



Dane Hart

**OSSO Wearable Vital Sign Monitor**

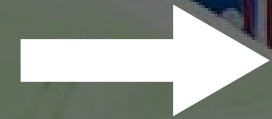


# “Hospitals are horrible places to get better”

- Joe Schlesinger, musician and anesthesiologist at Vanderbilt Medical Center



Several alarms attempt to alert clinicians all at once



Alarms quickly lose meaning



Clinician experiences alarm fatigue and saturation



Patient outcomes worsen as a result

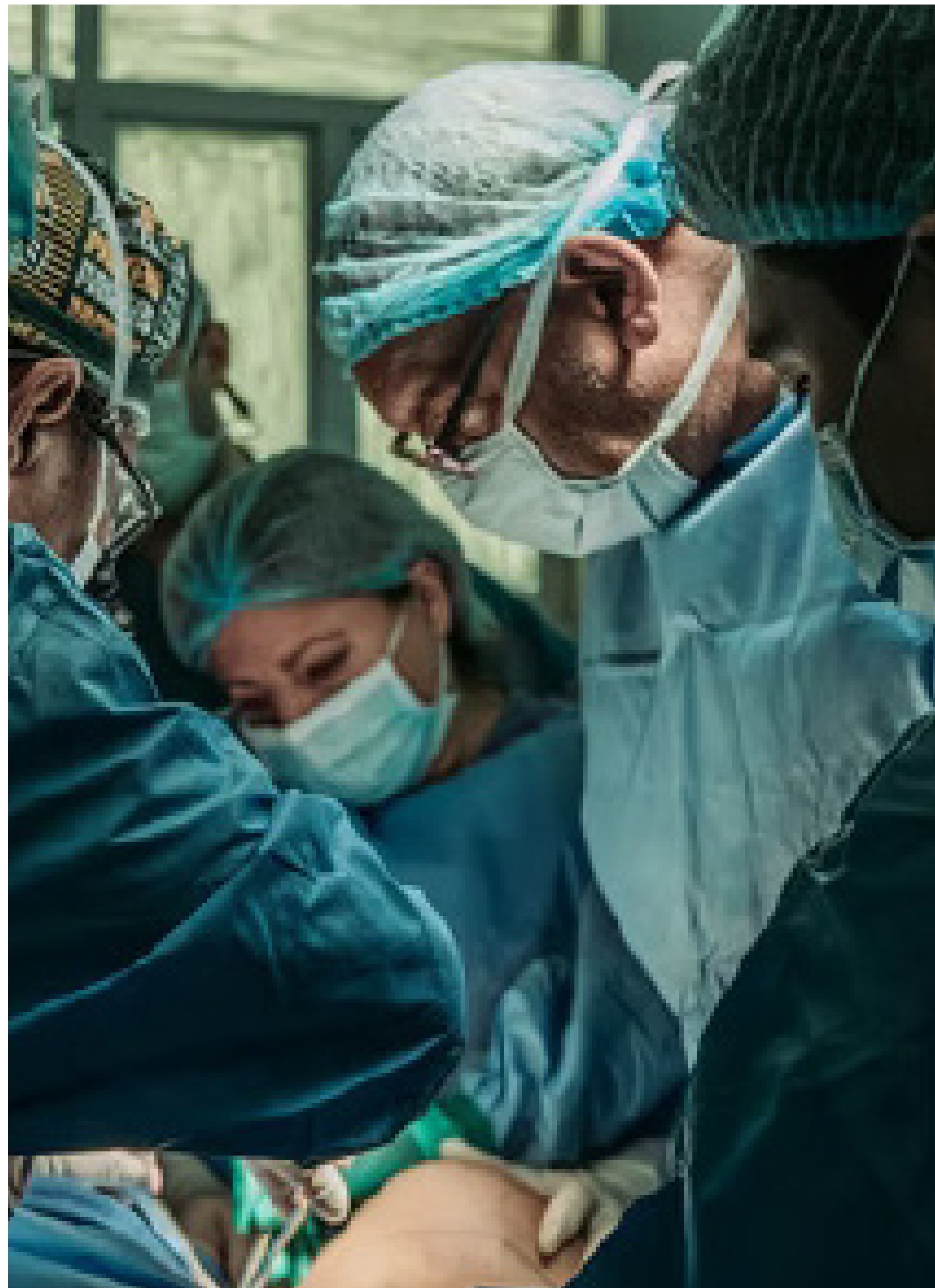
Discover

## Stakeholders Interviewed

**7** clinicians interviewed in person

**60+** minutes per conversation

**20+** clinicians survey



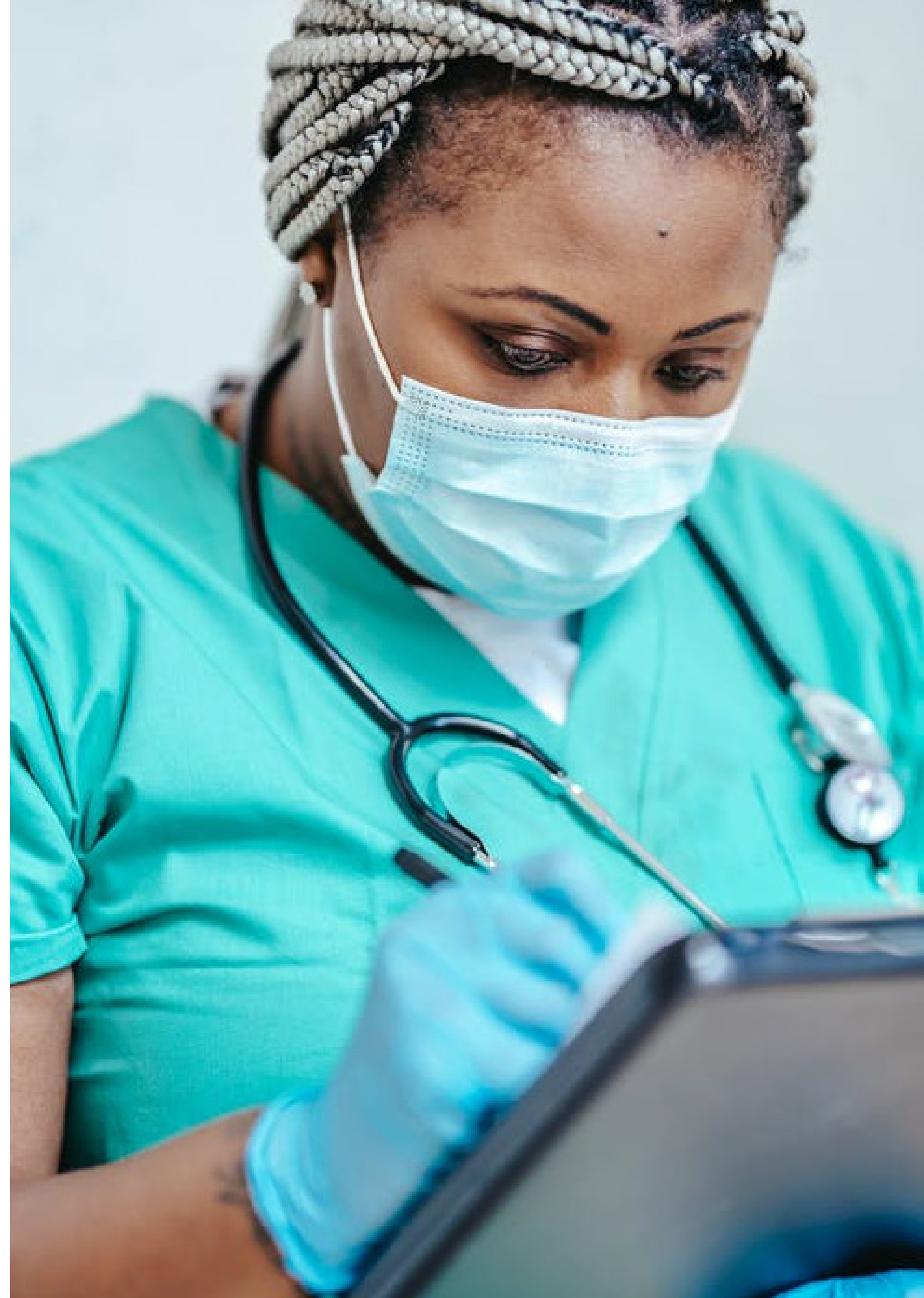
Key Stakeholder

## **The Floor Nurse**

Operates as a floor nurse at their hospital

They are exposed to a considerable amount of meaningless alarms

Wants to reduce time and ease operating activities



Insights

# Alarm Fatigue Iceberg

Noise Fatigue

An iceberg is shown floating in a teal-colored ocean under a bright sky with scattered white clouds. The iceberg's tip is visible above the water surface, while the much larger, jagged portion of the iceberg is submerged below the surface. A thin black horizontal line extends from the text 'Noise Fatigue' to the tip of the iceberg above the water.

Insights

# Alarm Fatigue Iceberg

An iceberg floating in the ocean, with the waterline clearly visible. The tip of the iceberg is above the water, and the much larger base is submerged. Four horizontal lines extend from the right side of the iceberg to labels. The labels are: 'Noise Fatigue' (pointing to the tip), 'False Alarms' (pointing to the upper submerged part), 'Cable Management' (pointing to the middle submerged part), and 'Patient Transportation' (pointing to the lower submerged part).

