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Design Space

First responders are the ones who rush towards danger when everyone is running away from it. They are monumental in the protection and recovery of communities when disasters strike. Some elements of the system revolving around first responders are their funding, civilians, training, facility, department, team, diet, mental health, family, and themselves. These parts are interconnected through disasters such as fire, crime, or car accidents. Sadly, this flow is powered by all the dangers in our society that pose a threat to innocent lives and the purpose of this system is to protect communities. In order to get a better sense of this design space, we conducted a contextual interview with a first responder.

Contextual Interview with Officer Dahmar Wartts-Smiles

Conventional Interview

Officer Smiles is a community engagement officer who educates the community about how to stay safe while they're on campus. He became a police officer because he loves talking to people, finding solutions to problems, and engaging with the community. The best thing about his job is that his day is different every single day. One of negative aspects of being a police officer is the work-life imbalance. Hours range from ten to sixteen hours and Smiles has to lend himself to the community's needs. He expressed that he is lucky since he isn't married nor does he have kids so he doesn't have to worry about his hours affecting his home life. Another negative aspect of being a first responder is the stress. The UW campus community isn't too dangerous but the danger factor is always there. If one does not have a good coping mechanism in place to deal with stress, it potentially could have some vastly negative effects. Police officers deal with victims of crime who are usually in the worst moments of their life no matter what that looks like, and officers internalize that. They see these types of situations on a constant basis and there has to be a point in time when they can destress from that. Taking some time to sit and talk to someone is a good first step. At the same time, one should have

some type of system in place to release the stress such as exercising or reading. In terms of existing resources, there's a King County program where if for some reason a first responder needed to speak with a mental health professional, they have that available. The UW works with Carelink in particular which is another counselling service. First responders can get resources such as counselling and it's all confidential, so there's no stigma.

Transition

I thanked Officer Smiles for volunteering his time to be interviewed and asked if I could see where he works. He happily agreed and mentioned that we will be taking the scenic route. We conducted the interview in a large conference room with tables arranged in a "U" formation. There was a lot of natural light since the room is visible from the street. There was a projector screen at the front of the room with the American flag on the left and a podium on the right. From the conference room where we conducted our interview, he led me through a hallway with multiple doors on each side. I heard someone's voice in his walkie-talkie, and he listened to it like he did whenever someone spoke during the conventional interview. He is always on standby. Besides his walkie-talkie, he had his badge, handcuffs, and a gun on his belt. I asked him how long he was with University of Washington Police Department (UWPD) and he said he'll reach his two year anniversary by the end of this year. He has been a police officer for almost six years. He said that although each day is different, he uses his office as a space to plan everything he does since he is involved in so many areas of UWPD. We reached the end of the hallway and walked up a stairwell to the cubicles. There were windows in the stairwell as well, allowing natural light to flow in. The office space was eye opening for me because when I think of police officers, I think of them out and about. He mentioned that a big portion of his time is spent behind his desk as well.

Contextual Interview

Before we got to his desk, we walked through the office. It was quiet. We passed one person at a cubicle, but I did not see any other people. Then we arrived at his desk. The cubicles were arranged in a square formation so that each person had a corner. It was spacious. Some desks were clean with blank walls while other desks were more decorated. Officer Smiles's desk was the most decorated with pictures, thank you cards, badges, and posters. I asked if I could record

him working at his computer and he agreed. He sat at his desk and checked if he missed anything. I noticed his calendar was full of color, meaning he had a jam-packed schedule. After I collected some B-roll, I told him I was ready. We went back down the stairs and he led me past more cubicles and a wall filled with slots for mail distribution. It was quiet in this office space too. When we turned a corner, I saw a different hallway from the one we came from. He opened a door on the left and we walked into a small break room with a toaster, coffee machine, a sink, and restroom door. The break room led to another room. I walked inside and the first thing I saw was four desks, each equipped with multiple monitors. One desk had four monitors, another had seven, and two others had eight. Someone was working at one of the desks and Officer Smiles had a short conversation with him. That's when I noticed the four monitors near the ceiling. Each screen was filled with footage from hallway cameras all over the facility. This was the room where they monitored all the activities going on in the building. The furthest wall had windows to the ceiling allowing people entering the building to communicate with people in this room. This room was less spacious compared to Officer Smiles's office space. I looked around and noticed festive Halloween decorations as well. We exited the room and continued to walk down the hallway which led to the lobby area. Looking back, the whole facility had a modern design to it which means it was built not too long ago.

Wrap-Up

I asked Officer Smiles if he used his office space a lot. He said he does different things everyday since he works internally for the department and externally for the community's needs. When he's in the building, he works on planning and executing training for other officers. He and his team coordinates the whole process from the lesson plans to the actual training and makes sure the department is educated and prepared for unexpected situations. When he's doing outreach, he actually goes out into the community, away from the building. This involves tabling, speaking at events, and of course crime mitigation. Most of his time is dedicated to educating the community even if that means answering emails and planning meetings. He mentions again that every day is different and he loves it. The spaces that he showed me was a utility to help him deliver his best efforts to help our community. After our conversation, he led me to a monitor where I signed in. He asked me to take out the sticker badge that was printed for me when I came in and to scan it. I scanned the sticker and the screen said I was checked out. He said I was good to go. I thanked Officer Smiles again for volunteering his time to be interviewed and

for giving me a tour of his office space. He said it was no problem and to contact him if I had any additional questions. I mentioned that his input will help me design a way to intervene disasters and he said he was glad he could help.

