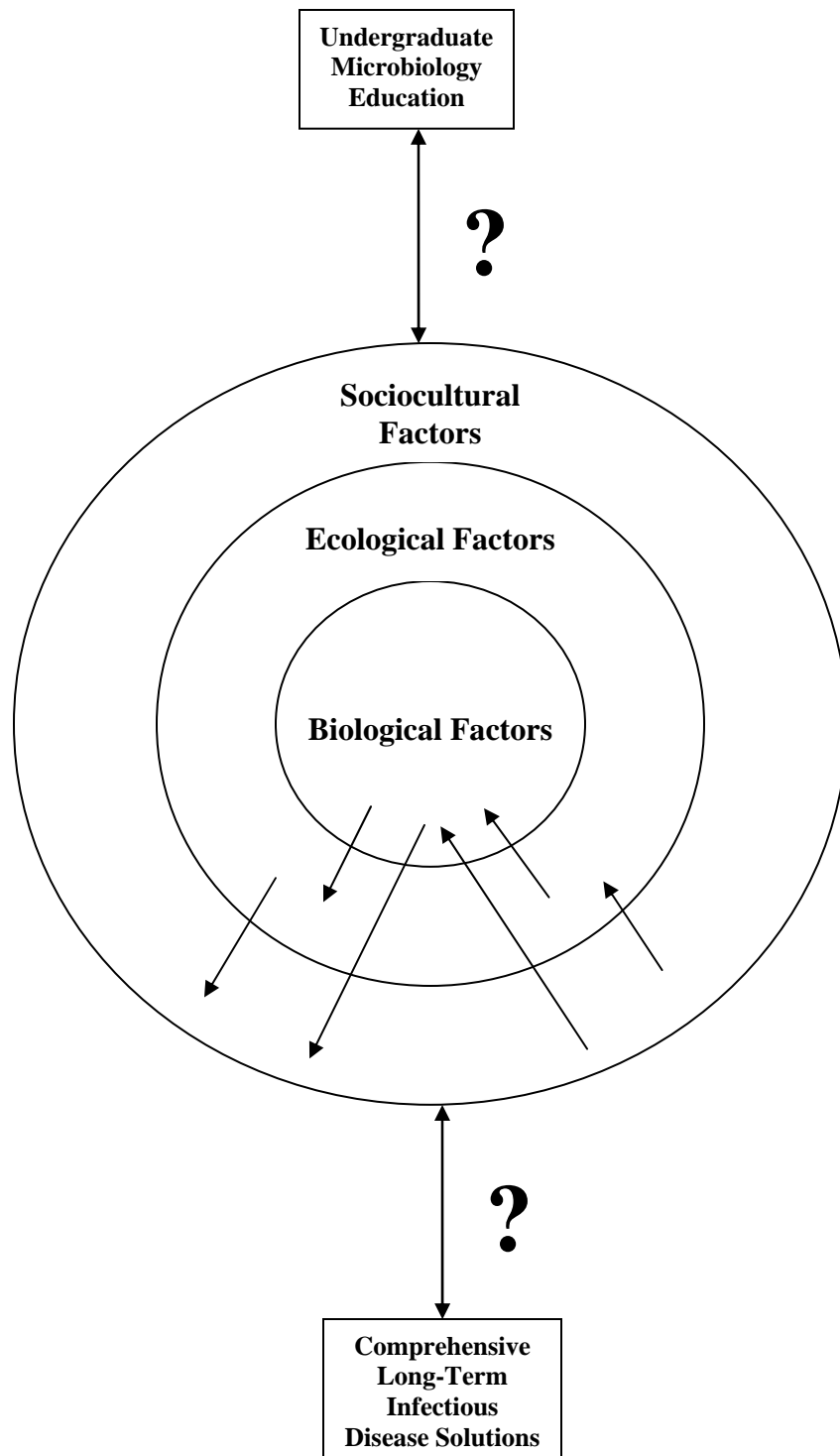


Figure 1. Onion Concept Map of a Comprehensive Perspective on Infectious Disease Education

In the second concept map (Figure 2), the factors are organized so that biological, ecological, and sociocultural factors are all interconnected. The factors are in the center of a circle that encompasses a comprehensive perspective on infectious disease. This map helps to show how each of the factors is equally important in terms of their contribution to infectious disease.

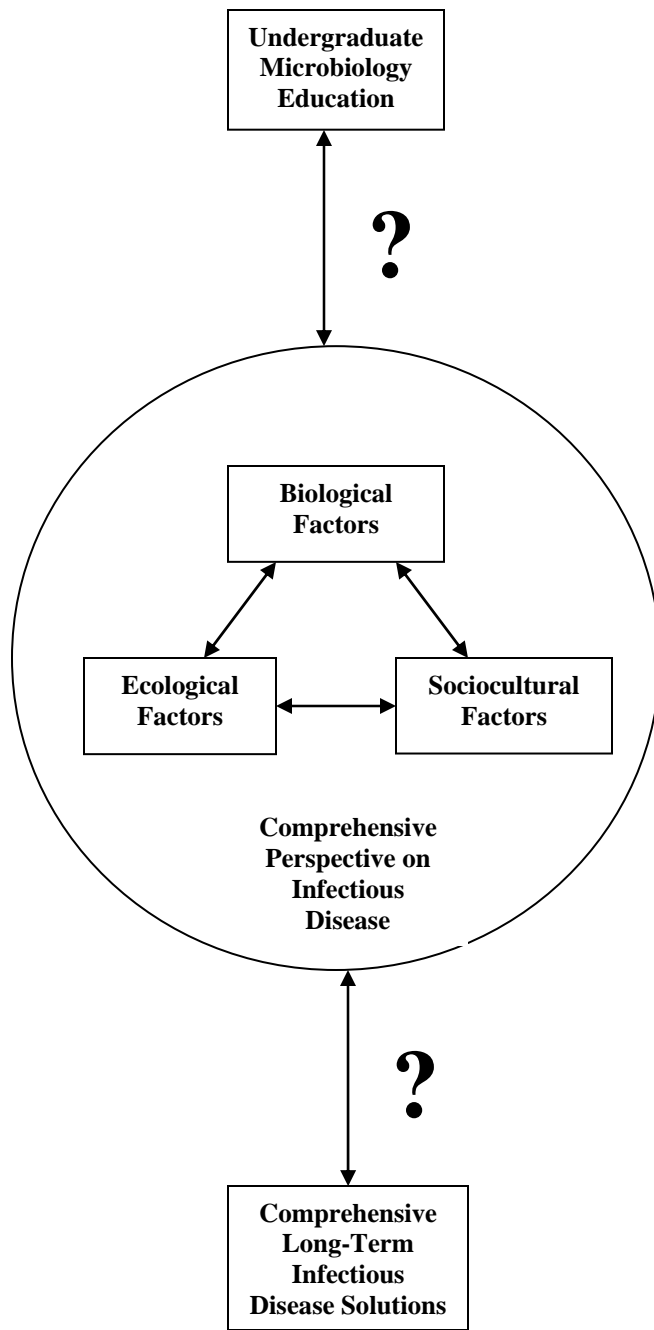


Figure 2. Interconnected Concept Map of a Comprehensive Perspective on Infectious Disease Education

Methods

At each meeting, I took notes on each case discussed. My notes were organized to provide an overview of the patient, their age, and chief complaint. Then my notes detailed every single factor that was considered about the patient's illness, their medical and lifestyle history, laboratory tests, physical exam findings, treatment options, and the outcome.

At the end of the study, I compiled a large list of every factor considered by the infectious disease experts over the course of the study. I then attempted to classify each of these factors as biological, ecological, or sociocultural.

Results

Infectious disease specialists considered a wide array of factors when thinking about and treating patients with an infectious disease. After weeks of frustration and inconsistent coding results, I decided that perhaps I needed to take a different approach. I noticed that some of the factors were clear-cut and easy to classify into only one category. I also noticed that some of the factors were easy to classify if I put them back into the context from which they were isolated.

For example a compromised immune system is a factor that should be considered by an infectious disease specialist when treating a patient with an infectious disease. A compromised immune system could be an innate characteristic of the patient due to an inherited condition and would be classified as a biological factor. A compromised immune system might also be caused by stress in a patient's life and this could be classified as either ecological or sociocultural depending on the source of the stress. An ecological example of a compromised immune system due to stress might be a recent

cold spell in the weather. A sociocultural example of a compromised immune system due to stress might be difficulties at work.

I also noticed that the particular factors varied depending on the context of the case. Sometimes, when the disease at hand was mysterious, it appeared that the physicians had covered every possible factor that must be considered when solving an infectious disease problem. It almost appeared as if they were working off a master list. But other times, when the disease was known, very context specific factors were considered and others were not mentioned.

The following is an example of a patient case in which the disease remained undiagnosed and because it was a mystery to physicians, they considered a wide variety of factors relating to the disease. The patient was an adolescent male who presented with severe abdominal cramping and diarrhea approximately 1 hour after eating a school lunch. His diarrhea changed from watery to bloody as time progressed. His physicians inquired about his social history. They determined that he had a girlfriend but did not engage in sexual activity. The patient also had animal exposures to his pets: a kitten and a salamander. The patient had traveled to Tokyo, Costa Rica, and Kenya. During his travels he had some exposure to water and some mosquito bites, but had only drunk bottled water. The patient had a history of acne and had been on doxycycline to control his acne for 2 years. At the beginning of the patient's illness he had suffered from some pruritis or itching. Physicians considered both foodborne toxins and parasitic infections from travel to be possible causes of the patient's illness. The patient slowly recovered despite the mystery of his illness to physicians.

The following is an example of a patient with a diagnosed disease and how the physicians focused only on the factors relating to the disease. The patient was a 30 year old male that was given his enlistment vaccines. After the administration of the vaccinations he was discovered to be HIV positive. The infectious disease specialists were consulted for advice on how to proceed with the patient. The infectious disease specialists advised that in general live vaccines should be avoided. In this case, because the patient's CD4 cell count was high, he should be fine after receiving live vaccines, but in a patient with a low CD4 cell count, live vaccines should be completely avoided. While the immune system of HIV positive patients is stimulated and functioning at a high level, they should definitely be given vaccines against common diseases in AIDS patients. The specialists stressed that physicians should choose to administer the safest version of each vaccine to HIV positive patients. They also advised that before each vaccine is given to an HIV positive patient, that a risk/benefit analysis should be conducted.

Discussion

This field study helped me to theorize that the thought processes of an expert are contextually triggered as they solve an infectious disease problem. I have already established the importance of comprehensively solving infectious disease problems. To improve infectious disease education and ensure that comprehensive thinking about infectious disease problem solving is nurtured, you need a way to measure comprehensive thinking about infectious disease. This led me to the question: How do you measure comprehensive thinking about an infectious disease if the thinking is

contextually triggered? A research methodology needs to be designed and piloted for measuring comprehensive thinking about infectious disease problem solving.

Chapter 3: Theory

Novice vs. Expert Reasoning / Problem Solving

Definition of Novice & Expert

Expertise is defined as “the possession of a large body of knowledge and procedural skill” (Chi et al., 1981). On the other hand, novices lack not only knowledge about a problem situation but also the skills to apply knowledge to solving the problem (Glaser, 1985).

Expertise is very context specific. Within a particular domain, novices lack knowledge and application skills. Intermediates possess vast amounts of unorganized knowledge but lack the ability to apply the knowledge to new situations. Domain experts have vast arrays of complex knowledge structures and know how to apply them to new problems. Novices make the transition to intermediates and intermediates make the transition to experts by continually confronting new problems and situations (Glaser, 1985).

Research into how novices become intermediates and how intermediates become experts is very important. All novices eventually cease to be novices. However, sometimes intermediates fail to become experts. It is important that educators understand how these transitions occur so that students don't spend the rest of their lives performing at an intermediate level (Bereiter & Scardamalia, 1993).

Experts have also developed metacognitive abilities that help them to focus on the abstraction of a problem into a schema; whereas, novices are only able to focus on the literal components of a problem. An expert's ability to abstract a problem into a schema allows them to demonstrate superior memory and recall large patterned blocks of information. Such pattern recognition can occur with such ease that it appears the expert is acting upon intuition (Chi et al., 1981 & Glaser, 1985).

Model for Development of Medical Expertise

The medical community has adopted the Dreyfus Model of Skill Acquisition to help medical educators understand the progression of a medical provider from a novice to an expert. The Dreyfus model consists of five stages: novice, advanced beginner, competent, proficient, and expert. Novices are taught objective knowledge and skills that they commit to memory. Such knowledge and skills may include the components of a patient history or vital signs and how to collect such information. Advanced beginners begin to recognize aspects of situations that they have seen before. Such aspects cannot be objectively defined outside of their context, but need to have been experienced. An example would include recognizing how guidelines are used for the discharge of a patient. Competent medical providers plan approaches to care for their patients. An example of this would be devising an order in which to perform diagnostic tests on a patient or planning out a strategy to manage all of the a day's multiple patients effectively. The proficient medical provider sees the whole picture and works towards developing routines. They easily recognize when a pattern is broken, but have to work hard to accommodate the change. An expert medical provider has an intuitive perspective on a situation from the vast amounts of knowledge and experience they possess. They are

able to rapidly recognize patterns and accommodate changes (Batalden et al., 2002 & Benner, 1982).

Education for Medical Expertise

Medical education researchers strive to help improve curricula to stimulate the development of expertise in students. Patel et al. stress that medical education is no different from any other educational program designed to help stimulate the development of expertise. Students need to routinely acquire knowledge through authentic exercises that allow the integration of their new knowledge into a schema. One of the many ways to achieve this goal in an educational environment is through the use of case-based learning (Patel et al., 2000).

The following studies were conducted by medical education researchers to see if they could develop methods to distinguish between medical novices and experts. Hmelo-Silver et al. compared expert cancer researchers to “novice” 4th year medical students in a task of developing a clinical trial for a new cancer drug. Both groups designed similar clinical trials in the end, but their reasoning processes along the way varied greatly. For the experts, the task challenged them to learn about a new cancer drug. For the novices, they were challenged to learn about the design of clinical trials and about the new cancer drug. The experts were more systematic and ran many more experiments than the novices. (Hmelo-Silver, 2002).

Experimental data suggest that experienced physicians are better able to utilize contextual clues to correctly diagnose a patient than novice physicians. Hobus et al. conducted an experiment in which they presented both novice and expert physicians with three slides of information about a patient. The first slide contained a picture of the

patient; the second slide, the patient's medical history; and the third slide, details of the patient's current complaint. Given this little amount of information about the patient, experts produced accurate diagnoses of the patient's problem more frequently than novices (Hobus et al., 1987).

Context Dependent Thinking about Infectious Disease

A unitary perspective assumes that an expert's perspective on infectious disease is constant and can thus be easily measured. A manifold perspective assumes that an expert's perspective on infectious disease is context dependent and thus changes from case to case. Proponents of the unitary perspective would design a measure by which students could be classified based on their position on the continuum between a naïve and expert perspective. This type of reasoning for a research program could be justified based on Carey and Kuhn's descriptions of the shift from naïve to expert content knowledge (Carey, 1986 and Kuhn, 1989).

A proponent of the manifold perspective would design a prompt to elucidate student thinking in a particular context. This type of a research program would be similar to the research that Southerland et al. conducted on students' biological knowledge structures. In their study they analyzed student interview data designed to elucidate biological structures. This data was analyzed using the unitary perspective that students' knowledge structures about biology can be measured and categorized. The same data was analyzed using the manifold perspective that students' biological knowledge structures are context dependent and can best be represented as the resources activated by a given situation or problem (Southerland et al., 2001). Southerland et al.'s analysis of their data from a manifold perspective was based on diSessa's work on phenomenological

primitives (p-prims). diSessa's p-prims are small knowledge structures that a person draws upon in any given situation to help them think through a problem or make sense out of a situation (diSessa, 1993). Hammer and Elby built upon this notion of p-prims to postulate a resource-based or manifold model of students' epistemologies (Hammer and Elby, 2002). From this perspective, each time a student or expert thinks about an infectious disease problem, they activate different cognitive resources to help them solve the problem.

My preliminary research of infectious disease experts revealed that their thinking about infectious disease problems was contextually driven. So, the second part of my study was designed to examine both novice and expert thinking about infectious disease from a manifold perspective.

Chapter 4: Study

Design

Rationale

The purpose of this study was to determine if I could develop a method to recognize comprehensive thinking about infectious disease in a particular context. The particular context I chose involved patient cases with a sexually transmitted infection. This type of infectious disease was purposefully chosen to maximize the chances that participants would think about both the biological and the sociocultural components of a comprehensive perspective on infectious disease. In addition, I purposefully chose to use three patient cases with distinctly unique manifestations of the same infectious disease. I was looking for how subtle differences in the context of a particular situation might alter the thinking of the participants.

Participants

In order to examine an undergraduate student's thinking about infectious disease, I designed a study to examine their thinking in response to different case study patient prompts. The study was conducted in the form of semi-scripted interviews of volunteer participants (See Appendix A). Each student participant must have completed at least one microbiology course at UMCP and have career goals in the healthcare industry.

Experts in infectious disease were interviewed using the same semi-scripted interviews with case study patient prompts (See Appendix B). Their responses will help

to validate the students' responses and will also strengthen the applicability and utility of the interview prompt tool under development and investigation. The experts in infectious disease are professionals whose work focuses on infectious disease.

Interviews

In the interview, each participant was presented with three different case study patients. Each of the patients is suffering from an infectious disease caused by the same bacterial agent, but each patient's disease manifestation is unique. One patient has a sexually transmitted disease, another has meningitis, and the third patient has an eye infection. I purposefully used a sexually transmitted infectious agent in the case studies because of the obvious social aspects of such a disease.

The study participants were presented with each case individually and were asked how they would go about treating each patient and what types of additional information they would like to know about the patient. The order in which these three cases are presented will vary. By mixing up the order in which the case study patients are presented, I hope to determine if the prior cases influence the students' answers to the other cases.

The object of the interviews is to explore the comprehensive thinking of students and experts as they solve an infectious disease problem. From this type of research, the types of situations and contexts that trigger comprehensive thinking about infectious disease can be examined and catalogued. This will help educators to create environments in the classroom which encourage students to practice thinking comprehensively about infectious disease.

Methods

Recruitment of Participants

The participants were undergraduate students at the University of Maryland, College Park (UMCP) who plan to pursue careers in healthcare. Participants must have taken at least one microbiology course at UMCP. I used three methods of volunteer participant recruitment for the study. Volunteer participants were recruited via advertisements (See Appendix C) in the Life Sciences email list serve and the Pre-Health email list serve at UMCP. Printed flyers of the same advertisement were also handed out to students in microbiology courses at UMCP (permission of each instructor was obtained). I also recruited participants by announcing the study to students in microbiology classes at UMCP. I read the study advertisement (See Appendix C) to each class.

The second set of participants was professionals whose work concentrates on infectious disease. Volunteer participants were recruited via in-person, email, or telephone communication. Initial contact information for infectious disease professionals was obtained through internet searches for infectious disease specialists in the state of Maryland.

Interview of Participants

At the beginning of the interview, the students were asked to read and sign the consent form (See Appendix D) for participation in the study as well as for audio recording of the interview. Then each participant filled out the student background information form (See Appendix E). Participants are only identified on this form by a code consisting of their initials and month and day of birth. Upon completion of this

form, I began audio recording the interview and asked the participant to state their initials and month and day of birth. I then followed the student interview prompt (Appendix A). I read the interview instructions and background information to each participant. Then I handed a case description to the participant on a small piece of paper. I asked the participant the interview questions and they responded verbally. I sought clarification of participants' answers as I felt necessary. This process was repeated for the other two cases. The order in which the case descriptions were presented to the participants varied. The purpose of varying the order of cases was to attempt to minimize the effect of case presentation order on participant's responses. I purposefully chose the order of the cases following the completion of the background information form. The reason for purposefully choosing the order of the patient cases during each interview was to generate a mixed variety of patient case orders. During the interviews with participants, I took notes on participants' responses and recorded the interview. Recordings of the interview were used during data analysis for clarification of notes and to obtain direct quotations.

