Pantastic: Development of Self-Monitoring Stovetop Fire Prevention Technology

Self-Monitoring Health Device Implementation During COVID-19

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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

From 2014 to 2018, the U.S. Fire Department responded to an estimated average of 172,900 home structure fires per year started by cooking activities in the United States (US) (Ahrens, 2020). From those annual fires, there were an average of 550 civilian deaths, 4,820 reported fire injuries, and more than 1 billion dollars in direct property damage (ibid). Fires originating on the stovetop, account for the majority of all these cooking activities with unattended cooking being the leading cause (Smith, 1999). From all these deaths from cooking fires, more than a quarter of the people that were killed were sleeping at the time with the highest death rate (30%), coming from people ages 85 and older (U.S. Fire Statistics, 2021). With losses this significantly high for property damages, injuries, and loss of lives, it is surprising to see no new advancements in technology to handle this problem, especially with the growing popularity of wearables and other monitoring tech. The primary issue that comes with the increasing amount of self-monitoring devices that are utilized, both commercially and medically, is in regard to the company's ability to manage customer's privacy.

Despite the drastic increase in the use of this technology, there still exists significant doubt in the ability of corporations and governments to handle the data. According to a 2019 research study performed by Pew Research Center, 81% of U.S. adults say that the potential risks of company's data collection outweigh the benefits of it, as well as 66% of U.S. adults regarding the governments data collection (Auxier, 2020). However, due to the COVID-19 outbreak of 2020, many companies and hospitals have begun to implement additional devices to track civilian health by using either new or existing technology to monitor contact tracing and perform forecast modeling on outbreaks (Lim, 2021). Therefore, whether it is a popular decision or not, the American people are becoming more used to these self-monitoring technologies, whether it is

by personal use for physical activity tracking or medical use with medical emergencies (Mohammed, 2018). With the integration and familiarization of self-monitoring devices in the US, our capstone team decided to develop Pantastic, a self-monitoring stovetop device that works to prevent the fiery disasters and aftermath caused by neglected stovetop activity.

Pantastic

With inattentiveness to stovetop cooking being a major factor in these deaths, injuries, and property damage, our project provides a IR sensor monitored, reminder based system to reduce stove top fires caused by forgetfulness and overall inattention. This project was designed to act, like a smoke detector, as a local alarm system. Consequently, the device is designed to sense and alert a nearby user of possible flash fires or prolonged stovetop heat, but it itself does not have the means to either turn off the stove or put out a fire. Since the alerting system is so crucial for the device's functionality, the determined best design would be an audible alarming system for near proximity users, as well as a webapp interface for users who may have wandered out of earshot range of the device. A block diagram of the alerting and sensing systems can be seen in Figure 1. Additionally, it was decided that Pantastic should be as universal of a kitchen device as possible. Therefore, the device is attached to a wall mount that can be aimed with a laser at the current stovetop being used. This allows the device to be used with both electric and gas stoves, as well as have the compatibility to be used with other high temperature cooking appliances.

