

Wearable Devices and Trust in Healthcare Providers

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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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Wearable devices are healthcare devices that are worn on or close to the skin and obtain medical data that can be analyzed to determine patient health. Wearable devices allow healthcare providers to remotely collect data on their patients, allowing for a higher level of care due to the continuous, closer monitoring than they would get outside of a hospital, including remote areas. Wearable devices show great promise for an increased level of patient care and a handful have already been implemented in the United Kingdom (Vijayan, Connolly, Condell, McKelvey, & Gardiner, 2021). A higher level of care overall reduces suffering for millions of Americans. Rural communities are in less favorable conditions for healthcare as compared to urban communities and can be helped greatly through the monitored use of wearable devices (Jang et al., 2018). Due to their greater distance from a healthcare provider, wearable devices can be more effective in rural environments yet have more hurdles to overcome to be successfully implemented. If proper measures are not taken, wearable device technology will stand to benefit richer, urban Americans significantly more than poorer or rural Americans.

The Technology Behind Wearable Devices

Healthcare is incredibly expensive and is essential for many people and families. Americans spend significantly more money on healthcare compared to many other countries (Cox et al., 2021). Greater healthcare costs impact every American, as they will end up paying for it somehow: whether it is a part of their premium, deductible, or their health due to the lack of adequate care received. As a result, It is in the best interest of everyone to keep the cost of healthcare as low as possible to keep Americans healthy. Specifically, Americans living in rural environments don't have the access to healthcare that urban Americans have. They often lack easy access to healthcare, posing a greater challenge for chronic illnesses or other times they

have to routinely visit the doctors (Rural Health and contextualizing data, 2020). As a result, rural Americans can benefit significantly from wearable devices and telehealth medicine in general.

Wearable devices partially exist in a subset of telehealth or remote healthcare. Wearable devices enable healthcare practitioners to monitor patients remotely, without the need to physically interact with patients. Even after the height of telehealth services in April 2020, telehealth is up 38x since before the pandemic and still has greater benefits to be reaped (Bestsenny et al., 2022). As a result, doctors can analyze and monitor patient conditions remotely and with greater effectiveness than current methods. Telehealth is here to stay and can positively impact the lives of all, specifically when location, a pandemic, or sickness prevents them from receiving care in person. Between 40 and 60 percent of Americans are searching for a broader virtual health solution, including virtual visits and potential for lower costs as well (Bestsenny et al., 2022). As telehealth has worked in the past, it will continue to adapt and providers will be able to offer greater services remotely and give its patients higher levels of care.

A caveat to wearable devices: they are only helpful in specific situations where a doctor can properly analyze the data gathered. For most instances, the patient will or cannot expect to interpret the data the wearable devices gathers, with a few exceptions, one of which is one who has a chronic condition. There is only a need to gather the correct and relevant data, for example, there is little benefit for those who do not take insulin to self-monitor their glucose levels (Bastian, 2013). The sensors and analysis must be studied and properly calibrated for many body types, such as different sizes, shapes, weights, and various quirks of humans, or else no diagnosis or a faulty diagnosis can be issued. The sensors will be exposed to and must withstand various

environments, such as hot and cold weather, rain, and normal exercise. Additionally, some of the changes provided may only be short term while the device is used, but regress once it is not monitored anymore (Bastian, 2013). Over time, as wearable device technology improves, there will be more uses of this technology combined with telehealth to provide greater levels of care to patients.

Current research on wearable devices is founded upon monitoring health conditions over extended periods of time. Specific metrics include measuring strain, pressure, and temperature among other metrics such as pulse, blood oxygen, and movement. Specific use cases for wearable strain sensors include monitoring those with chronic joint or muscle pain to gauge overexertion, uses in rehab and physical therapy for those coming back from injuries. For temperature sensors, to monitor skin temperature for sickness or chronic temperature swings. Seizure can be linked to changes in body temperature (Motta et al., 2014). By closely and religiously monitoring body temperature, wearable devices may allow patients and providers to predict seizures and further narrow down the signs of an oncoming seizure. Pressure sensors can potentially be used on the feet to analyze gait, walking patterns and improve posture.

For all the above sensors, they can also be used by athletes to monitor and improve performance as an extreme form of physical therapy. Just as current data can be gathered on distance ran and speed of athletes, more data could be gathered such as specific joint and muscle movement and impact forces to further improve athletic performance. The sensor could be worn to document and investigate specific aspects of their performance or worn during games to analyze trends and data after injuries to identify trends and prevent injuries in the future. This specific monitoring would add another layer of data-driven results to training regimens and allow them to also further fine tune training based on individual data.

