Literature Review

Introduction

GIS technology and other geographic methods play a powerful role in the medical field. Both public and private healthcare sectors are beginning to recognize the benefits of implementing geographic tools in the healthcare field. However, not enough resources are being allocated into funding how these methods can improve healthcare in our communities, despite their effectiveness. These GIS and geographically rooted techniques can dramatically enhance several aspects of public health, such as treatment accessibility, medical innovation and the quality of care that patients receive. This drastically improves the health of our community. Disease transmission, detection and treatment are large components of public health and these are necessary to continuously evolve for our safety. Tuberculosis is an example of an extremely infectious disease that affects the lungs and can potentially be fatal (Moonan et al. 2004). While we have made significant advances in our understanding of tuberculosis, there are still gaps in our knowledge. Perfecting our detection and treatment techniques, and studying more intricately how diseases such as tuberculosis spread and are transmitted between people will go a tremendous way in ensuring that more lives are saved. It will also make sure that our hospital systems don't get overwhelmed with patients who are infected with diseases that could have been prevented. This can shape the lives of so many members of the community, such as the thousands of patients who will get infected, and people in their proximity, in addition to all the medical professionals who work tirelessly to treat us. There is a huge opportunity for researchers to contribute to this work and collect more data using geographic techniques, which can play a monumental role in improving disease management on a global scale.

Tuberculosis Transmission and Tracking

Tuberculosis is a potentially life threatening disease that risks everyone's safety, targeting high risk groups especially. It is for this reason that transmission should be studied carefully. Uncovering everything we can about the disease will allow us to understand how it is transmitted. Tuberculosis transmission begins with an identified source, which results in particles that become infectious and remain in the air. These particles can then be breathed in by someone who may become infected and develop tuberculosis (Moonan et al. 2004). This disease can be fatal depending on the individual that it affects and whether or not they are able to get treatment on time. This is a globally pressing issue affecting people all over the world. In fact, there is an estimate of about 10.4 million cases in as late as 2015 (Moonan et al. 2004). Ending the spread of tuberculosis is not only necessary, but the best way to keep several high risk parties safe. Blocking the path of transmission is a much safer option than waiting until target groups are infected and struggling to fight it, both in terms of incidence rates and mortality rates (Moonan et al. 2004). Therefore, finding ways to track and eventually stop transmission patterns are an essential first step in ending this epidemic. However, there is still discussion on what the best way is to track tuberculosis transmission. The medical community has been unable to identify one tracking method as completely successful, which implies a lack of data to support one superior tracking method. This is an area of study that more resources should be allocated towards, in order to establish a successful method. We also need to rule out which methods are not worth looking further into. Once a method is deemed more promising than others, efforts can go into enhancing this method rather than extending energy on subpar methods. One way to evaluate different tracking methods is by analyzing them from a numeric standpoint. Another approach is studying how transmission itself occurs by narrowing in on any relevant statistical and mathematical components. This data is instrumental in understanding how tuberculosis spreads, which is reiterated in the following article on spatial analysis of tuberculosis epidemiology, "The limited number of articles that we found, and the lack of geographic representation, demonstrates a substantial gap in our understanding of these crucial parameters of TB transmission in diverse settings" (Shaweno et al. 2018, 2). This illustrates the many gaps in knowledge we still have in understanding tuberculosis transmission. Researchers believe that these gaps can be attributed to a lack of geographically inclusive data collection (Shaweno et al. 2018, 2). There needs to be more research conducted in different geographic contexts to make any substantial claims. As evident in these articles, tuberculosis transmission is a critical issue that needs to be addressed immediately, as it preys on vulnerable populations across the globe. It is significantly easier to halt tuberculosis transmission than to allow it to infect susceptible individuals, and then attempt to treat them (Moonan et al. 2004). There is a glaring lack of quantitative knowledge and

data regarding tuberculosis transmission and tracking methods because research in this area has not been explored to the fullest extent.