Contextual Interview with Lifeguard Dylan Dang

Conventional Interview

Can you talk about what you do as a lifeguard?

Well as a lifeguard, we watch to enforce the rules of the pool and to see if people are safe and in case of an emergency if somebody drowns, we will deal with them. If somebody passes out we will have to deal with them. Also, when people are not swimming, we also teach lessons so lessons to people who want to learn how to swim better.

Can you talk about the emergency procedures that are in place for the pool, specifically for earthquakes?

I don't recall being told about any emergency procedures specifically for earthquakes while being trained as a lifeguard. However, my first instinct would be to help assist people in evacuating the building after the earthquake dissipates as I wouldn't take my chances to see if the building would hold up or not. There isn't really much cover in such an open space. There are a few chairs on the side of the pool that people could get under but other than that, it's all open. If people are looking for cover, they could exit the pool and go into the other rooms/hallways where there are tables they could get under.

Could you share some ideas that you may have in helping the pool be better prepared for the event of an earthquake?

We could have plans (procedures) posted on the walls of steps what to do (in the event of an earthquake). This will help guide people towards areas with a lot of cover and inform them of what steps to take during and after an earthquake.

Do you believe the building of the community center will keep up and why?

This is one of the newer buildings and it was built around in 2013 and it's a really "green"

building and should be more resistant to earthquakes. It has a lot of support beams everywhere.

Living in Seattle, how prepared are you for when this earthquake hits?
In elementary, middle, and high school, we would have earthquake drills occasionally where we would get under our desks and stay there until the drill was over. With that said, what school has taught me has in a way helped prepared me for what to do when an earthquake hits. As for my house, we have extra water and canned food but that's about it.

If a person were to get hurt in the pool, how would you interact with first responders?
First, we would access the person to see what's wrong with them, and then we will give that information to the first responders, so they will take better care of them than us.

So, you basically just give the basic first aid?
We will give them basic first aid and since we're not like medically qualified to do certain things, we will let the first responders who are medically qualified (to deal with it).

Transition

After interviewing Dylan in a room just outside of the pool in the community center, I asked if I was able to setup a time where I could come in and observe him working as a lifeguard. He wrote down his schedule for the next day and told me that I wasn't allowed to reserved events or his swimming lessons. However, I was free to film him while he was guarding during public swim. By observing what the environment was like at the pool, I would be able to see what types of things could go wrong if an earthquake were to happen.

Contextual Interview

The next day before entering the pool, I looked around at the community center to see if there were any emergency procedures posted on the wall similar the one at the University of Washington where it has instructions for what to do for an earthquake, fire, hazardous materials release, power outage, suspicious person/object, and evacuation information. Unfortunately, I couldn't find any type of emergency procedures posted. Heading to the pool, I sat down at a chair on the side and saw Dylan and another lifeguard standing at different ends of the pool.

There were quite a lot of people and Dylan was walking back and forth to cover the larger end of the pool. Dylan was holding a rescue tube and had access to a plastic megaphone in case he needed to make an announcement or tell someone something. The pool was surrounded by huge windows on two opposite walls and had a large yellow water slide that reached up near the ceiling. I would assume that during an earthquake, the windows and water slide would be the most unstable. The pool had a lot of entrances and exits. Next to where I was seated, there were two doors reserved as an emergency exit. I noticed that there was a timer in the lifeguard office facing toward the pool that I found out was for lifeguards to keep track of time to switch out guarding efficiently.

Wrap-Up

After Dylan was over with his shift, another lifeguard came out and took his rescue tube and continued guarding. Conducting the interview and going to the pool, I was able to notice that there wasn't much emphasis on earthquake preparedness within the community center. Dylan mentioned that earthquakes weren't talked about during his training and I saw no emergency procedures posted within the community center or pool. I met with Dylan in the lobby after he got dressed up and asked him why there weren't any signs or procedures posted in the pool in case of an emergency and he told me that the community center was recently built in 2013 and the architect could've taken into account of the risk of earthquakes in Seattle and made it structurally safe to the point where there wouldn't be a huge need for earthquake preparedness. Dylan showed me a display on the wall in the community center that talked about the sustainable design features of the pool such as solar panels, ground source heat pumps, rainwater harvesting, etc. With that in mind, it's very plausible that the architect took into consideration the effects of earthquakes when designing the building. Dylan mentioned that this could also be why they weren't really given any training of instructions on what to do in case of an earthquake during lifeguard training. I thanked Dylan for his time and he replied saying that I could contact him at any time if there were any further questions.

Problem Space

In our project, we address the problem of first responders' well-being with a focus on mental and physical health. Constant exposure to trauma can be difficult to manage if one does

not have a coping system (Smiles, 2018). Some examples of this trauma could be near death experiences, proximity to distressed civilians, or casualties (Reagan, 2017). People can only handle so much pain and suffering until they too, start to feel the impacts of those events (First to Respond, Last to Seek Help, 2018). First responders may also feel strain on their personal relationships since their line of work is dangerous and demanding (Why Families of First Responders are the Silent Victims, 2016). In addition to mental health, first responders put their physical health at risk during disasters. They could experience overwork, sleep deprivation, physical injury, or even death (Macy). Assisting civilians or being on the premises of an unstable area that has just experienced a disaster magnifies the potential for physical harm. First responders forgo their own safety for the safety of others and that kind of mentality, while heroic, could also get them severely injured or even killed. Our project helps support the greater potential of first responders by providing a solution that helps them protect or recover their mental and physical health from the effects of disasters.

