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The Germ of Death Itself: A Study of Tuberculosis and Community Education in Ghana

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ABSTRACT

Background: Tuberculosis remains a significant threat to global public health, despite advancements in treatment and detection in recent decades. Treatment regimens are unpleasant and time-consuming, particularly when the disease-causing strain is partially or completely drug-resistant. Approximately one-third of the global population is currently infected with tuberculosis, but the majority of these cases are dormant and non-contagious. These dormant cases are more difficult to diagnose, but if the immune system is compromised, as in the case of HIV/AIDS, the individual will transition to an active and contagious case of tuberculosis. Resistant strains are increasing around the world, making treatment of a potential future drug-resistant tuberculosis pandemic all the more difficult.

Purpose: The purpose of this study is to examine the relationship between trends in tuberculosis prevalence, and community education regarding the nature of the disease. This study analyzes data collected in the West African nation of Ghana, which is considered to have a high-burden tuberculosis and HIV/AIDS epidemic. The study period is between 2008 and 2014, and examines the relationship between accuracy of tuberculosis education and trends in tuberculosis prevalence, over that time period.

Methods: This secondary data analysis used data from the Ghana Demographic and Health Survey, performed by the United States Agency for International Development. SPSS statistical software was used to relate tuberculosis prevalence numbers to correctness of tuberculosis-related responses in the Ashanti, Eastern and Northern regions of Ghana.

Results: Data analysis indicates limited improvement in correctness of tuberculosis-related education in the three districts, between 2008 and 2014. Ordinal regression indicates a weak or negligible difference in correctness of responses between the three districts under study.

Conclusion: While the DHS survey data is extensive, only a small proportion of the survey questions are related to tuberculosis knowledge. In addition, the data did not support a strong relationship between community levels of education, and tuberculosis prevalence trends.

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Introduction

Tuberculosis infection is the second leading cause of infection-related death, after HIV/AIDS (World Health Organization [WHO], 2016b). The majority of deaths from tuberculosis happen in the developing world (WHO, 2016b). Approximately one-third of people around the world are infected with tuberculosis which is not currently active, but which may become active if the immune system is compromised (WHO, 2016b). Because HIV/AIDS diminishes the victim's immune system, it is natural that HIV/AIDS and tuberculosis will each exacerbate the negative impacts of the other (WHO, 2016b). Approximately one-quarter of deaths in those infected with HIV occur due to tuberculosis (WHO, 2016b). In modern times, increased travel between nations makes it more likely that infected individuals will travel to areas in which tuberculosis is not endemic, making the disease a global public health threat, rather than merely a local one (Centers for Disease Control and Prevention [CDC], 2012).

Tuberculosis has a clear and significant impact on social and cultural stability in the nations in which it is endemic. Quality of life is severely decreased in those who are infected, and the impact on psychological health and family stability is correspondingly severe (Dhuria, Sharma & Ingle, 2008). Social support has been shown to contribute to recovery and positive outcomes, but naturally this support tends to disintegrate as the society's overall stability declines (Sengupta et al., 2006). Economic stability is also negatively impacted by tuberculosis, particularly because individuals of lower socioeconomic status [SES] are most likely to become infected with tuberculosis, and treatment may deplete their already-limited financial means (Barter, Agboola, Murray & Barnighausen, 2012). The economy suffers also because tuberculosis disproportionately impacts young adults, who are the most likely to be working and productive members of society (WHO, 2016b).

Although the incidence of tuberculosis has declined globally, in sub-Saharan Africa, the trend has been the opposite, due to a number of factors. One is the parallel HIV/AIDS pandemic; the immune system depletion of HIV/AIDS tends to make full-blown tuberculosis infection more likely (Tarekegne et al., 2016). Research indicates that young adults are the group most likely to experience tuberculosis and HIV/AIDS co-infection, increasing the threat to social and economic stability (Tarekegne et al., 2016).

This study focuses on the sub-Saharan nation of Ghana, which is located along the western, or Atlantic, coast of the African continent (WHO, 2016a). Ghana is listed as a "high-burden" nation in terms of both HIV/AIDS and tuberculosis infections (WHO, 2015). In 2014, 282 out of every 100,000 Ghanaians were infected with tuberculosis, and 36 of 100,000 died of the disease (WHO, 2016a). One-quarter of tuberculosis-positive individuals in Ghana are co-infected with HIV/AIDS (WHO, 2015). However, lack of infrastructure in Ghana means that the tuberculosis case detection rate is very low, only 33 percent (WHO, 2015). Also, very little data is maintained by Ghanaian health authorities about the proportion of tuberculosis cases which are drug-resistant (WHO, 2015). This paucity of monitoring may be linked to the overall poverty and lack of education in Ghana (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2010). Low literacy and school-enrollment rates are large contributors to this problem, although recently there has been a great deal of improvement in these areas (UNESCO, 2010).

This study will focus on the level of tuberculosis-related education and awareness in three of ten regions of Ghana (see Figure 1 below): the Ashanti, Eastern and Northern regions (United States Agency for International Development [USAID], 2016). The data analysis will compare levels of awareness to changes in tuberculosis prevalence in those same regions. Trends

in education level, based on correctness of answers to tuberculosis-related survey questions, will be correlated to changes in tuberculosis prevalence, in order to examine the potential relationship between these two trends. This relationship, if any, will then be examined as a part of the larger body of literature surrounding tuberculosis infection and the impact of community education on infection prevalence. This larger literature-based understanding will then inform discussion of the significance of this study's results.

Figure 1. Map of Ghana. Displays the location of the regions discussed in this research. *Map from Ghana Statistical Service Demographic & Health Survey, 2009*

Given the current trend toward prevention and cost-control in healthcare and public health, community-based education is a natural model to turn to when attempting to prevent and control tuberculosis. Loveman et al. (2003) demonstrates how patient education can increase treatment adherence and success, and how this method is relatively cost-effective and not time-consuming. With regard to tuberculosis specifically, treatment adherence has been shown to improve with patient education. For instance, Rondags, Himawan, Metsemakers and Kristina (2014) showed that a lack of knowledge regarding tuberculosis is a major reason for non-adherence to treatment. Patients who display a lack of understanding of treatment methods and

duration have been shown to be more likely to stop treatment before it is complete (Ibrahim et al., 2013). A review of studies by M'imunya, Kredo and Volmink (2012) provides a range of evidence demonstrating that education and counselling are effective at increasing adherence to tuberculosis treatment.

Ideally, this study will contribute to the larger body of research surrounding tuberculosis prevention, as well as how community education may have a positive impact on prevention of infectious disease. Adherence to treatment is critical to preventing the onset of resistance, and education has been demonstrated as being critical to improving adherence (M'imunya et al., 2012). It may be possible to weave community education into already-existing structures, such as education programs for healthcare workers [HCWs] (Malangu & Adebanjo, 2015). Community education is a relatively inexpensive way to reduce infectious disease, ultimately bringing about a decrease in healthcare spending nationwide. Increased contact between community health organizations and the public also increases trust and communication, theoretically promoting the likelihood that an infected individual will receive treatment and regain health. An education-based model dovetails well with current trends in public health, which tend to focus on prevention.

Theoretical Foundation

This study relies on a number of public health theories and models. Some of these center entirely around individual-level behaviors and perceptions. These include the Health Belief Model [HBM], the Theory of Planned Behavior [TPB] and the Transtheoretical Model [TTM]. A second group consists of theories and models which examine both individual- and community-level factors, specifically the Social-Ecological Model [SEM] and the Sociocultural Theory [SCT]. The final group consists of models which examine community-level factors: the

Community Organization Model [COM] and the Sociocultural Environment Theory [SCE]. Both of these levels of study are germane to this paper; tuberculosis knowledge circulates among close relationships, and that circulation is impacted by the capacity and characteristics of the community in which it exists.

Health Belief Model

This model addresses the beliefs of individuals regarding a particular disease, in an effort to understand why some people participate in health-promoting behaviors, and others do not (NCI, 2005). The HBM was originally developed in order "to explain why so few people were participating in programs to prevent and detect disease", making it particularly germane to behaviors which would help to eradicate infectious disease (National Cancer Institute [NCI], 2005, p. 20).

The HBM focuses mostly on the perceptions of individuals, regarding their susceptibility to illness, the severity of that illness, the benefits of the health-promoting behavior, and the nature of any barriers which exist to carrying out that behavior (NCI, 2005). Tuberculosis education, if well-executed, would help to bring individuals' level of perceived susceptibility in line with reality (Wong & AbuBakar, 2013). That is, a person who believes that they are not at risk of developing tuberculosis because they are young and healthy is unlikely to seek tuberculosis screening. A well-informed person, however, would be aware that tuberculosis typically remains dormant in a healthy individual, and that testing might be beneficial, even to a healthy person.

Perceived severity relates to the individual's understanding of the nature of the disease's symptoms, and the associated risk of death (NCI, 2005). In relation to tuberculosis, this might

include this awareness that reduction in immune system strength can lead to illness in those who were previously healthy, as well as the existence of drug-resistant strains which are more likely to lead to death.

Two other useful HBM constructs are perceived benefits and perceived behaviors. A person is more likely to proceed with a health-promoting behavior if they understand its potential benefits (NCI, 2005). In this context, awareness that treatment is even possible is not universal, therefore increasing the awareness that tuberculosis can be cured if it is adequately treated is important. This is particularly vital with tuberculosis, the treatment for which is arduous and requires absolute adherence. This last point also relates to perceived barriers; a person's understanding that treatment will be difficult, but it is accessible and can be completed successfully, is critical to continuation of and adherence to treatment (Wong & AbuBakar, 2013). Of course, this supposes that treatment is indeed available in this person's community, which is not necessarily true in all parts of the world; this issue will be discussed later in this paper.

Additionally, the HBM construct known as "cues to action" is relevant to the tuberculosis context. Cues to action "[p]rovide…information, promote awareness, and employ reminder systems" (NCI, 2005, p. 21). In the case of infectious disease, these may include symptoms of the disease in question, as well as interpersonal cues from other individuals which prompt the person to seek or continue treatment (NCI, 2005). In the case of tuberculosis, it may be imagined that a person who is knowledgeable about the disease's symptoms is more likely to recognize them and seek treatment. Additionally, others are more likely to prompt the infected individual to seek treatment if they possess adequate tuberculosis-related knowledge. The process of gaining knowledge, for example by consuming written or spoken information, may itself serve as a cue to action in this instance.

A final HBM construct, and perhaps the most vital in this context, is known as self-efficacy (NCI, 2005). Self-efficacy is described as "[c]onfidence in one's ability to take action", or whether an individual believes that his or her attempts to engage in a health behavior will be successful (NCI, 2005, p. 21). Increased self-efficacy in turn increases the likelihood that a person will in fact perform the behavior. This construct is therefore critical to the individual's eventual behavior, and naturally self-efficacy is a part of several of the other individual-level theories and models discussed later in this behavior (NCI, 2005).

The HBM is useful in the tuberculosis context, however it does have some limitations, such as the lack of consideration of socio-cultural factors, and the differences in individual access to and availability of healthcare-related resources (Boston University School of Public Health [BUPH], 2016). This may particularly be relevant to the region of West Africa, which is generally a region which displays a low socioeconomic status [SES].

