

GNG 1103

# **Deliverable D: Conceptual Design**

## **OPIOID OVERDOSE DETECTOR**

By

**GNG1103, SECTION C00, GROUP 5**

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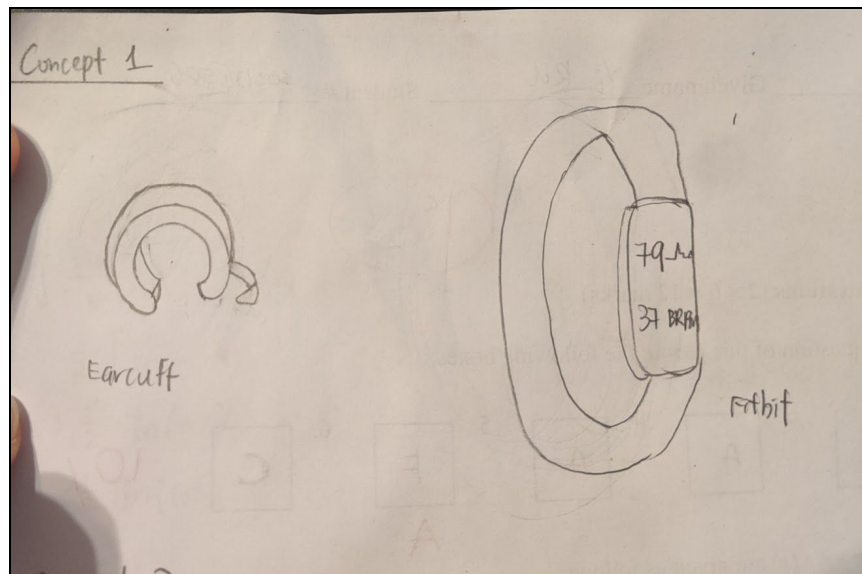
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# Introduction

The goal of this deliverable is to develop an overall design concept based on the problem statement, needs identification, benchmarking, and list of prioritized design criteria created in the previous deliverables. Each team member is in charge of developing three concept designs according to the determined design criteria. The designs are then collectively evaluated and given points based on how well each design follows the guidelines. The points are determined by a 5 point scale and points are summed and compared. The top designs are then analyzed and the best subsystems from each design are chosen and combined into one global concept. Once the synthesis of designs is completed, the final design is chosen. Moreover, each decision and choice is documented in case of any later modifications. At the end of the report, the next steps that need to be taken are discussed, as well as how the project will proceed.

## Team Member Concepts

### Ru's Concepts



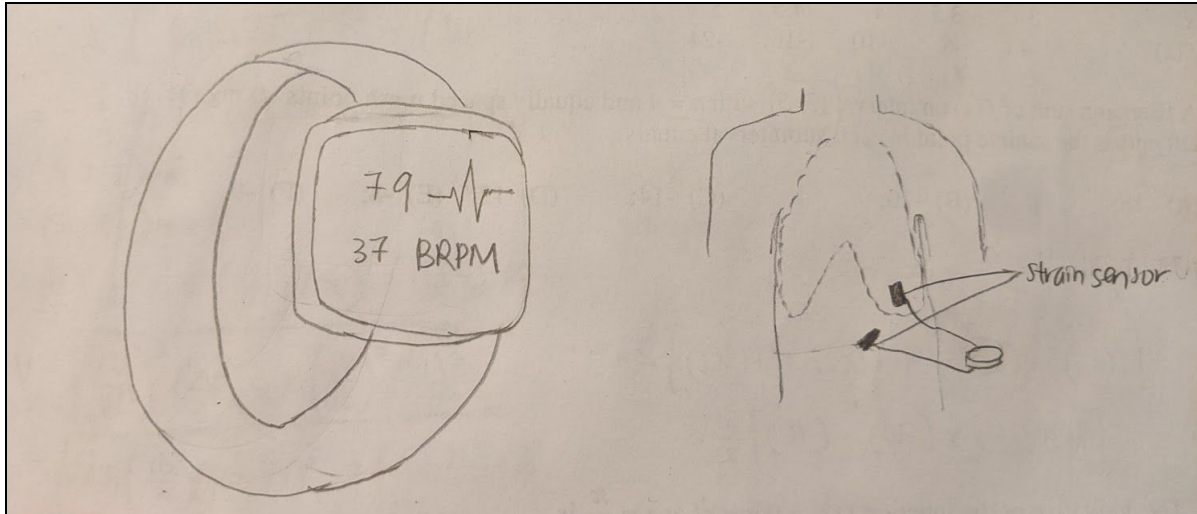
**Concept 1:** This design comes in two parts: ear cuff and slim fitbit watch. A breathing rate detector will be installed in the ear cuff and the readings that are measured will be sent to the fitbit watch and displayed on the screen via bluetooth. The fitbit will be installed with solar battery, bluetooth receptors and GPS detectors that can send emergency signals to emergency services. The screen of the fitbit will display the heart beat rate and the breathing rate per minute of the user.