First responder well-being affects multiple indirect stakeholders. If the mental health of a first responder is poor, they are putting those they are helping at risk by making poor decisions. If a first responder's physical health is poor, they may not have the strength to help those in need. Volunteers, who are also considered first responders, may put themselves at risk, not realizing they could be affected by the things they witness. They may experience post traumatic stress after a disaster and anything that reminds them of the event could be a trigger, affecting their daily lives (Abel, 2013). Another indirect stakeholder of first responder well-being is families. The people who care about first responders have to be prepared for the worst when disaster happens. These families may be safe at home but they still worry about their loved one who is putting their life on the line to save others. This puts stress on relationships and family dynamics. Additionally, if a first responder is injured or experiences trauma such as PTSD, their families must be there to help them recover and make sure that they can get past whatever they are facing (Abel, 2013).

Below is a system diagram which shows the relationships between what a first responder does and how the events that occur while he or she is on the job can affect their well-being. This diagram shows a what could possibly happen in the event of a disaster.

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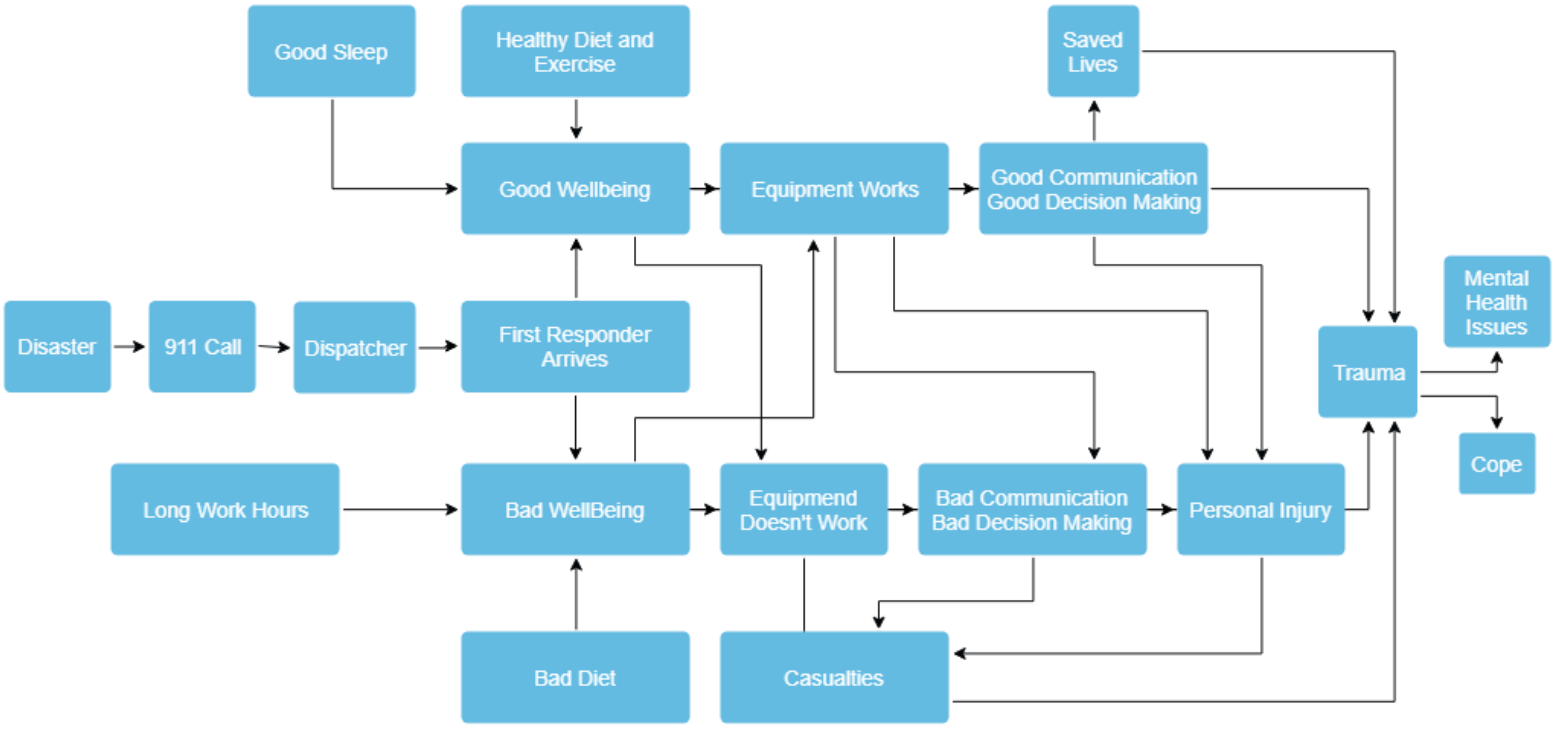