Theory of Planned Behavior

The TPB is very similar to the HBM, but it does serve the needs of this study, in that it provides some insight into social and cultural factors related to health behaviors and outcomes. Like the HBM, the TPB focuses on an individual's disease- and health-behavior-related beliefs and intentions (NCI, 2005). The more positive the beliefs, and the stronger the intention to undertake the behavior, the more likely that the theoretical individual will indeed participate in the health behavior in question (NCI, 2005). The TPB also includes the concept of "perceived behavioral control", which is essentially the same as the aforementioned self-efficacy (NCI, 2005, p. 24). Naturally, a greater degree of perceived control over one's health increases the

likelihood that an individual will engage in health-promoting behaviors (NCI, 2005).Positive expectations of success, and positive beliefs about one's control, will lead to a more positive attitude towards undertaking the health behavior, in this case receiving treatment for tuberculosis (Munro, Lewin, Swart & Volmink, 2007). Combined with positive beliefs that treatment will reduce one's symptoms, the belief that one is capable of accessing treatment and sticking with it, increases the likelihood that treatment will occur and continue (Munro et al., 2007).

There are two concepts which distinguish the TPB from the HBM, which are called subjective norms and social norms (NCI, 2005). Subjective norms relate to the views of others who are close to the individual in question (NCI, 2005). That is, will the individual's family, friends and other key individuals view this health behavior positively? If so, this increases the likelihood that the individual will participate in the behavior (Munro et al., 2007). In the tuberculosis context, an individual who believes that his or her loves ones feel positive about their treatment, and want them to stick with it, are more likely to start and adhere to treatment regimens (Munro et al., 2007). Social norms are those cultural standards and customs which help to shape an individual's own beliefs and choices about what behaviors are appropriate (NCI, 2005). Community and individual education about the causes and treatment of tuberculosis might increase communication and trust between community members and the healthcare infrastructure. Over time, increased trust makes it more socially acceptable to seek out modern medical care when suffering from tuberculosis (Addisu, Birhanu, Tilahun & Assefa, 2014). Research does indicate a relationship between positive beliefs on the TPB constructs, and treatment intentions and adherence among tuberculosis patients (Addisu et al., 2014).

The TPB displays similar limitations to the HBM, in that it does not address individual or community-based differences in access and resources (BUPH, 2016). This assumption that every

person's ability to access and pay for healthcare is equal is a hindrance, particularly when discussing an economically disadvantaged nation such as Ghana.

Transtheoretical Model

The TTM focuses on behavioral change, or more specifically, intent to change behavior, over the course of time (NCI, 2005). The first stage is pre-contemplation, in which the individual has no plans to change their behavior; contemplation is logically the next stage, in which the individual is planning a behavior change in the near future (NCI, 2005). Next is preparation, which consists of roughly the month just before the behavior change occurs (NCI, 2005). Action is the early stages of behavior change, maintenance is the continuation of that change, and termination is characterized by long-term continuation of the behavior change (NCI, 2005).

When related to tuberculosis, the behavior change would be participating in testing and, if disease status is positive, treatment. Pre-contemplation individuals in this context would be those who have little or no knowledge regarding tuberculosis, and in some cases who may accordingly hold incorrect beliefs about the disease. Interaction with health educators, public health workers or healthcare workers might prompt an individual in the contemplation stage to move towards the action stage, ideally followed by the maintenance and termination stages (Naar-King et al., 2008).

The TTM also includes a number of terms to describe events or interactions which might prompt an individual to move from one stage to the next. Consciousness-raising is one, which in this context might consist of the process of tuberculosis education itself, which would naturally serve to increase awareness of the threat posed by tuberculosis (BUPH, 2016). The TTM construct known as social liberation is also relevant, as it addresses the degree to which one's

society supports the pursuit of treatment and adherence to it (BUPH, 2016). Individuals in all stages of the TTM have been shown to benefit from activities and events which increase their self-efficacy and perception of social and cultural support (Naar-King et al., 2008). These help to encourage individuals to move through the TTM stages in a positive direction (Naar-King et al., 2008).

As with the HBM and the TPB, the TTM does not address SES or other resource- or access-related issues which might impact individuals and communities (NCI, 2005). Further, the TTM is constructed as though people only move in the forward direction; in reality of course, people may slide backwards in the TTM timeline (BUPH, 2016).

Sociocultural Theory

The SCT's central focus is on the interaction between different factors which impact individual behavior (NCI, 2005). This SCT construct is known as "reciprocal determinism", which describes the interaction between the individual, his or her experiences, and his or her sociocultural environment (NCI, 2005). The SCT posits that what people do to change and improve their health is based on this interaction of these three pieces; the result of this interaction changes as the person goes through life and has additional experiences, or as societal and cultural factors fluctuate (NCI, 2005). This reciprocal interaction of factors may be particularly relevant in areas of socioeconomic deprivation, in which economic factors may have more impact on the prevalence of infectious disease than individual beliefs or cultural norms (Ho, 2004).

The "behavioral capability" construct describes an individual's abilities, skills and knowledge, and how these combine to create the person's ability to engage in a given health behavior (BUPH, 2016). Behavioral capability, naturally, is increased as health education takes

place. “Reinforcements” are factors which make an individual more likely to continue with treatment (BUPH, 2016). This concept is particularly relevant to tuberculosis, given that strict adherence to treatment is vital, and the treatment process is quite difficult (WHO, 2016b). The concept of “expectations” is also important, because if an individual expects that the health behavior will ultimately result in a positive outcome, this will increase their motivation to continue with treatment; the converse is also true (BUPH, 2016). In the context of tuberculosis, research shows that the reciprocal interaction between social factors such as disease-related stigma, personal experience, and individual education plays a significant role in whether infected individual seek treatment for tuberculosis (Nyasulu et al., 2015).

Interestingly, the concept of self-efficacy, which was discussed previously in this paper with relation to the HBM and the TPB, was initially developed when the SCT was created (BUPH, 2016). The SCT is somewhat limited in that it is based on the assumption that change in one of the three interacting “pieces” will automatically result in a change in the other two (BUPH, 2016). The SCT is also focused exclusively on personal experience and learning, without reference to emotions or biological factors (BUPH, 2016).

Social-Ecological Model

Figure 2. The Socio-Ecological Model. Illustrates the components of the SEM. *Figure from Boston University School of Public Health, 2016.*

As seen in Figure 2 above, the SEM is a multi-level model which examines individual, interpersonal, community-level and society-level factors, and how these may interact and influence one another to create behavioral patterns (CDC, 2015). Individual-level factors are related to "biological and personal history" (CDC, 2015). In the infectious disease context, this might include the strength of one's immune system and how effectively it is able to fight off the tuberculosis bacterium. Relationship-level factors are interpersonal factors which bring a person more or less in contact with either the infectious agent. An individual's contact with others may also make them more or less likely to receive prompting to be tested or treated for tuberculosis, and to adhere with treatment once it has begun.

The community level in the SEM involves "the settings, such as schools, workplace or neighborhoods, in which social relationships occur and…the characteristics of these settings" (CDC, 2015). Again, one's physical environment can make one more or less likely to come into contact with the tuberculosis bacterium. It may also impact the availability of treatment facilities,

medications and other treatment-related resources. The final and broadest level delineated by the SEM is the societal level; this "includes social and cultural norms…[and] health, economic, educational and social policies" (CDC, 2015). In terms of tuberculosis, this may relate to disease-reporting laws, detection initiatives, the allocation of human and economic resources to combating the disease, and customs or taboos which might make a person more or less likely to receive and continue with treatment.

Community Organization Model

The COM is particularly relevant to the issue of tuberculosis education and knowledge levels. This model addresses a given community's ability to deal with public health issues, the awareness level of community members, and the salience of the issues being addressed to the members of the community (NCI, 2005). Specifically, the COM construct known as community capacity relates to "characteristics of a community that affect its ability to identify, mobilize around, and address problems" (NCI, 2005, p. 24). In communities with low SES, lack of access to reliable electricity, running water, transportation, and effective communication methods may exist (NCI, 2005). These difficulties may negatively impact the ability of a community to work together to solve public health problems (NCI, 2005). As noted above, Ghana is not considered a wealthy nation, and infrastructure is generally poor, so this concept is helpful when studying Ghana.

An additional important COM construct is called critical consciousness (NCI, 2005). This construct addresses "social, political and economic forces that contribute to social problems (NCI, 2005, p. 24). It is vital to be aware that in low-SES communities, poverty may

significantly decrease community members' ability to adjust work and childcare schedules to take the time to receive long-term, thorough tuberculosis treatment (NCI, 2005). A lack of educational opportunities in a community may mean that there are fewer trained healthcare workers available to provide care, particularly the intensive treatment required to deal with tuberculosis (NCI, 2005). Like the community capacity construct, critical consciousness may be used to examine a lack of access to transportation, plumbing, and electricity.

Finally, the COM construct of issue selection highlights the importance of focusing on public health issues which are particularly significant to the community (NCI, 2005). Issue selection also promotes the creation of "immediate, specific, and realizable targets for change" which are ideally formed with the participation of the community members themselves (NCI, 2005, p. 24). Focusing on issues which are particularly salient to the community increases the engagement of community members, and increases the likelihood that the community will make and stick to, necessary changes in health behavior (NCI, 2005). Because it is so vital that tuberculosis patients adhere strictly to their treatment regimens, and because this can be difficult to fit into a patient's social and community relationships, it is key that the entire community be engaged in supporting the treatment and prevention of tuberculosis. Furthermore, in many communities, tuberculosis is a serious, entrenched and long-term problem. It is vital that when attempting to reduce the incidence and impact of tuberculosis, public health officials have realistic goals in place. Community members themselves are aware of the impact of disease on their daily lives, and as such they may be extremely helpful in setting appropriate goals.

Sociocultural Environment Theory

The SCE addresses a number of facets of the community culture which may impact the way a community addresses public health issues (NCI, 2005). For example, the SCE addresses

community norms and customs (NCI, 2005). It is important to understand that some communities may have cultural norms which may make people less likely to seek care from modern medical providers. This may be particularly true with regard to tuberculosis, the treatment for which may involve long separation and isolation from one's community. It is also important to know what legal systems may be in place to compel individuals to undergo treatment and isolation; this of course will vary depending on the country and community in question.

The SCE also addresses opportunities to develop healthcare capacity, education capacity, and healthcare promotion and prevention (NCI, 2005). Increasing the number of healthcare and public health professionals will increase the capacity of the community to deal with a problem like tuberculosis, by increasing the effectiveness of options like directly observed treatment short course [DOTS]. Increased prevention of tuberculosis itself, and of the onset of resistance, can be improved by increased education of the community at large, regarding the nature of tuberculosis, and its inherent dangers. This increase in awareness may also lead to an increased ability to identify cases, further improving the chances of preventing the spread of tuberculosis and of resistance.

Literature Review

The purpose of this study is to examine the extent, quality and impact of tuberculosis-related education in Ghana, as well as to identify gaps that are well-suited to health education interventions. Therefore, this literature review will begin by discussing papers which offer background information on the extent of the worldwide tuberculosis epidemic. This background

information, particularly about the complexity of treatment. This information is also crucial to make it clear that tuberculosis is challenging to treat, and why adherence to treatment is such a problem. The extent of the global pandemic is also discussed in this section, in an effort to make the extent of the global public health threat, and the importance of this and related research, clear to the reader.

