Medical Deserts and the Inequitable Distribution of Medicine

A Research Paper submitted to the Department of Engineering and Society

Presented to the Faculty of the School of Engineering and Applied Science
University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements of the Degree
Bachelor of Science, School of Engineering

By
Megan Hillen Talarek
Spring, 2022

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.

Signature _____ Date _____
Megan Talarek

Approved _____ Date _____
Joshua Earle, Department of Engineering and Society

Introduction

Healthcare and medicine are rapidly growing fields in the United States along with the rest of the world. The development of new medical devices, medical techniques, and other medical discoveries have led to new procedures, tests, and drugs and the growth is not slowing down. Through the continuous development of medicine, patient care quality and positive patient experiences are generally increasing across the nation, but along with the positive impacts, this development is also causing an increase in the complexity of the field, increasing costs, and decreasing accessibility (Mark & Hlatky, 2002).

Accessibility in healthcare is a growing issue in the United States and the first barrier to accessible healthcare relies on the definition of access. While care may seem accessible to most Americans, it becomes a different issue when we include the act of seeking care and the delivery of care (Guagliardo, 2004). Studies on care access focus on two main categories of medical accessibility: spatial accessibility and financial accessibility. Spatial accessibility refers to the barrier of distance from the patient to the healthcare provider and the ability of a patient to get there (Tao et al., 2018), while financial accessibility refers to the monetary barrier to receiving medical attention (*The Era of Exponential Improvement in Healthcare? | McKinsey*, n.d.). Recent studies show that spatial accessibility is a real problem because as the travel distance to receive care increases, the probability of a patient utilizing that care decreases (Guagliardo, 2004). Specifically, studies have shown that travel distance affects the probability of utilization for mental health treatment (J. Fortney et al., 1999), alcoholic treatment (J. C. Fortney et al., 1995), and breast cancer treatment services (Athas et al., 2000; Nattinger et al., 2001) as well as living a greater distance from a hospital is associated with a lower likelihood of admission for discretionary conditions (Goodman et al., 1994). Financial accessibility is also a huge issue in

the United States because if patients can physically receive care, they likely can't afford it. While healthcare advances have provided benefits to the American medical system, it is also causing "an ever-expanding portion of the US GDP to be consumed by healthcare expenses, as medical inflation continues to outstrip GDP growth and inflation in the rest of the economy" (*The next Imperatives for US Healthcare | McKinsey*, n.d.). If this continues, individuals will simply be priced out of receiving medical care and the financial accessibility crisis will continue to grow.

Another accessibility issue in medicine is the large differences in a healthcare clinic's perceived accessibility versus the actual accessibility. Over the last few years, accessibility is becoming a hot topic with more companies and fields expanding on their perceived accessibility, but not many impactful changes have been made to their actual accessibility (Sanchez et al., 2000). Although the effort is there, sometimes the policies introduced do not apply to marginalized groups. For example, when the United States federal government decided to send four COVID-19 at-home tests to every household in America, a variety of issues occurred including the limitations on number of tests available to each address, residents in multi-unit buildings being unable to order tests after their neighbors have, and houseless individuals and undocumented citizens having additional barriers to access these tests (*Fact Sheet: The Biden Administration to Begin Distributing At-Home, Rapid COVID-19 Tests to Americans for Free*, 2022; Elllis, n.d.; Mazer, 2021). In order to have real accessibility changes, these policymakers must listen and respond to the needs of individuals facing accessibility issues in their medical care (Lättman et al., 2018). By doing this, there is a chance to decrease the differences in a clinic's perceived accessibility versus actual accessibility.

Problem Frame

Currently, the United States has standardized non-emergency and emergency supply chains for the storage, distribution, and dispensing of medical supplies and pharmaceuticals which are supposed to create accessible medicine. In non-emergency times, after the product development of medical supplies is complete, the product is distributed to wholesalers (distributors), who manage the physical logistics of moving the products from the manufacturer's warehouse to the retailers. Once the retailers—including places like Walgreens, CVS, or a hospital—have the product they are the ones who finally sell to the consumer (Figure 1). Profit margins in the medical world are small for all parties except for manufacturers. For the wholesaler and retailer, they sell medical products for only a small profit because they have fewer fixed costs when compared to the research and development costs paid by the manufacturer. Additionally, inventories for medical supplies are typically pretty low with no backup supply in non-emergency times. When following this supply chain, there are a few main physical logistics that must be considered. These include the storage of the medicine and medical supplies in a clean and biological hazard-free area, the organization of the products to ensure no cross-contamination and that everything is labeled correctly, and lastly the packaging and transportation of the supplies to ensure medicine stays fresh and technology isn't broken (Belson & D, 2005; *The Basics of Healthcare Distribution*, n.d.).