Patient Care and Demographics

While it is important to focus on the scientific aspects and the geographic methodology of tuberculosis transmission, something important to keep in mind is demographic information. We need to examine the patients, especially regarding how they respond to treatment and which groups have the higher chance of getting infected with tuberculosis. It appears that ethnicity and skin color is a factor in individuals contracting this disease. The following article aims to study the epidemiology of tuberculosis in children and adolescents, to contribute more knowledge in treatment and prevention (Cowger, Wortham, Burton 2019). Incidence rates for tuberculosis in this demographic were calculated during the time period between 2007 and 2017. Demographic information that was included in this research consisted of age, sex, race and country of birth (Cowger, Wortham, Burton 2019). This work was very informative regarding demographics and transmission. After researchers broke down how incidence rates vary in different age groups and locations, it is evident that there was a disproportionately high rate of tuberculosis in children and adolescents who belong to ethnic or non white groups, people living in islands affiliated with the US and children born to parents from countries other than the US (Cowger, Wortham, Burton 2019). These findings are fascinating, providing a solid foundation to continue this research. There is a great opportunity to dive into racial and socioeconomic factors and how the demographic category shapes a patient's tuberculosis infection rate. It raises the question, why are colored people and ethnic groups facing a disproportionately higher tuberculosis incidence rate? While this study was a great starting point, questions like these need to be explored in future studies and investigations. We need to make sure that everyone is aware of any medical trends that are present, and if some groups need to exercise more caution then they need to be made aware of it. However, one study isn't enough to state these findings as fact, so there needs to be more research conducted in this field to improve patient care and healthcare applications. Another article reached similar results in their studies and their target group was adults (Jacob, Mehta, Leonard 2009). This is an age group that was excluded from the previously mentioned article, so using these sources together helps ensure that I am examining transmission and treatment in patients of all ages. Again, there is a correlation between people of color and the likelihood of these groups being infected with tuberculosis (Jacob, Mehta, Leonard 2009). These results need to be reevaluated through similar studies to ensure that the findings are accurate, and then the medical field can modify their practices if it is appropriate. There are concerning correlations between both of these studies, in that people of color may be more vulnerable to tuberculosis. More research and focused experiments are necessary to establish these results. Our focus needs to include patient advocacy. If there is accuracy in these findings, then this needs to be addressed. It may serve as a catalyst for patient care to improve, which is essential in treating a group that has been historically discriminated against.

Diagnosis, Treatment and Management in Healthcare

A valuable constituent of this investigation is the role that medical systems and healthcare workers play in treatment, and everything that it entails. Treatment also consists of diagnosing and managing this disease. Medical guidelines dictate protocols that structure the outcomes of tuberculosis patients. These guidelines can include different medical models, infrastructure, and practices which come together to shape the healthcare system and regulations that medical professionals adhere to. Therefore, education and new research are both vital in ensuring that medical standards are maintained. This means also understanding where there is room for improvement and taking steps in this direction. Medicine is always evolving and growing by nature. It is not productive to grow stagnant, which is why disease management and diagnosis protocols should be continuously evaluated. This is apparent in articles analyzing how tuberculosis is managed and diagnosed (Pitrak 2007). With treatment, we also need to take into account how recovery occurs, and this source gives a glimpse into what successful treatment looks like. It ties together the perspectives and interactions of the patient and the medical team. While the main focus is diagnosis, there is also emphasis on what treatment is like and how patients can potentially show different recovery rates based on their geography (Pitrak 2007). When discussing transmission in the earlier paragraph, I did not include much commentary on how much of a role medical professionals play in disease transmission. It is a large element to overlook. An article that captivated me on this subject examined how workers in the medical setting can contribute to transmitting tuberculosis to their patients (Churchyard et. al. 2017). While steps are taken to prevent this, there is still room for advancement, especially using geographic strategies. Further considering the importance of medical training led me to consult another source that does a deep dive in programs for training medical workers (Wu, Roychowdhury, and Khan 2016). It aims to appraise and present treatment methods and outcomes in the context of tuberculosis within medical training programs in developing countries. This research concluded that more time and capital needs to be invested into medical training to treat and handle tuberculosis patients in developing countries (Wu, Roychowdhury, and Khan 2016). For example, analyzing another article centered around healthcare management provided insight because rather than just studying the system that is in place, it makes an effort to outline areas that may need improvement (Neshati et. al. 2018). According to the article, tuberculosis is often subjected to diagnostic errors. There are several opportunities for an error to be made, and diagnosis can be delayed or even missed. Medical error is unfortunately one of the leading causes of death (Neshati et. al. 2018). This error may be due to overworked medical professionals or other issues, but a chunk can be attributed to diagnosis issues. In the case of tuberculosis, it is absolutely necessary for control programs to be introduced that prioritize early detection, diagnosis and treatment. Different treatment methods and their effectiveness were also