At the beginning of the interview, the infectious disease professionals were asked to read and sign the consent form (See Appendix F) for participation in the study as well as for audio recording of the interview. Then each participant filled out the professional background information form (See Appendix G). Participants are only identified on this form by a code consisting of their initials and month and day of birth. Upon completion of this form, I began audio recording the interview and asked the participant to state their initials and month and day of birth. I then followed the attached interview prompt (See Appendix B). I read the interview instructions and background information to each

participant. Then I handed a case description to the participant on a small piece of paper. I asked the participant the interview questions and they responded verbally. I sought clarification of participants' answers as I felt necessary. This process was repeated for the other two cases. The order in which the case descriptions were presented to the participants varied. The purpose of varying the order of cases was to attempt to minimize the effect of case presentation order on participant's responses. I purposefully chose the order following the completion of the background information form. The reason for purposefully choosing the order of the patient cases during each interview was to generate a mixed variety of patient case orders. During the interviews with participants, I took notes on participants' responses and recorded the interview. Recordings of the interview were used during data analysis for clarification of notes and to obtain direct quotations.

Analysis of Data

Notes from the interviews were analyzed using an open coding strategy. Infectious disease concepts or factors were identified in interview notes and compiled into a large list. Similar concepts were grouped together into overarching categories and these categories were used to code the interview data. These categories were revised multiple times until coding the interview data revealed both similarities and differences between patient cases and interviewees. Operational definitions for each category were written. The interview data was then coded a final time using the operational definitions of each category. Once coded, the interview data was analyzed for patterns.

There are eight categories into which data were coded. The categories are: **1. biomedical technology (B)** – tests or procedures performed on a patient(s) or

pathogen(s) in a laboratory setting; **2. treatment (T)** – pertaining to the treatment of a patient’s disease state; **3. pathophysiology (P)** – factors contributing to and/or pertaining to a patient’s disease state; **4. patient history (H)** – background information about a patient(s) and their health and lifestyle; **5. prevention (V)** – efforts to improve a patient’s health behaviors and/or prevent future illness; **6. outside resources (R)** – consultation with other medical providers or referral services utilized by the medical provider or a patient; **7. education (E)** – information referenced by the medical provider or information given to the patient; and **8. mechanism (M)** – factors contributing to the transmission of the disease.

1. Biomedical Technology (B)

Data coded into the biomedical technology category refer to tests or procedures performed on a patient(s) or pathogen(s) in a laboratory setting. Examples of data coded into this category include: identification of the causative agent; testing for gonorrhea and other STDs; sampling, analyzing, and culturing of body fluids; blood work; antimicrobial susceptibility testing; screening for co-infection; and considering laboratory error.

2. Treatment (T)

Data coded into the treatment category pertain to the treatment of a patient’s disease state. Examples of data coded into this category include: unspecified treatment; timing of treatment; treatment with antibiotics or other medications; route of treatment; follow-up care; supportive care; efforts to avoid complications or worsening of the disease; and improper or inadequate treatment.

3. Pathophysiology (P)

Data coded into the pathophysiology category refer to factors pertaining to a patient’s disease state, excluding factors relating to transmission of the disease. Factors

relating to the transmission of the disease were very prevalent in the data and were coded into the mechanism category. Examples of data coded into this category include: co-infection with other infectious agents; signs and symptoms; innate host characteristics; diagnosis; progression of illness; pathogen characteristics; prevalence of disease; complications; physical examinations; and causative agent characteristics.

4. Patient History (H)

Data coded into the patient history category refer to background information about a patient(s) and their health and lifestyle. Examples of data coded into this category include: sexual and behavioral activity; gathering information from the patient, family, or previous medical providers; living situation; abuse; previous medical problems, procedures, and/or treatments; allergies to medications; current medications; and socioeconomic status.

5. Prevention (V)

Data coded into the prevention category refer to efforts to prevent future illness in a patient and/or the population. Examples of data coded into this category include: notification and testing of sexual contacts; avoid re-infection from source; prophylactic treatment; immunizations; and failed prevention.

6. Outside Resources (R)

Data coded into the outside resources category refer to consultation with other medical providers or referral services utilized by the medical provider or a patient. Examples of data coded into this category include: consultation with other medical providers; notifying the state health department of a reportable disease; notifying infection control; and referral to counseling or resources.

7. Education (E)

Data coded into the education category refer to information referenced by the medical provider or information given to the patient. Examples of data coded into this category include: safe sex education; encourage healthy behaviors; information about gonorrhea; information about meningitis caused by *Neisseria gonorrhoeae*; and distribution of media.

8. Mechanism (M)

Data coded into the mechanism category refer to factors contributing to the transmission of the disease. Examples for data coded into this category include: source of infection and mode of transmission.

Clarifications of Coding

There were many participant responses to the interview prompts that could be coded into multiple categories. When details about a mother's health or lifestyle were mentioned in reference to the infant case study, a mechanism of transmission was implied. In addition, a mother's health in the context of the infant case study was considered to be gathering information about the patient history of the infant. For any of the three cases, when sexual activity was mentioned, a mechanism of transmission was implied. Most of the responses that were coded as education were also coded into another category because the education concerned components of another category.

Participants

A total of ten people participated in my study. Five of them were professionals in the field of infectious disease and were considered experts. Five of them were current or

former microbiology students at the University of Maryland, College Park. All of the participants have been assigned pseudonyms to protect their identity.

Experts

Infectious disease specialists serve as consultants to other physicians and as primary care providers of patients with chronic infectious diseases. Infectious disease specialists are initially trained in internal medicine and then receive specialized training in infectious diseases and clinical microbiology (Norrby, 2005).

Matthew Dunn (MD) is an infectious disease specialist (a physician specializing in infectious disease). His research focuses on the molecular pathogenesis of *Escherichia coli* infections. He earned a bachelor of science in biology in 1979 and a doctor of medicine in 1983. Interview notes were transcribed (See Appendix J).

Michael Kim (MK) is a clinical microbiologist. His research focuses on improving diagnostic testing of infectious organisms, basic virulence/mechanism research on infectious organisms, and epidemiology. He earned a bachelor of science in microbiology in 1999 and a doctor of philosophy in microbiology and immunology in 2005. Interview notes were transcribed (See Appendix J).

Jill Krump (JK) is an infectious disease specialist (a physician specializing in infectious disease). Within the field of infectious disease she specializes in human immunodeficiency virus (HIV) patient care and serves as a general infectious disease consultant. Her research focuses on the interaction between the HIV virus and host cells. She earned a bachelor of science in biology in 1987 and a doctor of medicine in 1996. Jill's interview tape was transcribed (See Appendix H) and notes from the interview were transcribed (See Appendix J).

Tom Miller (TM) is a clinical microbiologist. His research focuses on biological defense. He earned a bachelor of science in biology in 2000 and a doctor of philosophy in molecular and cellular biology in 2006. Interview notes were transcribed (See Appendix J).

Betty Smith (BS) is a clinical microbiologist. Her research focuses on resistant strains of *Acinetobacter* and methicillin resistant *Staphylococcus aureus*. She has earned a bachelor of science in microbiology, a bachelor of science in medical technology, and a master of science in microbiology. Interview notes were transcribed (See Appendix J).

Students

Katie Art (KA) is a pre-nursing sophomore. She plans to become a registered nurse. Katie feels that her courses in nutrition, human development, general microbiology, anatomy and physiology, and introductory chemistry have helped to prepare her for a career in healthcare. Interview notes were transcribed (See Appendix K).

Robin Carter (RC) is a senior majoring in biochemistry. She plans to go to pharmacy school. Robin feels that her courses in microbiology, chemistry, math, philosophy, economics, and psychology have helped to prepare her for a career in healthcare. Interview notes were transcribed (See Appendix K).

Georgia Grant (GG) is a post-baccalaureate student in biosciences planning to go to medical school. She has earned a bachelor of science in public and community health. Georgia feels that her courses in introductory biology, introductory chemistry, introductory english, general microbiology, genetics, anatomy and physiology, organic chemistry, biochemistry, cell biology, human sexuality, social psychology, and

immunology have helped to prepare her for a career in healthcare. Georgia's interview tape was transcribed (See Appendix H) and notes from the interview were transcribed (See Appendix K).

Robert Kimble (RK) is a senior majoring in biochemistry. He plans to go to medical school. Robert feels that his courses in mammalian physiology, cell biology, genetics, general microbiology, biochemistry, and physical chemistry have helped to prepare him for a career in healthcare. Interview notes were transcribed (See Appendix K).

Nick Stout (NS) is a junior majoring in biochemistry. He plans to pursue a doctor of philosophy and research and teach the biomedical sciences. Nick feels that his courses in biochemistry, general microbiology, pathogenic microbiology, medical ethics, and cutting-edge science have helped to prepare his for a career in healthcare. Interview notes were transcribed (See Appendix K).

Results

During the study, five student and five expert interviews were conducted (See Appendices J & K). Analysis of the interview data revealed that participants discussed eight different components of infectious disease². These components are: **1. biomedical technology (B)** – tests or procedures performed on a patient(s) or pathogen(s) in a laboratory setting; **2. treatment (T)** – pertaining to the treatment of a patient's disease state; **3. pathophysiology (P)** – factors contributing to and/or pertaining to a patient's disease state; **4. patient history (H)** – background information about a patient(s) and their health and lifestyle; **5. prevention (V)** – efforts to improve a patient's health

² For the remainder of this chapter when I refer to "the components of infectious disease", I am referring to those components that were identified and defined from participant interviews in this study.

behaviors and/or prevent future illness; **6. outside resources (R)** – consultation with other medical providers or referral services utilized by the medical provider or a patient; **7. education (E)** – information referenced by the medical provider or information given to the patient; and **8. mechanism (M)** – factors contributing to the transmission of the disease. For this study, I am setting the criteria for a comprehensive response to a patient case at discussing at least four of the components of infectious disease.

Description of an Expert Interview

Jill Krump is an infectious disease specialist. Her interview was fully transcribed and is included in Appendix H as an example of an expert interview. I will discuss the particular findings from her interview by referring to examples from the interview transcript.

At the beginning of each interview I read the following description to participants: “You will be given a case description of a patient with an infectious disease. I will ask you a series of questions about your thoughts on how to solve the infectious disease problem. This process will be repeated for a total of three different cases. There are no correct answers to my questions. I am more interested in how each case description influences your thoughts and problem solving processes. All of the cases of infectious disease that will be discussed today result from infections caused by *Neisseria gonorrhoeae*.”

Case 1: Infant with an Eye Infection

I handed Jill a small piece of paper with the following case description: “A newborn infant has an eye infection caused by *N. gonorrhoeae*.” The first question I asked Jill was “in an ideal world if you were the patient’s doctor what would you do?”

Her immediate response focused on how this illness is completely preventable and how one of the normal preventative measures must not have been followed since the infant is ill. Her response was “Uh in an ideal world, this wouldn’t happen. Umm, so my first thought about this is a newborn infant umm with presumably I mean this sentence is saying has an eye infection so we’ve already missed the boat. Umm, this newborn’s mother should have been screened and treated for *Neisseria gonorrhoeae*. And the newborn should have had drops placed in their eyes even after the mom was treated to prevent any infection with gonorrhea or chlamydia.” I coded Jill’s discussion of how the normal prevention methods failed as prevention because she was acknowledging that the disease is preventable. Jill implied a mechanism of transmission from the mom to the infant during childbirth, I coded this as mechanism.

Then Jill acknowledged that she needs advice from an ophthalmologist to treat an eye infection. I coded consulting with an ophthalmologist as utilizing outside resources. Jill stated “Since I’m not a pediatrician, I don’t actually know what the next step should be. I think I would consult an ophthalmologist.” But in the meantime, she would begin treating the infant with a topical medication. Jill advised “And I would probably think about using some kind of topical thing right away.” I coded treating the infant with a topical medication as treatment.

The next question I asked Jill was “what questions would you ask the patient’s family?” Jill’s immediate response was to gather more information about the mom’s medical history, specifically as it relates to her possibly transmitting gonorrhea to the infant. She asked “Did the mom get any prenatal care? Umm, does the mom have an active infection? Has the mom been treated for that active infection? How long has the

mom had that active infection? That active infection being presumably umm vaginitis with a vaginal discharge or pain... Umm, has the mom received any antibiotic treatment in the last month? I guess. Uh, how many sexual partners does the mom have? Has the mom been tested for HIV? Umm, has the mom been screened and tested for other sexually transmitted diseases?" I coded Jill's questions about the mom's medical history as gathering patient history for the infant because information about the mother's disease is an important part of the infant's medical history. Again, I coded Jill's implication of the mechanism of transmission from mom to infant as mechanism. I coded Jill's asking about the mom's recent history of antibiotic treatment as pathophysiology because she considered the possibility that the causative agent may be antibiotic resistant. I coded Jill's inquiring about whether the mom had been screened and tested for other STDs as biomedical technology. In the middle of her concern with the mom's health status and its impact upon the infant, she wanted to know the age of the infant. Jill said "Umm it's says newborn, I'd certainly want to know how old the kid is." This is interesting because it appears that Jill is double checking her assumption that the infant acquired the infection from the mom during childbirth.

The third question I asked Jill was "what additional information would you seek?" At this point, she focused in on the infant's health. She asked "Umm, has the child received any treatment prior to my seeing this child?" I coded this question as patient history because any previous treatments are part of the patient's medical history. Jill continued "Umm, I guess I would probably then being pushed imagining that I am in the Appalachians and I am the only physician there and I don't have a pediatrician to go to. I would ask umm, is the baby eating normally, behaving normally, exhibiting any unusual

umm behaviors, sleeping well, umm, again don't know how many days post birth this newborn is, but umm, is the child losing weight, gaining weight? Umm, does the child have any rashes? Umm, is the child extremely irritable, thinking about whether this is a disseminated gonorrheal infection versus simply a localized infection to the eye. So thinking about meningitis, thinking about septicemia." I coded all of Jill's questions about the patient's current illness as pathophysiology because they all relate to the current disease state.

Overall, during the discussion of this case, Jill mentioned seven out of the eight possible components of infectious disease. She discussed biomedical technology, treatment, pathophysiology, patient history, prevention, outside resources, and mechanism. Jill's responses to this case were comprehensive in nature because she mentioned more than 50% of the components of infectious disease.

Case 2: 25 year old Male with a Urethral Infection

I handed Jill a small piece of paper with the following case description: "A 25 year old male has a urethral infection caused by *N. gonorrhoeae*." The first question I asked Jill was "in an ideal world if you were the patient's doctor what would you do?" Jill responded by briefly discussing how she normally sees a patient with a urethral discharge and then diagnoses the problem. Jill said "Well, umm, well this is not quite the normal state of affairs. Or maybe it is actually for me. Cause I would usually be thinking about seeing someone with a urethral discharge and then diagnosing them." I coded Jill's mentioning of the diagnosis as pathophysiology because it refers directly to the patient's disease state.

Despite mentioning that this case strays a bit from what she normally handles, Jill quickly adapted into skipping this step and discussed how she would proceed in treating a

patient who has already been diagnosed with gonorrhea. Jill discussed laboratory tests for identifying other common STDs and treatment options for this patient. Her response was: “So this is presumably saying okay and now a patient who I guess I can imagine was diagnosed by their primary doctor. Umm so they have gonorrhea, so umm. In an ideal world I would already have from the primary physician an HIV test and an RPR for syphilis.” I coded Jill’s discussion of information that she would receive from the primary doctor as utilizing outside resources because she was consulting with another physician. I coded Jill’s mentioning of laboratory tests for other STDs as biomedical technology. Because Jill implied a sexual mechanism for how this patient acquired their disease I also coded this response as mechanism.

Jill then inquired about the antibiotic sensitivities of the causative agent. She said “Umm, I would umm, well I don’t know what the sensitivities of this gonorrhea is, I guess I would want to know that in the newborn case too.” When Jill inquired about the antibiotic sensitivities of the causative agent, I coded this as biomedical technology because of the tests necessary to determine this information. I also coded this as pathophysiology because Jill was seeking more information about the characteristics of the causative agent. It is interesting to note that Jill’s responses to this particular case triggered her to remember to add more information to her previous case response.

Then Jill discussed how the patient may be allergic to a medicine she would prescribe. She said “Umm, does the guy have any allergies to any medications that preclude use of any antibiotics that I might want to choose. I coded this as patient history because she was inquiring about the patient’s medical history.

The second question I asked Jill was “What questions would you ask the patient?” Jill responded by asking the patient questions about their symptoms. She said “So I would ask the patient, how long have you had symptoms? ...Umm, are you having any pain with ejaculation or with urination?” I coded this response as pathophysiology because she was gathering information about the patient’s disease state.

Next Jill asked the patient questions about their sexual history. She asked “Umm, how many sexual partners have you had in the last year? Or six months depending on what the answers are to those depends on how far back I will go. Have you told your partners? Have you been tested for HIV? Are your partners male, female, or both?” I coded all of these questions as mechanism because of the implied sexual mechanism of transmission. I coded questions about sexual partners as patient history. Jill inquired if the patient’s partners had been notified of their exposure to the disease, so I coded this as prevention because it was an effort to prevent future disease in other people. I coded Jill’s asking about the status of HIV testing as biomedical technology in addition to patient history and mechanism.

Jill asked some additional questions about the patient’s medical history. She asked “Umm, again are you allergic to any antibiotics? Umm, have you had this kind of infection before?” I coded these questions as gathering patient history and the second question I also coded as mechanism because it implies a pattern of behavior leading to repeated episodes of disease.

The third question I asked Jill was “what additional information would you seek or what else would you do?” Jill’s first response was to order appropriate tests for STDs. She stated “I would get all those tests. I would get an RPR and HIV test.” I coded this

response as biomedical technology and mechanism because of the implied sexual mode of transmission. Jill wanted to ensure that this case of gonorrhea was properly reported to the state. She said “Make sure that uh that this has to be reported to the state lab, it probably has been already by the lab.” I coded this as utilizing outside resources. Jill also wanted to treat the patient as appropriate and follow-up to ensure the infection is gone. Jill stated “Umm, treat him obviously and have him follow-up to make sure that he’s cleared this infection.” I coded treating and follow-up with the patient as treatment.

Next Jill focused on helping the patient with other contributing factors to catching an STD. She would counsel the patient on safe sex. Jill said “Umm, counsel him on safe sex practices. Umm, by definition if he’s gotten *Neisseria gonorrhoeae* he’s having unsafe sex with somebody.” I coded her focus on safe sex education as prevention, education, and mechanism.

Jill also would inquire about substance abuse. She said “Umm, I would probably in a 25 year old male, I would also ask him about substance use, whether he is using umm, IV drugs, whether he is using umm, cocaine, heroine, ecstasy, any of those types of things and investigate whether he needs referral for counseling in terms of stopping those things. Alcohol included actually.” I coded Jill’s line of thinking about substance abuse as gathering patient history and any referral to counseling is coded as utilizing outside resources.

Jill would also ask the patient about his lifestyle and social history. She also mentions identifying any mental health problems. She stated “Umm, I mean I want to inquire into his social patterns and lifestyle, what he does for a living, I mean you know... I mean this also could have repercussions in terms of does he have umm a

mental health situation that umm disinhibits him. Does he have bipolar disorder and he umm engages in risky behavior because of that? So, just as an example.” I coded inquiring about his social history, lifestyle, and history of mental illness as gathering patient history. I also coded these items as mechanism because Jill was exploring these factors as contributing to how the patient acquired the disease.

Jill also discusses the role of a primary case physician in treating the whole patient. Jill’s response was “This kind of depends, the context of this kind of depends on am I seeing this guy in say an urgent care clinic setting where I have a one time thing and I am just dealing with gonorrhea or am I gonna have a long term relationship with him where I am gonna be his primary doctor and I am gonna start needing to take care of these things. So this particular situation has a lot of ramifications if I am going to be his primary care provider.” I coded this line of thinking as treatment because answers to these questions impact what type of treatment Jill will be able to provide for the patient.