*Pros:*

- *Discreet*
- *Easy to use (user-friendly)*

*Cons:*

- *Does not measure the blood oxygen saturation level*
- *Cost*



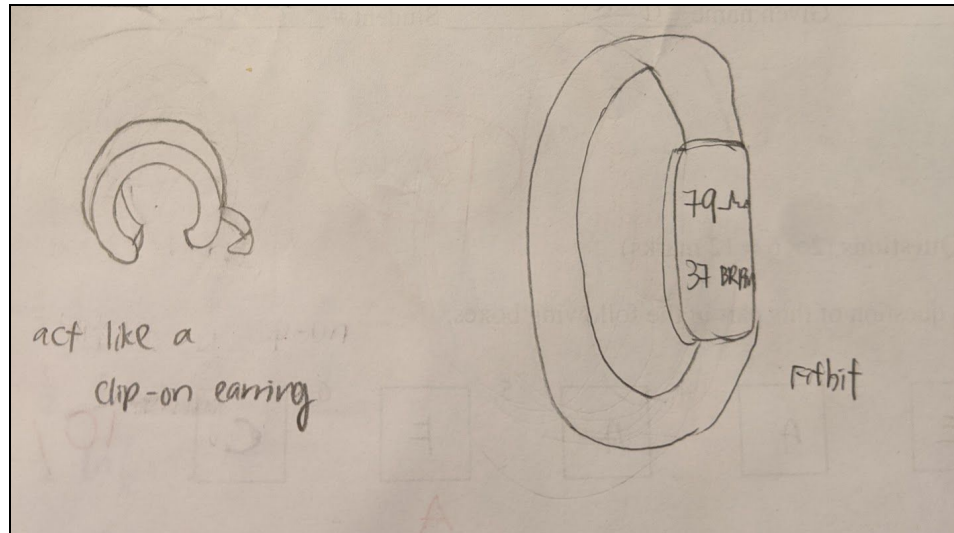
**Concept 2:** This design comes in two parts: fitbit watch and strain sensors. Strain sensors are attached to the ribcage and abdomen of the user to measure respiration rate. The readings are then sent back to the the fitbit watch through Bluetooth. The fitbit will be installed with solar battery, bluetooth receptors and GPS detectors that can send emergency signals to emergency services. The screen of the fitbit will display the heart beat rate and the breathing rate per minute of the user. If the readings exceed a certain standard set by the designer, the screen will blink in red color while an emergency signal will be sent to emergency services immediately.

*Pros:*

- *Discreet*
- *Easy to setup and use*
- *Larger display for the readability of user*

*Cons:*

- *Strain sensors that are attached to the user may cause inconvenience to the user's daily activities.*
- *Cost*
- *Does not measure blood oxygen saturation level*



**Concept 3:** This design concept is similar to design Concept 1. This design consists of two parts: a device that looks like a clip-on earring and a slim fitbit watch. The “clip-on earring” acts as a pulse oximeter or better known as  $SpO_2$  sensor that can detect blood oxygen saturation level of the user. The readings that are measured will be sent to the fitbit watch and displayed on the screen via bluetooth. The fitbit will be installed with a solar battery, bluetooth receptors and GPS detectors that can send emergency signals to emergency services. The screen of the fitbit will display the heart beat rate and blood oxygen saturation level. If the readings exceed a certain standard set by the designer, the screen will blink in red color while an emergency signal will be sent to emergency services immediately.