Noise Fatigue

False Alarms

Cable Management

Patient Transportation

# Market Research

## Current Solutions



GE CARESCAPE V100



Masimo Rad-67



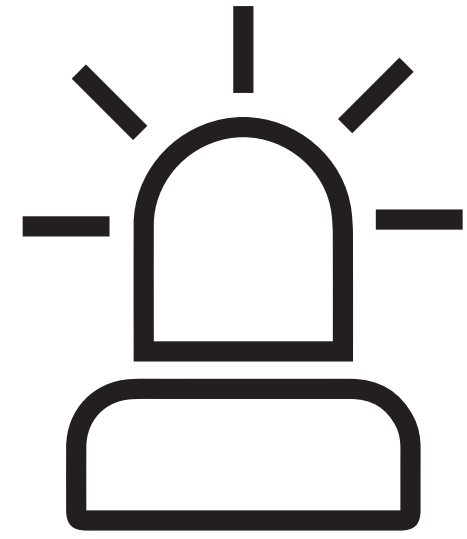
Apple Watch



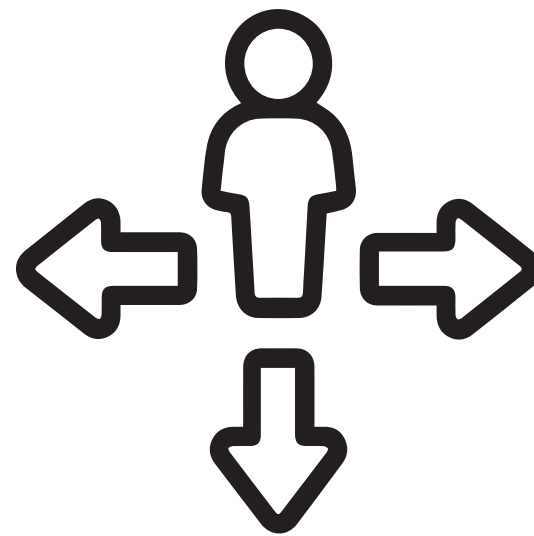


Insights

## Wearable Advantages



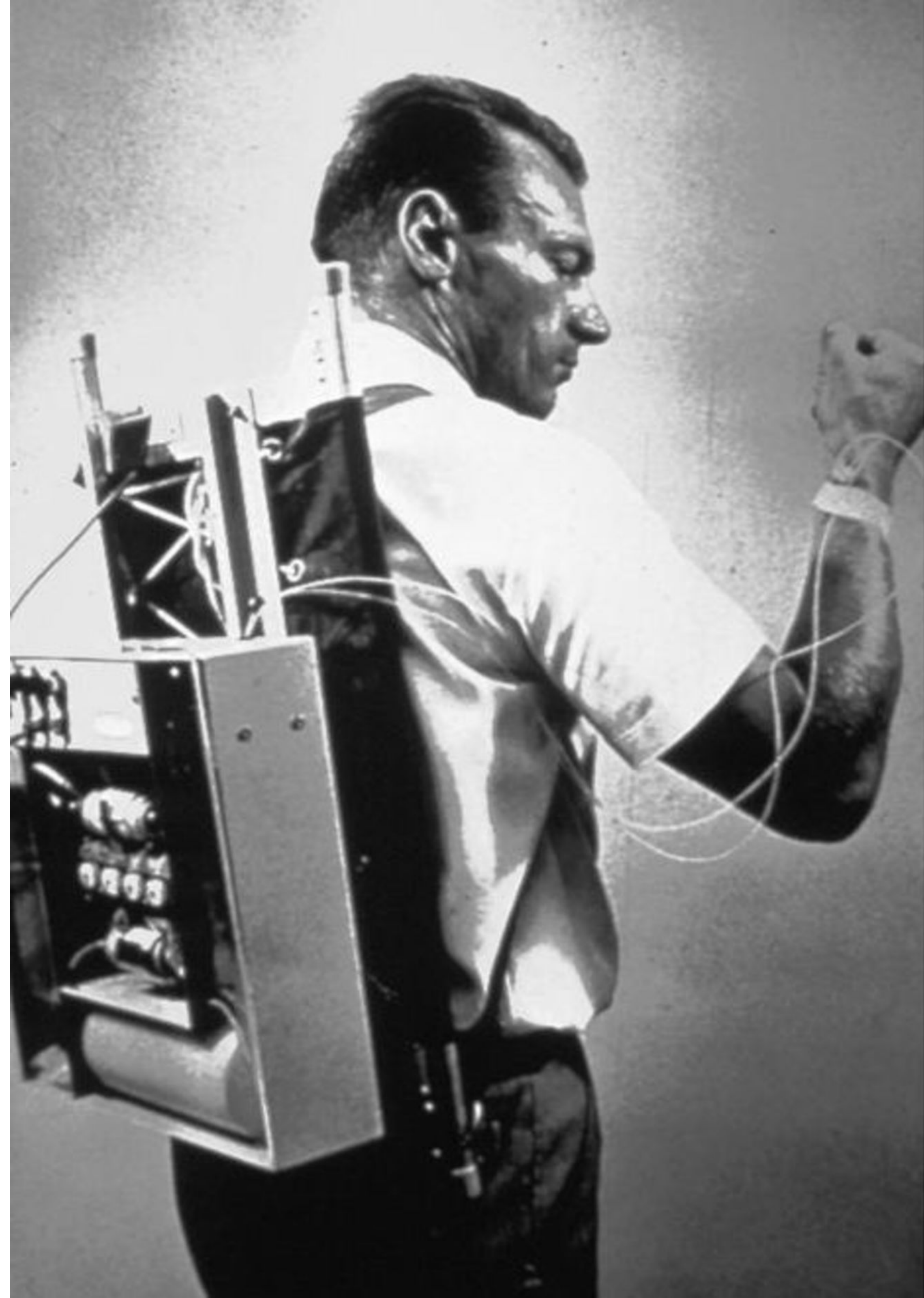
Mitigates misplaced sensors