Overall, during the discussion of this case, Jill mentioned eight out of the eight possible components of infectious disease. She discussed biomedical technology, treatment, pathophysiology, patient history, prevention, outside resources, education, and mechanism. Jill’s responses to this case were comprehensive in nature because she mentioned more than 50% of the components of infectious disease.

Case 3: 70 year old Female with Meningitis

I handed Jill a small piece of paper with the following case description: “A 70 year old female has meningitis caused by *N. gonorrhoeae*.” The first question I asked Jill was “in an ideal world if you were the patient’s doctor what would you do?” Jill’s first thoughts centered on treating the patient. She stated “Umm, well obviously she needs to be treated. Umm, so I would treat her in the hospital, most likely. Umm, and that depends

on her situation, but she needs to receive IV antibiotics as opposed to the young man who would receive probably oral antibiotics.” I coded Jill’s thoughts on treating the patient as treatment.

Then Jill focused on determining how the patient acquired the infection. Jill said “Umm, I would need to figure out what her risk factors are for acquiring this infection. Umm, so presumably she had a septicemia, a meningitis seeded by a septicemia process and then she acquired this organism. The question then becomes how did she acquire this organism? So, one needs to know what her living situation is. Is she being abused by say a caregiver? Umm that would cause her to have umm acquired this infection.” I coded all of these items as mechanism because each is aimed at helping to identify how the patient acquired this infection. I coded inquiring about a patient’s risk factors as pathophysiology and patient history because risk factors are host characteristics that contribute to a disease process. I coded thinking about the infection as a septicemia process as pathophysiology. I coded inquiring about the patient’s living situation and possible caregiver abuse as gathering patient history.

The second question I asked Jill was “what questions would you ask the patient?” Again she inquired about the patient’s living situation and caregiver. Jill asked “Umm, where do you live? Who takes care of you? ...Umm, does, I mean all of these things would or many of these things would move towards umm contacting adult protective services if it seems like that’s an issue.” Again, I coded inquiring about the patient’s living situation as gathering patient history and mechanism. But in addition, I coded contacting adult protective services as utilizing outside resources.

Next Jill inquired about the patient's medical history. She asked "What is your umm what is her past medical history? Umm, what kinds of umm compromises to her immune system might she have? Is she diabetic? Is she umm got heart disease? Does she have pulmonary diseases? Any number of kidney disease? Any number of things that can affect her resistance to umm getting an infection. Umm, so you need to know all of her comorbidities basically. Umm, is she allergic to any medications that would preclude antibiotic therapy?" I coded gathering up all of the patient's medical history as patient history. In addition, I coded asking about any possible compromises to her immune system as pathophysiology because they would directly contribute to the patient's disease state.

The third question I asked Jill was "what additional information would you seek?" She discussed obtaining information that is standard and useful for hospitalized patients. She also discussed determining the status of the infection. Jill stated "Umm, well, I need to know, I mean in this case you need to know all of the usual things that you would need to do when you hospitalize a patient. You need to know vital signs, umm, whether she has disseminated umm *Neisseria* infection that may compromise other organs besides her CNS right now." I coded all of these items as pathophysiology because they directly relate to the patient's disease state.

Jill would also like to find out the baseline mental status for the patient. She said "Umm, the other thing that would be in this setting probably complicating is that she may have mental status changes and you don't always know in a 70 year old what the baseline mental status is unless you have a prior relationship with them, so you would probably, if you didn't know the patient already, you would need to find a family member or a friend

or someone who has some understanding of them so that you can figure out what the baseline is. Umm, so that you know when you've reached your endpoint is first cure." I coded determining the patient's current mental status as pathophysiology because it relates to her disease state. In contrast, I coded determining the patient's baseline mental status as gathering patient history and also as mechanism because of the possible abuse situation.

Then Jill listed exams and tests that she would perform on the patient to help gather more information about the patient's disease and how she acquired the infection. Jill said "Umm, I would collect blood cultures umm obviously I should examine her completely again looking for a rash. Umm, I suppose this does also probably it depending on the answers to all of the rest of this. You would probably also umm, mandate looking for again those other sexually transmitted diseases, getting an RPR, getting tested, looking into getting an HIV test. Umm, again depending on her mental status because she has to consent." I coded collecting blood cultures as biomedical technology. I coded a physical exam looking for a rash as pathophysiology, because Jill was looking for more specific information about the patient's disease state. I coded testing for other STDs as biomedical technology and mechanism because of the implied sexual mode of transmission. I also coded inquiring if the patient has any other STDs as pathophysiology because there may be multiple current infections causing the patient's current disease state.

Then Jill asked questions about the patient's past history of infections. She said "Umm, has she had meningitis before? Has ever had other infectious processes before? Umm, that again might argue in terms of looking at some kind of barrier breakdown or

some other immunocompromised state.” I coded these questions as gathering patient history and mechanism because Jill was looking for possible host factors that predispose the patient to acquiring infectious diseases.

Overall, during the discussion of this case, Jill mentioned six out of the eight possible components of infectious disease. She discussed biomedical technology, treatment, pathophysiology, patient history, outside resources, and mechanism. Jill’s responses to this case were comprehensive in nature because she mentioned more than 50% of the components of infectious disease.

Looking at all three patient cases combined. Jill’s overall response to the cases was also comprehensive in nature. In each case, she mentioned more than 50% of the components of infectious disease and met the criteria for a comprehensive response. Jill also exceeded the requirement because she mentioned more than 75% of the components of infectious disease for each case.

Description of a Student Interview

Georgia Grant is a post-baccalaureate student in biosciences planning to go to medical school. She has earned a bachelor of science in public and community health. Her interview was fully transcribed and is included in Appendix H as an example of a student interview. I will discuss the particular findings from her interview by referring to examples from the interview transcript.

At the beginning of each interview I read the following description to participants: “You will be given a case description of a patient with an infectious disease. I will ask you a series of questions about your thoughts on how to solve the infectious disease problem. This process will be repeated for a total of three different cases. There are no

correct answers to my questions. I am more interested in how each case description influences your thoughts and problem solving processes. All of the cases of infectious disease that will be discussed today result from infections caused by *Neisseria gonorrhoeae*.”

Case 1: 25 year old Male with a Urethral Infection

I handed Georgia a small piece of paper with the following case description: “A 25 year old male has a urethral infection caused by *N. gonorrhoeae*.” The first question I asked Georgia was “let’s say we are in an ideal world, if you were this patient’s doctor what would you want to do for this patient?” Georgia’s first response was to treat the patient with antibiotics. She said “Umm... give them antibiotics.” I coded this response as treatment.

Then Georgia focused on the risky behaviors that usually precede acquiring an STD. She wants to talk with the patient about his lifestyle and educate him about the risks associated with his behavior. Georgia said “usually you know getting an STD is umm caused by doing risky behaviors so you umm may want to have a conversation with him about what kind of lifestyle he is leading...it’s likely that it that if you are engaged in risky behaviors that you might catch something maybe worse than gonorrhea and umm this is one of those things that you can treat but umm you might catch something that umm you can’t treat...” I coded Georgia’s discussion of the link between risky behaviors and STDs as mechanism. Because Georgia also wanted to educate the patient about the risks of catching STDs from risky behavior, I coded her response as education and prevention. I also coded Georgia’s mentioning of how gonorrhea is treatable as opposed to other STDs as treatment.

The second question I asked Georgia was “what questions would you ask the patient?” Georgia wants to ensure that the patient understands the disease he has been diagnosed with. She said “Umm well I would say do you know what you have?” I coded this response as pathophysiology because she is ensuring that the patient understands the diagnosis. I also coded this response as education. Georgia also wants to know the patient’s socioeconomic status. Georgia said “it doesn’t say anything about you know his socioeconomic status” I coded determining the patient’s socioeconomic status as gathering patient history.

Georgia feels that the setting in which she sees her patient determines her treatment and educational options. She said “What kind of setting you are seeing him in I mean am I seeing him in an STD clinic or am I seeing him in my private practice? It’s really gonna you know depend on what kind of setting am I seeing this person in because if you are at an STD clinic you might not have a lot of time to talk to this person and you might have ummm you might just want to give him pamphlets or something but if you have a little more time then you can you know ask the person if you know how you got this? Do you know what kind of behaviors lead to this? Do you know how to use a condom? Umm a lot of people a lot of 25 year old males do not know how to properly use a condom. Umm, do you know about umm the risks associated with umm unprotected sex, which is how you get gonorrhea? Questions like that.” I coded Georgia’s opinion that the setting determines the treatment options as treatment. I also coded her opinion that the setting determines the education options as education. More specifically I coded educating the patient about safe sex and condom use as prevention and mechanism.

The third question I asked Georgia was “what additional information would you seek out from anywhere?” Georgia acknowledged that gonorrhea is a common illness and that antibiotics should cure the infection. She said “I mean gonorrhea is pretty common it’s very common umm if you have a urethral infection caused by gonorrhea the antibiotics should take care of it.” I coded Georgia’s reference to the prevalence of gonorrhea as pathophysiology. I coded her reference to antibiotics curing the infection as treatment.

Then Georgia discussed how she would speak with the patient about gonorrhea being common and not a big deal. She said “What additional information would I seek out? I would just try to talk to the patient, I mean it’s not really the biggest deal in the world, it’s not comparably speaking, it happens.” I coded this response as pathophysiology again for the reference to prevalence of the disease and also as education and mechanism.

The fourth question I asked Georgia was “how would all of this information that we have talked about...how would you use that to help treat the patient?” Georgia thinks that a doctor should not just treat the patient with antibiotics and send them home. But instead, should help the patient understand their disease, and discuss the risky behaviors that led to acquiring the infection. She said “Well I think that treating the patient is more than just giving him antibiotics and telling him to go home... by asking the patient questions and causing the patient to think about how his behaviors lead to his pathology hopefully you know we’ll get some thinking started and make them actually realize why they are there and umm you know also make them see that their doctor cares about them and that they umm are not just there to get a pill they are there to get treatment as a

person not as an animal and umm I mean 25 year old male that's a time when males engage in risky behaviors and umm and if uh if their doctor is willing to have a conversation with him about it instead of just you know saying you have gonorrhea it's not a big deal here's antibiotics for it here is a prescription go home maybe if you talk to him about it and give him some skills about umm you know condom usage maybe how to negotiate safe sex something like that you might prevent them from getting in the future something worse." I coded Georgia's idea that properly treating this patient involves more than just prescribing antibiotics and sending them home as treatment. I coded her efforts to help the patient understand their disease and how risky behaviors lead to acquiring the infection as education. Because Georgia also implied a sexual mechanism of transmission I coded her response as mechanism. I also coded Georgia's response about educating the patient to prevent future infections as prevention.

Overall, during the discussion of this case, Georgia mentioned six out of the eight possible components of infectious disease. She discussed treatment, pathophysiology, patient history, prevention, education, and mechanism. Georgia's responses to this case were comprehensive in nature because she mentioned more than 50% of the components of infectious disease.

Case 2: 70 year old Female with Meningitis

Georgia was handed a small piece of paper with the following case description: "A 70 year old female has meningitis caused by *N. gonorrhoeae*." Before I asked Georgia the first question she noted how she didn't know that gonorrhea could cause meningitis. She said "A 70 year old female has meningitis caused by gonorrhea. I didn't know gonorrhea caused meningitis." I coded this response as pathophysiology because she was referring to how the disease had progressed.

The first question I asked Georgia was “in an ideal world if you were the patient’s doctor what would you do?” Georgia focused on how the socioeconomic status of the patient is important in deciding how to approach the case. She said “there is so little information and so you don’t know anything you don’t know if you’re in Africa or if you’re in America or if you’re in a what kind of setting you’re in again socioeconomic status.” I coded this idea as gathering patient history.

Georgia states that different conversations will occur between the doctor and patient depending on the socioeconomic status of the patient but she doesn’t really elaborate on the differences. She said “again socioeconomic status is really going to come into play here because a 70 year old female who is very well educated and umm you know comes from you know a high socioeconomic status they are going to have it’s going to be someone who has had access to healthcare you’d have a very different conversation with somebody who has been you know living in poverty you know and lives in you know a slum somewhere umm it’s going to be very different.” I coded Georgia’s ideas about socioeconomic status and setting influencing type of care as treatment.

In both cases she wants to ensure that the patient understands their disease, how they acquired it, and how to prevent it. She said “because if it’s somebody who is more affluent you could you would talk to them about you know Do you know what you have? Do you understand how you got it? Do you understand how this treatment is going to help you? Umm do you know how to prevent this kind of thing in the future? Please come back for a follow-up visit. Umm, somebody who is in a low socioeconomic status, you really have to stress to them first of all you really have to make them understand

what they have, how it's caused and a very different ummm very different language and it's gonna be really important to get this person back because a lot of times they won't come back for a follow-up visit and something like meningitis could kill them so umm it would be a very different conversation. It's hard to say." I coded Georgia's efforts to help the patient understand their disease as pathophysiology and education. I also coded helping the patient's understand how they acquired the disease and how to avoid it as mechanism and prevention.

In an effort to steer Georgia back on track, I reminded her that a patient with meningitis is in critical condition. Georgia then focused on getting the patient treated in a hospital and ensuring that the other doctors providing care for the patient are fully aware of the situation. She said "you want to get them to the hospital, you want to get them treatment as soon as possible and you want to make sure to follow-up with the patient as much as possible and umm make sure that they are not, make sure that wherever they go to the hospital that the... whoever is treating... whoever else is treating them besides me, because it's not just going to be me, knows exactly what they have and they are giving them the right treatment so that it doesn't kill them." I coded Georgia's ideas about how to treat the patient as treatment. I coded her ideas about collaborating with other physicians as utilizing outside resources.

The second question I asked Georgia was "what questions would you ask this patient?" Again Georgia reiterates that she had no idea that gonorrhea could cause meningitis. Then she discussed how she assumes that the patient had gonorrhea and ignored the symptoms for so long that it developed into meningitis. She said "so if it's in critical condition that means they haven't been to see a doctor and that they've ignored

other symptoms so I would ask them how long their symptoms have been going on.” I coded Georgia’s ideas about gonorrhea symptoms being ignored until they developed into meningitis as pathophysiology because they speak to the progression of her disease.

Georgia then wanted to know what symptoms the patient may have been experiencing and why they hadn’t sought care from a doctor. She said “Why they haven’t been in to see a doctor umm and stress them the you know the urgency of this situation umm ask them what is going on in their life that they have been ignoring their symptoms and that they you know have not been in to see a doctor I mean umm really try to find out what is going on with them in their life because they are in bad shape unless you see I don’t know what the symptoms are, I mean I just have no idea.” I coded inquiring about the patient’s symptoms as pathophysiology because it specifically relates to the patient’s disease. I coded asking questions about what has been going on in the patient’s life that she has ignored her symptoms as gathering patient history.

Georgia also discusses how a 70 year old patient has a compromised immune system. She said “but you’re 70 years old you’re immune system is really compromised so I would discuss with them the fact that they are 70 years old and that their immune system is compromised and make sure that they are taking care of themselves umm but they are in critical condition so that would be a conversation that we had hopefully after they survive.” I coded Georgia’s consideration of the immune status of the patient as pathophysiology and patient history. I also coded discussing with the patient how to take care of themselves as prevention and education.

The third question I asked Georgia was “what additional information would you seek out about this case?” Georgia’s first thought was to research meningitis caused by

gonorrhoea. She said “I would find out about meningitis caused by gonorrhoea. And umm find out you know what, is there any sort of different treatment then umm a earlier case of gonorrhoea would be and find out if there is anything that you have to I mean this is a 70 year old patient so they are going to have other issues I mean there is no perfectly healthy 70 year old.” I coded Georgia’s seeking out more information about meningitis caused by gonorrhoea as education and pathophysiology.

Georgia inquired about the patient’s medical history. She said “Yeah I mean what else is you know what else is their history I mean I feel like that is a pretty standard thing.” I coded Georgia’s inquiring about the patient’s medical history as gathering patient history.

Georgia next wanted to know about the implications of this disease in an elderly patient. She said “Umm, but I mean 70 year olds with an STD depends again very much depends on where, what part of society they are coming from, what their lifestyle is like but umm you know you really want to find out about the umm the implications of an older person with this infection... Like well your body acts differently to things when you are 25 than when you are 70. You are as you get older, your immune system is very very different so it’s not going to be able to fight as well as a 25 year old would and especially if you haven’t been taking care of yourself. I mean I don’t know if this person has or not, hopefully I will find out.” I coded Georgia’s questions about the patient’s living situation and lifestyle as mechanism because they imply a sexual or environmental mode of transmission. I coded Georgia’s concerns that the disease would progress differently in a 70 year old as pathophysiology.

The fourth question I asked Georgia was “how would you use this information to treat the patient?” Georgia’s first thoughts were concerned with the type of doctor that she is acting as in this case. She said “Umm, what kind of doctor am I? Primary care? If I am this person’s primary care physician once their, if they are in critical care, I am going to be you know I’m not going to be the person that is in charge of their treatment at that point. I’m going to be you know definitely advising on it but I’m not going to be the person that’s making the decisions because when someone is in critical care like that and I am a primary care physician, I don’t specialize in that,” I coded Georgia’s consideration of the role of different doctors in treating the patient as treatment.

Georgia also felt that her role as the primary care doctor of a patient in critical care was to provide the treating physicians with important information about her patient. She said “so uh, I am going to make sure that the doctor that is doing the, that is treating my patient really knows I mean I am their primary care doctor I am going to be I am going to know more about them than they would know. Yeah make sure I communicate.” I coded Georgia’s emphasis on doctors working together as a team to treat a patient as utilizing outside resources.

Georgia wanted to make sure that her patient receives follow-up treatment. She said “And make sure I follow up, I mean I think that is a big problem, follow-up. And again it’s really really different depending on where you are, what kind of medical setting you’re in. I’ve been in such extreme cases of medical setting and I am so hyperaware of how different treatment is unfortunately.” I coded her discussion of follow-up treatment as treatment.

Overall, during the discussion of this case, Georgia mentioned seven out of the eight possible components of infectious disease. She discussed treatment, pathophysiology, patient history, prevention, outside resources, education, and mechanism. Georgia's responses to this case were comprehensive in nature because she mentioned more than 50% of the components of infectious disease.

Case 3: Infant with an Eye Infection

Georgia was handed a small piece of paper with the following case description: "A newborn infant has an eye infection caused by *N. gonorrhoeae*." The first question I asked Georgia was "in an ideal world if you were the patient's doctor what would you do?"

The first thing Georgia did was to clarify that she was the infant's doctor, not the mothers. I advised Georgia that she was the patient's doctor, so she was the infant's doctor.

Georgia suspected that the infant may have contracted the illness from the mother, so she wanted to speak with the mother and get the mother tested for STDs. She said "I need to talk to this infant's mother because if it's a newborn infant and they are a newborn like newborn I would really want to talk to you really want to get the mother tested for the STD and get the mother tested for gonorrhea." I coded speaking with the mother as gathering patient history and as mechanism because of the implied mode of transmission from mother to child. I coded getting the mother tested for STDs as biomedical technology and mechanism, again for implied mode of transmission.

Georgia also had a very interesting idea that the mode of transmission to the infant did not necessarily have to come from the mother but could have occurred as a result of sexual abuse. She said "hopefully it came from the mother because sometimes it

doesn't come from the mother it comes from the very sick father or uncle." I coded this possibility of sexual abuse as patient history and mechanism because of the implied mode of transmission via sexual abuse.

Next, Georgia wanted to make sure that the infant received the proper treatment for the infection. She said "umm so that's the first thing I would do is well you would treat the eye infection of the infant but I mean I can't talk to the infant I can't ask the infant any questions so I'm going to be treating the infant with antibacterial." I coded this as treatment.