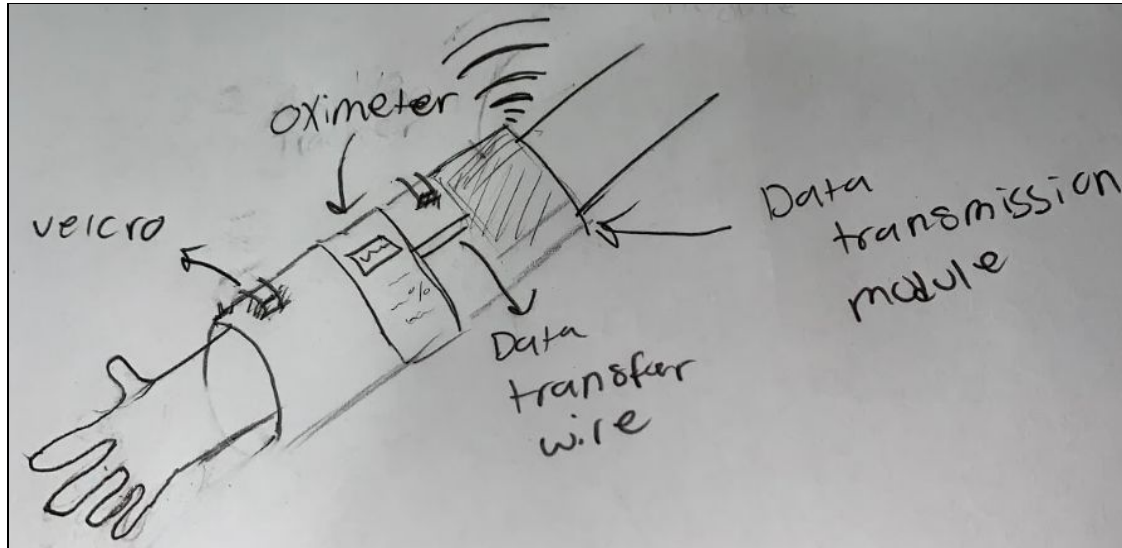
*Pros:*

- Discreet
- Able to measure both blood oxygen saturation level and respiratory rate
- Easy to use (user-friendly)

*Cons:*

- Cost

## Mohamad's Concepts



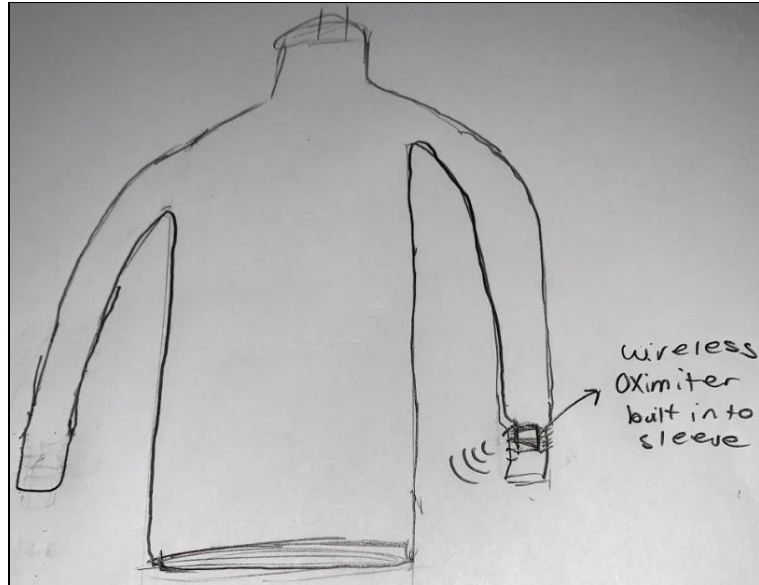
**Concept 1:** This design uses a wired oximeter which is already present on the market, paired with a data transmission device. Data will be recorded from the oximeter then sent to the transmission module via a wire. From there, the data can be transmitted wirelessly to the user's phone and then redirected to emergency services if necessary. It will fit over the forearm of the user and be strapped down by velcro.

### *Pros:*

- Cost effective since it doesn't require an advanced wireless oximeter.
- All one component (rather difficult to lose a piece of it).
- Able to measure blood oxygen saturation.
- No user interaction required - autonomous.

### *Cons:*

- What if the user's phone is dead? (dependency)
- Rather obstructive/large (non-discreet)
- Doesn't necessarily optimize user comfort.



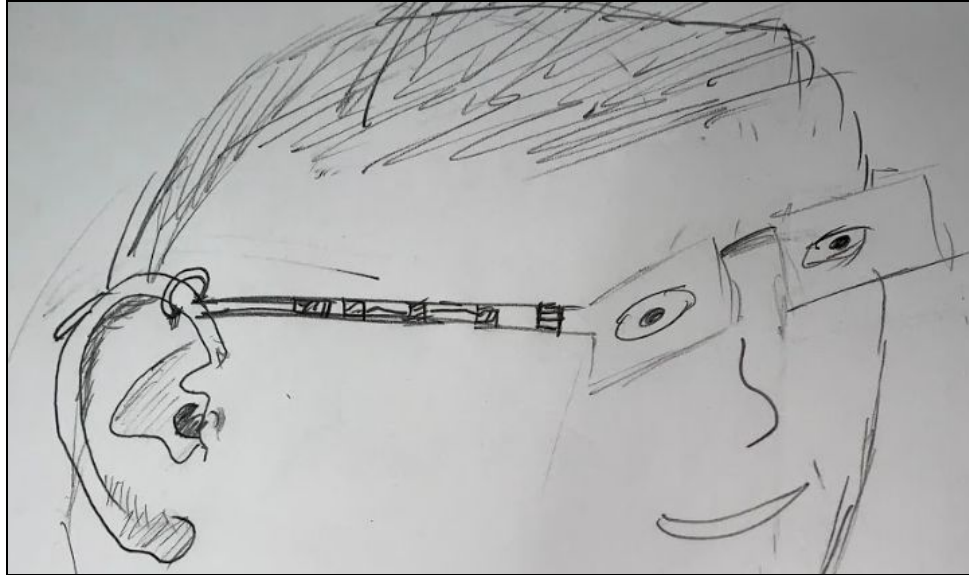
**Concept 2:** This design uses a wireless oximeter which is integrated into a t-shirt sleeve. The display would likely be removed and thus the user wouldn't be able to see the data for themselves. This keeps things discreet and small (no bright lights on a shirt and no large rectangular screen protruding). The device would consist of components built into the lining of the shirt. To keep the shirt thin, components can be spread out across the shirt's sections (not just the wrist area).