Design Intervention Ideas

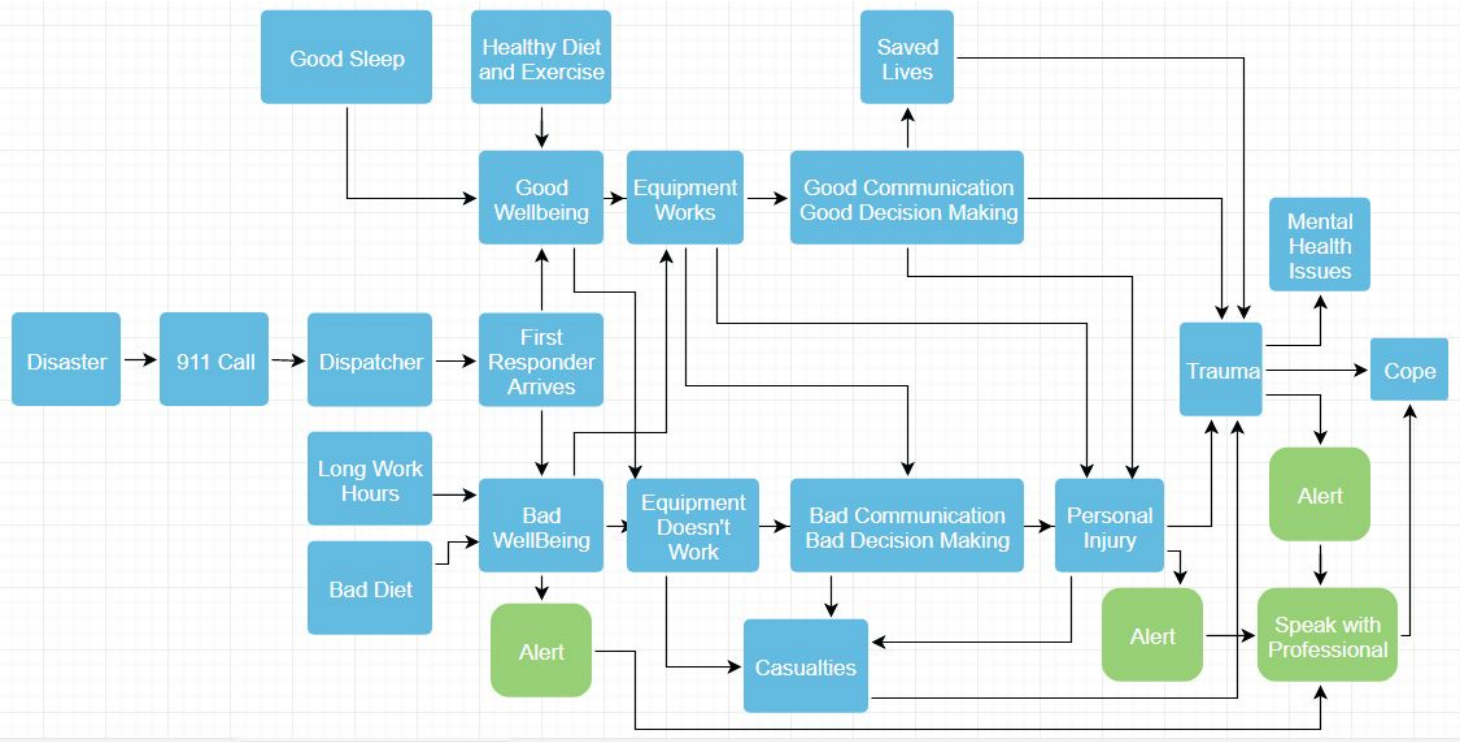
A biotechnical monitoring device designed specifically for first responders is needed because their well-being affects many stakeholders with high stakes. A small, lightweight device would be versatile for all types of first responders. The device would constantly monitor bodily function so that someone will be notified when a first responder should not be on site. Additionally, data collected over time will allow reviewers to spot abnormalities during data analysis. For example, if a responder's heart-rate spikes during a disaster, they might reveal that they had a panic attack and tried to remain on the scene to help. In 2017, 103 firefighters and 140 police officers committed suicide, whereas 93 firefighters and 129 officers died in the line of duty (Ruderman Family Foundation). Only 3 - 5% of the United States' 18,000 law enforcement agencies have suicide prevention training programs (Cerullo, 2018). The intent for this device is to make room for difficult conversations and break down the strong exterior first responders are expected to have.

We want our design to make it easier for first responders to talk about their mental health and what kinds of experiences they have without the stigma of being unmanly or weak. We would like to increase the safe space for first responders to talk about their feelings and

hopefully better cope with the kinds of situations they experience. In addition to this we hope that first responders would use these sensors that we propose, so when they are out in the field their health is monitored and after a high stress situation they will be able to explain why their data showed what it did. Hopefully this will create more of a platform for first responders to talk about how they were feeling or what they were experiencing while in high stress situations. The device will create a platform like this because if someone monitors the vitals and health of a first responder they can also see if there are any abnormalities in their data while in the field. After this information is compiled, then there is someone who would speak with them about why there could have been an anomaly in their data and how they were feeling during the time when there was a change in their data. With this device we also hope that if a first responder is injured or something happens to them physically someone would be notified to help them as well. If a first responder like a policeman were to be in a shooting then if they were injured their device would sense that their heart rate is dropping and help would be sent to them. This helps reduce the dangers of getting injured while on the job. We want to not only preserve and address the effects of post traumatic stress on first responders, but make sure that they are safe while performing their jobs because they do risk their lives for others.

We wanted to create a device that tracks the vitals of a first responder in time using a sensor that is placed on the surface of the skin. First responders would wear this sensor while out in the field so that if there were any anomalies in their health data then an outside party would be able to recognize and either ask the first responder about what was wrong or what they were experiencing during that time or send help to them if they were in a dangerous situation.