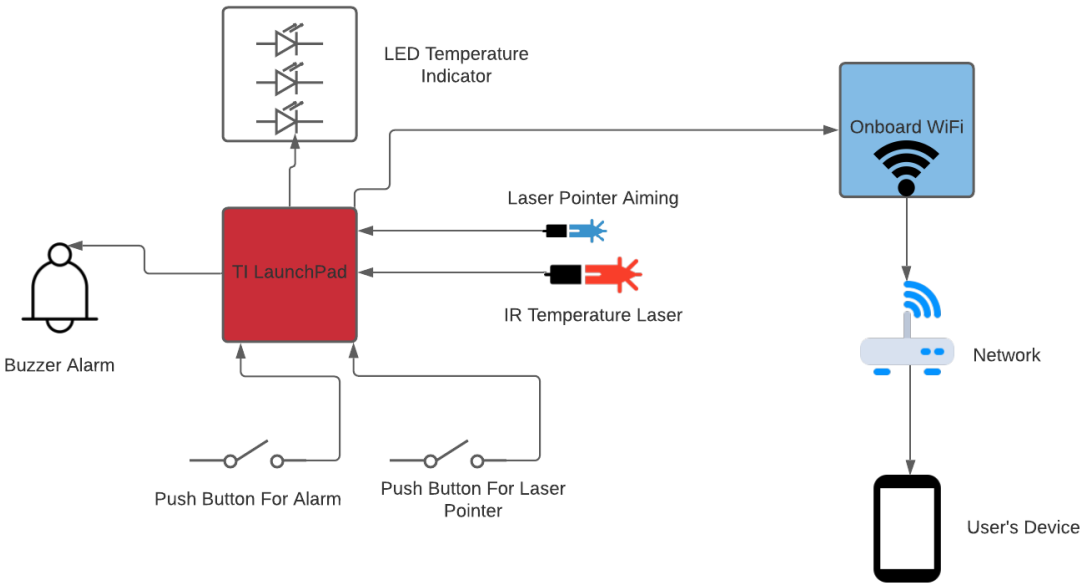

Figure 1: Block Diagram of Pantastic

Currently, products with a similar end goal have been developed but most of them focus solely on electric stovetop fires. One example of these such devices, is the iGuardStove. This device uses a motion sensor instead of a heat sensor as the indicator for when to power off the electric stove (Newfoundland, n.d.). If a user's motion cannot be sensed in the room for five minutes while the stovetop is hot, it will automatically cut the electricity to the stove (Ibid). While the inattentiveness indicator of a motion sensor does provide a solid baseline for preventing stovetop fires, the Pantastic group determined that a physical infrared heat sensor for the device would be substantially better, due to the live feedback of stovetop temperature instead of user movement. Another device that exists to help prevent stove inattentiveness is the BurnerAlert. This device beeps and flashes on a set interval as soon as the knob of the stove has been moved into an on position and will keep on alerting the user that the stove is live until the knob has been turned back to the off position (Bold, 2019). Although this device is universal

among both electric and gas stoves, a lack of web interface and actual temperature sensors reduce important information accessibility. Although both devices solve the problem of overall stovetop inattentiveness, the Pantastic team felt that the product did not interact with certain groups of people in an effective way.

Pantastic will display a visual with the stove's temperature and have a buzzer go off if a stove is left on for excessive amounts of time to prevent death from stovetop fires. Although these technical dimensions mentioned are specifically catered towards helping any and everybody from the dangers of stovetop fires, the specifics of the components were specifically catered towards two primary social groups of people. First, the phone and web interface system were chosen because of the target group of university students. According to a study from Baylor University, college students tend to spend eight to ten hours a day on their phones (Wood, 2014). Since college students tend to be very busy and distracted, it would not be unreasonable to imagine that they would have a high probability of accidentally leaving a stovetop on. Therefore, having a web interface for alerts if the stovetop was detected to be hot past the default, elapsed time of one hour, would prevent stoves from being left on extensively. Another target social group that would benefit greatly from the web interface would be the elderly community, specifically those suffering with dementia. Due to the high death rate among the elderly in house fires, the web interface alerting system, along with the proximity alarming system would serve a good purpose. The last specific groups that were accounted for with the device's components were the deaf and color-blind communities. Since deaf people would not be able to hear the alarm going off, a visual indicator of all the LED's blinking red would be a good visual cue, in case they are not near a device connected to the web for any given reason. Additionally, instead of using a singular RGB LED to indicate the temperature via change in color, an array of six

were chosen as to accommodate to anybody who may not be able to distinguish said change in color of the LED's. Thus, with the components chosen to accommodate for these groups, Pantastic can prevent more incidental deaths, injuries, and property damages from these stovetop fires.

Effects of Self-monitoring Technology Integration

While our technical project looks at how a safety-based monitoring device is created, I am interested in exploring the socio-technical effects of health-oriented monitoring technology in the United States and what factors lead to a smooth integration into society. These devices can be divided into two types: monitoring devices for medical use and monitoring devices for personal or commercial use. However, due to large data breaches concerning civilian Sprivacy, improper device design for the target social groups, and civilian technical illiteracy, these monitoring devices have struggled to gain the expected popularity over the past twenty years (Graham, 2020). Both medical and commercial technologies have also had their issues in their integration attempts over the past twenty years, but some outliers have broken into the realm of commonly accepted and used devices (Yassein, 2019). Consequently, a socio-technical deep dive into the devices intended use and integration is required to understand what makes a health-oriented monitoring device successful.