The second section examines the nature of drug-resistant tuberculosis. This section again serves to communicate the nature of the public health threat. The presence and diversity of resistant strains also shows why tuberculosis-related community education may be difficult. This may be especially true in disadvantaged areas of the world, in which education is not generally robust. The third section will examine which discuss the nature and extent of tuberculosis in West Africa, the region which contains Ghana. This section will include a review of the most recent tuberculosis-related research taking place in this area of the world. There is also a strain of tuberculosis which is endemic to this region of Africa, which will be discussed in this section.

The fourth section of this literature review focuses on social, economic and cultural factors which impact education and treatment related to tuberculosis. These include socioeconomic factors which put certain populations at a disadvantage, as well as cultural norms which negatively or positively impact one's access and adherence to treatment.

The fifth and final section of this literature review will focus more specifically on how educational efforts may positively change the global picture of tuberculosis. The papers discussed in this section will examine the positive impact of community education on tuberculosis and other infectious diseases, to make the case that education can be a tool in the arsenal of public health workers who are attempting to combat tuberculosis.

Tuberculosis Around the World

Historical context. Harries and Dye (2006) provide a comprehensive review of tuberculosis in past and present, noting that the bones of Egyptian mummies display signs of tuberculosis, and that genetic analysis of the tuberculosis bacterium indicates even a significantly longer span of existence for this pathogen. With the onset of the Industrial Revolution, tuberculosis became "the leading cause of death in most European countries, with annual incidences of the disease reaching as high as 8 cases/1,000" (Harries & Dye, 2006, p. 416). The advent of microscopes, X-rays and diagnostic tools in the nineteenth century revolutionized scientific understanding of this disease (Harries & Dye, 2006). However, treatment with antibiotics did not become commonplace until the mid-twentieth century (Harries & Dye, 2006).

Disease and pathogenesis. It is estimated that approximately "one-third of the world population is infected with [tuberculosis bacteria]" (Ducati, Ruffino-Netto, Basso & Santos, 2006, p. 697). While most cases are suppressed by the individual's immune system and therefore quiescent, tuberculosis is nonetheless a very significant public health hazard around the world (Ducati et al., 2006). Indeed, because such a high proportion of tuberculosis cases occur in parts of the world without the resources to adequately diagnose and treat cases, the current estimates of the public health burden created by tuberculosis are thought to be quite conservative (Schito, Maeurer, Kim, Hanna & Zumla, 2015).

On a biological level, the disease is caused by one of the many bacteria which fall into the "complex" known as *Mycobacterium tuberculosis* (Ducati et al., 2006). *M. bovis*, *M. tuberculosis,* and *M. africanum* are some of the types of mycobacteria which fall into this group; these various types are differently distributed around the world (Ducati et al., 2006). Bacteria are expelled due to the frequent coughing patients experience, and pass through the air to infect others (Ducati et al., 2006). In addition to coughing, victims also experience a great deal of

malaise, fatigue, difficulty breathing, chest pain, and fever (Ducati et al., 2006). Because symptoms typically occur over a long period of time, and worsen gradually, it can have a significant negative impact on overall health, vitality and productivity (Ducati et al., 2006). In rare cases, bacteria will reproduce in unusual numbers, and pass into the bloodstream and infect the brain and other major organs (Ducati et al., 2006).

For most patients, the immune system is able to attack the tuberculosis bacteria, kill the majority of them, and sequester the rest in small, contained patches within the lungs (Ducati et al., 2006). These are known as tubercles, and provided that the patient's immune system is sufficiently strong, the infection may be confined to those tubercles indefinitely (Ducati et al., 2006). These individuals cannot infect others, but have roughly a 10% chance of transitioning to active tuberculosis at some point in their lives (Ducati et al., 2006). Given that HIV/AIDS impacts the immune system, it is naturally associated with transition from dormant to active tuberculosis in co-infected patients (Ducati et al., 2006).

Diagnosis and treatment. Medical professionals may diagnose tuberculosis using smear tests for the tuberculosis bacterium, as well as analysis of chest X-rays (Harries & Dye, 2006). Examination for possible tuberculosis is indicated in patients who present with persistent cough, in areas where tuberculosis cases are common (Harries & Dye, 2006). Some cases of tuberculosis are what is known as "smear-negative", meaning that they will not yield positive results using the most common diagnostic methods (Harries & Dye, 2006). Smear-negative cases are more common in tuberculosis patients who are also infected with HIV/AIDS (Chakroborty, 2010). In addition, the mycobacteria which cause tuberculosis are generally quite slow to grow in laboratory cultures, further complicating laboratory-based testing for tuberculosis (Harries & Dye, 2006). These facts, coupled with the ability of a healthy individual's immune system to

contain the disease and its impacts, mean that the true burden of tuberculosis is probably much greater than those cases which are positively diagnosed (Harries & Dye, 2006). Unfortunately, more advanced and efficient diagnosis methods are cost-prohibitive in many of the areas of the world which are most heavily impacted by tuberculosis (Harries & Dye, 2006).

In "normal" cases of tuberculosis, that is, those without resistance, or spread outside the lungs, treatment has two goals (Harries & Dye, 2006). One is to kill those bacteria which are currently active and causing illness; the second is to kill those which currently remain inactive, but could cause relapse in the future (Harries & Dye, 2006). Typical tubercles are a combination of these two types of bacteria (Harries & Dye, 2006). To this end, "anti-tuberculosis therapy includes streptomycin, isoniazid, rifampicin, pyrazinamide and/or ethambutol" (Harries & Dye, 2006, p. 422). The strength of this regimen means that the treatment course lasts six months (Harries & Dye, 2006). While onerous, this amount of time is far less than that required to completely kill drug-resistant cases (Harries & Dye, 2006). Without strict adherence, the bacterium becomes resistant to antibiotics, and treatment becomes even more complex and longer-lasting (WHO, 2016b).

As noted above, HIV/AIDS is a common co-infection with tuberculosis, because the decline in immune function which is characteristic of the former allows for the progression of the latter (Harries & Dye, 2006). Naturally, with the worsening of HIV-related immune deterioration, the symptoms of tuberculosis become more severe (Harries & Dye, 2006).

Worldwide tuberculosis epidemiology. The impact of tuberculosis is felt most strongly in sub-Saharan Africa, particularly the southern and eastern regions (Harries & Dye, 2006). It is the second most common cause of death from infectious diseases worldwide, following HIV/AIDS (Harries & Dye, 2006). After HIV/AIDS and malaria, tuberculosis "is responsible for

more years of healthy life lost than any other infectious disease" (Harries & Dye, 2006, p. 417). Around the world, new cases of tuberculosis in 2014 totaled 9.6 million, with 1.5 deaths from the disease (WHO, 2016b). About one-third of deaths in those infected with HIV was the direct result of tuberculosis infection (WHO, 2016b). Relative to the rest of the world, sub-Saharan African nations experience a much higher number of tuberculosis cases relative to overall population (WHO, 2016b).

Co-infection with HIV/AIDS. Discussing the connection between HIV/AIDS and tuberculosis, Ducati et al. (2006) note that "HIV infection represents the major risk for the progression of a latent infection into the active disease" (p. 704). Indeed, co-infection with HIV/AIDS increases the likelihood of a transition to active tuberculosis by 30 times, relative to those who are not infected with HIV/AIDS (Ducati et al., 2006). This is the natural consequence of a diminished immune system due to the progression of the immune-destroying HIV infection (Ducati et al., 2006). Even worse, the tuberculosis infection induces a cytokine response in the body, and a decrease in CD4 cell count, thereby increasing the chances of transition from HIV to full-blown AIDS (Ducati et al., 2006).

Andrews, Shah, Gandhi, Moll & Friedland (2007) note that patients who are co-infected with HIV/AIDS and tuberculosis experience poorer outcomes for both diseases, compared with those infected with only one or the other (Andrews et al., 2007). Patients with HIV/AIDS experience immune suppression, which allows dormant tuberculosis bacteria to escape the lungs and cause infection (Andrews et al., 2007). Andrews et al. (2007) further note that patients have difficulty staying in compliance with both the grueling antibiotic regimen for tuberculosis, and also anti-retroviral therapy [ART] for HIV/AIDS (Andrews et al., 2007). Either regimen alone is difficult on the body, and because they are typically not administered at the same time or place,

patients may find that convenience and scheduling are also problematic (Andrews et al., 2007). Unfortunately, lack of compliance with the antibiotic regimen "enable[es] selection and growth of resistant populations", increasing the probability that resistance will develop (Andrews et al., 2007, p. 482).

Tuberculosis patients co-infected with HIV/AIDS are more likely to die than their non-HIV-infected counterparts (Harries & Dye, 2006). This is because the body, and the immune system in particular, is so severely weakened by HIV/AIDS infection (Harries & Dye, 2006). These co-infected patients also experience a greater number of "adverse drug reactions" than non-co-infected patients (Harries & Dye, 2006, p. 423). Finally, co-infected patients are more likely to experience the recurrence of their tuberculosis after treatment has been completed (Harries & Dye, 2006). Recurrence engenders the development of resistant strains (Harries & Dye, 2006). However, Andrews et al. (2007) note that there have been conflicting results from different studies, and it is unclear "whether HIV infection is an independent risk factor for the development of MDR-TB" (Andrews et al., 2007, p. 484).

Certain clinical features are characteristic of tuberculosis patients who are also co-infected with HIV/AIDS. One predictable finding is a relative increase in the proportion of patients whose tuberculosis transitions from dormant to active (Erokhin, Kornilova & Alekseeva, 2005). Co-infected patients are also more likely to experience extra-pulmonary tuberculosis, which progresses to the point that it escapes the lungs and moves into other vital organs, such as the brain or kidneys (Erokhin et al., 2005).

Patients being treated for one, or both diseases, are often treated in close conditions in crowded facilities (Harries & Dye, 2006). Therefore, prevention of the spread of tuberculosis is particularly vital in conditions in which both diseases are being treated (Harries & Dye, 2006).

However, this makes these treatment facilities all the more dangerous for immunocompromised HIV/AIDS patients, and the facilities are hotbeds of resistance development (Harries & Dye, 2006).

A case-control study in Iran by Hadadi, Tajik, Rasoolinejad, Davoudi and Mohraz (2011) examined the characteristics of TB in HIV-infected persons, versus those not infected with HIV, to discern differences in symptoms and clinical presentation of TB (Hadadi et al., 2011). The study population consisted of 56 cases and 56 controls, who were matched for age and sex (Hadadi et al., 2011). Researchers compared laboratory findings such as the tuberculin skin test and CD4 cell count, as well as reported symptoms such as fever and coughing (Hadadi et al., 2011). They also examined lung X-rays for the presence of tissue patterns indicative of TB progression (Hadadi et al., 2011). The study found that "weight loss and sweating were more frequently reported" among those not infected with HIV (Hadadi et al., 2011, p. 101). Additionally, the chest X-rays of the HIV-positive cases were more likely to exhibit marked progression of TB, probably due to diminished immune function (Hadadi et al., 2011). Interestingly, tuberculin skin tests were less likely to come out positive among those co-infected with both HIV and TB, as opposed to those only infected with TB (Hadadi et al., 2011).