Georgia also wanted to make sure that the infant did not have any complications such as meningitis. She said "umm making sure that the infant doesn't have any other complications besides the eye infection for example meningitis which apparently might cause that." I coded Georgia's consideration of complication as pathophysiology. In this instance, it appears that the previous discussion of the patient with gonococcal meningitis triggered Georgia to consider possible complications of the infant's infection.

Georgia reiterated her earlier point that she needs to talk with the mother by saying "and then once you treat the infant you really want to talk to their parents to see what's going on." I asked Georgia to elaborate on her idea that the father or uncle could be abusing the child. She said "I mean if it didn't come I mean if the mother is not positive for gonorrhea then you really gotta wonder where it came from and unfortunately sometimes it comes from the very sick father or uncle or grandfather or whoever I mean it happens a lot where it shouldn't be and umm so you want to investigate and it's not an easy thing to do but you definitely want to talk with the mother or if she comes up negative for gonorrhea you definitely want to make her consider those

things.” I coded Georgia’s talking with the parents and consideration of sexual abuse as gathering patient history and mechanism because of the consideration of mode of transmission.

The second question I asked Georgia was “what questions would you ask the patient’s parents in this case?” Georgia’s first thoughts focused on determining if the mom transmitted the infection to the infant. She said “Umm the first thing I would do is test the mother for gonorrhea.” I coded testing the mom for gonorrhea as biomedical testing and mechanism for the implied mode of transmission.

Then Georgia wants to make sure that the mother understands her child’s illness. She said “umm and inform the mother of what the issue is.” I coded Georgia’s informing the mom of the problem as education about the pathophysiology of the disease.

Georgia also discusses how the mother should have been tested for gonorrhea during her pregnancy. She said “whether the mother is positive for gonorrhea or not then she really should have been or would have been tested before maybe she got it sometime during the pregnancy.” I coded Georgia’s mentioning of how the mother should have been tested for gonorrhea during her pregnancy as biomedical technology, gathering patient history, prevention of transmission to her child, and as mechanism.

Georgia then focuses in again on the possibility of transmission via sexual abuse. She said “if the mother is negative for gonorrhea then I would pull the mother in alone and and tell her her results and tell her that she is negative and that her child is positive and that it’s a you know sexually transmitted disease and umm you know make her think about where this may have come from and discuss what is going on in her life and it’s not an easy conversation to have but it’s definitely necessary.” I coded Georgia’s discussion

of the implications of the mother testing negative for gonorrhea as biomedical technology, gathering patient history about possible events in the infant's life, and as mechanism for the consideration of sexual mode of transmission.

I attempted to steer Georgia away from her concentration on the possibility of sexual abuse by leading her "and if she is positive you would explain." Georgia said "If she is positive then I would explain to her what happened and I feel like this is another one of those I have no idea but I think its another one of those things that are treatable." I coded Georgia's discussion of the implications of the mother testing positive for gonorrhea as biomedical technology and education for advising the mother about the mechanism by which she contracted the disease and that it is treatable.

Georgia also wanted to discuss with the mother the risks of unprotected sex. She said "and you want to have the same conversation that you have with the 25 year old man you know explain to her the risks of unprotected sex and explain to her that this is a sexually transmitted disease and you know maybe find out if she if she is aware of of you know where this may have come from or even where it doesn't matter where it came from but just make sure that she knows that the risks are that are associated with sexually transmitted diseases because most people that become HIV positive already have already have had 3 or 4 STDs... And that would be I am very biased but umm my my big concern is always HIV." I coded Georgia's discussion with the mother of the risks of unprotected sex as education about the mechanism of transmission and as prevention of future infections. I also coded her brief discussion of identifying the source of the infection as gathering patient history, prevention, and mechanism.

The third question I asked Georgia was “what additional information would you seek out?” Georgia stated that the situation depends on the mother’s infection status. She said “It’s really going to depend on if she’s uh the mother is positive for umm gonorrhea or not I mean it’s a completely separate issue when umm the mother is not positive.” I coded this as biomedical testing and patient history and mechanism because of the possibility of other modes of transmission to the infant.

Georgia’s next thoughts are on consulting with social services and/or psychology for help. She said “so you’re gonna need you’re gonna definitely need to incorporate some kind of umm you know psychotherapeutic or maybe social services with this mother because it’s not gonna be solved in the medical setting I mean that’s that’s gonna need something that’s going to be dealt with you’re gonna need to address those things so I’m going to seek out that type of information.” I coded consulting with these services as utilizing outside resources.

The fourth question I asked Georgia was “how would this information that you are gathering how would you use it to treat the patient?” Georgia ensured that the patient would be treated. She said “Well if the mother is positive then you’re well you’re treating the patient by giving my patient is the infant so I’m treating the patient in giving them antibiotics and hopefully curing them of their of their bacterium infection.” I coded this as treatment.

Georgia discussed how educating the mother helps to treat the child. She said “by speaking with the mother in addition to just treating the umm the infant you are you know preparing the mother for you know raising a healthy child umm which helps to treat the patient.” I coded this education as treatment and prevention of future illness.

Georgia also mentioned how you are treating the infant by helping the family receive the counseling they need. She said “if the mother is negative for gonorrhea umm and you are facilitating your patient into further treatment beyond what you can give them that’s a big that’s a big thing in helping the mom and the infant because it seems as though they have been born into a very unsafe situation and if you can do anything to take them out of it you’re certainly are helping them out you know case management social social worker therapist the works for this situation because this is not a joke.” I coded the infant being born into a dangerous situation as patient history. I coded helping the patient with social services as treatment and outside resources.

Georgia also emphasizes the need for follow-up treatment. She said “and it’s definitely continued communication with the mother she just needs to be sure to follow-up with her which would hopefully help to treat the infant.” I coded this as treatment.

Overall, during the discussion of this case, Georgia mentioned eight out of the eight possible components of infectious disease. She discussed biomedical technology, treatment, pathophysiology, patient history, prevention, outside resources, education, and mechanism. Georgia’s responses to this case were comprehensive in nature because she mentioned more than 50% of the components of infectious disease.

Looking at all three patient cases combined. Georgia’s overall response to the cases was also comprehensive in nature. In each case, she mentioned more than 50% of the components of infectious disease and met the criteria for a comprehensive response. Georgia also exceeded the requirement because she mentioned more than 75% of the components of infectious disease for each case.

Analysis

Comprehensive Responses

All of the interviewees responded to the cases in a comprehensive manner that touched on many of the different components of infectious disease. When considering each participant's responses to each individual case, at least four out of the eight components of infectious disease were mentioned for each case. When considering each participant's responses to all three case studies combined, each participant mentioned at least six out of the eight components of infectious disease identified in this study. All participants mentioned six categories of infectious disease. Each participant mentioned biomedical technology, treatment, pathophysiology, patient history, prevention, and mechanism during their interview. The only two categories that were omitted during any interviews were outside resources and education. Two of the experts and two of the students discussed all eight components of infectious disease during their interview. (See Table 1).

Table 1. Infectious Disease Components from each Participant's Interview

	<i>Experts</i>					<i>Students</i>				
	MD	MK	JK	TM	BS	KA	RC	GG	RK	NS
Biomedical Technology	x	x	x	x	x	x	x	x	x	x
Treatment	x	x	x	x	x	x	x	x	x	x
Pathophysiology	x	x	x	x	x	x	x	x	x	x
Patient History	x	x	x	x	x	x	x	x	x	x
Prevention	x	x	x	x	x	x	x	x	x	x
Outside Resources	x		x	x				x		x
Education	x		x			x	x	x	x	x
Mechanism	x	x	x	x	x	x	x	x	x	x
All Categories	x		x					x		x

Differences between Patient Cases

There were some patterns that emerged when discussion of infectious disease components was examined at the case level instead of at the participant level. In a few interviews, the participants were triggered by a later case to think of an idea they had forgotten to mention in discussing an earlier case. However, the order in which the cases were presented to the participants does not appear to have had an overall affect on their responses to the interview prompt. No pattern could be discerned where discussing a particular patient case before another tended to lead to different responses to the cases that followed.

Educational interventions were mentioned by seven participants in reference to the 25 year old male with a urethral infection; whereas, the number of participants who discussed educational interventions for the infant or the 70 year old female were four and three respectively (See Table 2 & Figure 3). This makes sense because most of the participants assumed that the 25 year old male acquired his infection by practicing unsafe sex and educational interventions would help to prevent this problem in the future. Not every participant was as sure about the mechanism by which the infant or the 70 year old female acquired their infections. Some participants entertained other possibilities such as abuse, childbirth, or weakened immunity.

Table 2. Infectious Disease Components Discussed by Patient Case

	Infant w/ Eye Infection	25 year old Male w/ Urethral Infection	70 year old Female w/ Meningitis
Biomedical Technology	9	7	7
Treatment	8	10	10
Pathophysiology	10	8	10
Patient History	9	9	10
Prevention	7	9	4
Outside Resources	4	2	3
Education	4	7	3
Mechanism	10	10	10
All Components	2	2	0

Prevention strategies were only mentioned by four participants in reference to the 70 year old female with meningitis (See Table 2 & Figure 3). It is also interesting that none of the participants thought about every infectious disease component for the 70 year old female. During the interviews the 70 year old female patient case with meningitis was the most confusing and surprising for the participants. Many of the participants implied or directly stated in their responses that sexual activity decreases with age and seemed to be baffled by the possibility that a 70 year old female could have contracted a sexually transmitted infection. Several participants explored other mechanisms of transmission such as abuse or an unhealthy living situation. Participants surprise and lack of familiarity with this type of presentation of the infection may have inhibited consideration of prevention strategies.

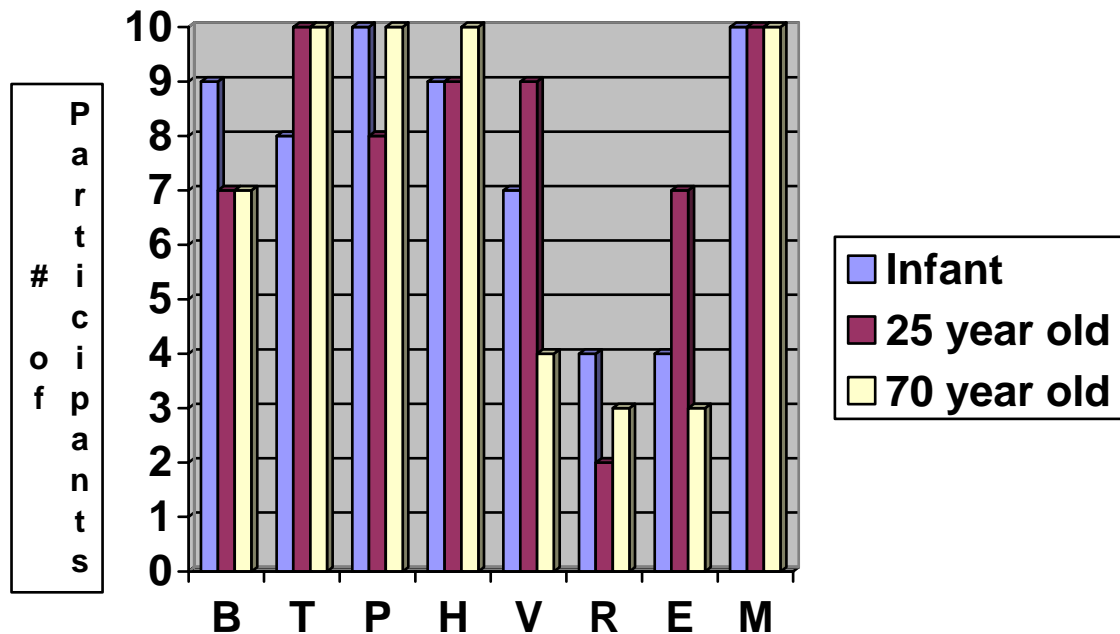


Figure 3. Infectious Disease Components Discussed by Patient Case

Novices vs. Experts

For each participant, I calculated the average number of infectious disease components mentioned per patient case (Table 3). The starred participants were not asked each interview question. Excluding the truncated expert interviews, the experts mentioned on average 7 infectious disease components per patient case. The novices or students mentioned on average 6.2 infectious disease components per patient case. The truncated expert interviews mentioned on average 5 infectious disease components per patient case. This data is interesting because it clearly shows that completion of the interview prompt increased the number of infectious disease components that were mentioned per case. This data also shows a slight difference between experts and novices.

Table 3. Average Number of Categories Coded per Patient Case

<i>Experts</i>					<i>Students</i>				
MD	MK	JK	TM	BS	KA	RC	GG	RK	NS
7.3	5*	6.7	5.3*	4.7*	6	6	7	6	6

Despite the minimal quantitative differences observed between the students and the experts, there were qualitative differences that could be detected during the interviews. All of the experts seemed much more comfortable with the two unusual cases: the infant with an eye infection and the elderly woman with meningitis. The students were mostly surprised that gonorrhea could be associated with such infections, although some were more familiar than others with the unusual manifestations of the infection.

The three clinical microbiologists were more focused on the laboratory aspects of the cases than any of the other participants. This is not surprising because they are experts in the clinical laboratory aspects of infectious disease. The infectious disease specialists responded with much more specific detail than any of the other participants. This is not surprising because they are experts in treating patients with infectious disease and possess vast amounts of knowledge on the subject.

There were significant differences in the depth and breadth of interview responses between participants. Most of the participants mentioned several of the infectious disease components multiple times while discussing each patient. The interview prompt was designed to give participants multiple opportunities to think of as many components of infectious disease as possible. I was pleased to see this repetition because it supports that the interview prompt was working as designed.

Mechanism

The infectious disease component mechanism was coded for every patient case during every interview. Sometimes the participants directly discussed possible mechanisms by which the patient could have acquired their infection. Sometimes the participants did not directly discuss the mechanism of transmission but instead a mechanism of transmission was implied by their answers.

I found the prevalence of the infectious disease component, mechanism of transmission, very interesting. The mechanism of transmission helps contribute to the understanding of the pathophysiology of the disease and helps with the design of educational interventions and prevention strategies. Knowing the mechanism of transmission can be helpful in treating the whole patient, but is not necessary to treat most infections. An understanding of the mechanism of transmission of an infectious disease helps medical providers and infectious disease researchers to simultaneously understand many of the details of how to work towards solving the problem, while keeping the big picture in perspective. For example, specific details about the pathophysiology of the infection are revealed by understanding that *Neisseria gonorrhoeae* is transmitted via sexual contact. But this piece of information also provides information about the lifestyle and behavioral habits of the patient as well as larger scale prevention and educational measures.

Explanation of disease causation is an important idea in medicine. Some researchers have attempted to link the study of causation from psychology to the development of causal disease explanations in medicine (Thagard, 1998). Other

researchers have studied the changes in causal explanations of infectious disease over time from both a historical and evolutionary perspective (Cochran, 2000).

Experts' Definitions of Comprehensive Infectious Disease Problem Solving

At the end of each expert interview, I asked each expert “How do you define comprehensive infectious disease problem solving?” The experts mentioned many components of comprehensive infectious disease problem solving including: mechanism of transmission, epidemiology, immunology, microbial characteristics, treatment options and cost, biomedical testing options, prevention, education, and clinical research. Most of the experts only focused on a few components of infectious disease when defining a comprehensive infectious disease problem solving. But together, their collective definition more closely resembles the definition of a comprehensive infectious disease problem solving that I have been working towards defining in this paper.

Michael Kim focused on the components of epidemiology and mechanism of transmission. Betty Smith focused on the components of prevention and education. Tom Miller focused on the component of education about several other components including: microbial characteristics, treatment options, biomedical testing options, prevention, and mechanism of transmission.

Both of the infectious disease specialists gave the most overarching and detailed definitions of comprehensive infectious disease problem solving. Matthew Dunn described components such as epidemiology, mechanism of transmission, immunology, microbial characteristics, treatment options, and prevention strategies.

Jill Krump's description of a comprehensive perspective on infectious disease closely resembled one of my original concept maps (Figure 1). She said “Well in my

mind an infection is a state where you have an organism and host interacting in a way that is deleterious to the host so the normal barrier between host and invading organism is compromised and that ends up being broken down into all the biological layers that then also all the there's overlying those umm multisystemic influences from all the organ systems so you have to think about the immune system responses but then every other layer umm that can have interactions within the system and then there's overlying that the behavioral component and the interaction between that particular individual and their entire environment so it's kind of like an onion peel." Figure 3 depicts a concept map of Jill's definition of a comprehensive perspective on infectious disease.

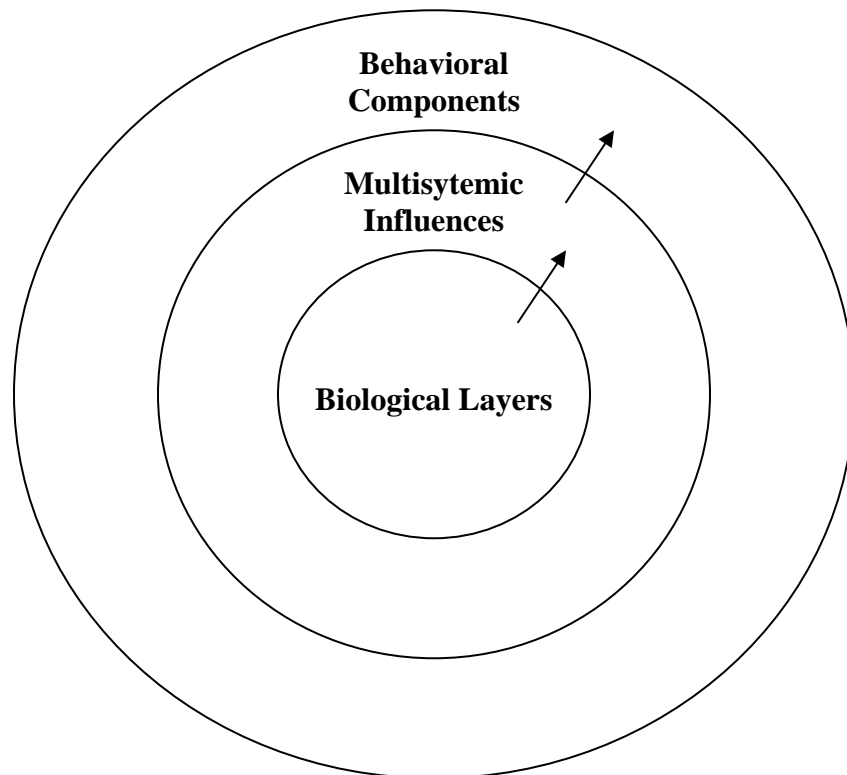


Figure 4. Onion Peel Model of a Comprehensive Perspective on Infectious Disease

Discussion

Progress Towards Answering Research Question

My research question is: what is the impact of undergraduate microbiology education on future healthcare providers' and medical researchers' approaches to thinking about infectious disease problems? The research discussed in this paper was designed as preliminary research to developing a methodology for measuring comprehensive thinking about infectious disease. Once such a methodology is developed then the research to specifically address my research question can be conducted. I think that more preliminary research needs to be conducted before such a research methodology can be fully developed. I will discuss in more detail in Chapter 5: Future Study, the other preliminary studies that should be conducted before attempting to develop such a research methodology.

Comprehensive Thinking about Infectious Disease at the University of Maryland

This case study based interview prompt was purposefully designed using a sexually transmitted infection to maximize the participant's comprehensive thinking while approaching the problem. It was thought that the social aspects of a sexually transmitted infection would enhance the comprehensive thinking about a problem.

I did observe comprehensive thinking about the case studies presented. This is exciting because it could mean that the undergraduate students at the University of Maryland are already thinking comprehensively about infectious disease. This could also mean that I have developed a research methodology capable of triggering comprehensive thinking about infectious disease.