Increases patient mobility



Reduces cables



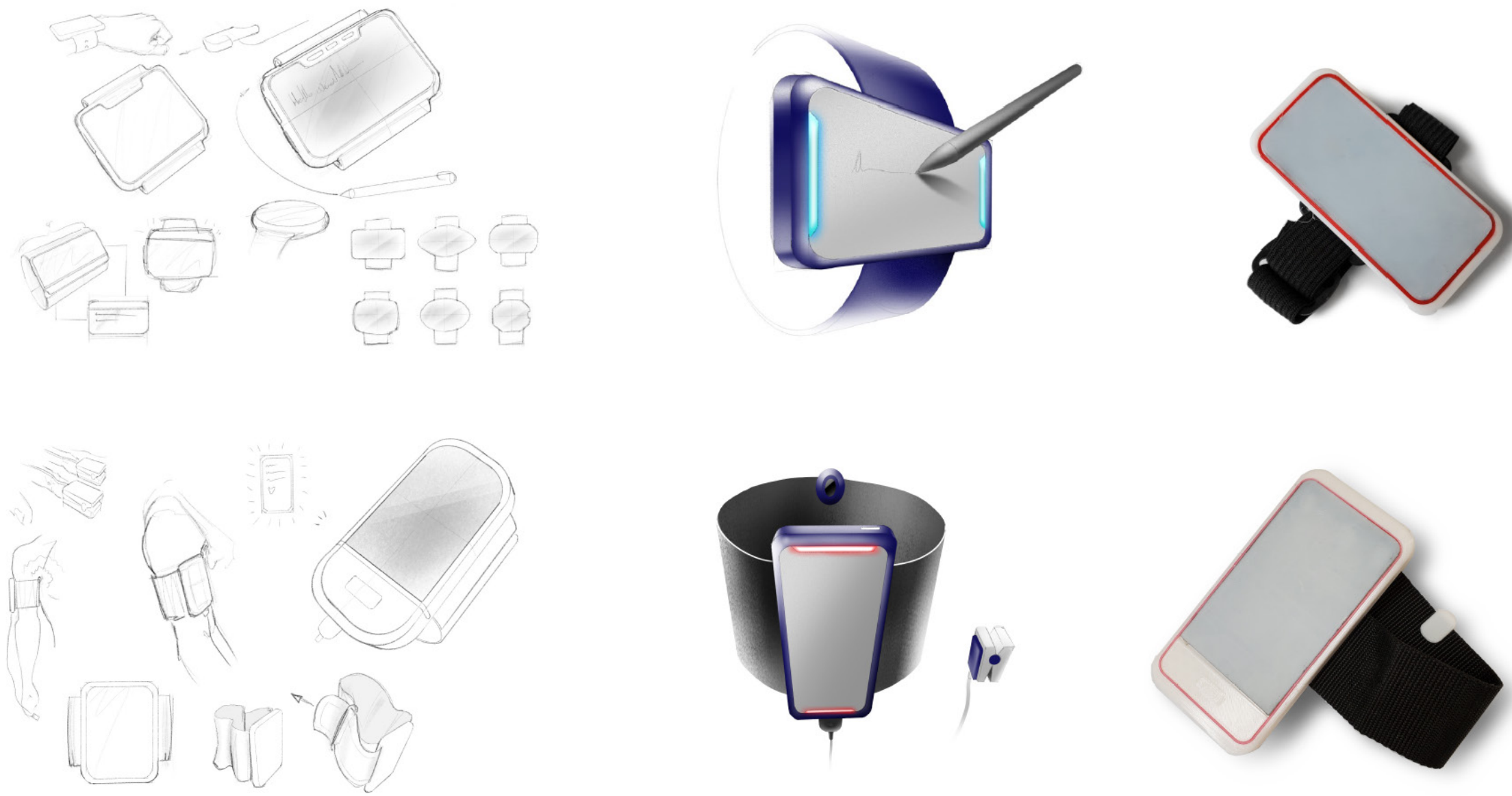
A photograph of an operating room with several surgeons in green scrubs and masks. In the background, there are multiple medical monitors displaying vital signs and a large monitor showing a surgical procedure. The scene is dimly lit with overhead surgical lights.

