The Effect of Technology on Disparities between Rural and Urban Healthcare

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

Access to medical technology is important in providing quality healthcare to patients. A common barrier to this is a lack of funding to afford these essential resources, which can commonly be seen in rural medical centers (Akinleye, McNutt, Lazariu, & McLaughlin, 2019). Because urban areas receive more public funding and private investment due to greater economic opportunity in population dense areas, there exists a disparity between rural and urban healthcare that impacts the lives of those rural and urban residents. This causes conditions in the respective populations that further encourage public funding and private investment to continue to go to urban areas and neglect rural areas (Rural Health Information Hub [RHIH], 2018). In the same vein, expensive resources are another side of the barrier of underfunded medical centers (Safarani, Ravaghi, Raeissi, & Maleki, 2018). Medical technology is often extremely expensive due to high research and development costs, the costs of clinical studies, and market factors (Nieves, 2022).

A way to ease the problem and ensure that underfunded medical centers have access to the resources they need to provide quality healthcare to patients is to ensure the resources are more affordable (Rosenthal, Rapfogel, & Johns, 2022). Creating technologies that are too expensive contributes to the disparity between rural and urban healthcare because it prevents rural medical centers from attaining access to necessary resources that urban centers do not have trouble accessing. On the other hand, creating technologies that are inexpensive and affordable to underfunded medical centers increases access to those necessary resources and helps to decrease the disparity between rural and urban healthcare. This paper explores how technology impacts the quality and accessibility of patient care, and the affordability of this resource will dictate whether it contributes to or eases the disparity between rural and urban healthcare.

Case Context

It is typical in the healthcare industry that institutions must pay for the resources they need to carry out their functions. This makes sense considering the United States' mixed market economy and capitalist society, but it fails to consider those institutions that cannot afford those resources (Sell, 2019). One of the prevalent disparities in quality of healthcare exists between rural and urban geographic areas. Rural areas face unique struggles in accessing high-quality medical care driven by innate factors like geographic size and distance, along with a market bias toward population-heavy metropolitan areas. These inherent barriers are exacerbated by the financial motives of healthcare providers themselves (Pifer, 2019). The effect of these barriers is that healthcare facilities and medical institutions in rural areas do not create enough revenue or receive enough funding to support themselves and provide high-quality care. One aspect of this is that rural medical institutions do not have the funding to secure resources to adequately train their medical students and professionals (Akinleye et al., 2019). These obstacles cause a disparity in quality healthcare between rural and urban areas, ultimately resulting in higher complication and mortality rates in rural hospitals than in urban ones (Villapiano, Iwashyna, & Davis, 2017). There is a need for funding and resources to be devoted to rural medical institutions to improve their quality of healthcare, including their training of medical professionals and students.

When examining the disparities in healthcare between rural and urban areas, the existing political hierarchies must be considered (Hickman, Lemley, Eisenberg, & Swan, 2022). Due to having much greater, denser populations, urban areas have larger and more stable economies, more political power, greater financial incentives for private companies to conduct business, and higher prioritization by the government to provide resources to (Kopparam, 2020). This results in a stronger healthcare industry with better educated medical professionals as well as higher

quality medical care (Pifer, 2019). Conversely, rural areas are often impoverished, economically unstable, and are often overlooked as opportunities for investment by both private and public entities (RHIH, 2018). This results in poorer quality healthcare available to those rural citizens, markedly affecting their overall health, life expectancy, and quality of life. A study in 2014 found that metropolitan areas had a life expectancy of 79.1 years, compared with 76.9 years in small urban towns and 76.7 years in rural areas, and, ultimately, life expectancy was inversely related to levels of rurality (Singh & Siahpush, 2014). There is a cycle in play here where urban areas with better funded healthcare support healthier populations, allowing the communities to flourish and create environments that are more attractive to private and public entities to focus on. It also attracts individuals to migrate to these urban areas, further increasing the population and incentive for those private and public entities to focus their efforts and resources there. On the other hand, the lack of funding and investment that causes poor healthcare in rural areas gives rise to a less healthy and able population, further debilitating the workforce, economy, and causing individuals to migrate out of these areas and decrease the population, giving even more reason for private and public entities to choose not to focus their efforts and resources there (RHIH, 2021). As such, it is seen that disparities in healthcare are both a cause and effect of the existing political hierarchy between rural and urban areas.

