

One Emergency From Disaster: The Impact of High Medical Bills

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 for the Degree
Bachelor of Science, School of Engineering

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Spring 2022

On my honor as a University Student, I have neither given nor received unauthorized aid
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Introduction

In the U.S., despite medical advancements, several factors cause unequal quality of and access to medical care. “Black persons had an overall mortality rate that was 1.6 times higher than white persons in 1995... for multiple causes of death (heart disease, cancer, diabetes, and cirrhosis of the liver) the racial discrepancy was larger in 1995 than in 1950” (Williams, 2000). African Americans are more likely to be financially unstable; research exploring correlations between disease, gender and socioeconomic status found “25 of the 29 diseases analyzed showed a significant inverse [socioeconomic position (SEP)] gradient: the lower the SEP, the higher the frequency” (Carrileo et al., 2021). With the rising rate of uninsured Americans, and with 73.7 percent of uninsured adults claiming cost as their reason to not be insured (Orgera et al., 2020), it is important to consider the limitations in quality and access to medical care.

The technical project focused on creating a hat that provides tactile and auditory feedback to visually impaired individuals based on obstruction detection. This was done by embedding LiDAR sensors into the hat and connecting them to a central MSP430FR2433 board to process current surroundings. The device gathered information regarding a user’s surroundings from the front, sides, back, and any incline changes. Then, using the information provided by the LiDAR sensors, vibrating direct current (DC) motors were programmed to vibrate whenever their respective sensor detected an object, and increased the vibration frequency as the object got closer to the individual. Additionally, small piezo buzzers were mounted to the side of the cap and connected to the microcontroller to provide tones for users who may prefer to have auditory feedback. Lastly, the cap had a sensor that provided feedback when the user was approaching steps or some type of change in surface elevation. This project addresses the issue of discreetly

assisting the visually impaired with obstacle avoidance and wayfinding when it comes to ambulatory-related tasks in their daily lives.

The research paper will focus on exploring the impact of high healthcare bills. With inflation and the stagnant minimum wage, building up savings is increasingly difficult. Among U.S. adults, 35 percent could not easily afford an unexpected expense of \$400; 12 percent could not afford any such expense (BGFR, 2021). With healthcare costs trending higher and a tendency towards pushing off non-emergent care to manage more immediately consequential emergencies (Kalousova and Burgard, 2013), there are significant risks both to individuals requiring medical care and the debt holders.

Literature Review

The greatest apparent impact of high healthcare bills falls upon the individuals responsible for paying them. Individuals with some chronic illnesses are frequently in the hospital for treatment, where they can feel temporary relief from their illnesses, claiming, “‘I didn't have the fear I'm gonna drop dead every minute,’ he says. ‘I felt a lot better.’ Then the bill came” (Ungar, 2020). Even having insurance won’t always protect these individuals. If they are ‘functionally uninsured’, a term the author uses to refer to those with high deductibles that are greater than their savings, frequent visits to the hospital can cause financial distress such as being forced to file for bankruptcy (Ungar, 2020).

Individuals hospitalized due to a medical emergency are also significantly impacted by prohibitive costs. These individuals are unable to plan and budget for their procedures. Additionally, even if they wanted to go to a hospital that was in-network with their insurance, they would not have a choice of where or by whom they are treated, meaning even those with good insurance can be stuck with an astronomical bill. Both emergency hospitalizations and

those with chronic illnesses have a shared value of billing transparency and affordability in healthcare, with increased ““fairness and equality in the system... This should be ingrained into the system so that when you have a problem and you are due relief, you get it”” (Aleccia, 2019).

The possibility of emergency medical need is further exacerbated by people’s reluctance to keep up with their preventative care needs. Long et al. (2020) found that, specifically for hand surgery, even those who actively pursued treatment within their insurance network could receive surprise charges falling outside their coverage, leading to distrust of medical professionals. This is especially problematic as the researchers noted that there are things outside of what is understood to be out of network, such as an ambulance ride or visit to the emergency department, which will also incur surprise bills, such as certain types of prescribed medication or tools used (Long, 2020). Receiving a high bill even after doing the work to receive treatment in-network that discourages the financially disadvantaged from attaining help, allowing preventable diseases to deteriorate into more significant and costly problems.