*Pros:*

- All one component (rather difficult to lose a piece of it).
- Able to measure blood oxygen saturation.
- Very discreet.
- No user interaction required - autonomous.

*Cons:*

- What if a user doesn't feel like wearing that shirt?
- Could be uncomfortable if components poke through fabric.
- May easily break if the user starts rolling over.
- How to wash the shirt? Can it even be washed?
- Users can't see the data for themselves.



**Concept 3:** This design uses a wireless oximeter which is integrated into a pair of glasses. This design would likely use a finger mounted oximeter's components. However, these components would be dismembered and then re-assembled in a straight line - across the glasses' frame. The oximeter itself would be mounted onto the ear of the user (finger oximeters require slightly translucent skin in order to work), with all other components following it.

*Pros:*

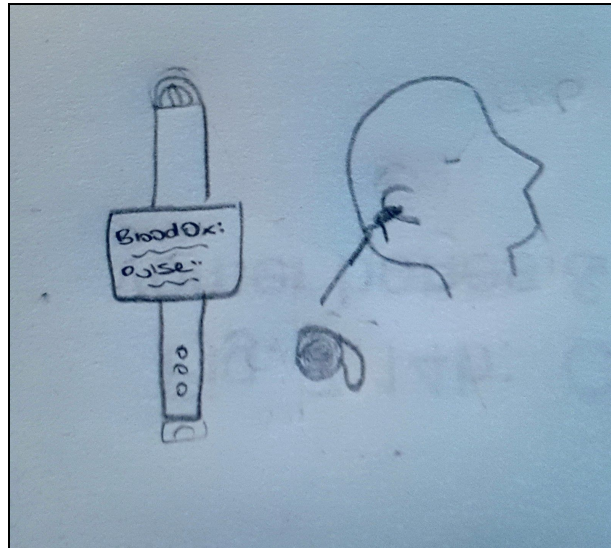
- All one component (rather difficult to lose a piece of it).
- Able to measure blood oxygen saturation.
- No user interaction required - autonomous.

*Cons:*

- What if a user doesn't feel like wearing glasses?
- Could be uncomfortable if the user is not familiar with having glasses on their face.
- May easily break if the user starts rolling over.
- Users can't see the data for themselves.
- Glasses' frames could be very thick (to allow room for all components) and not so discreet.



## Sheetal's Concepts



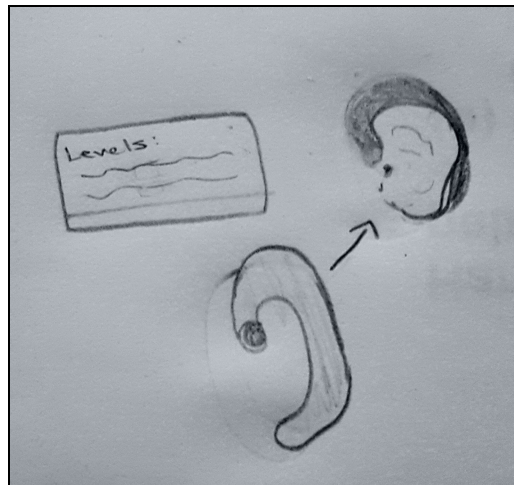
**Concept 1:** This design is comprised of two parts; ear clip and digital watch. Within the ear clip there will be a sensor that acts as a pulse oximeter to measure the blood oxygen saturation levels as well as the heart rate. These values will then be displayed on the digital watch via bluetooth. The watch will be powered using a battery and recharged using solar panels. In addition, it will be equipped with a GPS system that can send a location to emergency services in case of an emergency. The watch itself is water-resistant but not waterproof and durable.