# How might we create a wearable patient vital sign monitor to mitigate alarm fatigue?

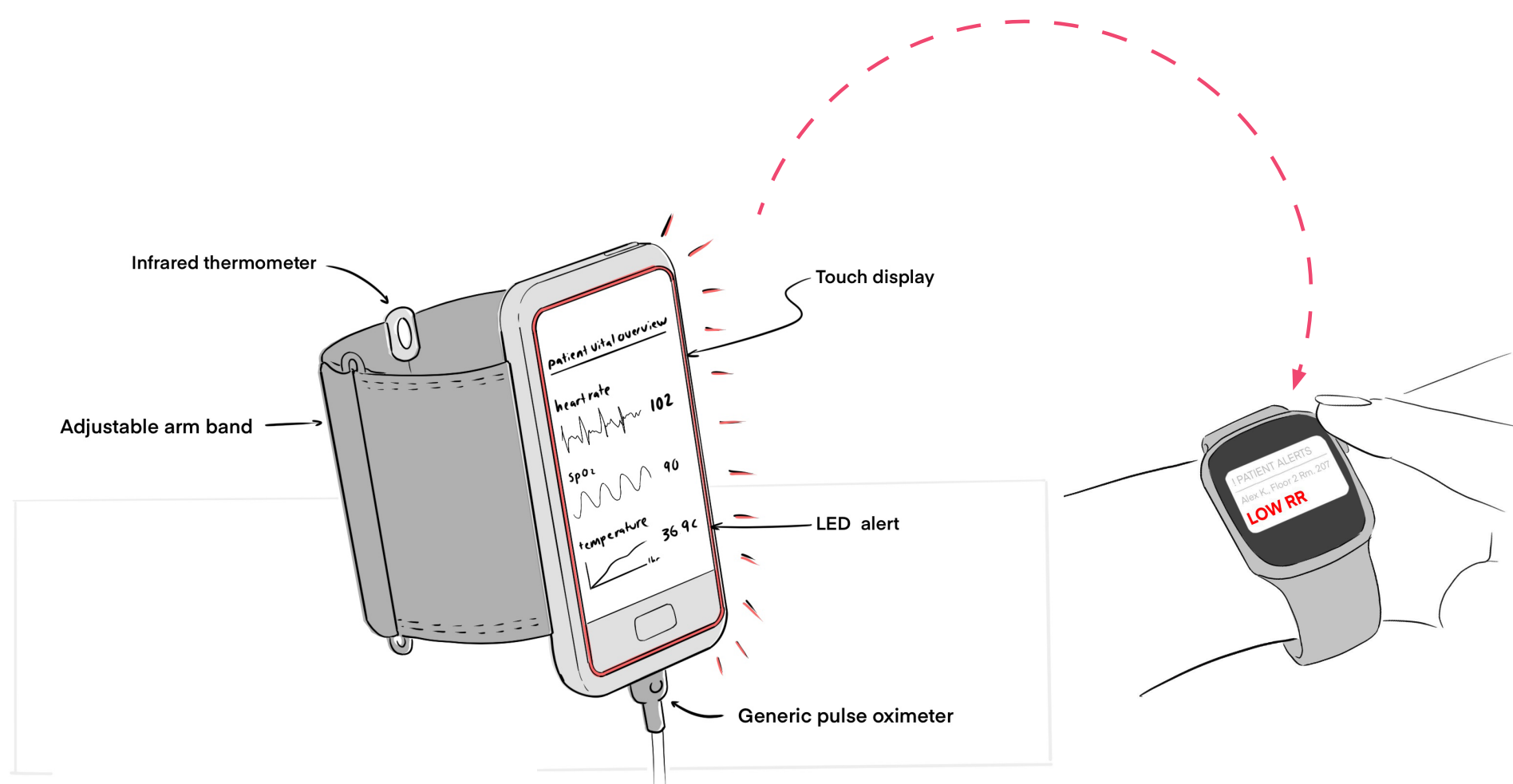
Heart Rate | Blood Pressure | Resp. Rate | SPO2