Privacy

With any sort of self-monitoring technology, a primary concern from Americans has consistently been regarding what happens with the collected data. In a 2019 Pew Research study, it was found that 81% of U.S. adults feel that they have a lack of control over the data that

companies collect while 84% (Auxier, 2020). Along with this, 79% of U.S. adults are concerned about how companies are using the data that is collected (Ibid). This much distrust already regarding companies handling personal data is only made worse when one investigates the United States HIPPA standards regarding outside technology companies. The U.S.'s HIPPA standards do not cover these companies creating medical self-monitoring technology which means that there is a possibility of either legal or illegal sharing and selling of user's personal data (Gerke, 2020). The lack of sufficient HIPPA regulations demonstrates a legal loophole that gives merit to the American concerns regarding issues of companies distributing private data. However, there is one case when the distribution of personal data directly helps the customer, as well as providing national benefit. In a 2019 Harvard study about U.S. auto insurance monitoring programs, it was found that monitoring did not only make drivers 30% safer, but also saved them money long term (Jin, 2019). However, despite the user reaping most of the benefits with the minority of the risks, the biggest pushback to widespread automobile insurance monitoring is still the overall fear of losing privacy.

Integration

When developing technology that has a specific target group, it is crucial to evaluate the actual integration process. While integration of a COVID-19 contact tracing with iPhones may be relatively easy due to it being a simple addition to an already existent and popular device, the integration of new monitoring devices targeting audiences such as the disabled or elderly is much more difficult. For example, in a case study regarding social alarms with the elderly, it was found that, although deemed necessary by the homecare staff, the technology was not being designed to assist in these situations (Kowalska, 2016). According to Kowalska, the technology was being

engineered with a very narrow technical focus that ended up ignoring the target group of the devices (Ibid). According to the study, many of the interviewed elderly discussed the inconvenience of only being designed for indoor use and not being movable (Ibid). By failing to consider the target actors for the technology, the socio-technical integration of the devices into a small network was unsuccessful, thus showing the importance of identifying and engineering for both the network and the actors within.

Framework

To analyze these health-related self-monitoring technologies, the two frameworks of Interactive Sociotechnical Analysis (ISTA) and actor network theory will be used to evaluate the socio-technical effectiveness of these devices. ISTA gives a good baseline for new medical technology as it focuses on the integration into existing socio-technical systems as well as the independent physical environments (Harrison, 2007). For evaluating self-monitoring technology, ISTA can be used to examine previous attempts of devices to analyze what prevented it from not being integrated properly or efficiently. This will be specifically targeted with the five different types of interactions and the unintended consequences that came from each interaction. First, New HIT changes an existing social system will be analyzed with the new COVID-19 monitoring technologies with the forced change that it brought. Second, technical and physical infrastructures mediate HIT use can be done with Apple's integration of the tracking into existing devices. Third, HIT-in-use changes social system's consequences will be looked at with respect to the unintended effects of these systems on the network. Fourth, HIT-in-use changes social systems can be looked at with the consequences resulting from these impactful devices. Last, HIT-social system interactions engender HIT redesign can be observed with the example of

the elderly living facility mentioned in an above section. Actor network theory will be used to fill the gaps left by ISTA by providing a broader view of networks and to specifically evaluate individual actors, humans, and nonhumans, instead of groupings (Latour, 1992). Together, these frameworks provide a good socio-technical skeleton to evaluate self-monitoring devices, both medical and commercial.

Research Question and Methods:

How does new monitoring technology and the current legislation affect United States citizens, both regarding overall safety and privacy concerns? With self-monitoring technology predicted to grow at a compound annual growth rate of 28.3% each year from 2017 to 2022, it is essential to understand how both the devices and integration may be flawed in a socio-technical sense (McWilliams, 2017). If life changing devices can be created but have sociological implementation or design flaws, target groups such as the elderly and disabled will suffer consequently. To understand why so many have struggled, I want to examine case studies on these self-monitoring technologies. Specifically, I want to look at the recent COVID-19 pandemic and the new monitoring devices, both medical and personal, that were developed. I want to compare these newer devices with older monitoring technologies like Fitbit or medical alert wristbands, that have successfully integrated into society. To get this data, I will not only look at the case studies of past technologies, but also perform a survey of my peers to get an understanding of what they use, why they use it, what concerns they have about the device, and how it affects their everyday life. Concurrently, I want to examine legislature regarding privacy and analyze what is the best way of protecting user data while examining possible legal restrictions that come with these devices. With both the legislative analysis to give a legal

boundary and case studies and surveys to determine the overall effects of the technology, I want to explore how future implementations of these devices could be bettered.