Technology and Politics

Technology has influence in both healthcare and politics and often intertwines the two. Medical technology is usually sold by a private company to medical institutions. The basic barriers for a medical institution to obtain a technology is knowledge of the product and sufficient funds to purchase the product. Due to the political hierarchy between urban and rural areas, the private company will market more toward large, well-funded urban medical

institutions rather than typically smaller, underfunded rural medical institutions. Better funded urban medical institutions have more funds to obtain medical technology, resulting in better equipped medical professionals working in that area in comparison to their rural counterparts. This ultimately results in healthier urban populations compared to rural, continuing the cycle and further widening the gap in quality of care. To analyze a technology's impacts on society, a framework must be used to measure data against to come to a specific conclusion in a clear and logical manner.

In his article, *Do Artifacts Have Politics?*, Winner discusses the connections a technical concept or object has to the human and social contexts around it, allowing engineers to better understand the potential impacts of a technology on society. The article examines technical arrangements as forms of order and inherently political technologies. The framework used to analyze a technology consists of four criteria. First, Winner asks whether the technology enforces a form of order. This considers whether a technology has influence on existing political hierarchies. Secondly, the Winner asks whether the technology is democratic or authoritarian. This criteria considers whether the nature of the technology is system-centered, immensely powerful, but inherently unstable — authoritarian — or man-centered, relatively weak, but resourceful and durable — democratic. Thirdly, the article considers the technology's temporal political power, which is about whether the technology has the ability to influence politics and society over time and considers data regarding the technology's impact over a period of time. Lastly, the article considers the technology's spatial political power, which is about whether the technology has the ability to influence politics and society over a geographic area and considers data regarding the technology's impact over different geographic areas (Winner, 1980).

Research Question and Methods

Because of the heavy influence and use of technology in healthcare, I considered the following question: How does technology function in political life? In the case of the disparities between urban and rural healthcare, the question becomes a refined research question: How does the technology impact existing disparities in quality of healthcare between urban and rural geographic areas?

The research question was answered using data collection that is measured against the criteria set forth: whether it enforces a form of order, whether it is democratic or authoritarian, its temporal power, and its spatial power. Data was collected through interviews with leaders of patient advocacy groups, which typically focus on a specific disease. The interviews consisted of questions regarding the disease pathology, epidemiology, treatment, and treatment access. The patient advocacy group leaders were chosen as interviewees because of their experience with patient populations, which give them expertise in the barriers that patients face when dealing with various diseases and the need for healthcare. Table 1 details the experts interviewed in the data collection process and Table 2 lists the questions that were asked during each of these interviews.

The expert interviews were converted to data by tallying what topics experts discussed, such as rural disparities, technological solutions, etc. These tallies provided evidence of the relevance of rural/urban healthcare disparities, the impact of technology, and societal and technological solutions that can address these issues. Qualitative evidence has also been drawn from the interviews by detailing what specifically the experts discussed about the tallied topics (Siedlecki, 2022).

Expert Name	Background	Patient Advocacy Group	PAG Position
Connie Lee, Psy.D.	Licensed Clinical Psychologist	Alliance to Cure Cavernous Malformation	Founding President, Chief Executive Officer
Tracy Hart	Chair of the Rare Diseases Clinical Research Network's Coalition of Patient Advocacy Groups	Osteogenesis Imperfecta Foundation	Founder, Chief Executive Officer
Christine Johnston, M.D., M.P.H.	Medical Director of the University of Washington STD Prevention Training Center	Herpes Cure Advocacy	Medical Advisory Board Member
Alessia Fornoni, M.D., Ph.D.	Professor of Medicine and Molecular and Cellular Pharmacology at the University of Miami Miller School of Medicine	NephCure	Scientific Advisory Board Member

Table 1. Interviewee information including expert name, background, and affiliation.