I believe that both of these possibilities played into my results. I do not think the students would have responded comprehensively to the patient case studies if they were not already capable of comprehensive thinking about infectious disease. I also think that the particular context of the patient case studies triggered the students to demonstrate comprehensive thinking. I suspect that there are other contexts in which students would not think comprehensively about infectious disease. I will discuss more thoroughly in the next chapter the possible situations that I think would not trigger comprehensive thinking about infectious disease.

Comprehensive Thinking vs. Expert Thinking

I was pleasantly surprised that all of the student (novice) participants responded comprehensively to the patient cases presented in the interview prompt. As a result of this, I questioned if I had really selected a novice population to compare to the expert population. It is important that I distinguish between comprehensive responses to the interview prompt and expert responses to the interview prompt. It is possible for a novice to demonstrate comprehensive thinking, but still lack the knowledge base and experience of an expert.

For example the student participants were less comfortable discussing the unusual patient cases presented in the interviews (70 year old female with meningitis and infant with an eye infection). The students discussed many different components of infectious disease in reference to the unusual cases, but they were baffled by the cases and less confident in their responses. In contrast, the experts were much more comfortable answering questions about the unusual cases, either from previous experience or an enhanced ability to apply their knowledge and skills to the new and unique cases. This

difference between the students and the experts can easily be explained by differences in how novices and experts approach problems.

I also questioned if the interview prompt was too simple to elucidate any major differences between the novice and expert participant populations. The use of gonorrhea in the interview prompt has strong social implications that the students are likely to have experience with. It is entirely possible that the students resemble more closely experts on a topic such as a sexually transmitted infection. This is not a weakness, but rather a strength in the case study based interview prompt. This type of case study based prompt could be transformed into an extremely useful tool to help novices learn how to extend comprehensive thinking to less familiar diseases such as malaria or ebola.

Comprehensive Thinking and Case Studies

As I found in my evaluation of the educational literature on infectious disease, case studies appear to promote comprehensive thinking about infectious disease because each case study focuses on multiple components of infectious disease. In this study I purposefully used one sentence case studies with minimal information about each patient. I did not want the interview prompt to be too detailed and mention specific components of infectious disease. It is interesting that despite the brief patient case studies, participants responded to the interview prompt with comprehensive thinking. Perhaps, participants were triggered to think about many different aspects of each patient's infection because the case study information was so limited. This just further supports the possibility that the student participants had already developed the capacity to comprehensively think about infectious disease problems.

Limitations

It is important to recognize that in these interviews, the participants will only be asked to think about specific cases of an infectious disease from a physician's perspective. The possible results are constrained by the contextual circumstances set up in the interview. Participants were asked what they, as physicians would do for the patient. Perhaps the participants would have considered different aspects of infectious disease if they had been asked to think about the problem from the perspective of an epidemiologist or a social worker. This may have also altered the frequency with which specific components of infectious disease were mentioned. For example, if the participants were asked to consider the patient case studies from a counselor's perspective, education and outside resources may have been discussed more frequently.

Error

The interview script was not followed precisely for each case presented to each participant. Some participants began responding to the cases without prompting of the interview questions. I let them continue their responses and would ask follow-up questions as needed. This means that sometimes all of the interview questions were not asked for each case or consistently within an interview. This creates a possible source of error, but I feel that it is outweighed by the natural responses of the participants.

For the first three expert interviews, I was still establishing a comfort level with the interview participants. My concern was that I wanted to be thorough but effective in my use of the expert's time. So when the first three experts appeared to be done responding to my questions with new ideas, I stopped asking questions. This created a source of error in the data. The three experts who had truncated interviews only

mentioned on average five out of eight categories per patient case compared to the other experts who averaged seven out of eight categories per patient case.

Chapter 5: Future Study

Horizontal Expansion of Methodology

Different Cases of Infectious Disease

In this study, a sexually transmitted infection was purposefully chosen to maximize the likelihood that participants would recognize the social implications of the disease and think comprehensively about the problem. It would be interesting to use a similar interview prompt but with cases of different infectious diseases.

For example it would be interesting to design similar patient based case prompts for *Helicobacter pylori* infections. *Helicobacter pylori* infections have been linked to ulcers. Traditionally ulcers were thought to be caused by factors such as diet, exercise, and stress. But recently, it was discovered that ulcers can be caused by *Helicobacter pylori* infections and even cured with courses of antibiotics.

Another interesting infectious disease to design a patient case based interview prompt for would be cholera. Cholera is a waterborne disease that is associated with contaminated drinking water in countries with poor sanitation systems. Both cholera and *Helicobacter pylori* infections would be likely to stimulate comprehensive thinking but for slightly different reasons than gonorrhea.

It would also be interesting to see if any participants respond comprehensively to a patient case based prompt about the common cold. Perhaps, the common cold is so

prevalent and familiar to participants that they do not think comprehensively about the infection.

Different Student Populations

In this study, I interviewed undergraduate level students who had completed at least one microbiology course. All of the students had career plans in the healthcare industry. It would be interesting to examine how other student populations would respond to the interview prompt.

An interesting student population to study would include pre-healthcare students without any microbiology background. Comparison of this student population to the students in my study would help reveal the effects of microbiology education on comprehensive thinking about infectious disease.

Another interesting student population to study would include undergraduate students without career plans in healthcare. This group could also be subdivided into those with and without microbiology education. These students would help reveal the effects of having an interest in healthcare on comprehensive thinking about infectious disease.

And a final student population that should be studied would include graduate students and professional school students. These students would be graduate students studying biomedical science or students in nursing, pharmacy, or medical school. These students would be much more advanced novices than undergraduate students and would help to show the progression from a novice to an expert. They would also provide interesting incite into the development of comprehensive thinking about infectious disease.

Vertical Expansion of Methodology

Survey Development

A goal of this study is to do the pilot research necessary to help with the development of a survey that could rapidly measure comprehensive thinking in large numbers of students. Several more of the studies suggested in the horizontal expansion of methodology should be conducted and then the vertical expansion can begin. The survey could be formatted similarly to the interviews with patient case-based prompts followed by questions. The questions would be open ended so as not to trigger thinking about any specific components of a comprehensive perspective on infectious disease; however, a coding scheme could be developed from which to quickly score participant's answers.

Improvement of Undergraduate Microbiology Education

Measurement of Comprehensive Reasoning

The development of a standardized research methodology such as a survey for measuring comprehensive reasoning about infectious disease would be extremely useful in improving educational programs. As my research has shown, comprehensive reasoning about infectious disease appears to be context dependent. This must be taken into account when developing standardized research methodology. The survey that is developed from this study and other preliminary research must be tested in many different settings and attempt to account for many different contexts in which students may think differently about infectious disease. These contexts will hopefully have been elucidated during the preliminary studies about very different infectious disease.

Evaluation of the Effects of Educational Interventions

Once a standardized research methodology is fully developed, different educational interventions can be evaluated for their effects on development of a comprehensive perspective on infectious disease. Using this research methodology in an entrance/exit survey would really illustrate the effects of a microbiology course on the development of comprehensive thinking about infectious disease. Populations of students taking the microbiology course over time could also be assessed to elucidate the effects of any educational interventions. The use of a standard research methodology to evaluate the effects of microbiology education on the development of comprehensive thinking about infectious disease would help answer my research question: what is the impact of undergraduate microbiology education on future healthcare providers' and medical researchers' approaches to thinking about infectious disease problems?

Appendices

Appendix A – Student Interview Prompt

You will be given a case description of a patient with an infectious disease. I will ask you a series of questions about your thoughts on how to solve the infectious disease problem. This process will be repeated for a total of three different cases. There are no correct answers to my questions. I am more interested in how each case description influences your thoughts and problem solving processes.

All of the cases of infectious disease that will be discussed today result from infections caused by *Neisseria gonorrhoeae*, the causative agent of the sexually transmitted infection, gonorrhea.

Patient Cases (Case Presentation Order will be Experimented Upon):

1. A newborn infant has an eye infection caused by *N. gonorrhoeae*.
2. A 70 year old female has meningitis caused by *N. gonorrhoeae*.
3. A 25 year old male has a urethral infection caused by *N. gonorrhoeae*.

Interview Questions:

(Elaboration and Clarification of Answers will be Sought as Needed)

In an ideal world, if you were the patient's doctor, what would you do?

What questions would you ask the patient?

What additional information would you seek?

Appendix B – Professional Interview Prompt

You will be given a case description of a patient with an infectious disease. I will ask you a series of questions about your thoughts on how to solve the infectious disease problem. This process will be repeated for a total of three different cases. There are no correct answers to my questions. I am more interested in how each case description influences your thoughts and problem solving processes.

All of the cases of infectious disease that will be discussed today result from infections caused by *Neisseria gonorrhoeae*.

Patient Cases (Case Presentation Order will be Experimented Upon):

1. A newborn infant has an eye infection caused by *N. gonorrhoeae*.
2. A 70 year old female has meningitis caused by *N. gonorrhoeae*.
3. A 25 year old male has a urethral infection caused by *N. gonorrhoeae*.

Interview Questions:

(Elaboration and Clarification of Answers will be Sought as Needed)

In an ideal world, if you were the patient's doctor, what would you do?

What questions would you ask the patient?

What additional information would you seek?

How do you define comprehensive infectious disease problem solving?

Appendix C – Student Recruitment Advertisement

Are you interested in pursuing a career in a healthcare field? We need your help to improve the education of pre-health undergraduates at UMCP. Eligible participants must have completed at least one of the following courses at UMCP: BSCI223, BSCI417, BSCI422, BSCI424, or BSCI425. Participants will be asked to complete a 30-minute interview about three infectious disease case studies. The confidentiality of participants and their interview responses will be maintained at all times. If you are interested in participating in this study, please send an email to Laura Cathcart at cathcart@umd.edu.

Appendix D – Student Participant Consent Form

Page 1 of 3

Initials _____ Date _____

CONSENT FORM

Project Title	Infectious Disease Case Presentation Influences on Student Responses
Why is this research being done?	This is a research project being conducted by Laura Cathcart under the supervision of Dr. David Hammer of the Science Teaching Center in the Department of Curriculum and Instruction at the University of Maryland, College Park. We are inviting you to participate in this research project because you have indicated an interest in pursuing a career in the healthcare industry. The purpose of this research project is to design a method to trigger different types of thinking about infectious disease clinical cases. This will help educators to understand how comprehensive approaches to solving infectious disease problems can be nurtured in pre-health students.
What will I be asked to do?	The procedures involve reading three brief infectious disease case study descriptions. Following the reading of each case description, the subject will be interviewed about their thoughts on how to solve each problem. These activities will be completed in the office of Laura Cathcart, Room 1202 Microbiology Building, University of Maryland, College Park, Maryland, 20742. The total duration of the subject's participation will be approximately 30 minutes.
What about confidentiality?	<p>We will do our best to keep your personal information confidential. This research project involves making audiotapes of your interview. The interview is recorded to allow written transcripts to be produced for the student researcher to fully evaluate the content of the interview. Only the student researcher will have access to the signed consent forms, digital media and printed documents. These items will be secured in a locked filing cabinet in Room 1202 Microbiology Building, University of Maryland, College Park, 20742.</p> <p><input type="checkbox"/> I agree to be audiotaped during my participation in this study. <input type="checkbox"/> I do not agree to be audiotaped during my participation in this study.</p> <p>To help protect your confidentiality, the written background information sheets and transcripts from the interviews will be tracked by codes. If we write a report or article about this research project, your identity will be protected to the maximum extent possible. Your information may be shared with representatives of the University of Maryland, College Park or governmental authorities if you or someone else is in danger or if we are required to do so by law.</p>

Project Title	Infectious Disease Case Presentation Influences on Student Responses
What are the risks of this research?	There is a psychological risk that you will feel unprepared for the interview questions. Your responses are not being judged or scored for correctness. All answers to the interview questions are valid and useful in the study. There is a social risk that your identity will be compromised. Your identity will only appear on this consent form and it will be stored in a secure location as described above.
What are the benefits of this research?	This research is not designed to help you personally, but the results may help the student investigator learn more about how to improve undergraduate pre-health education. The purpose of this research is to design a method to trigger different types of thinking about similar infectious disease clinical cases. Once such an assessment method is developed, the factors contributing to the different types of responses can be identified and studied. This will help educators to understand how comprehensive approaches to solving infectious disease problems can be nurtured in pre-health students. We hope that, in the future, other people might benefit from this study through improved undergraduate pre-health courses.
Do I have to be in this research? May I stop participating at any time?	Your participation in this research is completely voluntary. You may choose not to take part at all. If you decide to participate in this research, you may stop participating at any time. If you decide not to participate in this study or if you stop participating at any time, you will not be penalized or lose any benefits to which you otherwise qualify.
What if I have questions?	<p>This research is being conducted by Laura Cathcart under the supervision of Dr. David Hammer and the Department of Curriculum and Instruction at the University of Maryland, College Park. If you have any questions about the research study itself, please contact:</p> <p>Laura Cathcart, 1202 Microbiology Building, University of Maryland, College Park, Maryland, 20742; (e-mail) cathcart@umd.edu; (telephone) 301-314-2537 or</p> <p>Dr. David Hammer, 2226N Benjamin Building, University of Maryland, College Park, Maryland, 20742; (e-mail) davidham@umd.edu; (telephone) 301-405-8188</p> <p>If you have questions about your rights as a research subject or wish to report a research-related injury, please contact:</p> <p>Institutional Review Board Office, University of Maryland, College Park, Maryland, 20742; (e-mail) irb@deans.umd.edu; (telephone) 301-405-0678</p> <p>This research has been reviewed according to the University of Maryland, College Park IRB procedures for research involving human subjects.</p>

Project Title	Infectious Disease Case Presentation Influences on Student Responses	
Statement of Age of Subject and Consent	<i>Your signature indicates that: you are at least 18 years of age; the research has been explained to you; your questions have been fully answered; and you freely and voluntarily choose to participate in this research project.</i>	
Signature and Date	NAME OF SUBJECT	
	SIGNATURE OF SUBJECT	
	DATE	

Appendix E – Student Participant Background Information Sheet

Participant Code: _____
(First and Last Initial, Month and Day of Birth; Ex. LC0220)

Major(s): _____

Student Standing (Ex. Freshman, Sophomore): _____

Career
Goal(s): _____

Please list all classes you have taken at UMCP that you feel have helped to prepare you for a healthcare career:

Appendix F – Professional Participant Consent Form

Page 1 of 3

Initials _____ Date _____

CONSENT FORM

Project Title	Infectious Disease Case Presentation Influences on Student Responses
Why is this research being done?	This is a research project being conducted by Laura Cathcart under the supervision of Dr. David Hammer of the Science Teaching Center in the Department of Curriculum and Instruction at the University of Maryland, College Park. We are inviting you to participate in this research project because you are a professional whose work concentrates on infectious disease. The purpose of this research project is to design a method to trigger different types of thinking about infectious disease clinical cases. This will help educators to understand how comprehensive approaches to solving infectious disease problems can be nurtured in pre-health students.
What will I be asked to do?	The procedures involve reading three brief infectious disease case study descriptions. Following the reading of each case description, the subject will be interviewed about their thoughts on how to solve each problem. After the completion of this activity, the subject will be interviewed about their thoughts on comprehensive solutions to infectious disease problems. These activities will be completed either in the subject's office of choice or in the office of Laura Cathcart, Room 1202 Microbiology Building, University of Maryland, College Park, Maryland, 20742. The total duration of the subject's participation will be approximately 1 hour.
What about confidentiality?	<p>We will do our best to keep your personal information confidential. This research project involves making audiotapes of your interview. The interview is recorded to allow written transcripts to be produced for the student researcher to fully evaluate the content of the interview. Only the student researcher will have access to the signed consent forms, digital media and printed documents. These items will be secured in a locked filing cabinet in Room 1202 Microbiology Building, University of Maryland, College Park, 20742.</p> <p>___ I agree to be audiotaped during my participation in this study. ___ I do not agree to be audiotaped during my participation in this study.</p> <p>To help protect your confidentiality, the written background information sheets and transcripts from the interviews will be tracked by codes. If we write a report or article about this research project, your identity will be protected to the maximum extent possible. Your information may be shared with representatives of the University of Maryland, College Park or governmental authorities if you or someone else is in danger or if we are required to do so by law.</p>

Project Title	Infectious Disease Case Presentation Influences on Student Responses
What are the risks of this research?	There is a psychological risk that you will feel unprepared for the interview questions. Your responses are not being judged or scored for correctness. All answers to the interview questions are valid and useful in the study. There is a social risk that your identity will be compromised. Your identity will only appear on this consent form and it will be kept in a secure location as described above.
What are the benefits of this research?	This research is not designed to help you personally, but the results may help the student investigator learn more about how to improve undergraduate pre-health education. The purpose of this research is to design a method to trigger different types of thinking about similar infectious disease clinical cases. Once such an assessment method is developed, the factors contributing to the different types of responses can be identified and studied. This will help educators to understand how comprehensive approaches to solving infectious disease problems can be nurtured in pre-health students. We hope that, in the future, other people might benefit from this study through improved undergraduate pre-health courses.
Do I have to be in this research? May I stop participating at any time?	Your participation in this research is completely voluntary. You may choose not to take part at all. If you decide to participate in this research, you may stop participating at any time. If you decide not to participate in this study or if you stop participating at any time, you will not be penalized or lose any benefits to which you otherwise qualify.
What if I have questions?	<p>This research is being conducted by Laura Cathcart under the supervision of Dr. David Hammer from the Department of Curriculum and Instruction at the University of Maryland, College Park. If you have any questions about the research study itself, please contact:</p> <p>Laura Cathcart, 1202 Microbiology Building, University of Maryland, College Park, Maryland, 20742; (e-mail) cathcart@umd.edu; (telephone) 301-314-2537 or</p> <p>Dr. David Hammer, 2226N Benjamin Building, University of Maryland, College Park, Maryland, 20742; (e-mail) davidham@umd.edu; (telephone) 301-405-8188</p> <p>If you have questions about your rights as a research subject or wish to report a research-related injury, please contact:</p> <p>Institutional Review Board Office, University of Maryland, College Park, Maryland, 20742; (e-mail) irb@deans.umd.edu; (telephone) 301-405-0678</p> <p>This research has been reviewed according to the University of Maryland, College Park IRB procedures for research involving human subjects.</p>

Project Title	Infectious Disease Case Presentation Influences on Student Responses	
Statement of Age of Subject and Consent	<i>Your signature indicates that: you are at least 18 years of age; the research has been explained to you; your questions have been fully answered; and you freely and voluntarily choose to participate in this research project.</i>	
	NAME OF SUBJECT	
	SIGNATURE OF SUBJECT	
	DATE	

Appendix G –

Professional Participant Background Information Sheet

Participant Code: _____
(First and Last Initial, Month and Day of Birth; Ex. LC0220)

Education:
(Degree, Major, Year of Graduation)

Undergraduate:

Graduate:

Occupation: _____

Research Interests Relating to Infectious Disease:

Appendix H – Interview Tape Transcripts

Jill Krump (Expert) Interview Transcript

J = Jill Krump, Participant

L = Laura Cathcart, Researcher

Case 1: Infant w/ Eye Infection

1 **J:** I'm not a pediatrician.

2 **L:** That's okay, I just want to know the things you are thinking about. Umm, so the first
3 question I have is in an ideal world if you were the patient's doctor what would you do?

4 **J:** Uh in an ideal world, this wouldn't happen. Umm, so my first thought about this is a
5 newborn infant umm with presumably I mean this sentence is saying has an eye infection
6 so we've already missed the boat. Umm, this newborn's mother should have been
7 screened and treated for *Neisseria gonorrhoeae*. And the newborn should have had drops
8 placed in their eyes even after the mom was treated to prevent any infection with
9 gonorrhea or chlamydia. So, if there is an active eye infection, that's a really bad thing.
10 Since I'm not a pediatrician, I don't actually know what the next step should be. I think I
11 would consult an ophthalmologist. And I would probably think about using some kind of
12 topical thing right away. But this is an emergent situation.

13 **L:** Okay. And what questions would you ask umm questions the patient, what questions
14 would you ask the patient's family?