Due to ISTA being a more focused and specific framework than actor network theory, both the medical and the personal self-monitoring devices will be initially analyzed using the latter. By surveying peers and using case studies, I will be able to analyze multiple actors in the network these devices are trying to integrate into. Since the networks will differ across the devices, I will evaluate how changes in target demographics of the networks change the effects felt, both positive and negative. Along with this, I will do a deeper dive into the medical self-monitoring devices with the ISTA framework to look to evaluate the devices in a tighter knit medical environment. With both frameworks and collected data, I hope to be able to determine what actors in the network are affected the most and how to lessen the negative impact and increase the positive impact of this technology.

Conclusion:

With the high number of deaths, injuries, and property damage caused by stovetop fires and definitive numbers showing that inattentiveness is the primary cause, our team decided that developing a self-monitoring technology with Pantastic would be the best solution to this clearly stated problem. Since a large percentage of these fires can be narrowed down to a certain scenario, creating a technology that reduces the chance of stove inattentiveness would reduce life loss as well as property damage numbers greatly. However, to do this in an area of technology that already has a lot of skepticism requires knowledge of what has worked in the past and why

other technologies have failed. This is where the STS paper comes in as to analyze how these devices affect citizens of the U.S. and how they can be developed to reduce safety and privacy concerns. The success of this project will hopefully lead to significantly less house fire deaths as well as provide a solid framework for how self-monitoring technologies should be developed in the future to assure smooth integration.

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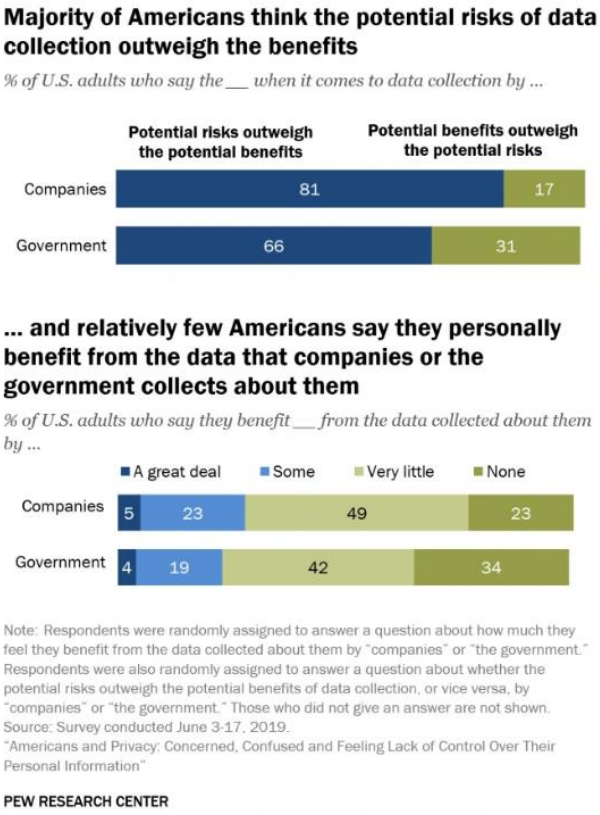
Appendix

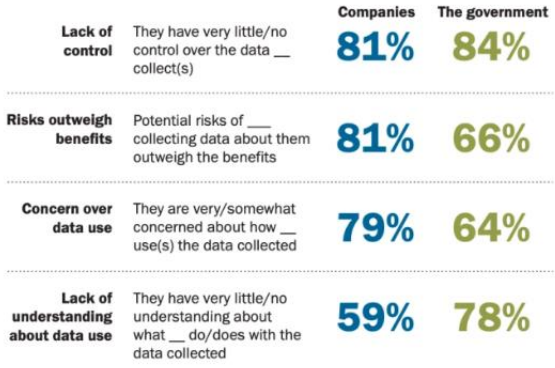
Appendix A

Appendix A displays the Pew Research Center data from 2019 that was used in the Prospectus. The diagrams display the survey data that was collected regarding U.S. adults' opinions on monitoring technology being used and how much control they have over the data.



Majority of Americans feel as if they have little control over data collected about them by companies and the government

% of U.S. adults who say ...



Note: Those who did not give an answer or who gave other responses are not shown.
Source: Survey conducted June 3-17, 2019.
"Americans and Privacy: Concerned, Confused and Feeling Lack of Control Over Their Personal Information"

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