	Question
1	What is the nature of this disease?
2	Which populations is this disease more common in or are more likely to have it?
3	Is there a difference in rural and urban populations
4	What is the state of the art treatment for this disease?
5	Is this treatment readily available at most hospitals, including rural hospitals?
6	Do you find that rural patients have a difficult time accessing care compared to urban patients?
7	Do you find that technology has an effect on the disparity between rural and urban healthcare?

Table 2. Interview questions.

Results

In the interviews, the experts discussed the following topics: rural/urban healthcare disparities, rural/urban disparities in diagnostic care, rural/urban disparities in treatment, rural geographic unavailability, financial inaccessibility for rural residents, lack of medical education in rural communities, and telehealth and centralized private laboratory testing as a possible

solution to aid in decreasing the rural/urban disparity. Overall, the results showed the existence of the disparity between rural and urban healthcare in many ways – in terms of diagnostic care, treatment, geographic unavailability, financial inaccessibility, and lack of medical education. The results also showed possible solutions to the existing problems in the form of telehealth and centralized private lab testing. The expert interviews were conducted to better understand the existence and nature of the issues related to rural/urban healthcare disparities. All four of the experts discussed the existence of the rural/urban healthcare disparity as well as disparities in diagnostics and treatments.

Disparity in diagnostics was related to the necessity of medical diagnostic and laboratory testing equipment, which many community and rural hospitals do not possess. This lack of equipment was connected to the lack of public funding and private investment in rural areas. The diagnosis of cerebral cavernous malformations requires an MRI machine and genetic tests, chronic kidney disease requires blood and urine tests, herpes simplex virus requires PCR and antibody tests, and osteogenesis imperfecta requires MRIs and blood tests. In her interview, Dr. Lee said that because "many community and rural hospitals do not possess the laboratories or MRI machines" necessary to conduct this diagnostic testing, patients must be referred to specialty hospitals in urban centers or academic institutions. She also recounted stories of "many patients having to travel up to ten hours simply to obtain the proper diagnostic care." This shows evidence of the spatial power that access to medical technology, where certain groups of people—rural residents — have less access to healthcare because of their geographic distance to medical technology.

Disparity in treatment was related to transfusions, surgeries, transfusions, and lack of confidentiality. In her interview, Dr. Fornoni mentioned that in treating kidney disease, "some

rural patients had to commute three to four hours three times a week to obtain dialysis." To obtain a kidney transplant, rural patients had to relocate to the urban area of the treating hospital for six months after the surgery due to the involved follow-up care. In treating osteogenesis imperfecta (OI), patients receive bisphosphonate transfusions that are offered at specialty hospitals or OI treatment facilities that may not be as geographically common in rural areas. The treatment of cerebral cavernous malformations involves brain surgery that can only be completed at large urban and academic centers because those hospitals have more experienced specialty care. In treating herpes simplex virus, there is no shortage of accessibility in medications. However, according to Dr. Johnston, "due to the small populations of rural communities where residents are familiar with each other, visiting a pharmacy lacks confidentiality." As such, the stigma that comes with sexually transmitted infections prevents rural patients from seeking out care or adhering to their treatment. Dr. Johnston discussed the potential of "medication shipment services in protecting the confidentiality of patients", making it easier and more comfortable for them to access care. This shows evidence of medical technology being authoritarian in nature, because the design of these lifesaving treatments are meant for large hospitals systems, and are not easily incorporated into smaller rural hospitals and clinics or pharmacies in small rural towns.

Geographic inaccessibility was discussed in terms of the previously mentioned lack of resources in community and rural hospitals for diagnostic and treatment care. This lack of resources is caused by a lack of funding. Because of the lack of funding and sparse populations, there is often a shortage in hospital personnel, including nurses, doctors, administrators, and even assistants. In Dr. Lee's interview, she stated that "community and rural hospitals also typically don't provide specialty care, as researchers and specialty care providers are more likely to work

at large urban hospitals or academic institutions." This means that the lack of resources in rural and community hospitals comes not only in the form of shortages in equipment, but also in personnel and expertise. This very directly shows evidence of the spatial power that access to medical technology holds. As many doctors and researchers tend towards working at urban institutions with the proper funding to aid them in providing care, this is what causes that spatial power to be exerted in a way that enforces the political hierarchy between rural and urban areas.