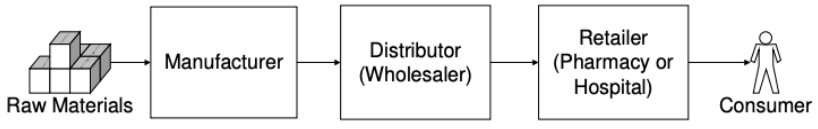

Figure 1: U.S. standardized non-emergency supply chain for medical supplies.

(Belson & D, 2005; *The Basics of Healthcare Distribution*, n.d.)

In addition to the non-emergency supply chain, the United States government has a different supply chain organization to prepare for times of emergency including terrorism, bioterrorism, and pandemics. There are multiple programs and modes of distribution that allow for a quick and reliable supply of medicine and medical devices to be delivered to local communities for distribution following an unexpected event. One of the most effective ways to respond to an emergency is through the use of the Strategic National Stockpile (SNS). When this program is required, a stockpile of medical supplies can be delivered to regional distribution centers within 12 hours by request of the Governor to then be distributed to the local community. Other programs allow for hospitals to be provided emergency funding as well as medical professionals to be provided to understaffed areas. Each program appears well thought out with a quick-to-action plan but most accessibility issues arise once the supplies are in the local community and there are no standardized distribution methods provided to the local jurisdiction (Belson & D, 2005; Socal et al., 2021).

Although well developed, the national supply chain for medicine is lacking in a few very important areas. First, in non-emergency times when the federal government is not involved, there is no backup supply available to respond to any increased demand. Without government intervention, an increased demand puts pressure on the manufacturers to increase production without any outside assistance. This can cause a variety of issues such as lower quality products, higher prices for products, or even just a shortage of medical supplies. Fortunately, the Federal government can intervene in urgent situations and provide support with one of their many emergency programs. Typically, these programs are not as successful as expected due to the unstandardized distribution methods used by local communities. Although these communities are

provided supplies, they typically end up distributing the supplies in an inequitable manner which adds to the medical accessibility issue in their community.

In this paper, I discuss failures in medical distribution techniques and demonstrate that our healthcare system must become more equitable by adopting technology to modernize the medicine distribution system. I provide examples including medical deserts in the United States, the unequal distribution of medical supplies during the COVID-19 pandemic, and the impacts of racial inequalities on the unequal distribution of medicine over time. Equality in medicine in the United States has much room for improvement and needs to change in order to properly support Americans through medical battles as well as everyday medical complications.

Medical Deserts in the United States

In order to address the inequitable distribution of medicine and medical supplies in the United States, we first must understand what a medical desert is. Similar to a food desert, in which there is a lack of healthy and fresh food available (*Food Deserts*, 2020), a medical desert is a medically underserved area that has a lower quality of healthcare. Medical deserts can be found in areas with a lower number of healthcare professionals, poor quality healthcare professionals, highly remote areas, as well as areas with a high need for care (Lucas-Gabrielli & Chevillard, 2018). Typically these areas are found in low-income and rural communities and often are created along racial lines. Studies have found that Black neighborhoods are the only neighborhoods that were consistently in medical deserts and that neighborhoods made up of mostly Black residents are more often 5 miles or more away from a trauma center, such as a hospital, compared with White or Hispanic neighborhoods (*Many Black Americans Live in Trauma Care "Deserts,"* n.d.).

Another feature of medical deserts is the lack of well-trained healthcare workers available in these communities. Specifically, when studying rural versus urban areas, there are around 68 physicians per 100,000 people in rural areas while there are 84 physicians per 100,000 people in urban areas with the national average being around 80 physicians per 100,000 people in the United States (Petterson et al., 2013). Not only do medical deserts have a lower quantity of medical professionals, but the medical professionals available are typically lower quality based on the amount of training provided. Studies have shown that physicians are more likely to work in urban areas while nurse practitioners and physician assistants, who train for fewer years, are more likely to work in rural areas (*Primary Care Workforce Facts and Stats No. 3*, n.d.).