This problem is felt not only by the patients, but also by the doctors who treat them. Tice et al. (2011) found restrictions placed by insurance companies forced doctors to spend additional time negotiating which medications they could affordably prescribe. This restriction forces doctors to search for alternative medical options, which may not be as high of a quality as what they originally prescribed. Additionally, doctors that are too busy to take the time to evaluate what is and is not covered by insurance may prescribe a medicine that their patient cannot afford. Patients are forced to choose between going into debt and going without potentially life-saving medication. This research found that doctors were also less likely to take on new patients under plans with uncooperative insurance companies, thus further restricting patient access to care (Tice, 2011). In the current climate this tradeoff may be necessary to allow doctors to provide

adequate care to those they have already built a rapport with, but disadvantages those looking for a good doctor due to circumstances they cannot control and may have been unaware of when choosing an insurance plan.

Furthermore, those who did receive emergency hospitalizations that they could not afford were not often met with any level of empathy. O'Toole et al. (2004) found that aggressive collections practice towards those unable to pay was unethical, unjustified, and caused greater reluctance to pursue necessary healthcare. This should be considered in the context of surprise out-of-network billing, and that not all states offer protections to the consumer to help alleviate this strain (Long, 2020). The burden of finding financial aid or contesting unreasonable bills falls on the consumer, causing undue stress that further alienates patients. Further, often the consumer is charged more than an insurance company may have to pay, as many insurance companies pay a fraction of the bill based on pre-negotiated contracts (AHIP, 2020). Consumers do not have the connections, power, or experience with negotiation that allows them to enjoy the same luxuries. This unfairly overcharges individuals who typically have less spending power than a company dedicated to doing just that.

Emergency hospitalizations can be avoided through the utilization of preventative care, but financial barriers can dissuade individuals from taking advantage of these services. Researchers Kalousova and Burgard (2013) found that individuals with negatively connoted debt were more likely to neglect preventative or non-emergent care necessary to reduce the possibility of medical emergencies. The variability of the costs of medical care and the difficulty of ascertaining the exact cost of treatment would make individuals less likely to risk an unexpected steep bill only to be told there is nothing wrong with them. Especially when combined with the fact that individuals who do overcome the financial barrier and go to the hospital often

experience deterrents that further exacerbate individuals' dislike. Weiner et al. (2006) found even free healthcare options for the uninsured were often difficult to access, citing long multi-day wait times as a deterrent beyond financial security. People who are uninsured or underinsured typically have extremely limited options for gaining access to medical care. Experiencing the long waiting times would have the unfortunate effect of discouraging individuals from pursuing preventative care and visiting for anything short of an urgent situation.

Despite research pointing to the contrary, a key justification for the potential for astronomical bills exists in the final participants of health insurance companies and trade associations. Health insurance companies exist to help consumers cover the prohibitive cost of their medical bills (ABCBS, 2018). It is in the best interests of health insurance companies, such as Anthem, to maximize money paid into policies while minimizing payouts on claims (ABCBS, 2018). The insurance companies' interests are supported by trade associations, such as AHIP. Their stated perspective is that "health insurance providers are an advocate for Americans, fighting for lower prices and more choices for them" (Swann, 2021). These claims may be a misleading form of astroturfing; unwaveringly protecting consumers conflicts with the business interests to retain as much money as possible. This is increasingly obvious when combined with the research outlined in previous sections about the hardships imposed upon both doctors and patients in attempting to abide by the stringent guidelines set forth by insurance companies.

The policy of a typical insurance company is that only certain hospitals and medical professionals will be paid for by insurance. A press release explaining this policy states "Your health plan's network of healthcare professionals and facilities makes it convenient for you to find affordable, high-quality care quickly" (ABCBS, 2021). This could also be an instance of astroturfing, with research concluding these restrictive methods introduced high complications

into the process (Tice et al., 2011). Beyond the research, it can be logically deduced that the most convenient medical care is the care closest in proximity, especially in the case of an emergency. While they may not directly be applying steep costs to healthcare, their existence normalizes the idea of these high bills, and shifts blame for being unable to pay onto the individual for not getting sufficient coverage.