Current technical hurdles, such as price and manufacturing limitations, limit the reach and effectiveness of wearable devices. The devices are difficult to manufacture reliably and to a large scale. There is no benefit to wearable devices if they cannot be reliable and readily manufactured. By streamlining the manufacturing process, the advantages of the devices can be fully reaped to provide better physical therapy rehabilitation (Skin-like sensors bring a human touch to wearable tech 2020). As the technology improves further, the sensors will be specialized more with different materials and techniques for different styles or strain, pressure, or temperature sensors.

Other problems are the testing of these devices. There is little current human testing done with these devices, especially over long periods of time, which is where they are most effective. There have not been any large-scale trials using state of the art wearable devices able to measure strain, pressure, or temperature. For example, a current, cutting edge, wearable device consisting of gold nanomesh sensors are worn and observed by only 18 people for one week (Miyamoto et al., 2017). Significantly, more testing in clinical environments must be done to ensure the safety and operation of the devices. The devices must be able to work with those of many skin types, exterior conditions, and function reliably in various environments, all while collecting reliable data.

The next challenge to overcome is the battery and data storage of the devices. To be a truly wearable device, the form factor must be so lightweight that it can power itself and store all the data it collects effortlessly, while being unnoticeable to the patient. An additional logistical challenge that needs solving is the reliability and manufacturing scalability of the devices. By analyzing and refining prototypes to reduce flaws and increase reliability, the devices can be utilized to provide constructive data to be analyzed. This issue affects all devices and all who use

them without discrimination. Current design and manufacturing challenges include reducing the size of the devices and storing the data they collect, but there are more pressing social issues to unlock the full potential of wearable devices.

Rural Communities and Trust

A large issue plaguing telehealth is the trust between the doctor and patient. Without key elements of trust that are present in person, patients are less likely to open up to their doctors to receive the right treatment (Building Trust into telehealth 2021). Surveillance and privacy concerns are a major barrier to acceptance of technology in rural communities due to the lack of trust between patients and healthcare providers.

Rural Americans place a large emphasis on privacy and trust and have a greater distrust in science when compared to urban or suburban Americans (Trager, 2019). Rural Americans also have a strong distrust of the government when compared to urban citizens, for example more than half of rural residents did not trust the government to fully test and ensure the safety of the Covid-19 vaccines (Hamel 2020). It is not a stretch to imagine the hesitancy and pushback when they are told to wear a sensor that will collect and transmit data. Furthermore, these rural Americans are significantly more likely to avoid seeking professional healthcare treatment, with a specific factor being the distrust in the doctors and medical system (Spleen et al., 2014). Influences like this widen the gap further that prevents this wearable technology from being as effective in environments where it is most needed. With trust being a cornerstone of telehealth, and wearable devices by extension, rural communities will not get the proper care and help that can be provided to them by wearable devices.

While wearable devices offer the potential for an increased degree of care provided, the privacy concerns that stem from the constant data collection is unavoidable (Dinh-Le, Chuang,

Chokshi, & Mann, 2019). The technical innovation made by wearable devices has the potential to create large rifts between different groups of Americans if not properly mitigated and fought against. Wearable devices present an opportunity for healthcare providers and government officials to easily gather information about its subjects and as such provides an informational and financial incentive for them to offer such services. For example, car insurance companies use remote, in vehicle trackers to gauge driving habits and collect data on their customers, promising lesser rates for safe drivers, and sometimes charging them more depending on their remote driving characteristics (Rainie & Duggan, 2019). Insurance companies could offer the same promise of reduced rates for those who consistently wear devices, while they are collecting valuable data on their patients. Those without the financial means for alternative healthcare plans will have no other option for care other than to give up their data.

As a result, with the advancement of wearable technology, these communities are at a disadvantage for the exact technology they would greatly benefit from. The technology must be adapted to be fully utilized and effective in rural communities. There are cultural differences that doctors and their healthcare providers must observe and change to improve the quality of life for rural communities. Rural Americans were 1.7 times more likely to avoid going to a healthcare provider for a problem due to various problems such as long transportation to their healthcare provider, concerns for lack of privacy, and lack of culturally appropriate interventions (Spleen et al., 2014). Small cultural differences add up to residents not fully trusting their providers and requiring greater levels of care and patient confidentiality.

For example, those living in areas without cell service would not be able to have their data sent to their healthcare provider, while those in dense, urban communities would have no problems. Rural communities consistently have less access to internet and cell reception, putting

them at a disadvantage when sharing data with their healthcare provider (Vogels, 2021). From this lack of access, the wearable devices will not work as well, limiting their effectiveness if the data cannot be easily sent back to be analyzed by their doctor. Data from wearable devices can be collected over a significantly larger window as compared to a simple check-up or doctor's visit. This is especially helpful for those with chronic illnesses, who are taxed financially and emotionally by constant doctor visits (What is the future of Wearable Technology in Healthcare? 2021).