### *Pros:*

- Discreet
- Easy to use (user-friendly)
- Can measure blood oxygen levels
- Can measure pulse rate

### *Cons:*

- Cost
- May be uncomfortable on ear



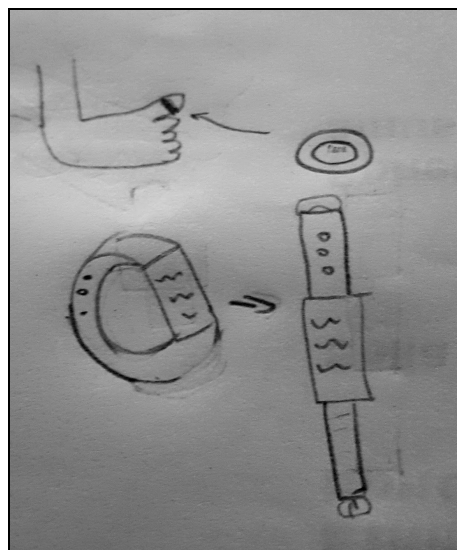
**Concept 2:** This design is also comprised of two parts; earpiece and digital display. Like the ear clip, there will be a blood oxygen saturation sensor and will also measure heart rate. The sensor will then send its values to a digital display that will show all of the data through a bluetooth connection. The display itself will have a GPS aspect to allow for location tracking, and be capable of sending a signal for help. The device will be small and able to fit into a pocket.

*Pros:*

- Discreet
- Easy to use (user-friendly)
- Can measure blood oxygen levels
- Can measure pulse rate
- Portable
- Fits well and won't fall off

*Cons:*

- Cost
- Could be lost or easily damaged
- Display needs to be carried around



**Concept 3:** This design is composed of a toe ring and a fitbit style watch. The toe ring contains a pulse oxygen saturation device that will then send the levels to the thin wristband through bluetooth. The watch will be powered using a battery and recharged using solar energy. In addition, it will be equipped with a GPS system that can send a location to emergency services in case of an emergency. As oxygen saturation levels begin to drop, the watch will vibrate and flash in order to warn the user. The watch itself is water-resistant but not waterproof and durable.

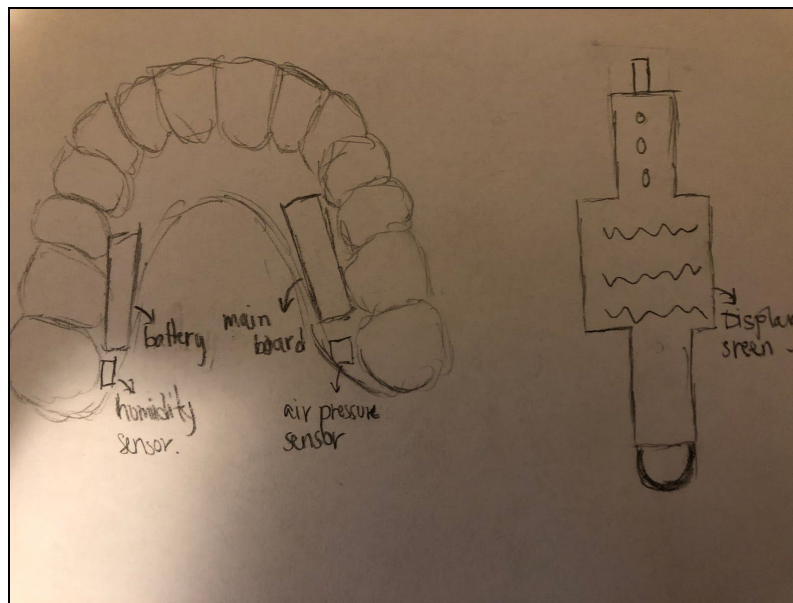
*Pros:*

- Discreet
- Easy to use (user-friendly)
- Can measure blood oxygen levels
- Can measure pulse

*Cons:*

- Cost
- Toe ring can be easily lost
- May be uncomfortable with certain shoes and socks

## Dhvani's Concepts



**Concept 1:** This design consists of a simple retainer like device that is worn by the user in their mouth along with a simple wristband to track data. The retainer will monitor the users' inhale and exhale rate via bluetooth and send updated information to the wristband on their hand. The device will use a humidity sensor and an air pressure sensor to track the users' respiratory with high accuracy, with or without their mouth being open. All the necessary hardware for the device will be embedded into the retainer and out of the way of the user. It will also be waterproof and