Drug-Resistant Tuberculosis Strains

Mono-resistant strains, multi-drug-resistant strains and "second-line" treatment. As outlined above, anti-tuberculosis drugs were developed in the mid-twentieth century (Chakroborty, 2010). *M. tuberculosis* bacteria began to display resistance to the individual use of these "first-line" drugs almost immediately, leading to the combining of these drugs into a six-month "short-course" regimen (Chakroborty, 2010). However, by the late twentieth century,

scientists observed strains with resistance to essentially the entire group of first-line drugs (Chakroborty, 2010). Therefore, scientists developed "second-line" drugs, such as fluoroquinolones (Chakroborty, 2010). Unfortunately, second-line drugs may have serious side effects, such as kidney damage, psychosis, and digestive upset (Reubenson, 2011). They are also a great deal more expensive, and their production quality more questionable, than "first-line" drugs (Chakroborty, 2010). For patients, the biggest negative is probably the duration of second-line treatment; depending on the extent of resistance, treatment may last from eight months to two years (Chakroborty, 2010). "Mono resistance" refers to a strain which is only resistant to one type of first-line tuberculosis medications (Chakroborty, 2010). "Multi-drug resistant" tuberculosis [MDR-TB] strains are resistant to "two main drugs of the first-line regimen-isoniazid and rifampicin" (Chakroborty, 2010). The WHO estimates that approximately 480,000 of the new tuberculosis cases in 2014 were MDR-TB (WHO, 2016b).

Extremely-drug-resistant strains. More troublingly, there have now been strains observed which are resistant to both the first and second lines of defense (Chakroborty, 2010). "Extremely drug-resistant" tuberculosis [XDR-TB] strains, meanwhile, are resistant to the same medications as MDR-TB strains, and also to some or all of the second-line tuberculosis drugs (Chakroborty, 2010).

Biological nature and complications of resistance. Resistant strains develop due to selective pressure on genetic mutations in the *M. tuberculosis* genome (Chakroborty, 2010). Reubenson (2011) notes that because "*Mycobacterium tuberculosis* does not demonstrate horizontal gene transfer…resistance develops following spontaneous gene mutation" (p. 349). Another complication in combatting resistance is the physical nature of the bacterium itself. The cell wall of the genus *Mycobacteria* are generally quite strong, making them all the more

difficult to attack using antibiotic agents (Ducati et al., 2006). Of the estimated drug-resistant tuberculosis strains circulating around the world, roughly 9.7% are estimated to be XDR-TB (WHO, 2016b).

Identification and characterization of drug-resistant strains. Resistance status of a particular patient's strain is accomplished by DST testing, which may take weeks to complete, because mycobacteria are typically slow to grow in laboratory cultures (Chakroborty, 2010). Successful treatment of MDR- and XDR-TB involves examination of the patient's strain, as well as those found in the local area (Chakroborty, 2010). This allows for the development of an individually tailored drug regimen for patients (Chakroborty, 2010). Given the negative side effects involved, it is often found that strict monitoring is necessary to ensure adherence (Chakroborty, 2010).

Risk factors for developing resistance. A number of papers examine the risk factors for the development of drug-resistant tuberculosis. A study conducted by Rifat et al. (2014) in Bangladeshi hospitals identified a number of risk factors. It was conducted in various hospitals in various regions of Bangladesh (Rifat et al., 2014). Cases were multidrug-resistant [MDR] patients, controls were non-resistant patients (Rifat et al., 2014). Past tuberculosis treatment was by far the factor most predictive of the development of resistance: 94% of MDR patients had been previously treated, while only 6.4% of non-resistant patients had (Rifat et al., 2014). Other factors shown to predict resistance included smoking, substance abuse and type 2 diabetes (Rifat et al., 2014). Those under the age of 40 were also more likely to develop resistance, as were subjects employed in "service or business or transport work" (Rifat et al., 2014, p. e105214).

A similar case-control study was conducted by Law et al. (2008). This study was conducted in Hong Kong (Law et al., 2008). Cases were 156 MDR-TB patients, and 322

individuals with drug-responsive tuberculosis were controls (Law et al., 2008). As in the previously noted study, prior tuberculosis treatment was named as the most reliable predictor for the development of resistance (Law et al., 2008). Again in accordance with the 2014 study discussed above, individuals in younger age brackets were more likely to develop MDR-TB (Law et al., 2008). This study identified a history of frequent travel as another risk factor for the development of resistance, which the authors suggest may be due to travel to Hong Kong from areas with higher degrees of resistance (Law et al., 2008).

Chakroborty (2010) also lists a number of risk factors for the development of resistance, including those already named above (Chakroborty, 2010). However, the 2010 paper also lists a long duration of illness, HIV infection, social isolation and poverty as risk factors (Chakroborty, 2010).

Reubenson (2011) notes that the nature of the pediatric tuberculosis patient population may provide a number of insights into the current status of tuberculosis generally within that community (Reubenson, 2011). This is because pediatric cases will naturally be those which have occurred most recently (Reubenson, 2011). Examination of the strains common in the pediatric population, and the levels of resistance present therein, will therefore tell health professionals about the status of the tuberculosis strains present in the larger community (Reubenson, 2011).

Tuberculosis in West Africa

***M. africanum* tuberculosis strain.** As noted earlier in this paper, there is a specific strain of M. tuberculosis which is only found in West Africa. A 2010 paper by deJong, Antonio and Gagneux provides a thorough examination of this strain. In some nations, this subspecies, known

as *M. africanum,* causes about half of all tuberculosis infections (deJong et al., 2010). *M. africanum* is further divided into two strains known as MAF1 and MAF2, while a third strain, known as *M. africanum* type II, is most common in Eastern Africa (deJong et al., 2010). In the eastern nations of the West African region, such as Cameroon and Nigeria, the MAF1 strain is more common than MAF2 (deJong et al., 2010). Meanwhile, the opposite is true in western nations of West Africa, such as Senegal and Guinea Bissau (deJong et al., 2010). Overlap of the two strains occurs in central West African nations such as Ghana: 21% of tuberculosis cases in Ghana are caused by MAF1, 8.4% by MAF2 (deJong et al., 2010). The remainder of tuberculosis cases were caused by the "original", or "euro-American", strain, which is known simply as *M. tuberculosis* (deJong et al., 2010).

Compared with *M. tuberculosis, M. africanum* is equally likely to cause infection and mortality, but disease progress is generally slower. Rates of HIV co-infection are also consistent between *M. tuberculosis* and *M. africanum* (deJong et al., 2010). Interestingly, deJong et al. (2010) hypothesize that *M. africanum* (MAF1 and MAF2) may have flourished only in West Africa because of relative genetic susceptibility. That is, West Africans have genes which will tend to make them able to resist infection by *M. tuberculosis,* but no such protection against *M. africanum,* so the bacterium will tend to do well only among West African individuals (deJong et al., 2010). Studies comparing the onset of resistance in *M. africanum* versus *M. tuberculosis* have obtained mixed results (deJong et al., 2010). A 1982 study in Ghana found greater resistance in *M. africanum,* while a 2008 study found no difference in resistance levels between the two strains (deJong et al., 2010). Results may be unclear due to the number of drugs involved in tuberculosis treatment, as well as the differing distribution of tuberculosis strains across West Africa (deJong et al., 2010).

Political and cultural instability of West African nations. There are also a number of social, cultural and economic conditions found in recent years in West African nations, which research shows to have had an impact on tuberculosis incidence. For instance, Ekaza et al. (2013) discuss the impact of Côte d'Ivoire's civil war. Such destructive events "often lead to the destruction of healthcare systems", making case surveillance and adequate treatment difficult, if not impossible (Ekaza et al., 2013, p. 2). When patients are unable to access care, it is naturally extremely difficult to diagnose tuberculosis early enough to save the patient's life (Ekaza et al., 2013). Indeed, in some parts of Côte d'Ivoire, "80% of healthcare units…have closed and 85% of the healthcare workers have left" (Ekaza et al., 2013, p. 7). Furthermore, Ekaza et al. (2013) propose that the increase in cases may also be due to poor nutrition and mixing of people carrying different tuberculosis strains, due to refugee flows (Ekaza et al., 2013).

This theoretical relationship may be observed in reality in the case of Côte d'Ivoire's civil war, which lasted from 2002 to 2006 (Ekaza et al., 2013). At the end of the civil war, the number of tuberculosis cases in Côte d'Ivoire alone "exceeded the number of cases in the entire region of sub-Saharan Africa" (Ekaza et al., 2013, p. 2). The main priorities in this nation according to the Ekaza et al. (2013) paper, are as follows: 1) training of healthcare personnel in all aspects of tuberculosis care, particularly transmission prevention, 2) improved availability of antibiotic regimens to combat tuberculosis, 3) provision of items such as gloves and masks to prevent transmission of infection, and 4) strengthen the nation's laboratory capacity to diagnose disease and resistance (Ekaza et al., 2013). While these steps are common to any nation attempting to combat tuberculosis, Côte d'Ivoire is at such a great disadvantage due to civil war, that it must rebuild a great deal of healthcare and public health infrastructure which other, more stable nations may already have in place (Ekaza et al., 2013). Fortunately, wealthy nations such as the

United States have donated significant amounts of money and expertise to help resource-poor Côte d'Ivoire cope with this enormous challenge (Ekaza et al., 2013).

Tuberculosis research in West Africa. A paper by Brookes et al. (2008) outlines the possibility of a new vaccine against tuberculosis. As noted in a previous section of this review, there are thought to be some genetic characteristics of West African individuals which may explain why differing strains of the *M. tuberculosis* complex tend to flourish among different human populations of the world (deJong et al., 2010). Therefore, while the vaccine tested in this study, which is known as MVA85A, had previously displayed efficacy in British study participants, the authors of this study believed it was critical to also test the vaccine in West African participants as well (Brookes et al., 2008). Prior to the advent of the MVA85A vaccine, the most commonly used vaccine worldwide has been the BCG vaccine (Brookes et al., 2008). However, this vaccine has displayed "variable efficacy against pulmonary tuberculosis' (Brookes et al., 2008, p. 1). Brookes et al. (2008) wanted to discern whether the immunogenicity engendered by the MVA85A vaccine would differ in those individuals who had previously received the BCG vaccine. To that end, researchers tested the MVA85A vaccine on 11 Gambian individuals who had not received BCG, and 10 individuals who had received it (Brookes et al., 2008).

Fortunately, the individuals studied displayed very few negative side effects from the MVA85A vaccine (Brookes et al., 2008). Even better, the administration of this vaccine engendered greater immunogenicity than any other vaccine so far trialed in human subjects (Brookes et al., 2008). However, in subjects already vaccinated with BCG, no increase in immunogenicity was observed in this study (Brookes et al., 2008). The authors note that, because

no negative side effects were observed in this study, further research on the MVA85A vaccine may include greater numbers of participants (Brookes et al., 2008).

Nsagha et al. (2015) discussed co-treatment of HIV/AIDS and tuberculosis in another West African nation, Cameroon (Nsagha et al., 2015). This cross-sectional study examined 200 individuals receiving tuberculosis treatment, HAART, or both (Nsagha et al., 2015). Because of the significant number of sub-Saharan African patients who experience overlap between these two conditions, the researchers wanted to learn more about how the treatment regimens interact (Nsagha et al., 2015). In particular, this study examined potential kidney disease resulting from the treatments individually, or in combination (Nsagha et al., 2015).