Below is a diagram of how our biotechnical device will intervene on the first responder system.



Initially, we brainstormed two biotechnical device ideas and wanted to pair it with software to display first responder data.

Idea 1: Smartwatch

The smartwatch was something that we were familiar with due to the popularity of devices such as the Apple Watch and the Fitbit. We had the idea of creating a smartwatch that was able to measure all four vital signs. After doing research on smartwatches and their capabilities (Johns Hopkins Medicine), we found that smart watches do not have the capability to measure respiratory rate as of today. Respiratory rate is measured through the number of breaths that a person takes per minute and can be done through a device placed on your chest. Knowing this, we moved to the idea of having first responders wear vests that are able to monitor their vital signs.

Idea 2: Vest

Our idea of a vest would ideally be able to track all four vital signs of first responders while they are out in the field. This vest would be able to get vital sign readings through contact with a person's skin. Doing more research (Measuring Blood Pressure), we found that our idea of a vest would not be able to track blood pressure that is measured through a person's arm. We decided that it would be better to reach out to an expert in sensors that would be able to help us with these problems in our design.

Idea 3: Software

Regardless of the prototype, we will need an interface to display the data collected. Therefore, we will be prototyping a user interface where first responder vital data can be viewed. The interface for the vital data will allow first responders to see their heart rate, blood pressure, respiratory rate, and temperature over an hour, day, week, month, or year. Another functionality we will need is a profile, where first responders can set their personal account information such as their name, birthdate, height and weight. This data will be secured within the app so first responders will not have to worry about their data being used for other purposes. The software will also have a communication feature where doctors, colleagues, and family members using the same software will be able to communicate with the first responder. Furthermore, a mood tracker tab will allow first responders an opportunity to write about their experiences daily, to let go of anything that bothered them during the day.

Interview With Subject-Matter Expert

After searching for an expert that would be able to help us with our design ideas, we found the University of Washington UbiComp (Ubiquitous Computing) lab that develops innovative sensing systems for real world applications in health, sustainability, and novel interactions. We tried reaching out to professor Shwetak Patel but realized that he may be too busy. Instead, we reached out to a few of his students and got in touch with Matt Whitehill. We were able to set up a time for a contextual interview and met with him in his office at the Computer Science & Engineering building. After discussing with Matt about our design ideas, he told us that correlating sensor data to someone's mental status is very tricky. He explained that

it's an active area of research to try to take sensor data and correlate it into actionable information. Matt suggested that we should pursue a multimodal solution. A multimodal solution would use a smartwatch for temperature and heart rate, some sort of respiratory monitor that goes on the chest for respiration rate, some sort of novel new blood pressure device that could do continuous measurement, and then some head mounted display that would be feasible for first responders and doing eye tracking work. We took his ideas into consideration and started working on our first prototype of a smartwatch that is able to measure temperature, heart rate, and blood pressure.

Design Constraint Iteration

For our project specifically, we were given the constraint of having "first responders down". Initially, we were panicked by this because our problem space revolves around first responders themselves. However, we took the constraint in a different light. We interpreted this constraint as having first responders down from physical or emotional stress and are in need of backup.

Although first responders are usually the ones we turn to when there is danger, they also need their own system of support to depend on. If first responders are down emotionally, we would mitigate this constraint by contacting their family and friends, in the case of emotional distress, and other first responders and professionals in the case of physical danger. In the case of emotional distress, friends and family are the ones who truly care about the first responder in need and are the highest stakeholders when "first responders are down". In a situation like that, family and friends will do whatever it takes to make sure their loved one is safe and accounted for. Our design is a biotechnical device that tracks biometrics and location. With the addition of a panic button, family and friends will be able to use software to track their first responder when they indicate they are in distress. Initially, our device idea was only meant to be used by first responder units, but after the introduction of this design constraint, we added a feature in the software so that family and friends can access information collected from the biotechnical device.

This new feature will also allow loved ones to address potential problems that the first responder may be bringing home with them but not speaking up about. This feature would connect the account to other account users that are friends and family, only with the permission of the account holder. In the case of a malfunction with the biometrics or the software of the

watch, we would also add the feature where an urgent notification would not notify the family and friends unless the situation demanded that they be notified. This would only be in the case if the situation is physical. While a first responder is in the field they might experience a malfunction and in these cases a direct notification to the family immediately is not beneficial. So, only sending an urgent notification when it is necessary would screen what types of notifications connected parties will receive. This would limit the amount of stress that is put on families and friends if they are monitoring the vitals of a first responder. Also, the data is a rough estimate of their vitals and not one hundred percent accurate, so if there was a complete drop in all of the vitals then the software should add a mark or some note that the software failed to send data, or that the watch lost power at a certain time, if either of those were the case. We would hope that the emergency button feature would only be used if the first responder needs help or backup in some way. For emotional distress, this would just show up in their data and on their charts that there is emotional distress. We hope that family and friends would mostly respond only in the case that something is wrong emotionally or if the first responder is experiencing anxiety or some form or PTSD. In this way we hope that if a first responder is “down” emotionally then their families will be able to help them as opposed to having a stranger, or therapist come in which can be uncomfortable and costly.