Conversely, there are also organizations existing to support people facing these bills when insurance does not cover it. HealthWell is an organization founded to help underinsured individuals pay their bills, by setting up funds that support specific diseases (HF, 2022). These organizations can provide significant relief to individuals facing these bills. However, they are unable to cover every bill that comes up, and as such many have specific treatments they are willing to cover (HF, 2022). It takes considerable time and research to discover these organizations, that the individual either may not have time to complete or may not know the opportunity exists. While they are a useful resource for consumers who struggle with these medical bills, the lack of awareness and simplicity in finding an organization to provide relief greatly diminishes their potential to offer support.

Methodology

This data was collected through a mixture of first-person accounts, press releases, and studies published in reputable journals. This was necessary to encompass the perspectives of all parties involved in the financial transactions of medical care. The accounts given by individuals and released by companies were evaluated with respect to the information given by case studies. Filtering the emotional and profit-driven perspectives of the companies and through the objectivity of measured research allowed the authenticity of each perspective to be included while objectively recognizing potential deceit in their accounts.

Body of the Paper

Inequality of medical care was a concern of my Capstone project, as it entailed creating a medically assistive device to improve the quality of life of the visually impaired. This capstone project was with the Computer Engineering Department, advised by Professor Powell and Professor DeLong. This was a team project with Mary DeSimone, Hafsa Shamsie, and Ricky Morales. Visual impairment is a widespread issue. In 2015, over one million Americans were blind and over three million Americans were visually impaired (CDCP, 2020). Visual impairment is a major disability that hinders one's ambulation (NASEM et al., 2016); this creates a lack of independence that complicates chronic illnesses and negatively impacts mental or physical health (NASEM et al., 2016). This project combats these issues through building a device that mitigates the dangers of ambulation for the visually impaired.

Methods for creating the prototype entail using sensors embedded into a hat to obtain information regarding the distance between the user and obstacles to their front, sides or back, and changes in incline. The MSP430FR2433 launchpad will process information from the sensors and trigger appropriate auditory warnings from speakers or tactile vibrations from DC motors. The alert frequency increases as the object approaches. Software will be written using Code Composer Studio to handle communications with the MSP430FR2433 launchpad. The ultrasonic sensors communicate using UART, the LiDAR sensors communicate using I²C, and the speakers and vibration motors communicate using pulse-width modulation. The software will also contain a task scheduler to manage the execution order of events. Other key components include a battery, waterproof casings, the hat, a PCB, and wiring components.

Constraints include IPC standards for electrical safety of PCBs (All About Circuits), IEC standards for the use of lasers (Rockwell Laser Industries), NEMA standards for the use of

hardware components outdoors (Engineering Toolbox), and the Barr Group safe coding standards (Barr, 2018). The size of the hat and amount of weight it supports are physical constraints. Considering the importance of ensuring the device has enough power to sustain several hours of continuous use, it was necessary to balance the tradeoffs between available space and weight, the amount of charge the battery can store, and the risk of excess heat produced by overestimating the Watts per hour required to run our device. Other obstacles include finding optimal placement of the sensors, ensuring durability and accuracy of the device after rough use or exposure to water.

The design of sensor-based object detection systems for the visually impaired is not completely novel. The Smart Cane uses ultrasonic sensors to detect obstacles and relays notifications using either auditory speakers, or tactile vibrations through special gloves, where each finger represents a different warning (Wahab et al., 2011). However, this product generates audio from a speaker mounted on the cane, which can be difficult to hear. Associating vibrations on different fingers with different meanings is overly complex, especially when considering the typical demographic for visual impairment products. The Path Force Feedback Belt uses video cameras placed around one's waist to build 3D images of the user's surroundings (Elmannai et al., 2017). This belt attempts to give the user an idea of their surroundings from all sides, but the use of video cameras results in the detection range for this system being too small to be effective (Elmannai et al., 2017). A commercially available product is the iGlasses Ultrasonic Mobility Aid, which detects obstacles using ultrasonic sensors and warns users through gentle vibrations increasing in frequency as the object gets nearer (iGlasses). But ultrasonic sensors are limited in range, and the device can only detect obstacles to the front of the user.