A study by Rabna et al. (2015) examined the usefulness of a new assay used to rapidly determine the type and degree of resistance found in the bacteria of a tuberculosis patient's sputum. The study occurred in the poor West African nation of Guinea-Bissau, allowing the assay's usefulness to be examined in the context of a resource-poor healthcare system (Rabna et al., 2015). The assay in question is known as Xpert MTB/RIF, and it identifies the presence of specific genetic mutations known to convey drug resistance (Rabna et al., 2015). During the time period of this study, 100 patients were found to have active tuberculosis which was suspected to possess some degree of resistance, due to the duration of illness (Rabna et al., 2015). The Xpert MTB/RIF assay detected MDR-TB strains in 8 of the 100 suspected MDR-TB patients (Rabna et al., 2015). This method is advantageous because it gives results in about two hours, and may be used in even relatively unsophisticated laboratory settings (Rabna et al., 2015). The authors note that in the absence of such techniques, medical teams must rely solely on the duration of illness despite treatment to determine suspected cases of resistant tuberculosis (Rabna et al., 2015).

In addition to examining the assay's effectiveness, Rabna et al. (2015) offers a description of the resistance found in strains in that West African nation (Rabna et al., 2015). While case detection and surveillance efforts were generally successful in the 1990s, those efforts have suffered due to "social and political instability" in the last few decades (Rabna et al., 2015, p. 9). Without detection of cases in the first place, it is obviously impossible to determine the type of resistance present, and therefore impossible to effectively treat patients with resistant tuberculosis strains (Rabna et al., 2015). The preliminary data found in this study found that in Guinea-Bissau, a great deal of resistance has emerged since widespread testing was last performed (Rabna et al., 2015). Researchers found that this resistance emerged due to mixing of a number of tuberculosis strains (Rabna et al., 2015). None of the strains found in this study qualified as XDR-TB, but they did qualify as MDR-TB, being resistant to both rifampicin and isoniazid (Rabna et al., 2015).

Another study carried out in West Africa is by Touray et al. (2010), the purpose of which was to map tuberculosis cases in urban areas of The Gambia (Touray et al., 2010). For this study, 844 cases of definitively diagnosed tuberculosis were examined in the Greater Banjul Area (Touray et al., 2010). Geospatial analysis of the cases and their locations yielded several settlements which were characterized as "hotspots" of tuberculosis (Touray et al., 2010, p. 669). Interestingly, the most statistically significant cluster of cases was located in an area with a relatively high saturation of healthcare facilities (Touray et al., 2010). Researchers point to this paper as a basis for future studies on the socioeconomic traits of communities in which tuberculosis clusters are found (Touray et al., 2010).

Sociocultural Context of Tuberculosis

Delay in receiving care. Logically, a delay in healthcare access means a delay in treatment, and Lin et al., (2015) examine the financial barriers to tuberculosis detection in treatment in China. Their research points to advanced age, female gender, rural dwelling and living in an area with high socioeconomic deprivation (Lin et al., 2015). Working-age individuals were also less likely to receive treatment, which the researchers hypothesize may be due to an inability to leave work or childcare duties to travel to healthcare facilities (Lin et al., 2015). As expected, those patients who experienced a delay in receiving treatment experienced greater progression of their disease (Lin et al., 2015).

Social determinants. Ducati et al. (2006) discuss a number of sociocultural risk factors associated with tuberculosis infection. One is the increase in highly-concentrated areas of human population in recent decades, coupled with increased migration of the human population (Ducati et al., 2006). Social inequality, leading to greater numbers of people of low socioeconomic status [SES], also leads to increasing risk of tuberculosis (Ducati et al., 2006).

Reubenson (2011) examines a number of social factors impacting the incidence of tuberculosis, and identifies several demographic groups who are particularly vulnerable. In children, cases of tuberculosis which move outside the lung to other organs are more common in the general population; this makes strains more difficult to isolate (Reubenson, 2011). Reubenson (2011) also notes that young women are most likely to provide care for children, and young women are also most commonly impacted by HIV/AIDS (Reubenson, 2011). Consequently, children are more likely to be exposed to caregivers who are infected with HIV/AIDS, tuberculosis, or co-infected with both (Reubenson, 2011). On a social level, children's families are often reluctant to allow them to be transported out of their communities

for treatment, making adequate localized care all the more critical for the pediatric population (Reubenson, 2011).

In communities of low SES, Chakroborty (2010) notes that intensive treatment with direct observation work best when used in conjunction with economic aids, such as food, shelter and transportation, increase the impact of DOTS (Chakroborty, 2010). These incentives create a greater positive impact by improving the overall health and flexibility of patients and their families (Chakroborty, 2010).

Cultural factors. As discussed previously in this review, Reubenson (2011) discusses particular challenges to treatment of tuberculosis in pediatric patients (Reubenson, 2011). The author advises that as new drugs are developed and resistance spreads, potential new TB drugs should be tested on pediatric patients to ensure that they are compatible with both child and adult treatment (Reubenson, 2011). Reubenson (2011) also notes that communities and parents are often resistant to allowing children to be removed from their communities in order to undergo treatment (Reubenson, 2011). This reluctance makes it more difficult to treat the patients and prevent them from passing tuberculosis on to their contacts (Reubenson, 2011). While these barriers may be overcome in some cases, it is critical that health professionals find ways to work within the socio-cultural conditions of a community, in order to ensure cooperation and trust in the patient population (Reubenson, 2011).

Education as a Tool Against Infectious Disease

Addisu et al. (2014) examined tuberculosis-related beliefs, intentions and behaviors in Ethiopia. The purpose was to identify which, if any, of these factors significantly impact treatment-seeking for symptoms similar to tuberculosis, specifically ongoing cough (Addisu et

al., 2014). This study was constructed using the concepts of the TPB, as discussed above in the Theoretical Foundation section of this paper (Addisu et al., 2014).

This study found that "[a]n individual's ability to recall or know about the etiology of a disease, chain of disease process, symptoms, preventions and treatment options plays a crucial [part] to motivate him/her to seek treatment" (Addisu et al., 2014, p. 136). Indeed, knowledge of tuberculosis-related facts, in addition to urban residence and being a smoker, were the three top predictors of treatment-seeking identified in this paper.

Arshad et al. (2014) is a review of studies which identified community-based strategies which were effective at prevention of tuberculosis. The results indicate that overall, community-based strategies offer a number of positives (Arshad et al., 2014). The paper notes that "a community-based approach helps empower each community to deal with its own problems", and "involvement of respected…community and family members increases the trust that is required to initiate treatment [and increases] adherence" (Arshad et al., 2014, p. 7). However, the authors also note that the studies examined in this paper occurred in various parts of Africa, with differing infrastructure quality and varying degrees of decentralization, so these results may not be observable in all communities (Arshad et al., 2014).

Methods

The data source for this survey is the Demographic and Health Survey [DHS], which is completed by the USAID, roughly even 5 years (USAID, 2016). The two most recent surveys conducted in Ghana, which are the source for this paper, were conducted in 2008 and 2014 (USAID, 2016). The variables for this study are to include the following:

1. Tuberculosis prevalence in 2008, according to available data

2. Tuberculosis prevalence in 2015, according to available data

3. Regional level of tuberculosis knowledge indicated by the 2008 survey

4. Regional level of tuberculosis knowledge indicated by the 2014 survey.

The DHS datasets include regional identifiers for each participant, allowing each respondent to be sorted into a single dataset per district (USAID, 2016). Each individual's answers will be examined together, and the individual will be given a score to indicate the overall correctness of their responses. On a regional level, an average correctness level will then be calculated, and correlated with the changes in tuberculosis infection status during the same period. Multiple logistic regression will then be used to examine the relationship, if any, between infection status and levels of community education in each region.

Description of Study

This study was comprised of a secondary data analysis. Data we obtained from the Demographic and Health Surveys [DHS] conducted by USAID. The purpose was to examine trends in tuberculosis-related knowledge and education, in light of concurrent trends in tuberculosis prevalence, which were examined in three regions of Ghana: Ashanti, Northern and Eastern Region. SPSS statistical software was used to conduct the data analysis and obtain results.

Data Source

The data used for this analysis is from the DHS conducted by USAID. The purpose is to examine trends in tuberculosis-related knowledge and education, in light of concurrent trends in

tuberculosis prevalence. These statistical surveys are conducted at regular intervals, offering a picture of change over a period of time (USAID, 2016). USAID personnel have conducted such surveys in Ghana approximately every 5 years since 1988 (USAID, 2016). The focus of the Ghana surveys is generally on sexual behaviors, HIV/AIDS infection status, and individual attitudes on health-related issues (USAID, 2016). Unfortunately, the Ghana DHS only began to include questions related to tuberculosis knowledge and behaviors with the 2008 administration of the survey (USAID, 2016).

The most recent DHS survey from Ghana was taken in 2014 (GSS, 2015). Eligible participants are men and women, ages 15 to 49 (Ghana Statistical Service [GSS], 2015). Sample selection was stratified, with geographical regions separated into sections, one of which was randomly selected (GSS, 2015). From each section, 30 households were then randomly selected, and only these households were approached to determine whether they contained any eligible study participants (GSS, 2015). The study designers made sure to survey the same number of urban and rural samples (GSS, 2015). Response rates for both urban and rural areas, and for both men and women, were high: approximately 96 percent (GSS, 2015).

Design

This study compares the datasets from Ghana DHS surveys in 2008 and 2014, which as noted above are the two most recent years in which the Ghana survey was conducted (GSS, 2015). Specifically, the responses examined were those related to tuberculosis knowledge, which are listed in Appendix A at the end of this document. Each respondent was given a score for correctness of responses, and average scores per region were calculated. These correctness scores were then compared between 2008 and 2014. Any changes in these correctness scores were then

examined in light of the trends in tuberculosis prevalence in that region, over approximately the same time period.

Data Analysis

Because each respondent is coded as residing in one of the 10 regions of Ghana, assigning the data points to a district was fairly simple. SPSS allows larger datasets to be sorted by the coded response to a particular variable, easily allowing for analysis of a data subset sorted by region.

Response data, organized by region, were then analyzed for correctness of responses to the tuberculosis knowledge questions. Awareness of tuberculosis in general was measured by answers to the first two questions. Positive answers to the following seven questions were indicative of a lack of knowledge, and were also scored as a group. The answers to the question about whether tuberculosis can be cured, and whether the respondent would keep a tuberculosis diagnosis a secret, were each scored separately.

These scores on the tuberculosis knowledge question were combined for each respondent individually, and then averaged across the region in which they reside. Results were then compared between the 2008 and 2014 data analysis results.

Results

Participants

Tables 1 and 2, seen below, are taken from the DHS surveys from 2008 and 2014. These tables describe the basic characteristics of the study participants for these two DHS survey years, including age and sex distribution, and rural versus urban residential status.