An example of how drastic medical deserts can be was recently reported on by The Washington Post. Ed Garner is a family medicine doctor in West Texas and is the only doctor working in an 11,000 square mile area (approximately the size of Maryland). He receives calls at all hours of the day and night to report to the hospital to treat patients who are injured as far as 2 hours away. At Garner's hospital, he is lucky to have a CT scanning machine because no hospital in a 100-mile radius has one, but beyond that, he is lacking most modern medical instruments. In Texas specifically, 159 of the state's 254 counties have no general surgeons, 121 counties have no medical specialists, and 35 counties have no doctors at all. 30 of the 254 counties are similar to Garner's county in which there is only a single doctor who has to work all of the medical professions including medical director, head physician, director, chief of staff, as well as run the emergency room ("'Out Here, It's Just Me,'" n.d.). Although this is a very extreme version of a medical desert, it is still common, especially in rural areas, for this extremity to be a reality and without further investment and innovation in the medical system, millions of Americans will continue to live with suboptimal medical care.

Beyond the issue of medical deserts existing in the United States, the arguably larger issue is the lack of medical desert research being conducted in this country. While researching for this paper, I was able to find countless peer-reviewed articles to be used as sources discussing the cause and impacts of medical deserts in other countries, namely France, Australia, and New Zealand. In these articles, the researchers would discuss "different methods to measure primary health care accessibility or imbalance between health care providers and needs" as well as "show the confusion generated by the concept of medical deserts and the stakes for public authorities to define measures to attract and retain general practitioners in such areas" (Lucas-Gabrielli & Chevillard, 2018). Through their research, these authors are not only discussing the concept of medical deserts but also addressing these issues through quantitative data analysis and determining the next steps by relating it back to the government officials in charge. When comparing this to the research I found conducted in the United States, I found that the American research was much broader, often not published in peer-reviewed journals, and didn't describe the next steps in as much detail as provided in the international research. In order to address the issue of medical deserts in the United States, the first step is to encourage the development of research around medical deserts to determine specifically why medical deserts exist in this country and the steps that are required to minimize them. For this to be successful, the research conducted needs to include an analysis of studied data and determine specific steps government officials can take to address this issue.

COVID-19 and Medical Distribution Problems

One way that medical deserts can impact a local community is through the unequal distribution of medical supplies to a certain area. A recent example of this problem is the distribution methods used during the beginning of the COVID-19 pandemic. During the first

peak of COVID-19 infection in March 2020, there was a massive shortage of supplies for medical treatment devices, such as ventilators, as well as personal protective equipment (PPE) in most of the country. While the shortage was nationwide, it especially impacted both rural communities as well as communities with a high number of cases of infection (Tsai, 2020; Wagtendonk, 2020). Not only was there a supply shortage during the pandemic, but due to this shortage along with the demand increasing, the prices for common medical supplies skyrocketed. For example, the price of isopropyl alcohol used in hand sanitizers went up from ~$1000 to $3160 per metric ton (Khot, 2020). Studies show that a single COVID-19 patient requires the use of 36 pairs of gloves, 14 gowns, 3 pairs of goggles, and 13 N95 face masks for only 24 hours in intensive care (*Personal Protective Equipment Needed; New COVID-19 Data Dashboard Unveiled | Governor Mike DeWine*, n.d.) causing the limited supplies available to be used rapidly. During times of the pandemic, healthcare professionals were required to reuse their PPE including single-use items such as N95 masks, face shields, and disposable scrubs

Figure 2: Medical workers were required to reuse PPE and use materials, such as trash bags, in replacement of PPE during the peak of the COVID-19 pandemic. (Ankel, 2020)

as well as used other household materials as PPE (Figure 2). Around 87% of hospital nurses surveyed reported reusing at least one type of single-use PPE (*National Nurse Survey Reveals Devastating Impact of Reopening Too Soon*, 2020).