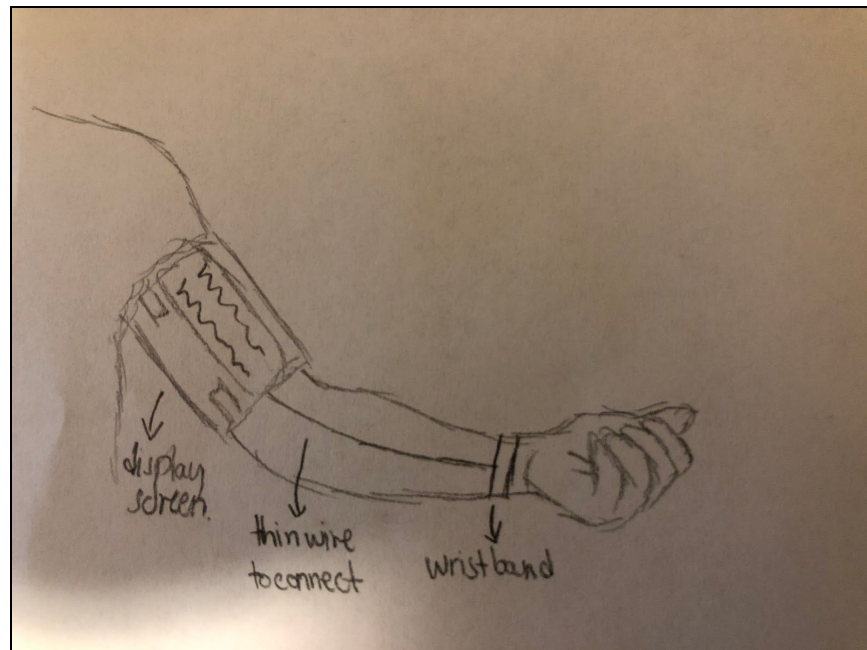
when the oxygen levels reach a danger level, the users' location will be sent to an emergency service nearby via GPS system in the wristband.

*Pros:*

- *Discreet*
- *Non-invasive*
- *Accurately tracks respiratory system*
- *Easy to use*

*Cons:*

- *Cost*
- *Uncomfortable to eat*
- *Requires customization (mouth shape)*



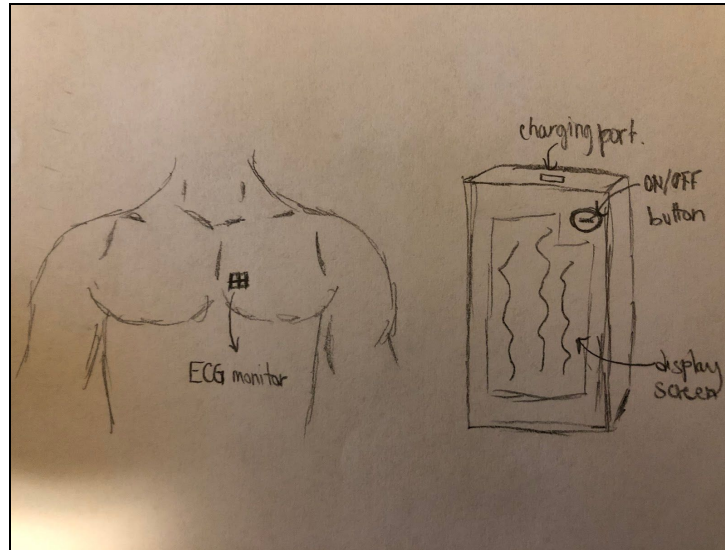
**Concept 2:** Similar to a blood pressure monitor, this device would be worn on the users' biceps and comes with a wristband like device that is worn on their wrist/forearm and monitors oxygenation levels. The data is monitored through the device on the users' biceps and will be updated frequently and accurately. With the device, there will be a pre programmed GPS system that is to send the location of the user to a nearby emergency facility incase of any abnormalities in their oxidation levels.

*Pros:*

- *Non-invasive (fairly small in size)*
- *Regularly monitors oxidation levels*
- *Easy to use*

*Cons:*

- *Cost*
- *Restriction to wearing certain clothes*
- *Unable to do day-to-day activities with comfort (lifting things)*



**Concept 3:** A wireless ECG sensor that is as small as an SD card and as thin as paper would be worn on the chest of the user. This would monitor the respiratory rate and then send the data to be viewed by a wireless screen that is the size of an average phone and can be carried around with the user. The portable screen which is connected through bluetooth has a long lasting battery life after being charged and comes with a charging wire, it is also water resistant and will have a GPS sensor that is programmed to notify nearby emergency services when there is abnormal activity detected within the users' system.

*Pros:*

- *Non-invasive (very small in size)*
- *Long lasting battery life*
- *Easy to use and assemble*
- *No unnecessary wires*

*Cons:*

- *Cost (Very expensive)*
- *Chances of losing the monitor screen*

## Evaluation of Concepts

Criteria	Ru's Concepts			Mohamad's Concepts			Sheetal's Concepts			Dhvani's Concepts		
	#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3
Functionality	3	3	5	3.5	2	4	5	4.5	4.5	2.5	3	3
Affordability	3	3.5	1	5	3	2	1	4	3	1	4	1
User-Friendly	4	3	5	2	1	3.5	5	4	3.5	1.5	2	4.5
Safety	4	2	5	2	2	3.5	5	4	3.5	4.5	2	4.5
<b>Total</b>	<b>14</b>	<b>11.5</b>	<b>16</b>	<b>12.5</b>	<b>8</b>	<b>13</b>	<b>16</b>	<b>16.5</b>	<b>14.5</b>	<b>9.5</b>	<b>11</b>	<b>13</b>

\*Evaluations are given on a 5 point scale:

- 1 - counterproductive based on user needs
- 2 - presenting problems
- 3 - manageable
- 4 - very good
- 5 - ideal

## Synthesis of Ideas

### How Our Top Concepts Were Chosen:

Each team member was to come up with 3 possible designs, the ideas were then discussed as a group and evaluated according to their functionality, affordability, safety, and how user friendly the device would be. After the evaluation, 3 of the most functional solutions were decided to be used upon and discussed to come to a final conclusion of one single design. Along with deciding potential designs, we had to keep in mind that they would also have to be realistic and could be designed by us with the restrictions given to us. After considering all these factors, the 3 designs below were carefully chosen as a group.