This technology has a specific potential to help those in rural communities as they will require less travel time to any doctor, including specialty ones. The specific challenges of adaption for rural communities include the lack of adaptation of new technology and the constant monitoring that rural Americans are not familiar with. In order to help these rural communities where wearable devices can be the most help, how will these obstacles be overcome and what can/should the government and the healthcare industry do about it? For example, policy changes are required, as telehealth reimbursements from Medicare are not fully covered in rural health clinics and other health centers, policy changes are required for rural residents to fully realize the benefits of telehealth (Ollove). Laws must be changed or passed to ensure that rural residents with Medicare are maximizing the benefit of their healthcare and telehealth capabilities.

As these wearable devices will be used along with traditional or telehealth doctors visits, they will end up costing more money. Those who can afford this treatment have no problem as this specific advancement disadvantages those who have less comprehensive healthcare or who cannot afford the cost. Regarding current wearable devices such as step counters, people of low socioeconomic status who "would benefit the most from these interventions are being left behind" due to low access to information communication about wearable technology(Western et

al., 2021). One challenge faced in the healthcare industry is that most wearable device companies are profit driven and generally target their devices to the most profitable consumers: rich ones (Wetsman, 2021). Those with the financial means will have the option for better care while others will not, putting them at a disadvantage due to their socioeconomic status.

Why do ordinary people and urban Americans care about this concept? To help as many people as possible, additional cultural and legislative barriers and rules must be changed. If these barriers are not addressed, current socioeconomic and cultural differences will increase and only benefit select groups of people. As seen with the resistance to the Covid 19 vaccine, rural Americans are significantly more likely to distrust the healthcare system and be afraid of constant monitoring by the government.

Solving and Mitigating Downsides

With the current and potential effects of wearable devices, there are some downsides that must be mitigated. The first is the trust in the healthcare providers and doctors. Without trust, patients do not fully communicate their issues and problems to their doctors. All four of the key components of trust: competence, logic, empathy, and reliability, are much more difficult to establish and build remotely, posing a problem for remote based technology built on trust (Building Trust into telehealth 2021). To build up this trust, doctors must be trained and adept at these skills in remote settings. By informing doctors and healthcare providers and having standards that they adhere to, patients can feel more engaged during their virtual visits and will be more trusting of their doctor. Additionally, doctors will have to be trained in specifically dealing with rural patients and their privacy concerns.

Another downside is the inherent bias towards benefiting those with a higher socioeconomic status more than others. By specifically focusing and catering wearable devices

to those of a lower socioeconomic status, they can be more effective to those that can be most benefited by this technology (Western et al., 2021). Furthermore, wearable devices that are designed specifically for rural populations will have a greater impact than generic wearable devices, but will need to be specifically designed. There isn't a simple legislative action that could solve this problem, rather the technology must be developed with different communities in mind. With no intervention, wearable devices will continue to be designed and developed towards rich, urban Americans, further increasing the gap between the health and healthcare of rural and urban communities.

A physical hurdle of the devices is the distance from healthcare providers. On average, rural residents live further away from hospitals compared to urban and suburban Americans (Lam et al., 2020). Furthermore, 23% of rural Americans say that access to good hospitals and doctors is a major problem in their community, compared to 9% of suburbanites. The greater distance poses a problem for those seeking quality care. The solution to this isn't easy, as more healthcare centers and hospitals cannot be easily made and staffed for small numbers of rural towns but need to be mitigated in other ways to ensure they receive quality and timely care. Additionally, there is significantly more variation in distance and travel time in rural residents. While very few urban residents are far away from a hospital, there is much more variation and longer travel times that are masked and averaged out in rural communities. More difficult access to healthcare providers coupled with trust issues put rural residents at a disadvantage for rural residents to receive care.

As further research is performed and other technological advancements are made, the reliability and manufacturing capabilities are increased. Additionally, the cost of the wearable devices will decrease, making them more accessible and more affordable, including more rural

communities. As the cost decreases and an effort is put in to replace the lost trust, the increased desire and use of the devices will result in greater patient care. It is paramount that reducing suffering for all is the primary driver of this technology.

Conclusion

Technological improvements are only as helpful as they can be implemented due to manufacturing, social, and legislative constraints. For wearable devices to help those that would most benefit from them, specifically rural Americans, there are trust issues that must be mitigated on top of healthcare infrastructures and practices that must be improved. If not, then wearable devices will disproportionately affect richer, more urban Americans. Current factors, such as distance to a hospital and rural internet access, favor urban Americans further, and can't be solved easily. Other technical factors, such as manufacturability, reliability, and the heavy data analysis required by the healthcare providers, decrease the potential of the devices and must be fixed to allow the devices to reach their full potential.

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