discussed, which will hopefully serve as a resource to other countries (Neshati et. al. 2018). This is another area where the geographic segment intersects with medical care. Public health is a matter of global safety and we often forget the magnitude of collaborating with other countries. If we can work together to handle infectious diseases, it will lead to a better outcome overall. This means advocating for stronger training programs and treatment in other countries as well as our own. Taking this a step further, it may be beneficial if we look towards countries that are having more success and emulate what they do. (Ma et. al. 2018). Many research papers such as the previously mentioned articles recognize the successes that certain medical systems are achieving. However, identifying this in other geographic settings is not enough. Work that compiles this information may prove to be useful in comparing and contrasting from a learning standpoint, to see what's working well and what can be improved. An approach that combines our knowledge will assist us in successfully executing what we learn into our own healthcare systems. This will require us to adapt, and demonstrate creativity because not every country is on the same social and economic level. Healthcare workers and medical personnel can have a tremendous impact on every aspect of tuberculosis treatment, but they need more guidance to achieve this. The key to this guidance may be rooted in global collaboration and other geographic approaches that focus on supplementing healthcare management and tuberculosis treatment.

GIS and Geographic Applications

GIS techniques can be extremely effective in tackling many aspects of tuberculosis, ranging from transmission to diagnosis, treatment and recovery. These techniques have been subjected to more development and advancement in recent years and are responsible for making enormous headway in the medical geography field. However, GIS and geographic methods need to be more of a focal point in the research community. At this point, data is only beginning to emerge on how useful this sector is in healthcare, and there is still scope for improvement. Conducting more research and providing more data to establish the usefulness of these techniques can contribute to this development. There appears to be a pattern where medical research utilizing geographic methods uses several techniques, rather than narrowing down on one. For example, an article that I assessed delves into transmission, and evaluates screening and testing practices. These are important components of diagnosis. The researchers applied GIS technology and other geographic methods, such as molecular surveillance, to collect and organize data regarding positive tuberculosis cases in a specific area (Moonan et al. 2004). This study aimed to test whether the current protocol that is in place regarding tuberculosis screening and testing is sufficient for public safety. In the US, the current protocol is that only high risk populations are screened for tuberculosis (Moonan et al. 2004)). Going back to the methods mentioned above, the researchers in this study identified a single strain of tuberculosis and recognized patients who had the same strain. This process was repeated for different types of strains. Next, their addresses were geocoded and mapped. This evaluation of the spatial distribution allowed the researchers to identify high risk areas (Moonan et al. 2004). . This is useful information to reduce tuberculosis transmission and incidence. The findings provided transmission data based on age, gender and race (Moonan et al. 2004). This supports the idea that increasing testing parameters and utilizing GIS methods may create a more successful detection process. However, we still are not aware of the extent to which parameters and testing guidelines need to be extended, and this will require further investigations. This is just one study where GIS is introduced as a tool but not quite used in its full capacity. Something similar is demonstrated in another article that explores different geography centered methods, evaluating what is most effective and comparing the different results. The environmental factors in the transmission of tuberculosis are scrutinized very closely through different methodological approaches (Shaweno et al. 2018, 2). What alerts me is the fact that there is not one established method in studying this. More research into GIS and geographic applications can likely provide the data to set one method apart in terms of effectiveness. Lacking the presence of a technique that is acclaimed for its efficiency above other techniques appears to be a common trend with many experiments using geographic analysis. This is evident yet again in an article conducting a systematic literature review of studies. It collects and presents data on different approaches and