### Determining Which Aspects to Include in Our Final Design:

#### **Solution 1:** (Sheetal's Concept #2)

Sheetal's second concept used the ear as the site of oximeter data collection (like a few other concepts). However, this concept used a frame which would wrap around the ear rather than a clip-on piece. The frame would thus likely be far more **comfortable** for the user than the clip-on.

In addition, instead of using a watch or other wrapped device to transmit oximeter data to, this concept used a rectangular digital display. This display device would be cheaper to build than buying a watch. Furthermore, the Arduino experience we have gained from the lab sessions makes this device seem **very feasible to build**.

Features integrated from brainstorming sessions:

- The distance of the two devices should be near each other to ensure the effectiveness of the Bluetooth signal transmission (Ru). Users could get a visual or auditory alert as a reminder to keep components on their person.

Possible downsides:

- Bulky box for the user to carry around.
- System components are dependent on each other (must have both components for the system to work).
- Larger battery is likely required to power the screen.
- Have to recharge 2 devices rather than one.

Things to think about:

- Waterproof?
- What if the oximeter falls off the ear lobe?
- What if the user rolls over? Will components break?
- How do we protect the internals? What protective material should we use?
- What size constraints should we set?
- What if the user doesn't have the data reception device on their person? Will a signal from the oximeter still be received by the display device?
- How far should the bluetooth range be?

### **Solution 2:** (Ru's Concept #3 & Sheetal's Concept #1)

Both of these concepts are similar as it consists of two parts: an accessory that would be placed at the ear area and also a fit bit band/watch. The ear accessories would act as a pulse oximeter to measure the blood oxygen saturation level as well as heart rate while the readings that are measured will be displayed on the fitbit watch via Bluetooth. The watch will be installed with a battery that powers the device and recharged using solar panels, Bluetooth receptors, and GPS detectors that can send emergency signals to emergency services in case of an emergency. The screen of the watch will display the heart beat rate and blood oxygen saturation level. The watch is durable and water-resistant.



Features integrated from brainstorming sessions:

- The distance of the two devices should be near each other to ensure the effectiveness of the Bluetooth signal transmission. Users will be advised to wear the ear accessory and the watch of the same side, for an example, if the watch is worn on the left wrist, the ear accessory should be worn on the left ear too.

Possible downsides:

- The size of the ear accessory has to be considered as the bluetooth modules may be too big to fit the ear piece which might affect the device's discreteness and user's comfort.
- The possibility of various software knowledge needed to make the devices work, for example, wireless Bluetooth connection from the ear accessory to the watch, GPS technology that can send signal to emergency services in case of emergency, and also the measurement of heart beat rate and blood oxygen saturation level.
- The accuracy and efficiency of the Bluetooth signal transmission at a certain distance.
- The ear accessory might be too heavy for the support of the ear as it will consist of small parts of chips and board inside of the structure to make measurement of blood oxygen saturation level works.

Things to think about:

- How to make it affordable and cost-effective?
- How accurate will the measurements of heart beat rate and blood oxygen saturation level be?
- What are the software needed to use to enable the device to send signals to emergency services in case of emergency?
- What is the approximate standard rate of blood oxygen saturation level that the device should be alerted to know that the user is near overdose?
- What is the technology needed to create an pulse oximeter?

### **Solution 3:** (Sheetal's Concept #3)

The third concept selected had been Sheetal's third concept. The concept had been a two-piece device composed of a toe ring and a fitbit style watch. The toe ring acts as a pulse oxygen saturation device with the watch being the display and monitor. The watch will be powered using a rechargeable battery that can be recharged using solar energy. The toe ring will measure the pulse oxygen levels and send the levels to the thin wristband through Bluetooth receptors. The watch will also be equipped with a GPS system that is capable of sending the user's location to emergency services in case of an overdose. As oxygen saturation levels drop, the watch will begin to vibrate and flash in order to warn the user. The watch itself is water-resistant but not waterproof and made to be durable.