The impact of the COVID-19 pandemic has affected every community across the country but due to the unequal distribution of medical supplies, underserved communities were hit the hardest. When comparing the risk of COVID-19 among rural residents by race and ethnicity, it is clear to see that these underserved communities have a much higher risk than those from more affluent communities. In the past decade, more than 125 rural hospitals have closed and many that are still open, are on the edge of closing. Additionally, rural areas have a very small percentage of ICU beds, ventilators, and respiratory treatment compared to other communities (Henning-Smith et al., 2021). Besides rural areas being underserved when compared to urban areas, rural areas tend to have older populations as well as higher incidences of pre-existing conditions. In addition to having a more medically fragile population, rural hospitals are less likely to be able to handle a sudden increase in patients caused by COVID-19 due to the lower number of specialists, worse technology, and smaller capacities (Brandily et al., 2020). Combining these points, it's clear that rural areas are consistently at a greater risk for health conditions and the COVID-19 pandemic was no different. In fact, rural areas have around double the number of COVID-19 cases when compared to urban areas with one study stating 3,400 cases per 100,000 people in rural places versus 1,284 cases per 100,000 people in urban places (Cuadros et al., 2021). Another study, comparing death rates due to COVID-19, found that around 1 in 434 Americans from rural areas have died from COVID-19 compared to around 1 in 513 in urban areas (*Covid Is Killing Rural Americans at Twice the Rate of People in Urban Areas*, n.d.).

Although the United States government typically has a backup stock of medicine and medical supplies for emergency situations, the COVID-19 pandemic exposed some weak spots in our supply chain methods that must be improved for future emergency situations. To ensure there is never a lack of medical supplies during an emergency situation, the government should develop separate methods and controls for the distribution of medical supplies and the distribution of medicine. Studies have found that using an optimization model for the emergency distribution methods of medical supplies increases the efficiency of the distribution with an increasing number of variables involved. These variables include things such as the population, confirmed and suspected cases, the scale of medical supplies demand, number of medical staff, gap rate of medical supplies, and the most important variable of demand urgency (Jian-you et al., 2020). By including a large number and variety of variables, researchers were able to develop the most efficient way to distribute medical supplies during the COVID-19 pandemic. Moving forward, if the United States government decided to research and implement an optimization model for the distribution of medical supplies, it is less likely for the country to be unprepared again during the next emergency situation. Additionally, the United States government needs to focus on implementing measures to ensure there are no medicine shortages in times of emergency. These measures could include preventing stockpiling by developing a nationwide database and limit on the amount of medical supplies each citizen can purchase, expanding the availability of mail-in and home delivery orders for medicine, and developing a method to protect essential medicines from becoming sparse during these times (Alexander & Qato, 2020). Government officials implementing policies to protect medicine and medical supplies can ensure that the distribution of these important items is done in a more equitable manner moving forward.

Racial Disparities in Medicine

Racial biases have always existed in the field of medicine and have had devastating effects on patients. Although racial biases do not exist only in medical deserts, understanding how biases and medical deserts interact is crucial in understanding inequitable medicine in the United States. Historically, racial biases have played a role in medicine in the United States for more than 400 years, since the first enslaved people were brought to the U.S., and have exaggerated impacts on the African American community (Byrd & Clayton, 2001). African Americans have had the worst health care, the worst health status, and the worst health outcomes of any racial group in the United States since arriving in the country as an enslaved people. Not only were they treated poorly based on their rank in society, but United States medical schools taught physicians throughout the 18th, 19th, and 20th centuries that Black people and other radicalized groups were biologically inferior (Byrd & Clayton, 2001). In modern medicine, we continue to see instances of racial biases. Countless stories have been told of clinicians refusing service to patients of certain racial groups based on biases and stereotypes. Inferiority theories also continue in the modern day with myths such as Black people being resistant to pain or that they have weak lungs that can be strengthened through hard work remaining relevant in modern medical education and practice (Villarosa, 2019). Though belief in genetic differences between races persist, studies have found that the genome, or the complete set of genetic DNA (*A Brief Guide to Genomics*, n.d.), of various racial groups are 99.5%-99.9% identical. In fact, genomic difference is greater between individuals within the same racial group, than is found between racial groups as a whole. This study shows that there are no identifiable racial genomic clusters, meaning that the inferiority theories taught for centuries have no biological support (Yearby, 2021).

One blatant example of racial biases playing a role in modern medicine is through the design of the pulse oximeter. A pulse oximeter is used to measure the oxygen level in the blood of a patient. To do this, a painless probe is placed on a finger or earlobe and light is emitted to measure the oxygen levels (*Pulse Oximetry*, n.d.). Since this device is simply using light to determine oxygen levels, studies have found that the device may not be accurate when used on people with darker skin tones. In this study, researchers were testing the pulse oximeter on patients to detect occult hypoxia, or arterial oxygen saturation of <88% compared to a pulse oximeter reading between 92% and 96%. When comparing a group who identifies as White with a group who identifies as Black, the Black patients had around three times the cases of occult hypoxia that the pulse oximeter did not detect (Sjoding et al., 2020). Another study focused on preterm infants found similar results. The researchers studied both Black and White infants who were born before or at 32 weeks through gestation and took their oxygen levels through both arterial blood gas measurements as well as pulse oximetry measurements. Similar to the adult study, there was an increased incidence of occult hypoxemia in the Black infants with around 2.4 times the number of cases in Black infants when compared to the White infants (Vesoulis et al., 2022).