Number of households, number of interviews, and response rates, according to residence (unweighted), Ghana 2008

	Residence		
Result	Urban	Rural	Total
Household interviews			
Households selected	5,458	6,865	12,323
Households occupied	5,252	6,661	11,913
Households interviewed	5,175	6,603	11,778
Household response rate[1]	98.5	99.1	98.9
Interviews with women age 15-49			
Number of eligible women	2,239	2,857	5,096
Number of eligible women interviewed	2,162	2,754	4,916
Eligible women response rate[2]	96.6	96.4	96.5
Interviews with men age 15-59			
Number of eligible men	2,014	2,755	4,769
Number of eligible men interviewed	1,914	2,654	4,568
Eligible men response rate[2]	95.0	96.3	95.8

[1] Households interviewed/households occupied
[2] Respondents interviewed/eligible respondents

Table 1. Demographic Characteristics of DHS Respondents, 2008 Survey. *Table from GSS, 2009.*

Number of households, number of interviews, and response rates, according to residence (unweighted), Ghana 2014

Result	Residence		Total
	Urban	Rural	
Household interviews			
Households selected	6,492	6,339	12,831
Households occupied	6,070	5,940	12,010
Households interviewed	5,939	5,896	11,835
Household response rate[1]	97.8	99.3	98.5
Interviews with women age 15-49			
Number of eligible women	4,753	4,903	9,656
Number of eligible women interviewed	4,602	4,794	9,396
Eligible women response rate[2]	96.8	97.8	97.3
Interviews with men age 15-59			
Number of eligible men	2,189	2,420	4,609
Number of eligible men interviewed	2,050	2,338	4,388
Eligible men response rate[2]	93.7	96.6	95.2

[1] Households interviewed/households occupied
[2] Respondents interviewed/eligible respondents

Table 2. Demographic Characteristics of DHS Respondents, 2014 Survey. *Table from GSS, 2015.*

Relationship Between Tuberculosis-Related Education and Tuberculosis Prevalence

The overall results of this study do not point to a significant relationship between trends in tuberculosis-related education, and concurrent trends in tuberculosis prevalence. However, it should be noted that there are limitations to this analysis which may explain why the results of this study do not line up with the larger body of literature related to this topic.

Overall picture. Overall, the data did not show significant changes in tuberculosis-related knowledge and attitudes, between the 2008 and 2014 surveys. However, tuberculosis

prevalence has generally been on the decline in Ghana, even as specific regions continue to struggle with high disease prevalence.

Specific regions. In the Ashanti region in particular, tuberculosis prevalence remains high. However, this region showed the greatest improvement in tuberculosis-related knowledge between 2008 and 2014 (Ghana News Agency [GNA], 2014). The Eastern Region displayed contradictory results, with belief that tuberculosis can be cured decreasing, but also decreases in incorrect responses about the causative agent. This region is somewhat in the middle of the pack in terms of changes in tuberculosis prevalence, so middling results related to tuberculosis knowledge are perhaps not surprising (GNA, 2014). In the Northern Region, tuberculosis prevalence seems to be on the decline overall, but results of this study indicate that tuberculosis-related knowledge is not improving, and indeed seemed to worsen between 2008 and 2014 (GNA, 2014). Each region was given a "correctness score", from 0 to 2, based on whether the subjects had heard of tuberculosis ("No" scored as 0, "Yes" scored as 1") and whether they identified coughing and sneezing as the mode of transmission (same scoring assignment). Combined, these answers gave a 0, 1, or 2, with 2 being the most correct, and the scores were averaged across each of the three regions. In the Eastern Region, the score in 2008 was 1.62, but decreased to 1.34 in 2014. In the Ashanti Region, "correctness" went from 1.64 to 1.63 in the same time period. In the Northern Region, "correctness" dropped from 1.02 to 0.95. Figures 3 through 6, seen below, display the statistical changes observed as part of this research.

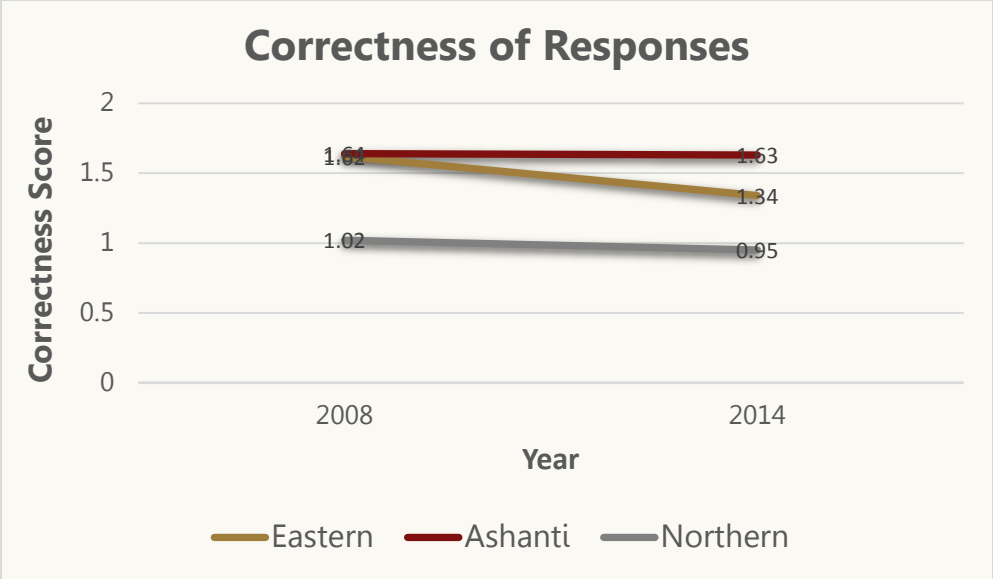

Figure 3. Correctness of Responses. Each region was given an average "correctness score"; this graph displays the change in this score between the 2008 and 2014 surveys.

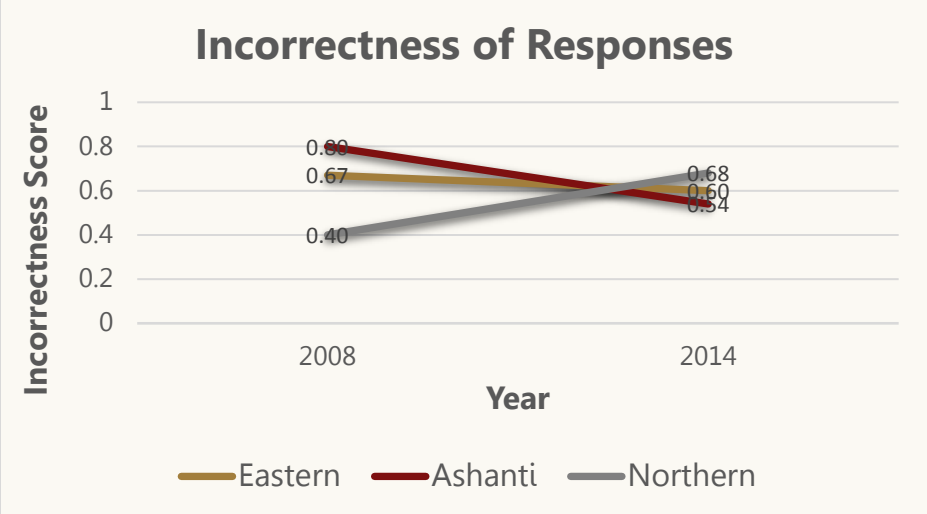

Figure 4. Incorrectness of Responses. Each region was given an average "incorrectness score"; this graph displays the change in this score between the 2008 and 2014 surveys.

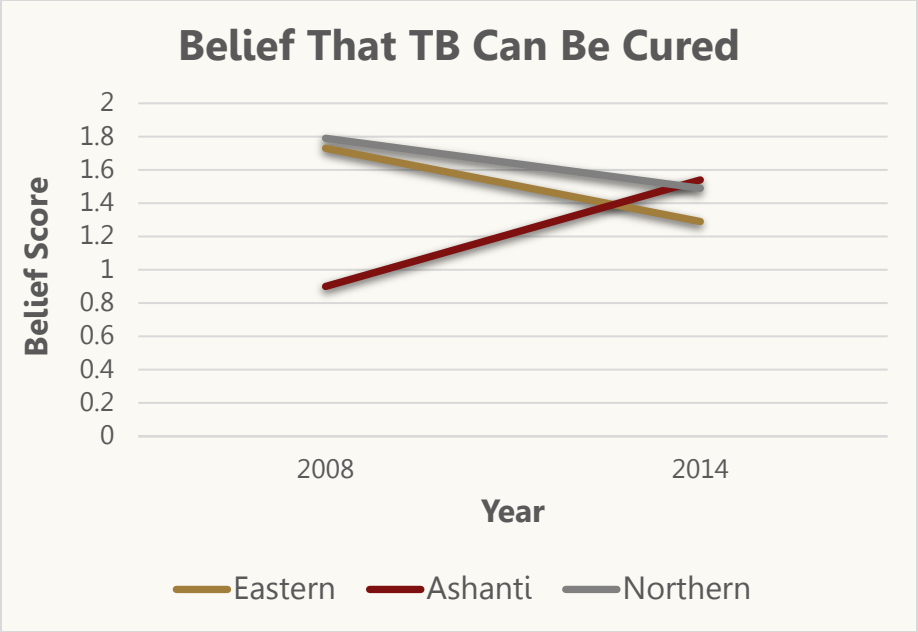

Figure 5. Belief That TB Can Be Cured. Responses to the question "Can tuberculosis be cured?" were averaged by region. This graph displays the change in these regional averages between the 2008 and 2014 surveys.

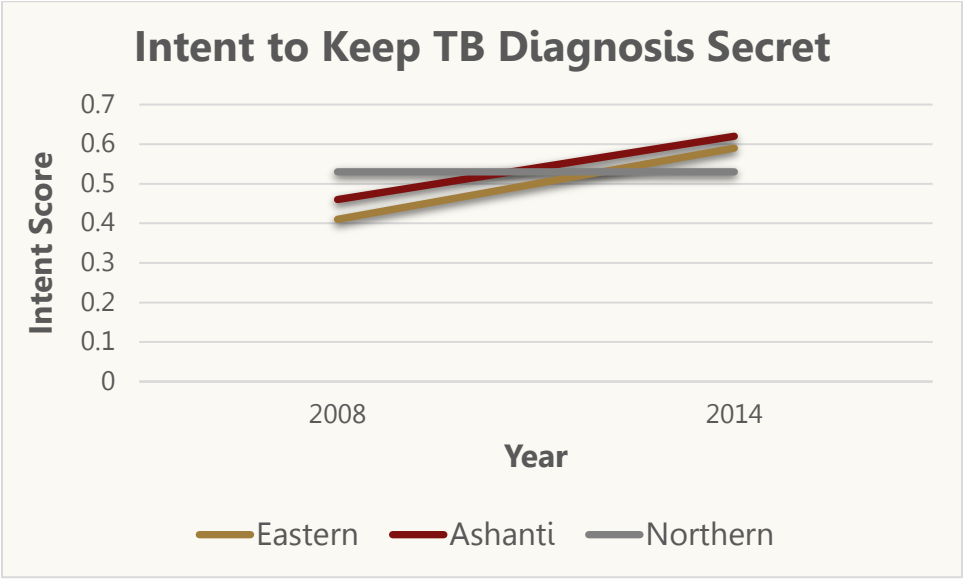

Figure 6. Intent to Keep TB Diagnosis Secret. Responses to the question regarding keeping a tuberculosis diagnosis secret were averaged by region. This graph displays the change in these regional averages between the 2008 and 2014 surveys.