15 **J:** Did the mom get any prenatal care? Umm, does the mom have an active infection?
16 Has the mom been treated for that active infection? How long has the mom had that
17 active infection? That active infection being presumably umm vaginitis with a vaginal

18 discharge or pain. Umm it's says newborn, I'd certainly want to know how old the kid is.
19 Umm, has the mom received any antibiotic treatment in the last month? I guess. Uh, how
20 many sexual partners does the mom have? Has the mom been tested for HIV? Umm, has
21 the mom been screened and tested for other sexually transmitted diseases? Umm, that's a
22 good start.

23 **L:** Sounds good to me. Okay, umm what additional information would you seek?

24 **J:** Other than all those questions?

25 **L:** Yes, this is designed to make sure you really spit it all out.

26 **J:** Umm, has the child received any treatment prior to my seeing this child? Umm, I
27 guess I would probably then being pushed imagining that I am in the Appalachians and I
28 am the only physician there and I don't have a pediatrician to go to. I would ask umm, is
29 the baby eating normally, behaving normally, exhibiting any unusual umm behaviors,
30 sleeping well, umm, again don't know how many days post birth this newborn is, but
31 umm, is the child losing weight, gaining weight? Umm, does the child have any rashes?
32 Umm, is the child extremely irritable, thinking about whether this is a disseminated
33 gonorrhoeal infection versus simply a localized infection to the eye. So thinking about
34 meningitis, thinking about septicemia. Umm.

35 **L:** Okay

Case 2: 25 year old Male w/ a Urethral Infection

36 **L:** Okay

37 **J:** Ahh, this is much better, more up my alley.

38 **L:** Okay, so first question is, in an ideal world if you were the patient's doctor what
39 would you do?

40 **J:** Well, umm, well this is not quite the normal state of affairs. Or maybe it is actually for
41 me. Cause I would usually be thinking about seeing someone with a urethral discharge
42 and then diagnosing them. So this is presumably saying okay and now a patient who I
43 guess I can imagine was diagnosed by their primary doctor. Umm so they have
44 gonorrhea, so umm. In an ideal world I would already have from the primary physician
45 an HIV test and an RPR for syphilis. Umm, I would umm, well I don't know what the
46 sensitivities of this gonorrhea is, I guess I would want to know that in the newborn case
47 too. Umm, does the guy have any allergies to any medications that preclude use of any
48 antibiotics that I might want to choose.

49 **L:** When you said you would have stuff from another physician does that mean the one
50 who diagnosed him or?

51 **J:** Right, given the fact that this is someone coming with the label that this infection is
52 caused by *Neisseria gonorrhoeae*.

53 **L:** Okay. What questions would you ask the patient?

54 **J:** So I would ask the patient, how long have you had symptoms? Umm, how many
55 sexual partners have you had in the last year? Or six months depending on what the
56 answers are to those depends on how far back I will go. Have you told your partners?
57 Have you been tested for HIV? Are your partners male, female, or both? Umm, are you
58 having any pain with ejaculation or with urination? Umm, again are you allergic to any
59 antibiotics? Umm, have you had this kind of infection before? Umm.

60 **L:** Umm, okay. So basically what additional information would you seek or what else
61 would you do?

62 **J:** I would get all those tests. I would get an RPR and HIV test. Make sure that uh that
63 this has to be reported to the state lab, it probably has been already by the lab. Umm, treat
64 him obviously and have him follow-up to make sure that he's cleared this infection.
65 Umm, counsel him on safe sex practices. Umm, by definition if he's gotten *Neisseria*
66 *gonorrhoeae* he's having unsafe sex with somebody. Umm, I would probably in a 25 year
67 old male, I would also ask him about substance use, whether he is using umm, IV drugs,
68 whether he is using umm, cocaine, heroine, ecstasy, any of those types of things and
69 investigate whether he needs referral for counseling in terms of stopping those things.
70 Alcohol included actually. Umm, I mean I want to inquire into his social patterns and
71 lifestyle, what he does for a living, I mean you know. This kind of depends, the context
72 of this kind of depends on am I seeing this guy in say an urgent care clinic setting where I
73 have a one time thing and I am just dealing with gonorrhea or am I gonna have a long
74 term relationship with him where I am gonna be his primary doctor and I am gonna start
75 needing to take care of these things. So this particular situation has a lot of ramifications
76 if I am going to be his primary care provider. I mean this also could have repercussions in
77 terms of does he have umm a mental health situation that umm disinhibits him. Does he
78 have bipolar disorder and he umm engages in risky behavior because of that? So, just as
79 an example.

80 **L:** Okay, sounds good.

Case 3: 70 year old Female w/ Meningitis

81 **L:** Umm, so again the first question is, in an ideal world if you were the patient's doctor
82 what would you do?

83 **J:** Umm, well obviously she needs to be treated. Umm, so I would treat her in the
84 hospital, most likely. Umm, and that depends on her situation, but she needs to receive IV
85 antibiotics as opposed to the young man who would receive probably oral antibiotics.
86 Umm, I would need to figure out what her risk factors are for acquiring this infection.
87 Umm, so presumably she had a septicemia, a meningitis seeded by a septicemia process
88 and then she acquired this organism. The question then becomes how did she acquire this
89 organism? So, one needs to know what her living situation is. Is she being abused by say
90 a caregiver? Umm that would cause her to have umm acquired this infection.

91 **L:** Okay, umm what questions would you ask the patient?

92 **J:** Umm, where do you live? Who takes care of you? What is your umm what is her past
93 medical history? Umm, what kinds of umm compromises to her immune system might
94 she have? Is she diabetic? Is she umm got heart disease? Does she have pulmonary
95 diseases? Any number of kidney disease? Any number of things that can affect her
96 resistance to umm getting an infection. Umm, so you need to know all of her
97 comorbidities basically. Umm, is she allergic to any medications that would preclude
98 antibiotic therapy? Umm, does, I mean all of these things would or many of these things
99 would move towards umm contacting adult protective services if it seems like that's an
100 issue.

101 **L:** Okay, umm, what additional information would you seek?

102 **J:** Umm, well, I need to know, I mean in this case you need to know all of the usual
103 things that you would need to do when you hospitalize a patient. You need to know vital
104 signs, umm, whether she has disseminated umm *Neisseria* infection that may
105 compromise other organs besides her CNS right now. Umm, the other thing that would be
106 in this setting probably complicating is that she may have mental status changes and you
107 don't always know in a 70 year old what the baseline mental status is unless you have a
108 prior relationship with them, so you would probably, if you didn't know the patient
109 already, you would need to find a family member or a friend or someone who has some
110 understanding of them so that you can figure out what the baseline is. Umm, so that you
111 know when you've reached your endpoint is first cure. Umm, I would collect blood
112 cultures umm obviously I should examine her completely again looking for a rash. Umm,
113 I suppose this does also probably it depending on the answers to all of the rest of this.
114 You would probably also umm, mandate looking for again those other sexually
115 transmitted diseases, getting an RPR, getting tested, looking into getting an HIV test.
116 Umm, again depending on her mental status because she has to consent. Umm, has she
117 had meningitis before? Has ever had other infectious processes before? Umm, that again
118 might argue in terms of looking at some kind of barrier breakdown or some other
119 immunocompromised state.
120 **L:** Sounds good to me. Okay.

Definition of Comprehensive Infectious Disease Problem Solving

121 **L:** How do you define comprehensive infectious disease problem solving?

122 **J:** Ahh Umm Well in my mind an infection is a state where you have an organism and
123 host interacting in a way that is deleterious to the host so the normal barrier between host

124 and invading organism is compromised and that ends up being broken down into all the
125 biological layers that then also all the there's overlying those umm multisystemic
126 influences from all the organ systems so you have to think about the immune system
127 responses but then every other layer umm that can have interactions within the system
128 and then there's overlying that the behavioral component and the interaction between that
129 particular individual and their entire environment so it's kind of like an onion peel...
130 that's a difficult question ...like the philosophy of infectious disease... so you know
131 infectious disease physicians are often the only people who know what the patient's
132 occupation is because a lot of us focus a lot on occupational risks

133 **L:** Okay umm so I guess how is it important that students approach problems like how
134 should students take this into account or how does this need to be taken into account
135 when solving problems

136 **J:** Yeah well I think that's such a great question I think that students tend to get caught
137 up in the microbiology in terms of the bugs and drugs question like I gotta learn the bug
138 the bug and you know we teach the bug in terms of lifecycles and in terms of
139 biochemistry and cell walls and how to recognize it on a gram stain and all of those
140 things and yet you have to understand the context of the bug in terms of who and how it
141 travels and where it goes how it effects people umm and these are great questions given
142 the fact that they show one organism with multisystem effects and so you can't get stuck
143 in the idea of you know this one bug is associated with this one disease umm and you're
144 left with the difficulty of medicine you've got a multitude of etiologies that can arrive at
145 one pathophysiology and you've got multiple pathophysiologies that can have one
146 etiology so umm having that trying to I went to a great grand rounds lecture a couple

147 weeks ago that talked about the evolution of medical students understanding of disease
148 generally not just infectious disease but definitely lends to infectious disease the idea that
149 you have like you'll have different little items of knowledge that you accumulate over
150 time and the end point of medical education and I think biology education is that you
151 learn how to connect networks of all these little items of information in very complex
152 pattern recognition umm algorithms I guess or paradigms but it's not an easy straight
153 forward thing it's not something that's very simple to put out cause it's not very linear
154 it's very multidimensional

155 **L:** Okay If it helps you to make any sense out of this we are I am interested in infectious
156 disease but we really don't understand fully we don't have complete models of how the
157 student's brain works they are not great

158 **J:** Yeah

159 **L:** It is sort of one of our biggest questions is how do they build this how does it work
160 what is the best way to represent it umm

161 **J:** I totally agree

162 **L:** And this research actually directly plays into it even though it doesn't appear to

163 **J:** Oh I think it totally does no I absolutely agree it's just I think it's a constant struggle
164 you know I teach in the hospital the levels from medical students , 3rd year medical
165 students, 4th year medical students, interns and then the residents up through the fellows
166 and it I think it's a very hit or miss you know we don't you're right we don't really know
167 how to systematically teach these skills and what we come up with in terms of well you
168 know medical education is this very kind of amorphous sort of an apprenticeship kind of
169 thing where you are lucky if you hit upon certain people that you can learn from and it's

170 very hard to know how you do learn from certain people you know I know that the way
171 that I teach some people just can't deal with at all because I am kind of umm relaxed not
172 like formal teaching necessarily umm and other people don't do well with the more
173 formalized teaching and I think that some attendings teach in a very antagonistic you
174 know him being like crazy way and umm other people don't and at the end of the day you
175 either do or don't come out with this construct of a complicated complex ability to
176 pattern recognize and and problem solve and I certainly know physicians who are in
177 practice who don't really have this have never really gained this you know very linear
178 thinking very kind of one thing is one thing equals that and uh lack of ability to
179 necessarily see all of the gray you know it's what we end up talking about in terms of the
180 science of medicine and the art of medicine and I think those two things go hand in hand
181 to some degree and that art component is I think you know I think when people say the
182 art of medicine they often are saying you know it's that hand holding it's that compassion
183 it's that kind of umm warm fuzzy but I think it's also this kind of almost magic you know
184 it's like you get a bunch of things that go into the box and then a diagnosis that comes out
185 and you don't quite know what happened in the black box to get there.

Georgia Grant (Student) Interview Transcript

G: Georgia Grant, Participant

L: Laura Cathcart, Researcher

Case 1: 25 year old Male w/ Urethral Infection

1 **L:** Okay so the first question is let's say we are in an ideal world, if you were this
2 patient's doctor what would you want to do for this patient?

3 **G:** What would I want to do for this patient?

4 **L:** Yeah

5 **G:** Umm... give them antibiotics.

6 **L:** Okay

7 **G:** And I want to uh well umm usually you know getting an STD is umm caused by
8 doing risky behaviors so you umm may want to have a conversation with him about what
9 kind of lifestyle he is leading and you know you don't want to you don't want to say
10 anything that is going to make him feel uncomfortable but you also want him to know
11 that there is umm there is it's likely that it that if you are engaged in risky behaviors that
12 you might catch something maybe worse than gonorrhea and umm this is one of those
13 things that you can treat but umm you might catch something that umm you can't treat
14 and uh what is going on in his life that he is umm engaged in these types of risky
15 behaviors because if you're doctor can't talk to you who can?

16 **L:** Okay umm so then the next question is what questions would you ask this patient?

17 **G:** Umm well I would say do you know what you have and uh it's tough because you it's
18 a 25 year old male but it doesn't say anything about you know his socioeconomic status
19 and what kind of setting you are seeing him in I mean am I seeing him in an STD clinic

20 or am I seeing him in my private practice? It's really gonna you know depend on what
21 kind of setting am I seeing this person in because if you are at an STD clinic you might
22 not have a lot of time to talk to this person and you might have ummm you might just
23 want to give him pamphlets or something but if you have a little more time then you can
24 you know ask the person if you know how you got this? Do you know what kind of
25 behaviors lead to this? Do you know how to use a condom? Umm a lot of people a lot of
26 25 year old males do not know how to properly use a condom. Umm, do you know about
27 umm the risks associated with umm unprotected sex, which is how you get gonorrhoea?
28 Questions like that.

29 **L:** Alright and the third question is what additional information would you seek out from
30 anywhere?

31 **G:** Oh, from anywhere?

32 **L:** From anywhere.

33 **G:** That I would seek out for this patient?

34 **L:** Yeah to help you solve this patient's case.

35 **G:** Umm well hopefully I mean gonorrhoea is pretty common it's very common umm if
36 you have a urethral infection caused by gonorrhoea the antibiotics should take care of it.

37 What additional information would I seek out? I would just try to talk to the patient, I
38 mean it's not really the biggest deal in the world, it's not comparably speaking, it

39 happens I don't know if I would seek out any additional information, I mean I should but
40 I probably wouldn't. This isn't mystery diagnosis, we helped you.

41 **L:** Okay, umm, so my last question is how would all of this information that we have
42 talked about umm like from 2 and 3 like what questions would you ask and what
43 additional information would you seek how would you use that to help treat the patient?

44 **G:** Well I think that treating the patient is more than just giving him antibiotics and
45 telling him to go home. You it's you're help, by asking the patient questions and causing
46 the patient to think about how his behaviors lead to his pathology hopefully you know
47 we'll get some thinking started and make them actually realize why they are there and
48 umm you know also make them see that their doctor cares about them and that they umm
49 are not just there to get a pill they are there to get treatment as a person not as an animal
50 and umm I mean 25 year old male that's a time when males engage in risky behaviors
51 and umm and if uh if their doctor is willing to have a conversation with him about it
52 instead of just you know saying you have gonorrhea it's not a big deal here's antibiotics
53 for it here is a prescription go home maybe if you talk to him about it and give him some
54 skills about umm you know condom usage maybe how to negotiate safe sex something
55 like that you might prevent them from getting in the future something worse.

56 **L:** Okay, sounds great.

Case 2: 70 year old Female w/ Meningitis

57 **G:** A 70 year old female has meningitis caused by gonorrhea. I didn't know gonorrhea
58 caused meningitis. Umm 70 year old female has meningitis again.

59 **L:** So let me just say the first question again. In an ideal world if you were the patient's
60 doctor what would you do?

61 **G:** Well again it's this uh there is so little information and so you don't know anything
62 you don't know if you're in Africa or if you're in America or if you're in a what kind of

63 setting you're in again socioeconomic status is really going to come into play here
64 because a 70 year old female who is very well educated and umm you know comes from
65 you know a high socioeconomic status they are going to have it's going to be someone
66 who has had access to healthcare you'd have a very different conversation with
67 somebody who has been you know living in poverty you know and lives in you know a
68 slum somewhere umm it's going to be very different because if it's somebody who is
69 more affluent you could you would talk to them about you know Do you know what you
70 have? Do you understand how you got it? Do you understand how this treatment is going
71 to help you? Umm do you know how to prevent this kind of thing in the future? Please
72 come back for a follow-up visit. Umm, somebody who is in a low socioeconomic status,
73 you really have to stress to them first of all you really have to make them understand
74 what they have, how it's caused and a very different ummm very different language and
75 it's gonna be really important to get this person back because a lot of times they won't
76 come back for a follow-up visit and something like meningitis could kill them so umm it
77 would be a very different conversation. It's hard to say

78 **L:** Okay, umm...let's assume at this point in time that this patient is in critical condition
79 because they have meningitis, umm, would that change any of that?

80 **G:** I mean if this person is in critical condition, 70 years old I mean you want to get them
81 to the hospital, you want to get them treatment as soon as possible and you want to make
82 sure to follow-up with the patient as much as possible and umm make sure that they are
83 not, make sure that wherever they go to the hospital that the...whoever is treating...
84 whoever else is treating them besides me, because it's not just going to be me, knows
85 exactly what they have and they are giving them the right treatment so that it doesn't kill

86 them, cause that wouldn't be good. I probably should have realized that this is a bad
87 thing, that meningitis is not good.

88 **L:** No, no, well, it depends on what kind you have umm, Okay so you Okay well that
89 answers that question. What questions would you ask this patient?

90 **G:** I mean unfortunately I don't really know, I mean I had no idea that gonorrhoea could
91 cause meningitis so if it's in critical condition that means they haven't been to see a
92 doctor and that they've ignored other symptoms so I would ask them how long their
93 symptoms have been going on and why they haven't been in to see a doctor umm and
94 stress them the you know the urgency of this situation umm ask them what is going on in
95 their life that they have been ignoring their symptoms and that they you know have not
96 been in to see a doctor I mean umm really try to find out what is going on with them in
97 their life because they are in bad shape unless you see I don't know what the symptoms
98 are, I mean I just have no idea.

99 **L:** Of meningitis or gonorrhoea?

100 **G:** Gonorrhoea I know what the symptoms are, but for meningitis I mean caused by
101 gonorrhoea, meningitis is umm the swelling of the brain umm tissue I don't know I mean
102 would someone know that right away, right?

103 **L:** Umm, they get suddenly violently ill, but

104 **G:** But it's after you've had gonorrhoea for a really long time and it's gone untreated I'm
105 assuming.

106 **L:** To be honest I don't know if it would be that way or if it could be a different way.

107 Umm I don't know. I'm not an expert on this.

108 **G:** I think that it's one of those things that like because bacterial STDs umm don't really
109 do too much damage until they've gone untreated for a long time. Syphilis, I think
110 gonorrhea is the same, I'm pretty sure. I would think that if you had meningitis but you're
111 70 years old you're immune system is really compromised so I would discuss with them
112 the fact that they are 70 years old and that their immune system is compromised and
113 make sure that they are taking care of themselves umm but they are in critical condition
114 so that would be a conversation that we had hopefully after they survive.

115 **L:** So, what additional information would you seek out about this case?

116 **G:** Well at this point in time, I haven't been to medical school yet, so I would find out
117 about meningitis caused by gonorrhea. And umm find out you know what, is there any
118 sort of different treatment then umm a earlier case of gonorrhea would be and find out if
119 there is anything that you have to I mean this is a 70 year old patient so they are going to
120 have other issues I mean there is no perfectly healthy 70 year old. So that is probably
121 something I would have answered for the last question.

122 **L:** So there are other health problems.

123 **G:** Yeah I mean what else is you know what else is their history I mean I feel like that is
124 a pretty standard thing. Umm, but I mean 70 year olds with an STD depends again very
125 much depends on where, what part of society they are coming from, what their lifestyle is
126 like but umm you know you really want to find out about the umm the implications of an
127 older person with this infection.

128 **L:** What do you mean the implications?

129 **G:** Like well your body acts differently to things when you are 25 than when you are 70.
130 You are as you get older, your immune system is very very different so it's not going to

131 be able to fight as well as a 25 year old would and especially if you haven't been taking
132 care of yourself. I mean I don't know if this person has or not, hopefully I will find out.

133 **L:** And I guess the last question is how would you use this information to treat the
134 patient, to help treat the patient?