# Develop Concept Feedback & Refinement

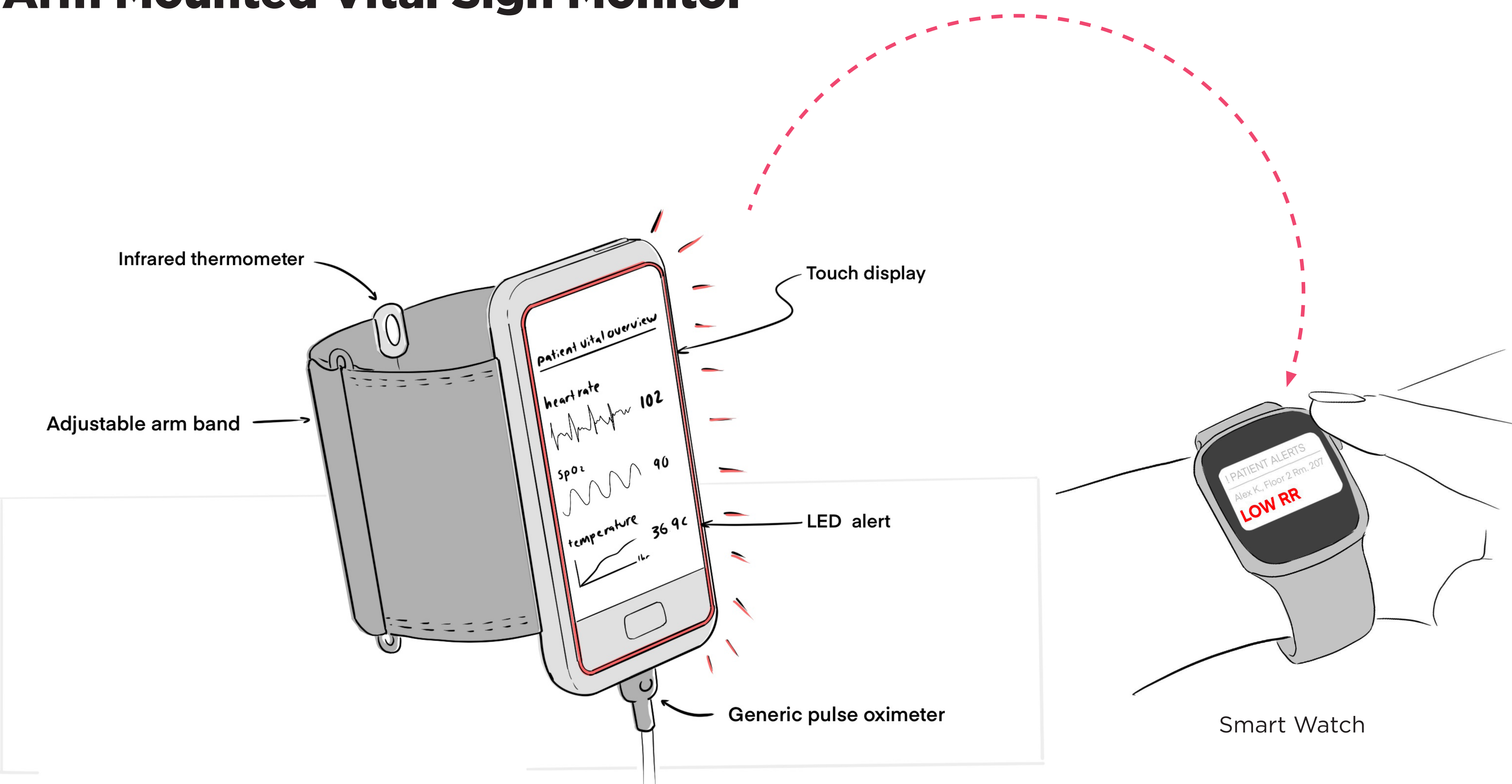
## Initial Ideation



## Refinement



# Develop Arm Mounted Vital Sign Monitor



# Develop Technology



**ECG Cables**

Heart Rate  