Discussion

This study does not point to a significant relationship between community-based education efforts, and concurrent trends in tuberculosis prevalence. However, there are a number of limitations to this study which may indicate why this study's results do not line up with the larger body of education- and tuberculosis-related literature.

It is possible that this lack of connection may be due to unintended consequences. That is, it may be that educational efforts have been increased in the regions most affected, thereby increasing reporting, in turn creating the appearance of increased tuberculosis prevalence. As noted earlier in the literature review section, Addisu et al. (2014) demonstrate that knowledge regarding tuberculosis symptoms and progression brings about an increase in treatment-seeking behaviors. This increase in treatment might make prevalence numbers appear artificially higher, even as a positive trend, of increased levels of treatment, is occurring.

Arshad et al. (2014) point to community-based efforts to cope with disease as helping to empower and motivate community members. However, this positive impact may vary in different communities, as the quality of infrastructure and the availability of funds also varies (Arshad et al., 2014). It is easy to see how Ghana, with its limitations around infrastructure and economic growth, might not respond rapidly to community-based educational initiatives (UNESCO, 2010).

Importance of education. The results of this secondary data analysis do not point strongly to a relationship between community education, and positive changes in a strong relationship between community education on infectious disease, and prevention of its spread. This section examines some possible reasons that education may indeed have a positive long-term impact on tuberculosis prevalence. While this study specifically does not provide

statistically significant results, the larger body of literature does point to a number of reasons that education might have such positive impacts in other communities and situations.

One reason for this positive impact is clear: those who are educated on the nature of tuberculosis are more likely to report their tuberculosis case and to seek treatment. Put simply, knowledge on the progression of symptoms allows an individual to recognize them in themselves or others. Awareness of how transmission occurs might also allow a person to think back to situations in which they may have been exposed, allowing for identification of dormant cases.

Awareness that treatment possibilities exist, and the increased communication and trust between communities and healthcare facilities, may make people more likely to seek care in the first place, and adhere to treatment regimens, even if they are difficult or demanding. Education of entire communities and families decreases the stigma associated with tuberculosis, increasing the likelihood of seeking treatment.

Education does not only benefit private citizens, but also healthcare workers and public officials. Investment in combating tuberculosis is more likely when those in power are aware of the threat. Awareness on the part of healthcare workers allows for more effective treatment, and may cause healthcare workers to become more engaged in encouraging patients to adhere to treatment. Better-educated healthcare workers may also be more likely to enforce segregation of tuberculosis patients from others, especially those with HIV/AIDS, reducing the likelihood of transmission and co-infection.

Current lack of awareness. It is clear from the body of research that tuberculosis poses a significant danger to public health, given the large proportion of the human population who are currently infected with dormant strains. In modern times, the relative ease of travel between

endemic and non-endemic areas of the world, creates an increased possibility of tuberculosis to spread worldwide. Finally, the onset of drug-resistant strains means that previously-dependable treatment methods are no longer reliable. Given this danger, there is a troubling lack of awareness in the global community of this threat. One instance of this may be seen in the limitations of this study: of the thousands of questions in the DHS, there are fewer than ten which examine tuberculosis, and the respondent's infection status is not requested as part of the DHS. Additionally, tuberculosis questions were not included in the Ghana DHS until the 2008 survey. Overall, the worldwide effort and funding amount devoted to tuberculosis are simply not proportional to the threat posed by this disease. Given the afore-mentioned discussion of barriers to treatment, this would be a logical place to begin working on this problem. For example, it would be beneficial to focus research on developing new, less-demanding treatments, or possibly even a vaccine. However, as of now this has not been a focus of worldwide research and funding.

Limitations

Limitations of data. While the DHS provides a large sample size for data analysis, the number of specifically tuberculosis-related questions is low, and the respondent is never asked about his or her tuberculosis infection status. This means that the Principal Investigator in this study was obliged to compare trends in tuberculosis knowledge, supplied by this study's results, to prevalence data from other sources. These numbers were, therefore, not gleaned from precisely the same individuals, making the basis for comparison somewhat tenuous. The same problem is also present when looking at any comparison between the 2008 and 2014 data, which are also not necessarily from the same specific individuals, and in any case are not identifiable as such. Additionally, the fact that tuberculosis-related questions were not even included in the

DHS prior to the 2008 survey means that trends can only be examined within a limited time period (USAID, 2016).

Conclusions

Significance

The results of this study may be slight, but this type of research is nonetheless vital as the world continues to deal with the threat to global health posed by tuberculosis. The questions being analyzed in this study, which come from the DHS survey conducted by USAID, offer a window into how basic education on disease transmission and cause may be undertaken. This basic knowledge level is an opening into promoting broader health-related education to increase community awareness and ability to prevent and deal with infectious disease outbreaks.

This research ties into the larger body of literature on education and its potential to impact the spread of infectious disease around the world. Research is still needed to determine how best to tailor educational efforts to specific communities and their needs. However, it is evident that educational efforts can and do have substantive positive impacts on community health, and may improve a community's capacity to cope with an outbreak of infectious disease.

Although the body of research clearly indicates that individual- and community-level education is critical to successfully fighting tuberculosis, it is equally clear that at the time of this writing, there is simply not yet adequate global attention to this threat. The necessary funding, which would naturally accompany such awareness, is likewise missing at this time. Entities such as local and national governments, non-governmental organizations, and other actors have a role to play in this fight, but these stakeholders have not yet been adequately engaged to work against

the threat. The remainder of this paper will be devoted to discussing recommendations for future efforts in research, stakeholder engagement, and promising education strategies.

Recommendations for Future Efforts

In order to maximize the potential for success, publicly and privately funded efforts to combat and prevent tuberculosis should include education as a central goal. Ideally, communities would build on one another's successes to create their tuberculosis-prevention programs, but at the same time each program must be tailored to fit the needs of the community. As was discussed in the Theoretical Foundation section, communities have differing capacities to deal with health crises. This is due to differences in educational level, resource availability, quality of infrastructure, to name only a few relevant factors. Thus learning from the efforts of others is critical, but a program being implemented in, for instance, an urban area should not be a copy of one from a rural area.

Incorporation of these educational goals, to say nothing of the long-term goal of tuberculosis eradication, require a significant investment of resources, both human and financial. Such a process may seem overly ambitious, and indeed eradication will likely require several generations before even significant progress is made. Therefore, it is critical to engage critical stakeholders as soon as possible, in order to establish a basis for success in the long term.

Strategies for education. Educational efforts should be ongoing on the local as well as the national and international levels. It is critical that governments, non-governmental organizations, and other key players be educated on the threat tuberculosis poses to global health, stability and long-term economic prosperity. Different levels of this educational plan will naturally require different techniques. For example, on the local level it may be beneficial to

focus on the impact on individuals, community cohesiveness and family stability. On a national level, economic stability might be the best aspect to emphasize. On an international level, it may be best to focus on the very real global public health threat posed by this disease. While those in the developed world may believe that tuberculosis is a thing of the past, or limited to only the developing world, this is not the case. Emphasizing the reality that any community may find itself facing a tuberculosis epidemic may be the key to engaging the developing world in the global fight against tuberculosis.

Recommendations for Future Research

Understanding relevant factors. One avenue for future research is to focus in on specific social determinants, such as age, gender, education level, marital status, and SES, in order to better understand how they contribute to tuberculosis outbreaks. Age is understood to play a role in the pathogenesis of tuberculosis. However, little is understood about how elderly patients' immune systems react to tuberculosis infection, and why older patients are more likely to survive the disease. While tuberculosis has been studied in pregnant women, there has been little research on how circumstances of exposure differ between men, women and children.

Knowledge on education status of communities is key to tailoring educational efforts to specific communities, in order to be most effective. As discussed in the Theoretical Foundation section, the SES of a community impacts is capacity to deal with disease outbreaks, and is also vital to understanding how a community will cope with such a situation. Being able to predict how education will best be absorbed by members of a given community will allow public health

workers to tailor their interventions to make them more credible, longer-lasting, and more efficient.

Identification and evaluation of educational strategies. Community status, in terms of education and SES, is critical to message-tailoring in another way. This information can allow public health workers to determine which type of media will be most effective for a given community. For instance, a community with low literacy rates will probably respond better to a visually-based campaign, as opposed to word-heavy pamphlets or similar materials. In addition, specific groups within a community, such as young people, may tend to consume a particular type of media, while their elders may tend to consume another. Awareness of these differences is critical to effectively tailor public health messaging.

Social and cultural tailoring. Ideally, Formation of partnerships will be the ultimate result of ongoing community education efforts**.** Interaction between local and governmental entities will, over time, ideally build trust between locals and the. Hopefully, this will make it more likely that communities will turn to modern, rather than traditional medicine, to deal with suspected cases of tuberculosis. Increased reporting and treatment are first steps in controlling the worldwide spread of tuberculosis. Making these community-level changes is a delicate process, requiring careful consideration of long-standing cultural traditions. It is critical to frame educational messages in a manner that is culturally sensitive to the needs of the specific community in question.

On the whole, the worldwide fight against tuberculosis infection is severely lacking in funding, focus and educational components. This study, and more importantly, the larger research picture, point to the need to bring prevention and treatment efforts in line with the extent and severity of the threat. Recent trends in drug-resistant tuberculosis strains and world

travel, coupled with the lack of worldwide preparation and education, make the threat of a worldwide tuberculosis pandemic as tangible as it is frightening.