135 **G:** Umm, what kind of doctor am I? Primary care?

136 **L:** That's a good question. Umm, how about you can be whatever you want.

137 **G:** If I am this person's primary care physician once their, if they are in critical care, I am
138 going to be you know I'm not going to be the person that is in charge of their treatment at
139 that point. I'm going to be you know definitely advising on it but I'm not going to be the
140 person that's making the decisions because when someone is in critical care like that and
141 I am a primary care physician, I don't specialize in that, so uh, I am going to make sure
142 that the doctor that is doing the, that is treating my patient really knows I mean I am their
143 primary care doctor I am going to be I am going to know more about them than they
144 would know.

145 **L:** So you are going to make sure you communicate that?

146 **G:** Yeah make sure I communicate. And make sure I follow up, I mean I think that is a
147 big problem, follow-up. And again it's really really different depending on where you
148 are, what kind of medical setting you're in. I've been in such extreme cases of medical
149 setting and I am so hyperaware of how different treatment is unfortunately.

Case 3: Infant w/ Eye Infection

150 **L:** So again first question is "in an ideal world if you were the patient's doctor what
151 would you do?"

152 **G:** The patient's doctor, am I the infant's doctor or the mother's doctor?

153 **L:** You are the patient's doctor, so you are the infant's doctor

154 **G:** I need to talk to this infant's mother because if it's a newborn infant and they are a
155 newborn like newborn I would really want to talk to you really want to get the mother
156 tested for the STD and get the mother tested for gonorrhea because hopefully it came
157 from the mother because sometimes it doesn't come from the mother it comes from the
158 very sick father or uncle umm so that's the first thing I would do is well you would treat
159 the eye infection of the infant but I mean I can't talk to the infant I can't ask the infant
160 any questions so I'm going to be treating the infant with antibacterial and umm making
161 sure that the infant doesn't have any other complications besides the eye infection for
162 example meningitis which apparently might cause that and then once you treat the infant
163 you really want to talk to their parents to see what's going on

164 **L:** Okay you said something about it could come from the father or the uncle

165 **G:** I mean if it didn't come I mean if the mother is not positive for gonorrhea then you
166 really gotta wonder where it came from and unfortunately sometimes it comes from the
167 very sick father or uncle or grandfather or whoever I mean it happens a lot where it
168 shouldn't be and umm so you want to investigate and it's not an easy thing to do but you
169 definitely want to talk with the mother or if she comes up negative for gonorrhea you
170 definitely want to make her consider those things

171 **L:** Umm so in this case what questions well you obviously can't ask the patient but what
172 questions would you ask the patient's parents in this case

173 **G:** Umm the first thing I would do is test the mother for gonorrhea umm and inform the
174 mother of what the issue is and then whether the mother is positive for gonorrhea or not
175 then she really should have been or would have been tested before maybe she got it

176 sometime during the pregnancy umm but umm if the mother is negative for gonorrhea
177 then I would pull the mother in alone and and tell her her results and tell her that she is
178 negative and that her child is positive and that it's a you know sexually transmitted
179 disease and umm you know make her think about where this may have come from and
180 discuss what is going on in her life and it's not an easy conversation to have but it's
181 definitely necessary

182 **L:** Okay okay umm and if she is positive you would explain

183 **G:** If she is positive then I would explain to her what happened and I feel like this is
184 another one of those I have no idea but I think its another one of those things that are
185 treatable and you want to have the same conversation that you have with the 25 year old
186 man you know explain to her the risks of unprotected sex and explain to her that this is a
187 sexually transmitted disease and you know maybe find out if she if she is aware of of you
188 know where this may have come from or even where it doesn't matter where it came
189 from but just make sure that she knows that the risks are that are associated with sexually
190 transmitted diseases because most people that become HIV positive already have already
191 have had 3 or 4 STDs

192 **L:** Okay

193 **G:** And that would be I am very biased but umm my my big concern is always HIV

194 **L:** Okay So what additional information would you seek out?

195 **G:** Would I seek out umm

196 **L:** Yeah

197 **G:** I don't know why I keep asking you about the question that ...It's really going to
198 depend on if she's uh the mother is positive for umm gonorrhea or not I mean it's a

199 completely separate is sue when umm the mother is not positive so you're gonna need
200 you're gonna definitely need to incorporate some kind of umm you know
201 psychotherapeutic or maybe social services with this mother because it's not gonna be
202 solved in the medical setting I mean that's that's gonna need something that's going to be
203 dealt with you're gonna need to address those things so I'm going to seek out that type of
204 information

205 **L:** Okay okay and how would this information that you are gathering how would you use
206 it to treat the patient?

207 **G:** Well if the mother is positive then you're well you're treating the patient by giving
208 my patient is the infant so I'm treating the patient in giving them antibiotics and
209 hopefully curing them of their of their bacterium infection umm and by speaking with the
210 mother in addition to just treating the umm the infant you are you know preparing the
211 mother for you know raising a healthy child umm which helps to treat the patient umm if
212 the mother is negative for gonorrhea umm and you are facilitating your patient into
213 further treatment beyond what you can give them that's a big that's a big thing in helping
214 the mom and the infant because it seems as though they have been born into a very
215 unsafe situation and if you can do anything to take them out of it you're certainly are
216 helping them out you know case management social social worker therapist the works for
217 this situation because this is not a joke and it's definitely continued communication with
218 the mother she just needs to be sure to follow-up with her which would hopefully help to
219 treat the infant

220 **L:** Okay alright so that is the interview so we are done.

Appendix J – Transcribed Notes from Expert Interviews

Matthew Dunn

Case 1: 70 year old female w/ Meningitis

<u>Codes</u>	<u>Notes</u>
	Question 1: In an ideal world, if you were the patient's doctor, what would you do?
P	-I have the diagnosis already
T	-Prompt antibiotics, ceftriaxone at a high dose
T P	-Would consider giving steroids depending on the illness
T P	-Consider supportive care for breathing, blood pressure, thinking
P	-Interesting case – unusual
B P	-Is the diagnosis correct? Is this a lab error? Verify
H M	-Patient history – how did this happen?
H M	-Is the patient sexually active?
H M	-Do they have more than 1 sexual partner?
P	-Bacteremia led to meningitis
	Question 2: What questions would you ask the patient?
P	-History of the illness
P	-When did you get sick?
P	-What is the chief complaint?
P	-What are your symptoms? When did they start?
P	-Any headache, photophobia, neck stiffness, or chills?
P	-Skin lesions or rash indicate disseminated infection
H, P	-Any arthritis?
H M	-Are you sexually active? When was the last time? Are you in an open ended relationship? What is the sex of your partners? How many sexual partners do you have?
H V M	-Do you use condoms?
H	-Comprehensive history
H	-Any hospitalizations?
H M	-Family and social history
	Question 3: What additional information would you seek?
B P	-Is the lab correct? Is this definitely <i>Neisseria gonorrhoeae</i> ?
B	-Use selective growth media and determine growth characteristics
B	-Other lab info to corroborate
B P	-Is the organism in the CSF?
B P	-Cell count, glucose, and gram stain on CSF

B P	-Susceptibility to antibiotics
P H	-Does the patient have a terminal complement component immunodeficiency?

Case 2: Infant w/ Eye Infection

<u>Codes</u>	<u>Notes</u>
	Question 1: In an ideal world, if you were the patient's doctor, what would you do?
T E	-Treat topically, but not sure, so look up
B P	-Confirm diagnosis
P	-More common than last case
T M	-Treat mother for <i>Neisseria gonorrhoeae</i>
V R	-Reportable disease, state initiates contact notification
	Question 2: What questions would you ask the patient?
T	-Intervene for your patients; everyone else sees their doctor
H V M	-Gather mom's sexual history. Number of partners? Condom use?
P	-What are the symptoms?
	Question 3: What additional information would you seek?
B M	-Test mom for other STDs, HIV and syphilis tests, chlamydia and <i>Neisseria gonorrhoeae</i> tests, pelvic exam
T V M	-Treat for Chlamydia anyways

Case 3: 25 year old male w/ Urethral Infection

<u>Codes</u>	<u>Notes</u>
	Question 1: In an ideal world, if you were the patient's doctor, what would you do?
T	-Treat for gonococcal urethritis
T	-Give a shot of ceftriaxone
T V	-Co-treat for Chlamydia
B M	-HIV and syphilis testing
V E M	-Counsel on the use of condoms
	Question 2: What questions would you ask the patient?
P	-What are the symptoms? When did they start?
P	-Any discharge? Any pain with urination? Pain anywhere else?
P	-Has it spread within the reproductive tract?
H V M	-How many partners and contraception use?

	Question 3: What additional information would you seek?
B	-Test results
P	-Are there any coinfections?
V R	-Notify the state health department for contact notification and testing

Michael Kim

Case 1: 70 year old female w/ Meningitis

<u>Codes</u>	<u>Notes</u>
	Question 1: In an ideal world, if you were the patient's doctor, what would you do?
B P	-Question the causative agent
B T	-Identify the agent to treat
H M	-How acquired?
P H M	-Does she have an STD?

Case 2: 25 year old male w/ Urethral Infection

<u>Codes</u>	<u>Notes</u>
	Question 1: In an ideal world, if you were the patient's doctor, what would you do?
T	-Treat the patient
V M	-Identify exposed individuals
H M	-How did acquire?
H M	-What was the initial transmission event?

Case 3: Infant w/ an Eye Infection

<u>Codes</u>	<u>Notes</u>
	Question 1: In an ideal world, if you were the patient's doctor, what would you do?
T	-Treat the patient
H V M	-This shouldn't happen if acquired during birth – pre-screen moms and antibiotic prophylaxis eyedrops at birth
H V M	-What happened? No eyedrops? No screening?
B V P	-Is this antibiotic resistance?

Jill Krump

Case 1: Infant w/ Eye Infection

<u>Codes</u>	<u>Notes</u>
	Question 1: In an ideal world, if you were the patient's doctor, what would you do?
V	-In an ideal world, this wouldn't happen
V M	-Prevention was missed: mother should have been screened and drops placed in the infant's eyes
R	-An eye infection is bad – consult a pediatrician and an ophthalmologist
T	-Give topical treatment right away
	Question 2: What questions would you ask the patient?
H M	-Did the mom have prenatal care?
H M	-Does the mom have an active infection?
H M	-Has the mom been treated for her infection?
H M	-How long has the mom had vaginitis?
H	-How old is the infant?
P H M	-Has the mom had any antibiotic treatment within the past month?
H M	-How many sex partners has the mom had?
B M	-Does the mom have HIV or other STDs?
	Question 3: What additional information would you seek?
H	-Has the infant received prior treatment?
P	-Is the baby eating and behaving normally?
P	-Is the baby sleeping well?
P	-Has the baby been losing or gaining weight?
P	-Does the baby have any rashes?
P	-Is the baby irritable?
P	-Is this a disseminated infection versus an eye infection?
P	-Look out for septicemia or meningitis

Case 2: 25 year old male w/ Urethral Infection

<u>Codes</u>	<u>Notes</u>
	Question 1: In an ideal world, if you were the patient's doctor, what would you do?
P	-Normally see urethral discharge, then diagnose
B R M	-What are the results of the RPR test for syphilis and the HIV test? These tests should have been done by the other physician who gave the diagnosis.
B P	-What are the antibiotic sensitivities of the infection?
H	-Does the patient have any allergies to medications?

	Question 2: What questions would you ask the patient?
P	-How long have you had symptoms?
H M	-How many partners do you have?
V M	-Have you told your partners?
H M	-What is the sex of your partners?
B H M	-Have you been tested for HIV?
P	-Do you have any pain with ejaculation or urination?
H	-Do you have any allergies to antibiotics?
H M	-Have you had gonorrhea before?
	Question 3: What additional information would you seek?
B M	-An RPR and HIV test
R	-This is a reportable disease so it needs to be reported
T	-Treat the patient, then follow-up with him
V E M	-Counsel the patient on safe sex
H R	-Does the patient have any substance abuse problems with drugs or alcohol that require referral to a counselor?
H M	-What are the patient's social patterns/lifestyle?
T	-Am I seeing this patient in an urgent care clinic for the short term or am I the patient's doctor treating them for the long term?
H M	-Does the patient have any mental health problems?

Case 3: 70 year old female w/ Meningitis

Codes	Notes
	Question 1: In an ideal world, if you were the patient's doctor, what would you do?
T	-Treat her in the hospital with IV antibiotics
P H M	-What risk factors does she have?
P M	-Is this a septicemia process? How did she acquire?
H M	-What is her living situation?
H M	-Is this caregiver abuse?
	Question 2: What questions would you ask the patient?
H M	-Where does she live?
H M	-Who is her caregiver?
H	-What is her past medical history?
P H	-Is she immune compromised?
P H	-Does she have any chronic diseases that lower her immune system?
H	-Does she have any allergies to medicines?
H R M	-Might need to contact adult protective services

	Question 3: What additional information would you seek?
P	-What are her vital signs?
P	-Is this a disseminated <i>Neisseria gonorrhoeae</i> infection?
P	-Are there any mental status changes?
H M	-What is her baseline mental status?
B	-Obtain blood cultures
P	-Perform a full exam looking for a rash
B P M	-Does she have any other STDs?
B M	-Order RPR and HIV tests
H M	-Has she had meningitis before?
H M	-Has she had any other prior infections?

Tom Miller

Case 1: 25 year old male w/ Urethral Infection

<u>Codes</u>	<u>Notes</u>
	Question 1: In an ideal world, if you were the patient's doctor, what would you do?
T	-Treat with antibiotics
T	-Follow-up to ensure the infection is gone
	Question 2: What questions would you ask the patient?
H M	-Behavioral questions about his sexual history
P M	-Any other STDs? HIV or syphilis?
P	-Other infections?
B	-Screening and testing
	Question 3: What additional information would you seek?
H M	-Behavioral history

Case 2: Infant w/ an Eye Infection

<u>Codes</u>	<u>Notes</u>
	Question 1: In an ideal world, if you were the patient's doctor, what would you do?
H M	-Question the mother
H V M	-Prenatal screening should catch – Was there prenatal care?
H M	-What is the behavior of the mom and dad?
B	-Screen for other diseases
T P	-Treat the patient right away to prevent meningitis

Case 3: 70 year old female w/ Meningitis

Codes	Notes
	Question 1: In an ideal world, if you were the patient's doctor, what would you do?
H M	-Shouldn't be as promiscuous at her age, caught by common means?
H M	-Behavioral questions
H M	-What is her living situation?
R	-If she lives in a nursing home, talk to the infection control or healthcare workers
H M	-Is this abuse?
T	-Treat quickly this is very severe
	Question 2/3: What questions would you ask the patient or what additional information would you seek?
P	-Assess the patient's mental health
H M	-Does she have Alzheimer's?

Betty Smith

Case 1: Infant w/ an Eye Infection

Codes	Notes
	Question 1: In an ideal world, if you were the patient's doctor, what would you do?
B M	-Test mom and re-test her
V M	-Were prophylactic eyedrops given to the child?
T P	-Can treat with a Beta-lactam antibiotic because organism is Beta-lactamase negative

Case 2: 70 year old female w/ Meningitis

Codes	Notes
	Question 1: In an ideal world, if you were the patient's doctor, what would you do?
B P	-Verify that the causative agent is <i>Neisseria gonorrhoeae</i>
H M	-Ask patient her sexual history
T	-Treat her right away
B P	-Ensure causative agent is not <i>Neisseria meningitidis</i>

Case 3: 25 year old male w/ Urethral Infection

Codes	Notes
	Question 1: In an ideal world, if you were the patient's doctor, what would you do?
T	-Treat right away
V M	-Get sexual contacts
P M	-Check for oral and anal infections

Appendix K – Transcribed Notes from Student Interviews

Katie Art

Case 1: 70 year old female w/ Meningitis

<u>Codes</u>	<u>Notes</u>
	Question 1: In an ideal world, if you were the patient's doctor, what would you do?
H M	-Any past medical history of meningitis or gonorrhea?
P H	-Can the infection be worsened by the patient? Is she immunocompromised?
T	-Give antibiotics to treat
	Question 2: What questions would you ask the patient?
H M	-How many sexual partners has the patient had?
H	-Any previous health problems?
	Question 3: What additional information would you seek?
H	-What is her past medical history?
B T	-Sample culture to determine proper type and dose of antibiotics
B P	-Determine blood type and other basic labwork in case of complications
	Question 4: How would you use this information to treat the patient?
T P H	-Use the patient history for complications and to help determine treatment
B T P	-Sample culture to determine how far along the infection is to determine if more than antibiotics is needed

Case 2: Infant w/ an Eye Infection

<u>Codes</u>	<u>Notes</u>
	Question 1: In an ideal world, if you were the patient's doctor, what would you do?
H M	-Gather mom's medical history
P	-Determine the newborn's health status – is the infection stable or worsening
V	-Administer immunizations
E V	-Encourage breast feeding to boost the immune system
P	-Examine and observe the eye
B	-Sample fluids from infection
P M	-Based on the mom's health status evaluate the infant
	Question 2: What questions would you ask the patient?
H M	-Gather the mom's history from medical records and speaking with her

H M	-Speak with the dad as well
H M	-Patient's can lie, so get both parents stories to see what coincides
	Question 3: What additional information would you seek?
P E M	-Is this an STD or bacterium?
P E	-Need more info about <i>Neisseria gonorrhoeae</i>
H M	-How did the mom acquire the infection? Poor hygiene?
	Question 4: How would you use this information to treat the patient?
E P	-Determine <i>Neisseria gonorrhoeae</i> growth characteristics
V E M	-Help the mom to be more hygienic and healthy

Case 3: 25 year old male w/ Urethral Infection

Codes	Notes
	Question 1: In an ideal world, if you were the patient's doctor, what would you do?
H	-Gather medical history
B P	-Sample infection and see if other causative organisms
P	-Determine if might spread to a UTI
T	-Antibiotics
T	-Drink a lot of water to clean out the system
V E M	-Maintain good hygiene
V E M	-Practice safe sex
	Question 2: What questions would you ask the patient?
H M	-What is their hygiene?
H M	-How many sexual partners in the last 5 months?
H V M	-Do you use condoms?
	Question 3: What additional information would you seek?
H M	-What are his living conditions like?
H M	-Does he live in a bachelor pad? Are his bathrooms dirty and contaminated?
	Question 4: How would you use this information to treat the patient?
H M	-What carried the bacterium? Sex or dirty bathrooms?
V M	-Advise other sex partners to get checked
V E M	-Use condoms
V E M	-Keep bathroom clean

H M	-Cause could be both dirty bathroom and sex contact
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Robin Carter

Case 1: Infant w/ an Eye Infection

<u>Codes</u>	<u>Notes</u>
	Question 1: In an ideal world, if you were the patient's doctor, what would you do?
B	-Rapid test to confirm organism
P M	-Examine eyes for deformities
P M	-Something innate about the child may have caused the disease
B M	-Mother should get tested for <i>Neisseria gonorrhoeae</i>
	Question 2: What questions would you ask the patient?
H M	-Has the mother ever had gonorrhea before?
H M	-Has the mother been treated for gonorrhea before?
	Question 3: What additional information would you seek?
H M	-Does the mother have any other kids who have had this problem before?
H M	-Does the spouse have gonorrhea?
H M	-Is the mother actively on treatment?
E M	-How else can you catch <i>Neisseria gonorrhoeae</i> infections?
E M	-Explore other routes of exposure besides from mom to child during childbirth

Case 2: 25 year old male w/ Urethral Infection

<u>Codes</u>	<u>Notes</u>
	Question 1: In an ideal world, if you were the patient's doctor, what would you do?
B P	-Confirm diagnosis through lab tests
E M	-How can a person in general contract the organism?
H M	-How does this patient think he contracted the organism?
	Question 2: What questions would you ask the patient?
B P	-Possibly other tests to confirm organism is what is causing his symptoms
P	-What are the patient's symptoms?
	Question 3: What additional information would you seek?
E M	-Is it solely contracted through sex?
H M	-If from sex, does the patient know who he got it from?
H M	-If he can get from outside of sex, where else might he have gotten if from?