The main benefit to our project is the discretion it is intended to provide. Many people do not like to advertise their disabilities, and particularly those who have a visual impairment that is not severe enough to be fully debilitating. The most extreme traditional methods of using a guide cane or a guide dog are very obtrusive and can make blending in with others difficult. The ideal design of our hat would have the sensors and buzzers concealed within the hat to reduce the amount of attention drawn to the user. Existing electronic wearables are also bulky and obtrusive, or provide feedback that is confusing to the user, as discussed previously. The development of our prototype included extensive testing of the placement of vibration motors; this allowed data to be conveyed more intuitively and precisely.

Results and Impact

The final deliverable is a hat with five sensors, speakers, motors, a power supply, and the PCB mounted on it. The hat will provide feedback upon startup to confirm the device has been calibrated successfully; object detection will be periodically performed through the sensors. Auditory and tactile feedback will be provided upon object detection, increasing in frequency as the object grows nearer to the user. The user will be able to adjust speaker volume and which of the feedback methods are active at any one time. The hat will be powered independently through a battery; all components will fall within reasonable size and weight constraints for usability. This deliverable provides a comprehensive awareness of surroundings to enhance the safety of the visually impaired.

Two significant ethical considerations are safety and environmental impact. Safety considerations include unexpected device failures during a journey. As such, when choosing components, the team was careful to overestimate the power required for the average user's day.

Additionally, future iterations of the device should include a monitor that would give alerts in the event of a malfunction, as well as low battery warnings. There are ethical concerns surrounding who would be at fault should someone get into an accident while using the device. As a result, we felt it was our responsibility to minimize complexity, and perform field testing to ensure our device is as intuitive as possible. Environmental concerns influence the design of the hat (Boyden et al., 2016), with a goal of easy deconstruction of the device for proper disposal of the sensors and battery. An additional consideration would be the ability to repair the hat, since it would be impossible to eliminate the cost to recycle the hat and it would be unlikely that every component would stop working at once. By making it easy to access components we expect would break most frequently, we would be able to extend the longevity of the hat and reduce environmental impact.

The key consideration of the technical project addressed in the research paper is costs and how they impact the user. As a product with the goal of improving the user's quality of life, we would want to ensure we did not add to the ethical dilemma of preventing widespread adoption by producing an insurmountable economic barrier. When developing our prototype, the costs of the materials required for our prototype equaled approximately \$298 for one hat. Considering the parts would be significantly cheaper when purchased at scale, the goal would be to get as close as possible to the market price of commercial competitors such as the iGlasses which are priced at \$100 (iGlasses).

While it is not always possible to mitigate the costs of a new device, providing the information necessary to make an educated decision is crucial to encouraging people to stay up to date with their preventative care; it will also help them feel more comfortable with going to the hospital when they feel the need. In lieu of universal healthcare, many people are forced to

rely on health insurance offered through their work without fully understanding how an emergency might make them financially unstable (Aleccia, 2019). Additionally, greater transparency in finding an in-network doctor, both in explaining what it means to have an in-network doctor and informing them when they are about to visit an out-of-network doctor, would go a long way towards mitigating the surprise charges that embitter users towards the healthcare system.

Conclusion

It is important to consider the cumulative impact beyond the immediate and obvious ramifications. The technical project has the potential to improve the quality of life for visually impaired individuals. It combines two forms of sensors with tactile and auditory feedback to provide the greatest potential range of usage. It is a self-contained independently powered unit. Not everybody wants to openly display their disability, and a refined prototype would provide a more discreet option to aid their independent mobility than traditional methods. This device provides greater information about their environment to those with a visual impairment, allowing them greater autonomy to safely go about their everyday lives.

Overall, research indicates that elevated levels of competition between the interests of participants sustain a convoluted process to manage medical debt. One harsh bill has the potential to negatively impact an individual for the rest of their lives. Shifting the cost burden onto those who require life-saving treatment without giving them the proper opportunity to take steps necessary is unsustainable long term. The steep financial barrier compromises the ability of medical professionals to follow their oath, and drastically increases the potential for someone to forgo life-saving medical care. This system demands greater transparency for users.

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