If first responders are down physically, others need to be called upon to respond to the danger at hand. In addition to being able to help emotionally, the biometric device will also allow stakeholders to determine the physical state of their loved one and bring necessary supplies or backup if they are in danger. This is when we turn to not only family and friends but also civilians. If there are off-duty first responders in the area who can manage the disaster, they will be notified through the device because their own location trackers will notify them when a first responder needs backup. The data collected from the device will notify people within a certain radius of the user that the user is in danger and needs help. This information would only go out to officials like police officers nearby, or a fire department that might be close to the user. Furthermore, if there is a disaster such as a terrorist attack that takes down all first responders, then there needs to be a way to notify the general public that their assistance is needed. It would be best to utilize the Emergency Alert System (EAS) which requires TV and radio broadcasters, cable television systems, and wireless cable systems to address the American public during an emergency (Federal Communications Commission, 2017). When multiple first responders are physically down, the software and location services will send a distress signal that notifies broadcasting stations of a terrorist attack. It is helpful to have location services on

these devices in the case that a first responder goes missing during a situation. However, with this said maybe sometimes the sensor may not be able to tell if the first responder is in real danger so we would also like to propose that there be a function on the device where if the first responder holds it down or touches it for an extended period of time then it would send a distress signal to whoever has access to his or her device information. To accommodate this, we designed additional software to let family and friends keep track of their first responder.

Proof-of-Concept Prototype

The prototype we chose to create was the smart watch, which first responders can use to collect data on their vitals. Many of the watches that are currently on the market do not encompass all four vitals: blood pressure, heart rate, temperature, and respiratory rate (Johns Hopkins Medicine). The watch will not only show the vitals on the face but also collect that data and use that to track the health of the first responder wearing it. We hope that by doing this then first responders will be more conscientious of their health and make sure that they are not overworking themselves. If there is ever a dangerous situation, they will also be able to call for help.

The watch would have a band that self-inflates to accommodate the blood pressure monitor. The self-inflating band would be made out of a flexible synthetic material that is stronger than steel and will keep its shape when inflated (Brown). For the blood pressure monitor itself, we would like to put it within the body of the watch. In addition to this, our design also has an optical sensor as well as a pressure sensor to test blood pressure (Brown).

The band will be connected to the watch's interface which will be similar in design to a FitBit. The face of the watch will be rectangular and long with a slight curve to accommodate for the curve of the wrist and arm. The width of the watch face will be as wide as the band. The watch will contain an optical heart-rate monitor that measures heart rate using LED lights. LED lights measure heart-rate by shining light through the skin and an optical sensor to measure the light that bounces back (Hayes).

The next piece of our design will be a GPS chip in the watch. This will monitor the first responder's location at all times. We wanted to add this part because having location services is beneficial if there are ever any issues or dangerous situations. This also facilitates another aspect of our design which would be the panic button. Our design incorporates a small button on the side of the watch face. Not only does this button allow for one to scroll on the face of the

watch and select things (when pressed) but if the button is held down for longer than 5 seconds the watch will send a “ping” to the operators or their supervisors notifying them that there is a situation and they need back up. The watch will not make a sound or flash but it will just send a distress signal with their location to the other people who are able to send back up for them. This way we hope that the first responder can call for backup in a non-obvious way if they are ever in a delicate situation.

Lastly, we would also like to measure body temperature using the watch. This would be a feature on the watch face as well. A thermometer also needs to be included in the watch in order for it to be able to take temperature measurements (Hayes). This would take the temperature of the skin so would most likely be placed on the back side of the face of the watch, directly against the skin.

In addition to these physical parts, we would also like to have a small screen on the face of the watch. Here one would be able to view the different measurements that the watch takes. It would normally just show the time as any watch would but when using the small button that would be located on the side of the watch one would also be able to scroll through the data and see things like current heart rate, current body temperature, and blood pressure (with the option of telling the device to take blood pressure). Then, once again, by pressing the button briefly it would select the desired option.

Not only will the watch have an interface, but it will also be paired with software, such as an app, that allows supervisors, medics, or family members to monitor first responders’ health. Stakeholders will have access to first responder data in order to determine if the first responder is healthy or needs to seek help. This software will display data unique to each first responder and will alert stakeholders when their physical health is in danger. This will also be where information about heart rate, body temperature, and blood pressure will be compiled. It will show trends and eventually it will compile enough data to tell when there is a major anomaly in the person’s vitals. The software will also have personal data such as name, birthdate, blood type, and more to calibrate danger levels. The emergency ping will also notify the people who are connected to this data and using the software. A notification will be broadcasted on the software and it will show the location of the individual. There will also be some form of confidentiality so that only a small group of people will be allowed to see the first responder’s data.

Below are some of the first iterations of our design that we began with. They show how we imagined our product looking and what kinds of functionality it would have, including the software that would show the data we collect.