SPO2  
Respiratory Rate



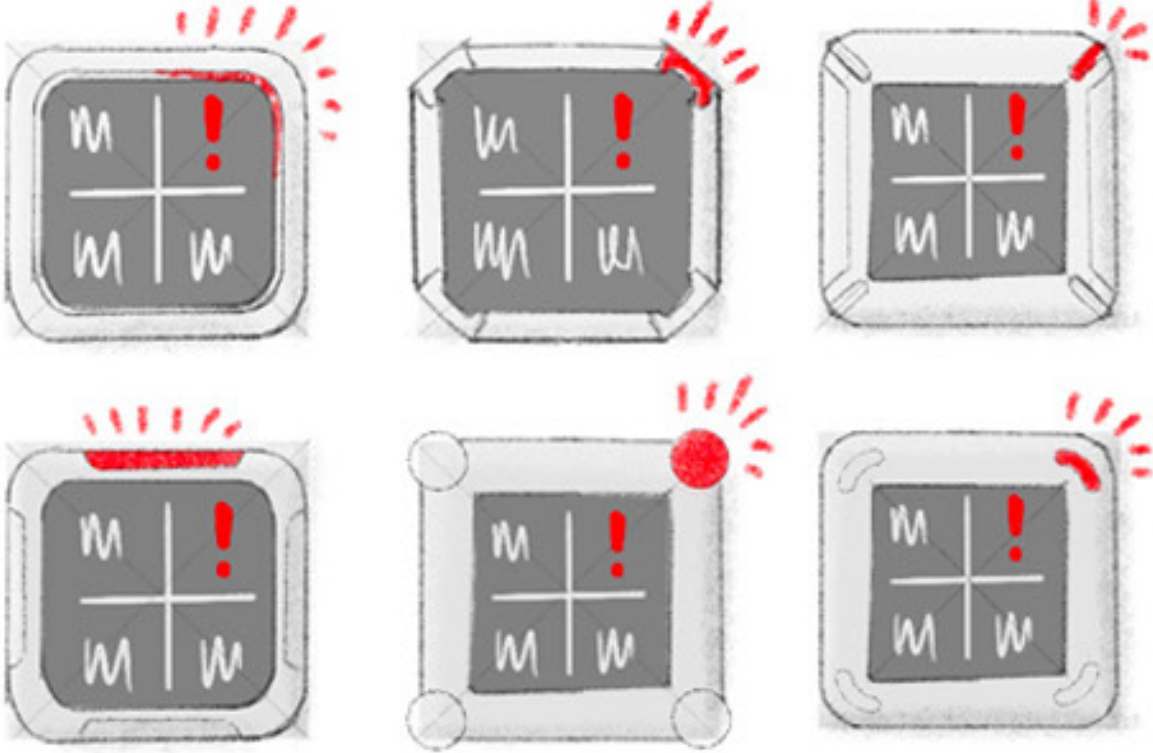
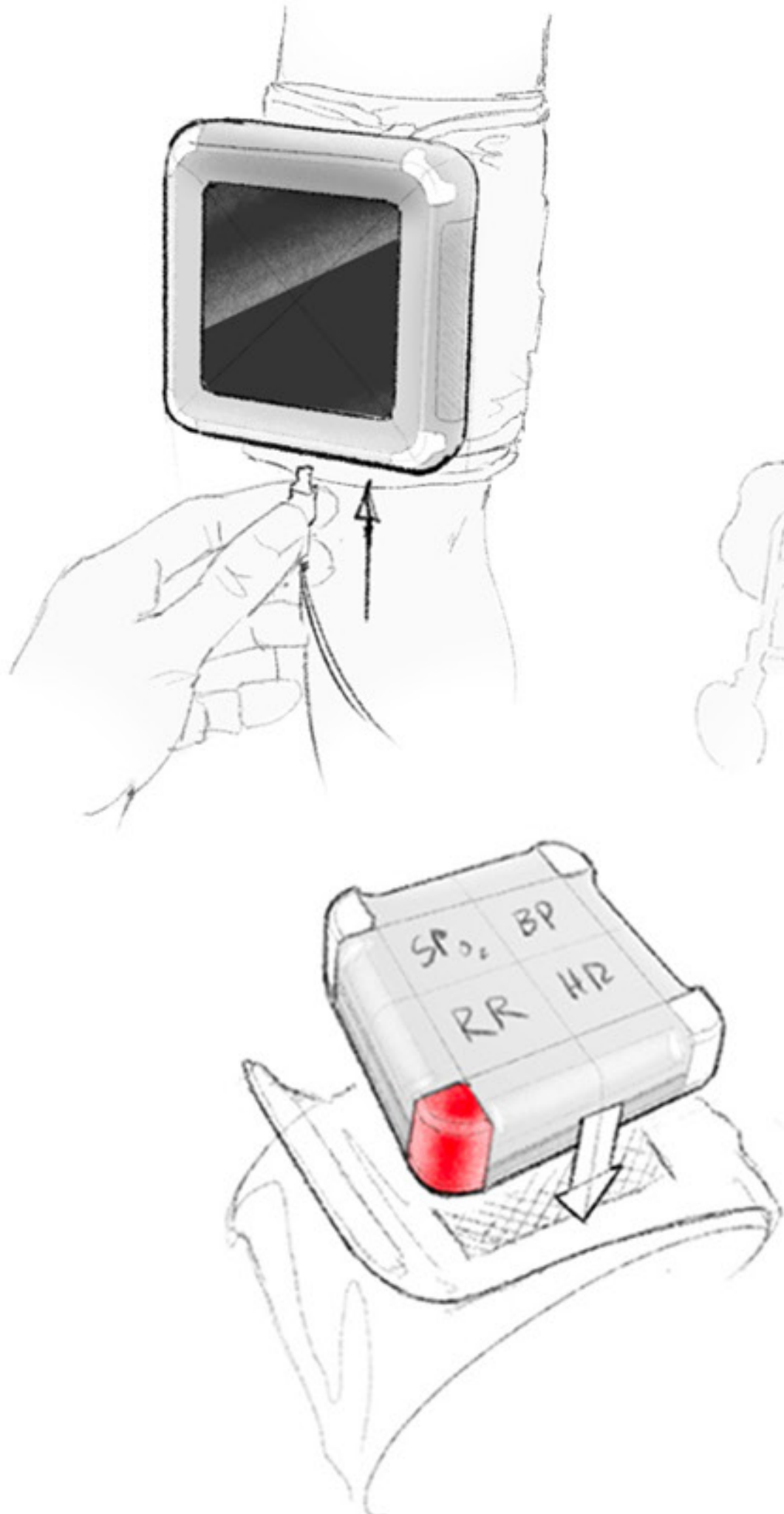
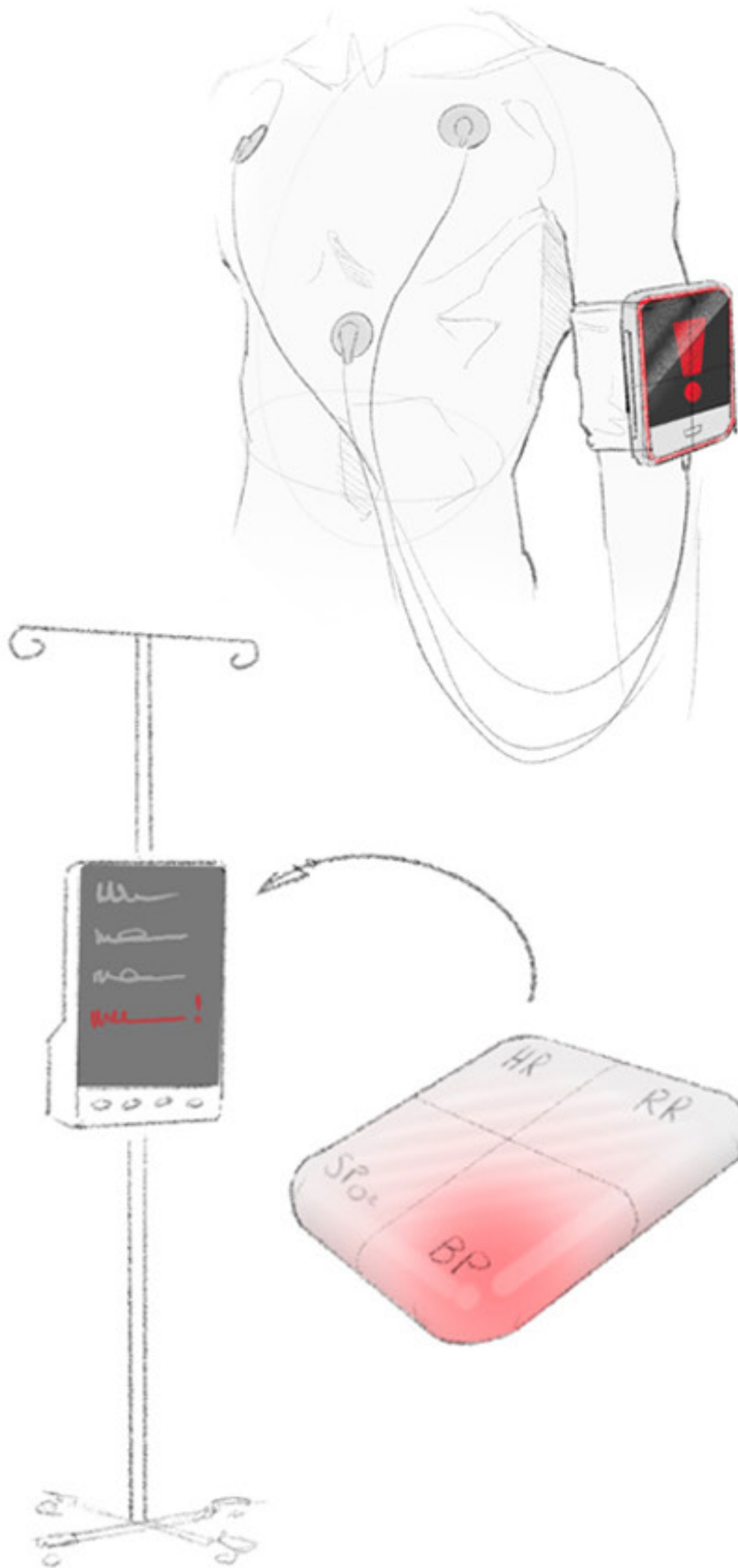
**Blood Pressure Cuff**