References

Addisu, Y., Birhanu, Z., Tilahun, D. & Assefa, T. (2014). Predictors of treatment seeking intention among people with cough in East Wollega, Ethiopia based on the theory of planned behavior: a community based cross-sectional study. *Ethiopian Journal of Health Sciences, 24*(2). 131-138. doi: 10.4314/ejhs.v24i2.5

Andrews, J.R., Sarita Shah, N., Gandhi, N., Moll, T. & Friedland, G. (2007). Multidrug-resistant and extensively drug-resistant tuberculosis: Implications for the HIV epidemic and antiretroviral therapy rollout in South Africa. *Journal of Infectious Disease, 196.* 482-490. doi: 10.1086/521121

Arshad, A., Salam, R.A., Lassi, Z.S., Das, J.K., Naqvi, I. & Bhutta, Z.A. Community based interventions for the prevention and control of tuberculosis. *Infectious Diseases of Poverty, 3*(27). 1-10. doi: 10.1186/2049-9957-3-27

Barter, D.M., Agboola, S.O., Murray, M.B. & Barnighausen, T. (2012). Tuberculosis and poverty: the contribution of patient costs in sub-Saharan Africa – a systematic review. *BioMed Central Public Health, 12*(980). doi: 10.1186/1471-2458-12-980

Boston University School of Public Health. (2016). *Behavioral Change Models.* Retrieved from http://sphweb.bumc.bu.edu/otlt/MPH-Modules/SB/SB721-Models/index.html

Brookes, R.H., Hill, P.C., Owiafe, P.K., Ibanga, H.B., Jeffries, D.J., Donkor, S.A., … Hill, A.V. (2008). Safety and immunogenicity of the candidate tuberculosis vaccine MVA85A in West Africa. *PLoS One, 3.* e2921. doi: 10.1371/journal.pone.0002921

Centers for Disease Control and Prevention. (2012). *Tuberculosis.* Retrieved from http://www.cdc.gov/tb/publications/factsheets/general/tbtravelinfo.htm

Centers for Disease Control and Prevention. (2015). *The Social-Ecological Model: A Framework for Prevention.* Retrieved from http://www.cdc.gov/violenceprevention/overview/social-ecologicalmodel.html

Chakroborty, A. (2011). Drug-resistant tuberculosis: an insurmountable epidemic? *Inflammopharmacology, 19.* 131-137. doi: 10.1007/s10787-010-0072-2

deJong, B.C., Antonio, M. & Gagneux, S. (2010). *Mycobacterium africanum*- Review of an important cause of human tuberculosis in West Africa. *PLoS Neglected Tropical Diseases, 4.* e744. doi: 10.1371/journal.pntd.0000744

Dhuria, M., Sharma, N. & Ingle, G.K. (2008). Impact of Tuberculosis on the Quality of Life. *Indian Journal of Community Medicine, 33*(1). 58-59. Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2782234/

Ducati, R.G., Ruffino-Netto, A., Basso, L.A., & Santos, D.S. (2006). The resumption of consumption- A review on tuberculosis. *Memórias do Instituto Oswaldo Cruz, 101.* 697-714. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/17160276

Dye, C., Harries, A.D. & Maher, D. (2006). Tuberculosis. In Jamison, D.T., Feachem, R.G., Makgoba, M.W. et al., (Eds.), *Disease and Mortality in sub-Saharan Africa* (Chapter 13). Washington, DC: World Bank.

Ekaza, E., N'Guessan, R.K., Kacou-N'Douba, A., Aka, N., Kouakou, J., LeVacon, F., … de-La-Cochetiere, M-F. (2013). Emergence in Western African countries of MDR-TB, focus on Cote D'Ivoire. *BioMed Research International, 2013.* doi: 10.1155/2013/426709

Erokhin, V.V., Kornilova, Z.K. & Alekseeva, L.P. (2005). The specific features of the detection, clinical manifestations, and treatment of tuberculosis in the HIV-infected. *Problemy*

tuberkuleza i bolezneĭ legkikh, 10. 20-28. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/16318255

Ghana News Agency. (2014, March 24). Adults TB prevalence twice WHO value. *Ghana News Agency.* Retrieved from http://www.ghananewsagency.org/health/adults-tb-prevalence-twice-who-value-ntp-72575

Ghana Statistical Service (GSS), Ghana Health Service (GHS), & ICF Macro. 2009. *Ghana Demographic and Health Survey 2008.* Accra, Ghana: GSS, GHS and ICF Macro.

Ghana Statistical Service (GSS), Ghana Health Service (GHS), & ICF International. (2015). *Ghana Demographic and Health Survey 2014.* Rockville, Maryland, USA: GSS, GHS and ICF International. Retrieved from http://www.dhsprogram.com/pubs/pdf/FR307/FR307.pdf

Hadadi, A., Tajik, P., Rasoolinejad, M., Davoudi, S., & Mohraz, M. (2011). Pulmonary tuberculosis in patients with HIV/AIDS in Iran. *Iranian Journal of Public Health, 40.* 100-106. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/23113062

Hargreaves, J.R., Boccia, D., Evans, C.A., Adato, M., Petticrew, M. & Porter, J.D. (2011). The social determinants of tuberculosis: from evidence to action. *American Journal of Public Health, 101*(4). 654-662. doi:10.2105/AJPH.2010.199505

Harries, A.D. & Dye, C. (2006). Tuberculosis. *Annals of Tropical Medicine & Parasitology, 100.* 5-431. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/16899146

Ho, M.J. (2004). Sociocultural aspects of tuberculosis: a literature review and a case study of immigrant tuberculosis. *Social Science and Medicine, 59.* 753-762. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/15177832

Ibrahim, L.M., Hadejia, I.S., Nguku, P., Dankoli, R., Waziri, N.E., Akhimien, M.O., … Nsubuga, P. (2014). Factors associated with interruption of treatment among Pulmonary Tuberculosis patients in Plateau State, Nigeria, 2011. *Pan-African Medical Journal, 17.* doi: 10.11604/pamj.2014.17.78.3464

Khazaei, S., Salehiniya, H., Soltani, S. & Mohammadian-Hafshenaji, A. (2016). Multidrug-Resistant TB as A Major Concern for Tuberculosis Control Programs. *Iranian Journal of Public Health, 45*(1). 114-115. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/27057534

Loveman, E., Cave, C., Green, C., Royle, P., Dunn, N. & Waugh, N. (2003). The clinical and cost-effectiveness of patient education models for diabetes: a systematic review and economic evaluation. *Health Technology Assessment, 7*(22). Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/13678547

MacLachlan, E.W., Shepard-Perry, M.G., Ingo, P., Uusiku, J., Mushimba, R., Simwanza, R., … O'Malley, G. (2016). Evaluating the effectiveness of patient education and empowerment to improve patient-provider interactions in antiretroviral therapy clinics in Namibia. *AIDS Care, 28*(5). 620-627. doi: 10.1080/09540121.2015.1124975

Malangu, N. & Adebanjo, O. (2015). Knowledge and practices about multidrug-resistant tuberculosis amongst healthcare workers in Maseru. *African Journal of Primary Health Care and Family Medicine, 7*(1). doi: 10.4102/phcfm.v7i1.774

M'imunya, J.M., Kredo, T. & Volmink, J. (2012). Patient education and counselling for promoting adherence to treatment for tuberculosis. *Cochrane Database of Systematic Reviews, 5.* doi: 10.1002/14651858.CD006591.pub2

Munro, S., Lewin, S., Swart, T. & Volmink, J. (2007). A review of health behaviour theories: how useful are these for developing intentions to promote long-term medication adherence for TB and HIV/AIDS? *BioMed Central Public Health, 7*(104). Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/17561997

Naar-King, S., Rongkavilit, C., Wang, B., Wright, K., Chuenyam, T., Lam, P. & Phanuphak, P. (2008). Transtheoretical model and risky sexual behaviour in HIV+ youth in Thailand. *AIDS Care, 20*(2). 198-204. doi: 10.1080/09540120701506812

National Cancer Institute. (2005). *Theory at a Glance: A Guide For Health Promotion Practice.* (NIH Publication No. 05-3896). Washington, D.C.: U.S.

Nsagha, D.S., Pokam, B.T., Assob, J.C., Njunda, A.L., Kibu, O.D., Tanue, E.A., Ayima, C.W., & Weledji, P.E. (2015). HAART, DOTS and renal disease of patients co-infected with HIV/AIDS and TB in the South West Region of Cameroon. *BMC Public Health, 2015.* doi: 10.1186.s12889-015-2331-z

Nyasulu, P., Piri, F., Sikwese, S., Chirwa, T., Singini, I., Banda, H.T., … Munthali, A.C. (2015). Factors Influencing Delayed Health Care Seeking Among Pulmonary Tuberculosis Suspects in Rural Communities in Ntcheu District, Malawi. *Qualitative Health Research.* doi: 10.1177/1049732315588083

Rabna, P., Ramos, J., Ponce, G., Sanca, L., Mane, M., Armada, A., … Viveiros, M. (2015). Direct detection by the Xpert MTB/RIF assay and characterization of multi and poly drug-resistant tuberculosis in Guinea-Bissau, West Africa. *PLoS One, 10.* e0127536. doi: 10.1371/journal.pone.0127536

Rondags, A., Himawan, A.B., Metsemakers, J.F. & Kristina, T.N. (2014). Factors influencing non-adherence to tuberculosis treatment in Jepara, central Java, Indonesia. *The Southeast*

Asian Journal of Tropical Medicine and Public Health, 45(4). 859-868. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/25507604

Schito, M., Maeurer, M., Kim, P., Hanna, D., & Zumla, A. (2015). Translating the tuberculosis research agenda: Much accomplished, but much more to be done. *Clinical Infectious Diseases, 61*. 95-101. doi: 10.1093/cid/civ608

Sengupta, S., Pungrassami, P., Balthip, Q., Strauss, R., Kasetjaroen, Y., Chongsuvivatwong, V. & Van Rie, A. (2006). Social impact of tuberculosis in southern Thailand: views from patients, care providers and the community. *The International Journal of Tuberculosis and Lung Disease, 10*(9). 1008-1012. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/16964792

Tarekegne, D., Jemal, M., Atanaw, T., Ebabu, A., Endris, M., Moges, F., Tessema, B. & Deressa, T. (2016). Prevalence of human immunodeficiency virus infection in a cohort of tuberculosis patients at Metema Hospital, Northwest Ethiopia: a 3 years retrospective study. *BMC Research Notes, 9*(1). 192. doi: 10.1186/s13104-016-2004-8

Touray, K., Adetifa, I.M., Jallow, A., Rigby, J., Jeffries, D., Cheung, Y.B., … Hill, P.C. (2010). Spatial analysis of tuberculosis in an Urban West African setting: is there evidence of clustering? *Tropical Medicine and International Health, 15.* 664-672. doi: 10.1111/j.1365-3156.2010.02533.x

United Nations Educational, Scientific and Cultural Organization. (2010). Retrieved from http://en.unesco.org/countries/ghana

United States Agency for International Development. (2016). *The Demographic and Health Surveys.* Retrieved from http://dhsprogram.com/

Wong, L.P. & AbuBakar, S. (2013). Health Beliefs and Practices Related to Dengue Fever: A Focus Group Study. *PLoS Neglected Tropical Diseases, 7*(7). e2310. doi:10.1371/journal.pntd.0002310

World Health Organization. (2015). *Global tuberculosis report 2015.* Retrieved from http://www.who.int/tb/publications/global_report/en/

World Health Organization (2016a). *Ghana.* Retrieved from http://www.who.int/countries/gha/en/

World Health Organization. (2016b). *Tuberculosis.* (WHO Fact Sheet number 104). Retrieved from http://www.who.int/mediacentre/factsheets/fs104/en/

Appendix A

Relevant Questions and Response Codes in the DHS Survey

Region: Question V024

1 – Western

2 – Central

3 – Greater Accra

4 – Volta

5 – Eastern

6 – Ashanti

7 – Brong Ahafo

8 – Northern

9 – Upper East

10 – Upper West

Heard of TB: Question V474

0 – No

1 – Yes

TB spread by air when coughing or sneezing: Question V474A

0 – No

1 – Yes

TB spread by sharing utensils: Question V474B

0 – No

1 – Yes

TB spread by touching a person with TB: Question V474C

0 – No

1 – Yes

TB spread by food: Question V474D

0 – No

1 – Yes

TB spread by sexual contact: Question V474E

0 – No

1 – Yes

TB spread by mosquito bites: Question V474F

0 – No

1 – Yes

TB spread by other: Question V474X

0 – No

1 – Yes

TB spread by don't know: Question V474Z

0 – No

1 – Yes

TB can be cured: Question V475

0 – No

1 – Yes

8 – Don't know

Keep secret when family member gets TB: Question V476

0 – No

1 – Yes, remain a secret

8 – Don't know/depends