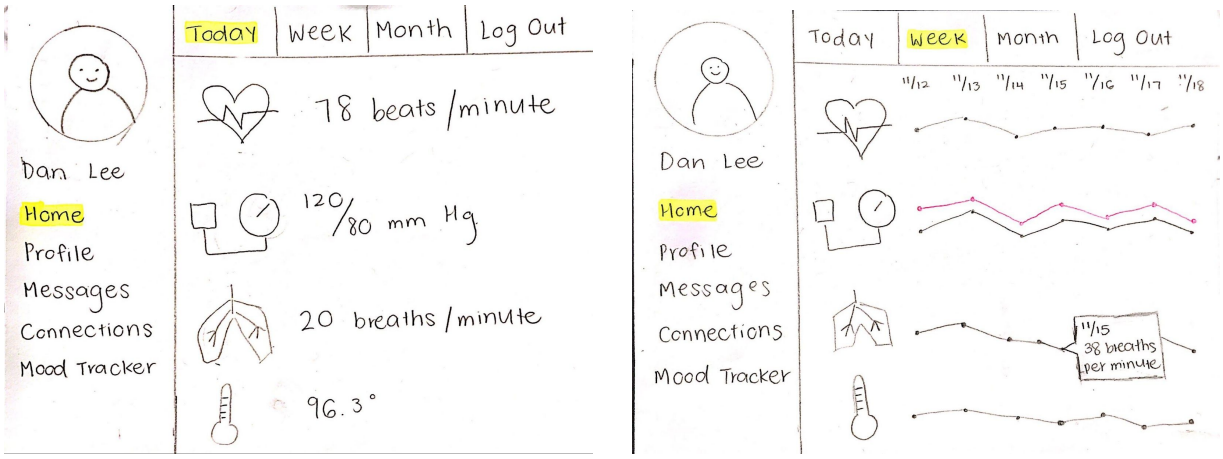


Fig 1 (left): The home page to ou design that we began with; Fig 2 (right): A view of what kind of data would be shown about the vitals that we would take.

We made multiple wireframes and pictures that show what the screens would look like on a computer screen. Our page would include multiple pages including a homepage, profile page, a connections tab, messages, and a mood tracker. The homepage is where the user would be able to see the data that is collected from the watch, looking at their own data and what their trends are. Then the profile page is where the user can put in his or her personal information and that is how their data is linked to them and how others can link to them. Then the connections tab shows who can view their data and who is connected to the users account. This would be like friends and family and possibly health care professionals. Then the messages tab is for people to message them, and this includes health care professionals so that the user can reach out and speak to someone if they choose to. Then the mood tracker page would be similar to a place where the user can keep tabs on their mood and keeps somewhat of a journal about how they feel and what they experience. This would be private to the user unless they chose to share that with any of their connections. The connections would only be able to see the vitals and their numerical data collected by the watch.

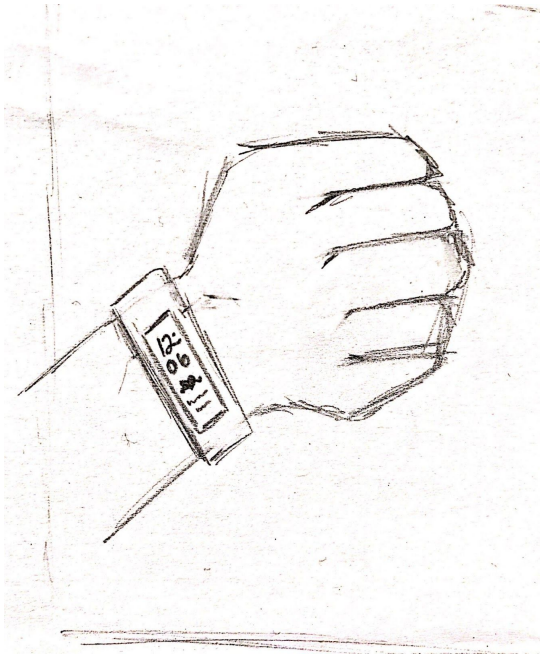


Fig 3 (left): A sketch of the face of the watch; Fig 4 (right): A sketch of how the watch would fit on the user's wrist and how it would look.

These were the first sketches of what we wanted the actual device to look like. We designed the interface for the watch to be very simple showing the time and also showing the different vitals that could be seen or taken from the watch. At the top is the time, and then at the bottom of the screen there would be the three different options for vitals: heart rate, body temperature, and blood pressure. The band would be somewhat slim and the face of the watch would be the width of the watch bands as well.

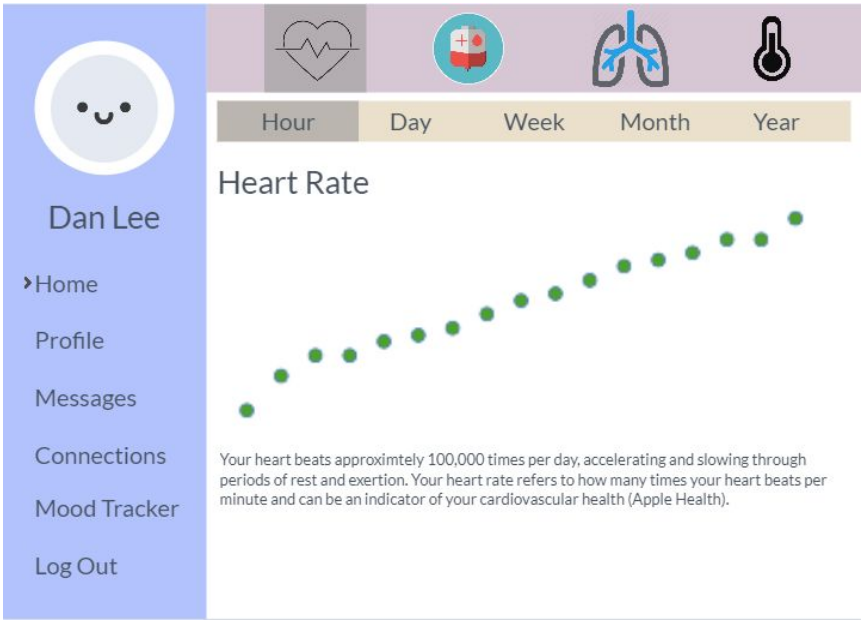


Fig 5: Shows the final iteration of our screens. This is what the home screen would show, the vitals at the top and then the data associated with that vital below. This is only one image of our device but below is a link to the rest of the screens, with some interactions.
Software Prototype: https://marvelapp.com/55989eg