In modern medicine, racial disparities in the medical field often exist due to implicit biases that medical professionals learn from their teachers, mentors, and peers. Implicit biases are unconscious attitudes or beliefs projected towards people of certain groups, typically marginalized groups, that are difficult to unlearn or remove due to their unconscious nature (Brownstein, 2019). In order to remove racial disparities from medicine, medical professionals need to learn to identify and unlearn these implicit biases. Many companies are beginning to implement implicit bias training into their required job training and although this is a good first

step, many employees simply skim over these training assessments and do not integrate their learning into daily life. To ensure medical professionals can identify and stop racial biases, they need to consistently be exposed to learning material to identify blind stops and actively work on dismissing the biases. To do this, companies and employers should develop a continuous learning cycle to teach individual employees while also working to remove systematic problems throughout the entire place of work (Edgoose et al., 2019). In terms of the medical research space and medical devices such as the pulse oximeter, racial disparities are not only caused by implicit biases but also by underdeveloped research and testing methods where researchers often exclude diverse studies in their methods. To diversify studies and ensure medical devices work for all individuals, the development of more expansive standards is crucial to ensure there are diverse patients involved in the development of all medical devices and a more detailed analysis process needs to occur for all medical devices before being approved for public use (Okunlola et al., 2022).

Future Approaches to Aid in the Accessibility of Medicine

When looking back at the problem of medical deserts and inequitable medicine, it is important to also look forward and plan for a solution. During the COVID-19 pandemic, for example, we've learned the effects of the unequal distribution of emergency medical supplies through this experience and can continue to apply this knowledge to ensure it doesn't happen again. I think it's important to study all failures of the United States medical system to be able to improve it over time and ensure mistakes do not occur twice. Since the COVID-19 pandemic started, the amount of research conducted to find innovative ways to distribute medicine has been studied that could be used in the future, even in non-emergency times.

Technological Advances

During the COVID-19 pandemic, researchers began to study how to deliver required medicine to infected individuals without risking the spread of the virus. To solve this problem, the researchers determined that it may be possible to use drones to deliver to each individual patient. Through their research, they found that it is possible to use drones to deliver medicine as well as sanitize the streets with minimal limitations in technical skills (Euchi, 2021). Beyond using drones during the COVID-19 pandemic, I think this technology could be modified to deliver medical supplies in bulk to rural communities to decrease the impacts of medical deserts. One of the main factors that cause medical deserts is underdeveloped infrastructure leading to fewer medical supplies being delivered to that area. Through the use of drones, medical supplies could be safely delivered to any location despite any physical accessibility issues. Paired with the telehealth technology developed during the pandemic, where patients can meet with a doctor virtually, this could be an easy solution to providing quality healthcare to even the most rural and underdeveloped areas. Before implementing this solution, rural communities would require additional infrastructure such as rural broadband for it to be successful.

The Restructuring of the Healthcare System

Additional efforts to counteract inaccessible and inequitable medicine include "the redirection" of medicine from the rigid centralized structure we currently have to a smaller scale, more flexible system which would be more evenly distributed across the nation. This effort would involve sensor networks which would allow for response to disease at the pre-symptoms stage as well as the developed symptoms stage to create an effective response at a much lower cost when compared to the central hospital-based systems. Additionally, there are minimal investments required and a low cost to maintain and manage so it can create great benefits in

both remote areas of advanced counties and developmental countries (Watanabe et al., 2019). I believe that this approach could successfully make medicine more accessible in the United States by applying this system to the more remote areas that are currently medically underserved. Again, it is important that all areas are well developed before implementing this technology because it will require a wide variety of resources including monetary policy, additional medical training, and other social support systems.

Conclusions

Overall, medical deserts and inequitable medicine are problems facing the United States in drastic ways. In order to address these problems, we need to focus research on optimizing the supply chain methods used for distributing medicine, medical supplies, and medical workers, especially during times of emergency. These issues were especially brought to light during the COVID-19 pandemic when the lack of medicine and medical supplies as well as the increasing demand and cost for them caused the pandemic to impact the United States in unimaginable ways. Beyond the supply chain issues, we must also focus on the everlasting issues involving racial biases in medicine to ensure medical developments can be used appropriately for all racial groups. With researchers actively searching for ways to decrease the prevalence of medical deserts and create a more equitable medical system, the future of medicine and medical technology is looking up.