Features integrated from brainstorming sessions:

- Toe ring could be used as a finger ring instead to avoid damaging

Possible downsides:

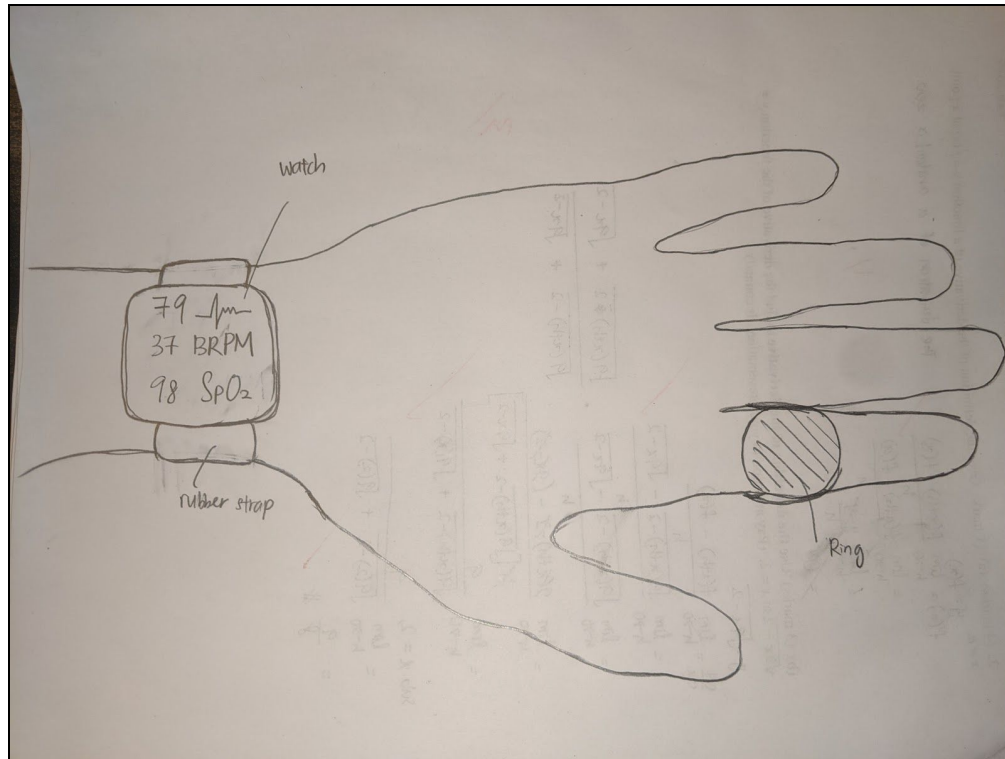
- The size of the watch will have to be able to house the bluetooth receptor and software
- Ring can be easily lost or misplaced
- Ensuring that the bluetooth connection between the ring and watch isn't lost can be difficult and possibly require multiple softwares
- Could end up being very expensive

Things to think about:

- How to make the ring more durable but not bulky?
- What materials will the ring and watch be made of to ensure it is water resistant
- What is the maximum distance between devices before bluetooth connection is lost
- How will the ring be charged?
- Size and weight constraints

## **Final Design**

The final design of the device had been determined by combining the best aspects of each concept. From the first design we decided to follow the same type of safety and user-friendly aspects. This is due to the first concept having the highest rating from our evaluation in those given criteria. From this, we have decided to ensure that the device is comfortable for the user, as well as poses no potential threat or danger. From the second concept we had decided to follow the same functionality aspects due to it having the highest rating in that category from our evaluation as well. We decided that this will be done by ensuring that the device's ability to measure oxygen saturation levels is the highest priority in terms of functionality. Moreover, from the third concept we had decided to use the design as our foundation for the device. Our final device has been decided to be a pulse oxygen saturation ring, which is connected to a watch through bluetooth. The ring and watch would be battery powered and rechargeable via solar energy; as well as have a GPS system within it. From the third concept there had been some alternation in changing the toe ring into a finger ring, as well as ensuring that the ring is worn on the same hand as the watch to ensure a strong and stable connection. With this final design, most of our concerns regarding each solution individually had been solved and or modified.



*A rough sketch of how the final design would be.*

## Next Steps & Continued Learning

Following our early-established problem statement, as well as design criteria, we have now converged onto a specific design. We must now determine what the upcoming tasks consist of (what needs to be ordered, what needs to be built) and when they should be done.

In this awkward transition phase between brainstorming and actually building, we have to hypothesize ways to finish our project when the parts actually come in. Thinking these thoughts in advanced will provide us with the following:

- Reduced confusion once we actually begin to execute our plans
- Identification of dependencies (i.e. if we can't attach this part onto this part, then the entire device won't work!)
- Precautionary contingency planning in case dependencies/deadlines aren't fulfilled.
- A drive to familiarize ourselves with the technology and procedures we'll soon be dealing with (i.e bluetooth modules, soldering, etc.).

This is a scary but exciting time for the team as things can actually begin to fail now - our work will soon be hands-on and physical rather than all mental.