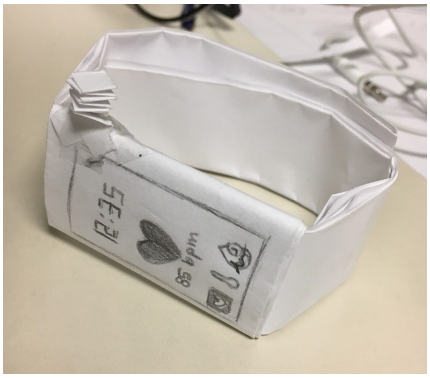


Fig 6 (left): A front view of the face of the watch; Fig 7 (middle): a side view of the watch; Fig 8 (right): a view of the button on the side of the watch face.

Above is what our final products would look like, or very similar. We made some very low fidelity models, using the Marvel application as well as paper. We used these prototypes to ask

people more about their functionality and what it would be like to actually have somewhat working models.

User Evaluation

To evaluate our biotechnical device and software, we conducted interviews and surveys. We felt that these qualitative methods would best help us in determining whether our product was feasible. An interview is the verbal conversation between two people with the objective of collecting relevant information for the purpose of research (Kumar, 2014). In interviews, the researcher has control over the flow of process and he or she has a chance to clarify certain issues or follow leads during the process if needed (Research Methodology). Disadvantages of interviews include longer time commitment and difficulties arranging an appropriate time with perspective sample group participants (Research Methodology). Interviews can range from unstructured to structured. Unstructured interviews are exploratory. No questions are prepared prior to the interview and data collection is conducted in an informal manner (Research Methodology). The interviewer can follow leads in formulating and ordering questions. This type of structure are where impromptu conversations take place. In structured interviews, the questions are asked in a predetermined order and the interviewer will not deviate from the interview schedule or probe beyond the answers received (McLeod, 2014). Structured interviews are easy to replicate since the fixed set of questions are easy to quantify. However, structured interviews are not flexible and they lack detail. Interviews are a type of method that is subject to social desirability bias and recall bias. Social desirability bias is an interviewee's tendency to subconsciously present themselves in a positive light (Lavrakas, 2008). Recall bias is a systematic error that occurs when participants do not remember previous events or experiences accurately or omit details (Catalogue of Bias).

A survey is a method of collecting information about a population of interest through a questionnaire (Research Connections). Surveys consist of close-ended and open-ended questions (Research Connections). Close-ended questions can be answered with "yes" or "no," or they have a limited set of possible answers (Farrell, 2016). Open-ended questions asks the respondent to provide feedback in their own words (SurveyMonkey). One must be careful when wording survey questions to avoid biased, double-barred, or double negative questions (Research Connections). An example of a double-barreled question is "Do you agree that global warming is a problem and that the government should be working diligently on a solution?" and

an example of a double negative question is “Do you disagree that global warming is not a problem?”. Some techniques for surveys are putting exciting questions up front, putting sensitive questions near the end, showing a progress indicator, putting demographic questions at the end, and conducting a pilot test.

Link to survey: https://goo.gl/forms/dGv8ETPOQPM60A6p2

We conducted a total of five interviews with different types of stakeholders and distributed our survey, asking questions about the biotechnical device design and user interface. We included pictures of our prototypes in the Google Form survey and made sure to ask open-ended, non-leading questions. For our watch design, we found that the face of the watch was intuitive since respondents easily listed the vital signs the watch measures. They also understood why first responders would benefit from wearing the biotechnical device. Respondents noted that the button on the side of the watch was ambiguous because there wasn’t a label on it. Furthermore, we learned that 72% of respondents would not wear our biotechnical device. This may be because the watch is tailored specifically to first responders and not for everyday use. For the user interface of our software, participants understood that the medical data of the biotechnical device could help stakeholders determine the health of a first responder. Most said it was helpful and also expressed that they would consult doctors, family and friends if there was an abnormality shown in the data. One user did express that the diary was unnecessary. Two participants said some people might not understand how to use the software which could cause unnecessary worry to those who are untrained in how to use it.

From the feedback we gathered, we learned that the button on the side of the watch was ambiguous. The button is there for first responders to use when they are in distress and need backup. If it is held for more than five seconds, the first responder’s team, family, and friends will be notified. To make this functionality explicit, we decided to add an “SOS” label to the button. We also learned that the diary option on our user interface was unnecessary so we decided to make it a mood tracker instead. First responders are not obligated to use it, but will be prompted to write about their feelings. The intent of this functionality is to give first responders a private space to write about their feelings if they ever needed to write some troubling thoughts down, privately.

Conclusion

Throughout our project, we have learned so much from contextual inquiries, user evaluations, system diagrams, and prototyping. Towards the end of our project, we learned that while our design may be a good idea, it is still an active area of research and ahead of its time. Through user evaluation, we also realized that while nurses and first responders expressed interest in the design, it is not designed for the everyday wearer. In a future iteration of this project, we would like to do more research to track first responder mood. We learned that mental health is a difficult subject area to tackle and this project is only one tiny step in breaking down the stigma first responders have around wellbeing.

Link to Video: https://www.youtube.com/watch?v=cNd-s7nWclU

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