References

A Brief Guide to Genomics. (n.d.). Genome.Gov. Retrieved February 8, 2022, from https://www.genome.gov/about-genomics/fact-sheets/A-Brief-Guide-to-Genomics

Alexander, G. C., & Qato, D. M. (2020). Ensuring Access to Medications in the US During the COVID-19 Pandemic. *JAMA*, *324*(1), 31–32. https://doi.org/10.1001/jama.2020.6016

Ankel, S. (2020). Photos show how shortages are forcing doctors and nurses to improvise coronavirus PPE from snorkel masks, pool noodles, and trash bags. Business Insider. https://www.businessinsider.com/photos-show-doctors-nurses-improvising-due-to-lack-of-ppe-2020-4

Athas, W. F., Adams-Cameron, M., Hunt, W. C., Amir-Fazli, A., & Key, C. R. (2000). Travel Distance to Radiation Therapy and Receipt of Radiotherapy Following Breast-Conserving Surgery. *JNCI: Journal of the National Cancer Institute*, *92*(3), 269–271. https://doi.org/10.1093/jnci/92.3.269

Belson, D., & D, D. B. P. (2005). *Storage, Distribution and Dispensing of Medical Supplies*.

Brandily, P., Brébion, C., Briole, S., & Khoury, L. (2020). *A Poorly Understood Disease? The Unequal Distribution of Excess Mortality Due to COVID-19 Across French Municipalities* * [Preprint]. Health Economics. https://doi.org/10.1101/2020.07.09.20149955

Brownstein, M. (2019). Implicit Bias. In E. N. Zalta (Ed.), *The Stanford Encyclopedia of Philosophy* (Fall 2019). Metaphysics Research Lab, Stanford University. https://plato.stanford.edu/archives/fall2019/entries/implicit-bias/

Byrd, W. M., & Clayton, L. A. (2001). Race, medicine, and health care in the United States: A historical survey. *Journal of the National Medical Association*, *93*(3 Suppl), 11S-34S.

Covid is killing rural Americans at twice the rate of people in urban areas. (n.d.). NBC News.

Retrieved February 8, 2022, from https://www.nbcnews.com/health/health-news/covid-killing-rural-americans-twice-rate-people-urban-areas-n1280369

Cuadros, D. F., Branscum, A. J., Mukandavire, Z., Miller, F. D., & MacKinnon, N. (2021). Dynamics of the COVID-19 epidemic in urban and rural areas in the United States. *Annals of Epidemiology*, *59*, 16–20. https://doi.org/10.1016/j.annepidem.2021.04.007

Edgoose, J. Y. C., Quiogue, M., & Sidhar, K. (2019). How to Identify, Understand, and Unlearn Implicit Bias in Patient Care. *Family Practice Management*, *26*(4), 29–33.

Ellis, R. (n.d.). *Mailed Rapid Tests Unavailable to Some Apartment Dwellers*. WebMD. Retrieved May 9, 2022, from https://www.webmd.com/lung/news/20220120/mailed-rapid-tests-unavailable-to-some-apartment-dwellers

Euchi, J. (2021). Do drones have a realistic place in a pandemic fight for delivering medical supplies in healthcare systems problems? *C*hinese Journal of Aeronautics, 34(2), 182–190. https://doi.org/10.1016/j.cja.2020.06.006

Fact Sheet: The Biden Administration to Begin Distributing At-Home, Rapid COVID-19 Tests to Americans for Free. (2022). The White House. https://www.whitehouse.gov/briefing-room/statements-releases/2022/01/14/fact-sheet-the-biden-administration-to-begin-distributing-at-home-rapid-covid-19-tests-to-americans-for-free/

Food deserts: Definition, effects, and solutions. (2020, June 22). https://www.medicalnewstoday.com/articles/what-are-food-deserts

Fortney, J. C., Booth, B. M., Blow, F. C., Bunn, J. Y., & Loveland Cook, C. A. (1995). The Effects of Travel Barriers and Age on the Utilization of Alcoholism Treatment Aftercare. *The American Journal of Drug and Alcohol Abuse*, *21*(3), 391–406. https://doi.org/10.3109/00952999509002705

Fortney, J., Rost, K., Zhang, M., & Warren, J. (1999). The Impact of Geographic Accessibility on the Intensity and Quality of Depression Treatment. *Medical Care*, *37*(9), 884–893.