	Question 4: How would knowing this information help you treat the patient?
V M	-If from sex – refrain from it
H M	-If AIDS – from hospital or drugs
V M	-Identify the source to prevent in the future
T M	-Different sources will be treated differently

Case 3: 70 year old female w/ Meningitis

<u>Codes</u>	<u>Notes</u>
	Question 1: In an ideal world, if you were the patient's doctor, what would you do?
E P	-Does <i>Neisseria gonorrhoeae</i> cause meningitis?
B P	-Lab tests to confirm causative agent
B P	-Test for other causative agents of meningitis
	Question 2: What questions would you ask the patient?
H	-What is the patient's history?
H M	-Has she ever had a <i>Neisseria gonorrhoeae</i> infection or meningitis before?
P	-What are her symptoms?
P	-Do her symptoms suggest meningitis or something else?
H M	-Has she ever been treated for this before?
	Question 3: What additional information would you seek?
H M	-Has her partner been infected with <i>Neisseria gonorrhoeae</i> before?
	Question 4: How would knowing this information help you treat the patient?
T M	-If you can identify the source, then you can target the organism for treatment
T P	-Give appropriate treatment for causative agent and illness
T P H M	-If repetitive, might be recurrent infections or improper treatments

Georgia Grant

Case 1: 25 year old male w/ Urethral Infection

<u>Codes</u>	<u>Notes</u>
	Question 1: In an ideal world, if you were the patient's doctor, what would you do?
T	-Give antibiotics
V E	-Having an STD means you have engaged in risky behaviors, so discuss lifestyle

M	and risks with the patient
T E M	-This is a treatable STD, some are not
	Question 2: What questions would you ask the patient?
P E	-Ask if understand disease
H	-Determine socioeconomic status
T	-Is this a clinic or private practice? Setting determines response
E	-Give pamphlets
V E	-Discuss condom use and unprotected sex
M	
	Question 3: What additional information would you seek?
P	-Gonorrhea is common
T	-Antibiotics should work
P E M	-Talk with the patient about how it's not the biggest deal, STDs happen
	-Don't know if would seek out any more info, should, but probably wouldn't
	Question 4: How would you use this information to treat the patient?
T E	-This involves more than just antibiotics and going home
E	-Help the patient understand, show the patient that you care
V E	-Patients of this age and sex frequently engage in risky behaviors, hopefully a
M	talk about risky behaviors will help

Case 2: 70 year old female w/ Meningitis

<u>Codes</u>	<u>Notes</u>
	Unprompted
P	-I had no idea that <i>Neisseria gonorrhoeae</i> could cause meningitis
	Question 1: In an ideal world, if you were the patient's doctor, what would you do?
H	-Socioeconomic status is very important
T	-Setting determining treatment options
P V E	-Discuss with the patient what they have, how they got it, and how to prevent it
M	
T	-Meningitis could kill, get patient to a hospital and treat
T	-Follow-up with the patient
T R	-Communicate with the other doctors of the patient
	Question 2: What questions would you ask the patient?
P	-I had no idea that <i>Neisseria gonorrhoeae</i> could cause meningitis
P H	-Assume the patient had gonorrhea and ignored it until it became meningitis
P H	-Why have you been ignoring the symptoms?
H	-What is happening in the patient's life?
P H	-70 year old with compromised immune system

V E	-After the patient survives, have a discussion about taking care of self
	Question 3: What additional information would you seek?
P E	-Research meningitis caused by gonorrhea
H	-What other health problems does the patient have?
H M	- A 70 year old with an STD, what is the patient's lifestyle/living situation like?
P	-Old age leads to worse health
	Question 4: How would you use this information to treat the patient?
T R	-Assuming I am primary care, then someone else is treating patient
T H R	-Ensure patient history is communicated to attending physician
T	-Follow-up with the patient is very important

Case 3: Infant w/ Eye Infection

Codes	Notes
	Question 1: In an ideal world, if you were the patient's doctor, what would you do?
H M	-Need to talk with the infant's mother
B M	-Since newborn, need to get the mother tested for STDs
T	-Treat infant
H M	-Could be from father or uncle
P	-Is the baby having any complications?
H M	-Talk with the parents
B H M	-If the mother tests negative for gonorrhea, investigate sick other contacts
	Question 2: What questions would you ask the patient?
B M	-Test mom for gonorrhea
E P	-Inform mom of the problem
B H V M	-Mom should have been tested during pregnancy
B H M	-If mom tests negative, talk with her about where it may have come from
B T E M	-If mom tests positive, explain to her what happened and how treatable
H V E M	-Explain STDs and the risks of unprotected sex to the mom and that STDs increase the risk of HIV
	Question 3: What additional information would you seek?
B M	-Depends if mom tests positive
B H M	-If the mom tests negative, there is a totally different problem
R	-Social services or psych needs to be consulted

	Question 4: How would you use this information to treat the patient?
T	-Patient is the infant, treat with antibiotics
T V E	-Speak with the mother about raising a healthy child, this is also treating the patient
H	-Possibly this child was born into a dangerous situation
T R	-Treating the patient will involve social services and psych care
T	-Communicating and following-up with mom helps to treat the infant

Robert Kimble

Case 1: Infant w/ an Eye Infection

<u>Codes</u>	<u>Notes</u>
	Question 1: In an ideal world, if you were the patient's doctor, what would you do?
T	-Cure infant's infection
	Question 2: What questions would you ask the patient?
H M	-What is the parent's sexual history?
H M	-Do the parents have gonorrhea or have they had it? Have they been treated for it?
	Question 3: What additional information would you seek?
B P	-Full blood panel on infant, eye infection probably visible diagnosed, want to see if missed anything invisible
B M	-Screen parents for gonorrhea

Case 2: 70 year old female w/ Meningitis

<u>Codes</u>	<u>Notes</u>
	Unprompted
P	-Didn't know meningitis was caused by gonorrhea
P H E	-How long does gonorrhea take to be symptomatic? A few years? If so, more history.
H M	-Is the patient sexually active?
B V M	-Get partners tested - Preventative treatment for gonorrhea
T	-Treat current infection
E M	-Safer sex education

Case 3: 25 year old male w/ Urethral Infection

Codes	Notes
	Unprompted
T	-Treat infection
V E M	-Safer sex education
H M	-History of sex partners
B V M	-Inform sex partners and have tested
	Question 2: What questions would you ask the patient?
B M	-Have partner get tested, by who is not really important
	Question 3: What additional information would you seek?
H	-Patient history

Nick Stout

Case 1: 70 year old female w/ Meningitis

Codes	Notes
	Question 1: In an ideal world, if you were the patient's doctor, what would you do?
T	-Give antibiotics
T	-Control the fever and swelling
H M	-Who did she get it from? Nursing home? Gonorrhea from a man?
H V M	-Identify the health risk who gave it to her
	Question 2: What questions would you ask the patient?
H M	-History of sexual activity
H	-Allergies to antibiotics
H	-Current medications
	Question 3: What additional information would you seek?
	-Can't think of anything
	Question 4: Is there anything else this case brings to mind?
P H	-How did this get to meningitis?
H	-What was the standard of care?
P H	-Did she have symptoms before it got to meningitis?

Case 2: 25 year old male w/ Urethral Infection

Codes	Notes
	Question 1: In an ideal world, if you were the patient's doctor, what would you do?
T	-Treat with antibiotics
H M	-Ask about sexual history
V E M	-Push protected sex
V E M	-Speak with about informing recent partners
P	-Is he presenting any other symptoms indicating an illness more severe than an UTI?
	Question 2: What questions would you ask the patient?
H M	-What is the approximate number of partners you had last year?
H V M	-Did you use protection?
H M	-Are you in a monogamous relationship?
H	-Are you allergic to any antibiotics?
H M	-Any history of past infections?
	Question 3: What additional information would you seek?
	-Can't think of anything
B P E	-Drug resistance for <i>Neisseria</i>

Case 3: Infant w/ an Eye Infection

Codes	Notes
	Question 1: In an ideal world, if you were the patient's doctor, what would you do?
T	-Treat with antibiotics by eyedrops
H M	-Talk with the mother and father
P M	-Need to diagnose the mother as well
	Question 2: What questions would you ask the patient?
H M	-What is the mother's recent sex activity?
P M	-Does mom have any symptoms?
H	-History of the infant
H	-Allergies of the infant
H	-Medications of the infant
H M	-Type of birth – C-section or Natural?

	Question 3: What additional information would you seek?
H M	-More sexual history of mom
H M	-Is the mom married? Mutually monogamous?
	Question 4: Is there anything else this case brings to mind?
H	-Talk to the birthing center to see if they know anything helpful
P H M	-Did mom have any symptoms before delivery?
V	-Could it have been prevented in the baby?
T R	-Follow-up with the pediatrician

Appendix L – Infectious Disease Educational Curricula

Non-Comprehensive

Epidemiology

Epidemiology is the study of factors that affect the health and illness of populations. In 2001, Deutch devised an investigative project for the microbiology unit of a non-majors biology course. His students were asked to investigate the microbial contamination of raw chicken wings. The students were asked to report their results to a food company which was concerned about how to prevent food poisoning. Once the students mastered a simple protocol for isolating bacteria from chicken wings, they were given the task of devising a method to decontaminate the raw wings. The students were horrified by the original levels of contamination on the chicken wings and were engaged in devising a method to decontaminate the chicken wings. This lab allowed students to explore the many of the problems associated with food poisoning.

Hammond et al. (2002) designed an activity in which students are given the task of investigating an outbreak of food poisoning. Before students begin their investigation, they are given the opportunity to practice gram staining and streak plating techniques, as these simple techniques will be very useful in their experiments. Students then survey samples of the “suspect” apple juice for the presence of *Escherichia coli* bacteria, which may be the source of the food poisoning.

Sorensen (1998) suggests inviting a public health official into the classroom to present AIDS surveillance data to the class. The students can then perform epidemiological calculations on the data and hopefully take home a prevention message.

Transmission

Transmission refers to the mechanism(s) by which an infectious disease spreads through a population. There are many different simple activities designed to model the transmission of an infectious disease among students (Jones, 1993; Waugh, 2003; Edwards, 1999; Grimes et al., 1998; Howard and Nozicka, 2000; Kelly, 1998; Link and Cardinale, 2007). Such activities include “exchanging” mock body fluids or demonstrating transmission from direct skin contact or contact with inanimate objects known as fomites. Most of these activities use “invisible” simulated pathogens that after “transmission” can be visualized via a chemical reaction or blacklight. By asking students to keep track of their “contacts and exposures” they can trace the infectious disease back to the source and learn a little about epidemiology.

Adamo and Gealt (1996) suggested using nematodes to study fomites and vectors, living organisms that do not cause disease by themselves, but transmit disease by carrying the pathogen from one organism to another. The students isolate nematodes from soil samples and feed them only pure strains of bacteria until the nematode gut contains only the pure bacteria. Students can then design experiments to investigate the fomite and vector properties of the nematodes.

Koch’s postulates of disease are traditionally the standard by which an infectious agent is concluded to be the causative agent of disease. Koch’s postulates can be safely modeled by viewing yogurt as the “disease” and milk as the “patient.” Students first isolate pure cultures of bacteria from yogurt. Then they “infect” milk with these “pathogens.” If the milk turns into yogurt, it has been “infected” with the “disease.” The

final step in modeling Koch's postulates is to isolate the same pure cultures of bacteria from the new yogurt (Coleman, 1995).

Prevention

Prevention involves acts designed to inhibit the transmission of infectious disease through populations. Goetsch et al. (2002) developed a protocol to "vaccinate" the New World bean plant against the Tobacco Mosaic Virus. While not well understood, plants have the ability to generate systematic acquired resistance to pathogens from a mild exposure. Using this safe model system, students can "vaccinate" their own plants and observe how the vaccination prevents infection by the Tobacco Mosaic Virus.

All healthcare workers need training in handling body fluids safely. Waechter-Brulla (2002) pairs up blood-borne pathogen training with critiquing the handling of blood-borne pathogens in the movie *Outbreak*.

Kerr and Elwell (2002) developed a method of teaching several hundred students at once about the preventing the transmission of tuberculosis. They obtained help from the local public health department in putting together a forum for the students. In addition, teachers were encouraged to further the lessons in their classrooms and students were encouraged to share the information with their families.

Pathogen Biology

Pathogen biology is the study of the characteristics of an organism that can cause infectious disease. Gillen and Mayor (1995) designed a modeling activity in which students made colored paper models of icosahedral-shaped rhinoviruses. The different colors represented antigenic variation among the different serotypes of rhinoviruses.

Scientists at the University of North Carolina at Chapel Hill developed a nanoManipulator, which allows scientists to remotely control the tip of an atomic force microscope as it examines a sample. By teaming up with classes, students were given the opportunity to use the nanoManipulator to remotely observe an adenovirus particle. This helped the students to learn more about microscopy and the relative size of microorganisms (Jones et. al, 1999).

Host Pathogen Interactions

Host pathogen interactions consist of the study of the effects a pathogen has on a host and the effects a host has on a pathogen. Houston et al. (2002) have developed an activity in which teams of students are assigned to research either the host defense factors against a specific pathogen or the pathogen's virulence factors. Once the students have researched their respective topics, they have an "immune war" competing to see whether the pathogen or host wins the battle.

Shupp et al. (2005) have developed a laboratory activity in which students grow pure cultures of mouse macrophage cells and *Escherichia coli* bacteria. The students then observe the macrophages ingest bacteria via phagocytosis and monitor the lethal activity of the macrophage on the bacteria. Terry (2002) has designed a worksheet to accompany a Flash multimedia learning object that explores phagocytosis. The students use the worksheet to guide them through learning how plague and tuberculosis bacteria avoid phagocytosis.

Merkel (2003) describes an set of in-class microbiology activities. One of the activities is designed to help students learn more about the virulence of pathogens and how the immune system responds to pathogens. Snitkoff's (1999) students complete

projects in which they are tasked with creatively teaching an immunology concept to the class.

Antimicrobial Compounds

Antimicrobial compounds are chemicals that inhibit the growth of or kill microorganisms. Instead of studying traditional antimicrobial compounds, students can test natural plant extracts for antimicrobial activity (Finer, 1997; de Castro-Ontengco and Capal, 2004). This allows students the opportunity to research natural and herbal infectious disease treatments and prevention strategies. From their research, students can plan out experiments to test various natural compounds for antimicrobial properties. The most exciting part of these activities is that some plants and herbs do exhibit antimicrobial activity. Benathen et al. (2004) designed a laboratory in which students investigate the antimicrobial properties of the blue pigment produced by *Pseudomonas aeruginosa*. Lots of soil microorganisms produce antimicrobial compounds. Gallo (2001) designed an activity in which students isolate actinomycetes and fungi from soil and test their antimicrobial activity.

Cooper (2001) describes an activity in which students can test various antiseptics and disinfectants for their antimicrobial activity on different cultures of bacteria. The students “contaminate” paper clips with the bacteria and then soak the paper clips in the test solutions for different amounts of contact time. The paper clips are then put into broth, which is incubated and observed for growth.

Anglehart et al. (2005) describes an activity in which students test the effectiveness of household cleaners and antimicrobials on their own skin flora. Gaydos

(2005) attempts to teach students the scientific method while they test antimicrobial chemicals for their effectiveness in soap.

Antibiotics target unique features of bacterial cells. Many antibiotics target components of the cell walls of bacteria. Merkel (2001) developed an activity in which students use their knowledge of bacterial cell walls to help them interpret mock data about antibiotic effects on a bacterial culture. Hampikian (1999) designed an activity in which students role play the mechanism of action for antibiotics. Some students are assigned to play parts of the cell, while others act as specific antibiotics. The remainder of the class guesses the antibiotic based on its actions on the cell.

Antimicrobial Resistance

Antimicrobial resistance occurs when a pathogen has been repeatedly exposed to an antimicrobial chemical. Sometimes the pathogen is able to acquire genes from the environment or mutations in their own genome are selected for. These new genes or mutated genes change the characteristics of the pathogen so that the antimicrobial chemical is no longer effective on the pathogen.

When studying antibiotic-resistant bacteria, students are often surprised and intrigued that such bacteria are common in their everyday environment. In 2003, Omoto and Malm published procedures for safely isolating students' microbial flora and testing the isolates for antimicrobial resistance. Brock et al. (2004) developed a laboratory protocol in which students isolate and characterize antibiotic-resistant bacteria from common vegetables. Woolverton and Hawkins (1999) designed a protocol for isolating environmental samples of *Escherichia coli* and testing them for antimicrobial resistance.

By performing these activities students are better able to grasp the vastness of the antimicrobial resistance problem.

Welden and Hossler (2003) designed an experiment in which students can induce biocide resistance in *Escherichia coli*. In this experiment, students induce resistance to triclosan, a common antimicrobial in household products and cosmetics. The authors' students were able to observe that subsequent exposures to triclosan caused the bacteria to evolve resistance to triclosan. This simple activity helps students to see how the overuse and misuse of antimicrobials contributes to the problem of antimicrobial resistance.

Snow (2004) has her students make large scale models of the transfer of genetic material among bacteria. The students view internet sites and watch some video clips before designing their models. The students are then asked to explain how genetic transfer relates to antimicrobial resistance.

Biomedical Technology

Biomedical technology is laboratory tests or assays that aid in the identification of infectious diseases and help to characterize pathogens. Verran (2005) has developed a simple lab activity in which students perform some of the simple diagnostic tests available to dentists. These tests center on identifying tooth decay and gum diseases.

Stuart and Cox (2000) use mock enzyme-linked immunosorbent assays (ELISA) and western blots to teach students how laboratories test blood samples for human immunodeficiency virus. Measuring the bacterial antibodies from chicken eggs is an indirect measure of bacterial contamination within chicken flocks. Students can use ELISA to screen chicken eggs for bacterial antibodies (Ogden, 2000). Pommerville et al.

(2001) have developed an activity in which students act out an indirect ELISA reaction with large scale props.

Katz and Leyva (2007) have modified a Kirby-Bauer laboratory activity designed to measure antimicrobial susceptibility of organisms to help students understand better the nature of antimicrobial resistance. Students repeat the test multiple times with different strains of the same bacteria. They will get different susceptibilities to different antimicrobials for each strain. Mitchell and Carter (2000) had their students use the Kirby-Bauer method to determine the sensitivity of a microorganism to bleach. Then, using Minitab statistical software, the students performed linear, quadratic, and cubic regression analyses. Then, the students were asked to determine the best fit model based upon mathematical and biological properties.

Microbe Library has a protocols section of their curriculum references. Each article in this section explains the history, purpose, theory, and use of standard microbiological media and tests. These media and tests are designed to aid in the identification and differentiation of bacteria. Many of these tests are used to help in identifying pathogenic organisms responsible for infections. Such media and tests include: triple sugar iron agar, blood agar and hemolysis, macconkey agar, CAMP test, mannitol salt agar, ELISA, eosin-methylene blue agar, and cytopathic effects of viruses (Lehman, 2005; Buxton, 2005; Allen, 2005; Hanson, 2006; Shields and Tsang, 2006; Fan, 2006; Lal and Cheeptham, 2007; Suchman and Blair, 2007).

Microbial Ecology

Microbial ecology is the study of the distribution of microbial life and the interactions of microbial life with their environment. Williams and Gillen (1991) devised

a simple activity to help students place infectious disease in its appropriate ecological niche within microbiology. To do this, they helped students to focus on the many benefits from microorganisms in the kitchen. Many foods such as: cocoa beans, coffee beans, olives, peas, pickles, sauerkraut, yogurt, and soy sauce depend on microorganisms for their production.

Boomer's (2006) students complete a project in which they investigate the proteobacteria in local rivers. The students perform microbiological tests to identify natural environmental proteobacteria and fecal contamination proteobacteria.

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