demonstrates which methods are most accurate. (Ma, Y., Horsburgh, C. R., WHite, L. F., Jenkins, H. E. 2018.) The validity of molecular and geospatial techniques, notification data, rate mapping and smoothing methods are all explored. (Ma, Y., Horsburgh, C. R., WHite, L. F., Jenkins, H. E. 2018.) Again, this makes me call into question why there needs to be so many different geographic approaches in studying one aspect of a disease. It is worth analyzing which ones are the most useful for researchers to save resources and energy. As the source synthesizes, "Future studies are needed to define the optimal method for each context and should account for unreported cases when using notification data where possible. Future studies combining genotypic and geospatial techniques with epidemiologically linked cases have the potential to provide further insights and improve TB control," (Churchyard et. al. 2017, 15) It would be a fair criticism to make that at this point, we don't know the degree to which GIS is useful in an experimental setting. However, as evident in the following articles, GIS can be an integral tool in studying geographic distribution, and how this fits into the transmission of diseases. This is crucial in recognizing high risk populations and high risk areas (Moonan et al. 2004). GIS can also be used in conjunction with other fields. Social and geographic factors are underlying contributors to the spread of tuberculosis, and a combination of ecological methods and GIS techniques can be used to inspect how the environment is involved in the tuberculosis incidence. In the following study, data on patients who were diagnosed with tuberculosis in a region of Iran was collected and recorded during a seven year time period (Beiranvand et. al 2016). Weather patterns and their correlation to incidence rate were analyzed using SPSS software. The results showed that the higher incidence rates for tuberculosis occurred in dryer areas, and the lower rates occurred in areas with more rain. (Beiranvand et. al 2016). These articles highlight how GIS can be implemented to further research, and it can also be used with other disciplines. The latter article concludes by saying "Thus to control TB in regions with high risk of disease and to identify other risk factors, conducting cohort studies is recommended" (Ma et. al. 2018). While the results of this study seemed fairly conclusive, there is enough reason to conduct more studies on this topic before establishing these findings. This is an example of an instance where future research needs to be conducted, and information that was collected needs to be reiterated for validity through more trials. When there is such a prevalence of articles that compare geographic methods or use several to target one research question, it signals to me that there are many geographic techniques that need to be evaluated and studied to establish which one is ultimately most useful in certain categories. If researchers either attempt to single out sole methods in different experimental settings or embrace GIS to its fullest extent in their work and extend their research when possible, it may pave the way for more progress in the field. Geographic methods such as GIS are still emerging applications in the healthcare field. Integrating these techniques into studies and collecting more research and data will undoubtedly draw attention to where the most efficient and useful methods

are. A common theme here seems to be a lack of data, whether that is regarding the effectiveness of a geographic technique or the findings from experiments that use these techniques. However, with more specific data collection, it is possible to establish geographic data and techniques in the scientific community and make strong advancements, which we can already see the beginning of in many research articles.

Conclusion

As explored in this paper, geography plays an instrumental role in shaping our healthcare system and medical workers, our patient care and other medical settings. Geographic applications and methods are severely underutilized, and can be integrated into medical geography to make a tremendous difference in our outcomes regarding tuberculosis cases. There are several driving forces in the tuberculosis epidemic we are facing. Applying geographic principles and ideas can make a vast difference in our fight against this deadly disease. It is truly a global issue and a threat to our public health, with our more vulnerable populations being at a high risk. Disease management branches into human geography and should be approached from a medical geography standpoint. A valuable next step may be to categorize which aspects of tuberculosis will be most efficiently tackled by which geographic application. I believe this will reduce excessive financial spending and allow us to expend energy and time in a more focused manner. Maximizing the way we allocate resources will be extremely beneficial in the long term, for our health and our economy. This may mean exploring the effect that GIS and geographic methods have in healthcare systems and patient care more deeply, or using geographic ideas to improve global relations and create a stronger network where countries are collaborating to face infectious diseases. Tuberculosis transmission and tracking can also be targeted with GIS or geographic techniques. There needs to be more data collection and research to not only substantiate the findings that geography oriented experiments are producing, but help researchers narrow down and corroborate through experiments which geographic techniques will be most useful in which area of tuberculosis treatment, transmission and detection. This introduction of data can facilitate growth and improve our word economy and healthcare management immensely.

Research Question: How can geographic applications be used to improve methods of detection, transmission and treatment in Tuberculosis patients, and which geographic techniques are most efficient in the different aspects of disease management?

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