Goodman, D. C., Fisher, E. S., Gittelsohn, A., Chang, C.-H., & Fleming, C. (1994). Why are Children Hospitalized? The Role of Non-Clinical Factors in Pediatric Hospitalizations. *Pediatrics*, *93*(6), 896–902. https://doi.org/10.1542/peds.93.6.896

Guagliardo, M. F. (2004). Spatial accessibility of primary care: Concepts, methods and challenges. *International Journal of Health Geographics*, *3*(1), 3. https://doi.org/10.1186/1476-072X-3-3

Henning-Smith, C., Tuttle, M., & Kozhimannil, K. B. (2021). Unequal Distribution of COVID-19 Risk Among Rural Residents by Race and Ethnicity. *The Journal of Rural Health*, *37*(1), 224–226. https://doi.org/10.1111/jrh.12463

Jian-you Z., Wan-li H. a. N., Wen-jie Z., & Yang Z. (2020). Distribution of emergency medical supplies in cities under major public health emergency. 交通运输工程学报, *20*(3), 168–177. https://doi.org/10.19818/j.cnki.1671-1637.2020.03.016

Khot, U. N. (2020). Navigating Healthcare Supply Shortages During the COVID-19 Pandemic. *Circulation: Cardiovascular Quality and Outcomes*, *13*(6), e006801. https://doi.org/10.1161/CIRCOUTCOMES.120.006801

Lättman, K., Olsson, L. E., & Friman, M. (2018). A new approach to accessibility – Examining perceived accessibility in contrast to objectively measured accessibility in daily travel. *Research in Transportation Economics*, *69*, 501–511. https://doi.org/10.1016/j.retrec.2018.06.002

Lucas-Gabrielli, V., & Chevillard, G. (2018). ["Medical deserts" and accessibility to care: What are we talking about? *Medecine sciences*, *34*(6–7), 599–603. https://doi.org/10.1051/medsci/20183406022

Many Black Americans Live in Trauma Care "Deserts." (n.d.). WebMD. Retrieved November 12, 2021, from https://www.webmd.com/first-aid/news/20190308/many-black-americans-live-in-trauma-care-deserts

Mark, D. B., & Hlatky, M. A. (2002). Medical Economics and the Assessment of Value in Cardiovascular Medicine: Part I. *Circulation*, *106*(4), 516–520. https://doi.org/10.1161/01.CIR.0000021407.93752.7B

Mazer, B. (2021). *Jen Psaki's Rapid-Testing Gaffe Is Not as Simple as It Seems*. The Atlantic. https://www.theatlantic.com/health/archive/2021/12/jen-psaki-free-rapid-covid-testing-sarcastic/620925/

National nurse survey reveals devastating impact of reopening too soon. (2020, July 27). National Nurses United. https://www.nationalnursesunited.org/press/national-nurse-survey-reveals-devastating-impact-reopening-too-soon

Nattinger, A. B., Kneusel, R. T., Hoffmann, R. G., & Gilligan, M. A. (2001). Relationship of Distance From a Radiotherapy Facility and Initial Breast Cancer Treatment. *JNCI: Journal of the National Cancer Institute*, *93*(17), 1344–1346. https://doi.org/10.1093/jnci/93.17.1344

Okunlola, O. E., Lipnick, M. S., Batchelder, P. B., Bernstein, M., Feiner, J. R., & Bickler, P. E. (2022). Pulse Oximeter Performance, Racial Inequity, and the Work Ahead. *Respiratory Care*, *67*(2), 252–257. https://doi.org/10.4187/respcare.09795

'Out here, it's just me': In the medical desert of rural America, one doctor for 11,000 square miles. (n.d.). *Washington Post*. Retrieved November 15, 2021, from https://www.washingtonpost.com/national/out-here-its-just-me/2019/09/28/fa1df9b6-deef-11e9-be96-6adb81821e90_story.html

Personal Protective Equipment Needed; New COVID-19 Data Dashboard Unveiled | Governor

Mike DeWine. (n.d.). Retrieved February 8, 2022, from https://governor.ohio.gov/media/news-and-media/personal-protective-equipment-needed-new-covid19-data-dashboard-unveiled