All four experts spoke of financial inaccessibility in relation to health insurance. Going off of the basis that treatment is almost completely inaccessible for chronic conditions without some form of health insurance, the experts delved into the matter further in terms of what types of insurance issues can prevent a patient from obtaining care. Two experts spoke of the Medicare Advantage program, which is an insurance plan that a private insurance company offers. The program is considered predatory because it attracts participants with a broader coverage of services, such as dental, but fails to make clear that the plan also limits access to service providers. This typically results in participants being able to access lower-quality rural and community hospitals but being barred from large urban centers or academic institutions. The experts spoke about the necessity of access to large hospitals that offer specialty care, especially for rare disease or chronic illness patients. Beyond rare disease and chronic illness, individuals may require a surgery or diagnostic care using MRI machines, or even simply laboratory testing. With the Medicare Advantage program, those individuals would not have access to possibly life-saving treatment. In Dr. Lee's words, "they are faced with the difficult decision between having a variety of essential primary care services, such as dental care, or preparing for serious health issues that may arise." Access to medical technology by way of insurance provides evidence that it is authoritarian in nature, where the large system of insurance is consistently upheld and

impacts society by creating barriers to obtain care specifically for certain populations such as rural and low-income.

Three of the experts spoke about lack of medical education as a part of the problem in the rural/urban healthcare disparity. Typically, residents in rural areas have less access to basic medical education. This results in rural residents being less capable of self-management of their own health. For example, knowing when certain symptoms require a day of rest or a doctor's visit. According to Dr. Fornoni, this "can result in individuals unknowingly living with serious illnesses that require treatment" — at times, this results in preventable patient deaths. While more populated urban areas have the resources to generally educate its communities on public and personal health, rural areas do not have the same allocation of resources or population density for the education campaigns that work in cities to be successfully applied in rural communities. On top of this, the previously mentioned stigma around certain types of illnesses prevent individuals from obtaining necessary care. Basic medical education would aid in increasing community understanding of taboo illnesses, decreasing stigma and allowing typically stigmatized patients to obtain care with less personal difficulty. This shows evidence of how access to medical technology enforces a form of order. Lack of access to technologies that provide basic medical education further enforces the disparity between rural and urban healthcare.

Telehealth was spoken about by all four of the experts as a solution to the disparity in rural/urban healthcare. Dr. Fornoni stated in her interview that "the surge of telehealth that was brought about the COVID-19 pandemic brought access to specialty care to rural patients." This made it so that rural patients could video call with providers rather than go in person for appointments, no longer having to travel several hours to obtain care. This expands access to

specialty care to anyone who can access wireless internet. Two of the experts also spoke about Project Echo. Project ECHO (Extension for Community Healthcare Outcomes) connects primary health care providers with specialists and professional experts via regular telehealth sessions. In her interview, Tracy Hart said that "this makes it so that rural primary care providers who may not have as much expertise in specialty care are better equipped to care for rural patients that have those diseases." This brings expertise back to rural areas, granting rural residents access to better qualified providers. Telehealth shows the medical technology's temporal power, where the change that has happened in healthcare over time, particularly the change that occurred over the course of the pandemic, was influenced by telehealth.

Two of the four experts also spoke about how centralized lab testing has helped some rural hospitals conduct diagnostic care for its patients. Rural and community hospitals that do not possess the laboratory equipment necessary to conduct blood, urine, PCR, and antibody tests are typically simply unable to provide diagnostic care for the patients who need it, making rural patients travel out to a further, better equipped hospital for the same test. However, Dr. Johnston spoke about how it has become more common in recent years for "private companies to provide services where they send test kits to hospitals, the hospitals carry out the tests with their patients, and then send the tests back to the company for analysis in the large company laboratories." This makes it so that rural patients whose local hospitals do not have the capabilities for in-house laboratory tests no longer have to travel out to a larger hospital for the proper diagnostic care. This shows evidence that technology has the ability to break down the form of order that exists in rural/urban healthcare disparities. Finding ways for rural patients to utilize their rural hospitals breaks down the geographic barrier to find care for those rural patients, which breaks down the current form of order. This also reduces the cycle of larger institutions attracting patients away

from their rural or community hospitals, which generates more revenue for the larger medical centers while taking it away from the rural and community ones.