Petterson, S., Robert L. Phillips, J., Bazemore, A., & Koinis, G. T. (2013). Unequal Distribution of the U.S. Primary Care Workforce. *American Family Physician*, *87*(11). https://www.aafp.org/afp/2013/0601/od1.html

Primary Care Workforce Facts and Stats No. 3. (n.d.). Retrieved October 4, 2021, from http://www.ahrq.gov/research/findings/factsheets/primary/pcwork3/index.html

Pulse Oximetry. (n.d.). Retrieved February 8, 2022, from https://www.hopkinsmedicine.org/health/treatment-tests-and-therapies/pulse-oximetry

Sanchez, J., Byfield, G., Brown, T. T., LaFavor, K., Murphy, D., & Laud, P. (2000). Perceived Accessibility Versus Actual Physical Accessibility of Healthcare Facilities. *Rehabilitation Nursing*, *25*(1), 6–9. https://doi.org/10.1002/j.2048-7940.2000.tb01849.x

Sjoding, M. W., Dickson, R. P., Iwashyna, T. J., Gay, S. E., & Valley, T. S. (2020). Racial Bias in Pulse Oximetry Measurement. *New England Journal of Medicine*, *383*(25), 2477–2478. https://doi.org/10.1056/NEJMc2029240

Socal, M. P., Sharfstein, J. M., & Greene, J. A. (2021). The Pandemic and the Supply Chain: Gaps in Pharmaceutical Production and Distribution. *American Journal of Public Health*, *111*(4), 635–639. https://doi.org/10.2105/AJPH.2020.306138

Tao, Z., Cheng, Y., Zheng, Q., & Li, G. (2018). Measuring spatial accessibility to healthcare services with constraint of administrative boundary: A case study of Yanqing District, Beijing, China. *International Journal for Equity in Health*, *17*(1), 7. https://doi.org/10.1186/s12939-018-0720-5

The Basics of Healthcare Distribution. (n.d.). Retrieved February 17, 2022, from

https://www.concordancehealthcare.com/blog/basics-healthcare-distribution

The era of exponential improvement in healthcare? | McKinsey. (n.d.). Retrieved February 8, 2022, from https://www.mckinsey.com/industries/healthcare-systems-and-services/our-insights/the-era-of-exponential-improvement-in-healthcare

The next imperatives for US healthcare | McKinsey. (n.d.). Retrieved February 8, 2022, from https://www.mckinsey.com/industries/healthcare-systems-and-services/our-insights/the-next-imperatives-for-us-healthcare

Tsai, R. L. (2020, April 13). *Inequality During a Pandemic, Part II: Rationing Life-Saving Gear and Care (Harvard Law Review) | The shortage of ventilators and personal protective equipment (PPE) in parts of the country has raised the most acute equality concerns regarding the treatment of people who are gravely ill. Some jurisdictions have more protective and life-saving equipment on hand than others do, but this pre-crisis distribution is a product of many factors beyond existing...* https://blog.harvardlawreview.org/inequality-during-a-pandemic-part-ii-rationing-life-saving-gear-and-care/

Vesoulis, Z., Tims, A., Lodhi, H., Lalos, N., & Whitehead, H. (2022). Racial discrepancy in pulse oximeter accuracy in preterm infants. *Journal of Perinatology*, *42*(1), 79–85. https://doi.org/10.1038/s41372-021-01230-3

Villarosa, L. (2019, August 14). How False Beliefs in Physical Racial Difference Still Live in Medicine Today. *The New York Times*. https://www.nytimes.com/interactive/2019/08/14/magazine/racial-differences-doctors.html, https://www.nytimes.com/interactive/2019/08/14/magazine/racial-differences-doctors.html

Wagtendonk, A. van. (2020, March 29). *The government is distributing emergency Covid-19 supplies. But some states are losing out.* Vox. https://www.vox.com/policy-and-

politics/2020/3/29/21198704/emergency-covid-19-supplies-fema-states-federal-government

Watanabe, S., Komatsu, Y., Ono, M., & Katayama, K. (2019). Distributed Healthcare and Medicine: Technological Feasibility and Future Scope for Redirecting the Current Centralized Model to Benefit Remote Areas. *2019 Portland International Conference on Management of Engineering and Technology (PICMET)*, 1–13. https://doi.org/10.23919/PICMET.2019.8893699

Yearby, R. (2021). Race Based Medicine, Colorblind Disease: How Racism in Medicine Harms Us All. *The American Journal of Bioethics*, *21*(2), 19–27. https://doi.org/10.1080/15265161.2020.1851811