Discussion

The results showed a clear existence in the disparity between rural and urban healthcare, and cite access to technology as the problem. However, the evidence also showed that the use of different types of technology is currently part of the solution. In considering the results in the framework of whether technology has politics, the results are viewed in terms of the criteria set forth: whether it enforces a form of order, whether it is democratic or authoritarian, its temporal power, and its spatial power.

In terms of temporal power, the results showed that access to medical technology has greatly influenced politics and society over time. This can be seen in the widening gap in health outcomes between rural and urban populations over the last several decades. However, telehealth has recently begun to bring greater access to healthcare to rural patients. In terms of spatial power, the results showed that access to medical technology has greatly influenced politics and society over a geographic area, in the way that lack of access to healthcare for rural residents perpetuates the existing political hierarchy between rural and urban areas and populations.

In defining democratic technology as man-centered, relatively weak, but resourceful and durable and authoritarian technology as system-centered, immensely powerful, but inherently unstable, medical technology would be considered authoritarian. Medical technology is highly system-centered rather than man-centered in the way that it is not designed with the idea of ensuring all patients are able to access the technology. Rather, its design prioritizes its role in a hospital system — typically a large urban one. Medical technology has an immense influence on

politics and society in the way access to it impacts the urban/rural political hierarchy. In the same way medical technology is not designed with access in mind, it is unstable because of the inconsistency with which it is able to provide care to various populations.

Currently, access to medical technology has enforced a form of order in which rural populations experience more barriers to accessing healthcare, making it so that those populations outcomes are poorer than those of their urban counterparts. The political hierarchy is enforced here by maintaining power in healthier urban populations and causing rural population health to continue to decline. Technological solutions, however, begin to break down this form of order by increasing access to healthcare for rural populations. Overall, medical technology — and more specifically, access to it — is political in the various ways it is described to enforce the political hierarchy between rural and urban areas and populations. However, technological solutions that work to increase access to medical technology and healthcare in general can also be seen as political in the way it works to break down the existing political hierarchy.

The main limitation of this research was the low number of interviews and the qualitative nature of the data. Also, the interviews were for experts in rare disease and chronic illness patient advocacy. They represented a population that is important, yet smaller than representative of typical rural residents. However, the experience of the rural rare disease and chronic illness patient population embodies the main problems that exist in the rural/urban healthcare disparity.

For future research in this study, it would be helpful to reach out to more patient advocacy groups and obtain more quantitative data, perhaps through surveys. If the study was to be conducted in a different manner, it could go in the direction of interviewing a large number of patients in rural and urban areas, collecting both qualitative and quantitative data such as cost of care or hours spent commuting. The study could also collect data on a large number or rural,

community, and urban hospitals such as the presence of medical equipment, number of personnel, and other quantitative data points. Expanding the research to take into account many perspectives of this disparity would increase understanding of the problem and where potential solutions lay.

This research into the disparity between rural and urban healthcare should be used in engineering fields to inform the way in which engineers innovate. It alerts them of the problem and suggests an area in which the engineering practice can be applied to find solutions. It also encourages engineers to take stock of other innovations to ensure the technologies they are creating are inclusive to rural populations.

Conclusion

Technology has the ability to decrease the disparity between rural and urban healthcare, especially when it serves as a tool to increase access to care for rural residents. Going forward, policy makers can implement legislation that directs funding to rural and community hospitals and incentivizes providers to work in rural areas. Engineers can work to create online basic medical education programs, improve access to internet connection in rural areas for access to telehealth, and develop effective shipment systems for diagnostic tests and medications. Public health often seems like an issue for policy-makers and doctors to handle, but engineers from all disciplines that handle medicine, infrastructure, sustainability, and many other issues can have a strong, lasting, and positive impact on public health as well.

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