You'll never guess,  
blood pressure

# Develop Sketching

ECG connection

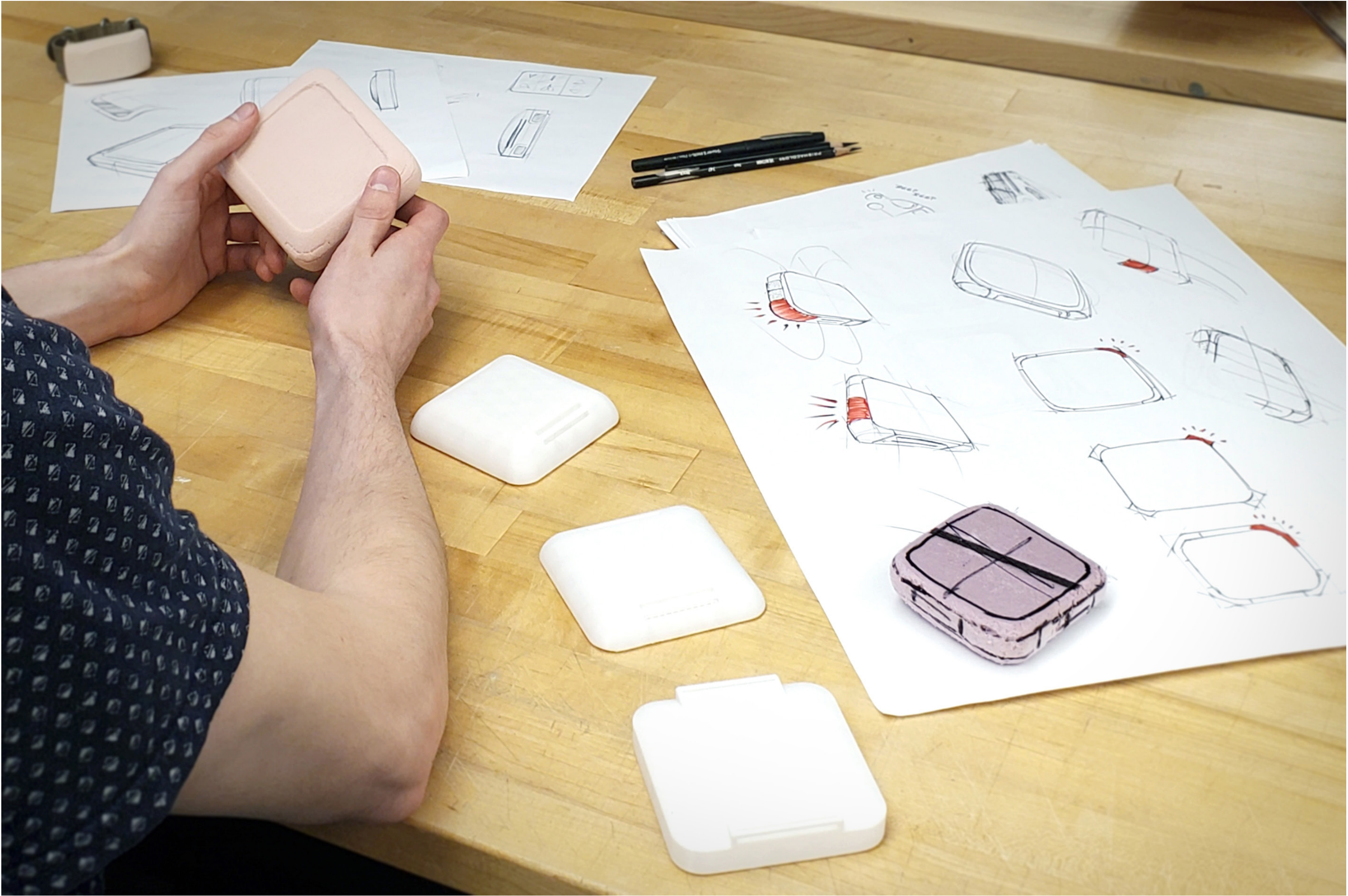
Easy patient transport



Velcro BP cuff connection

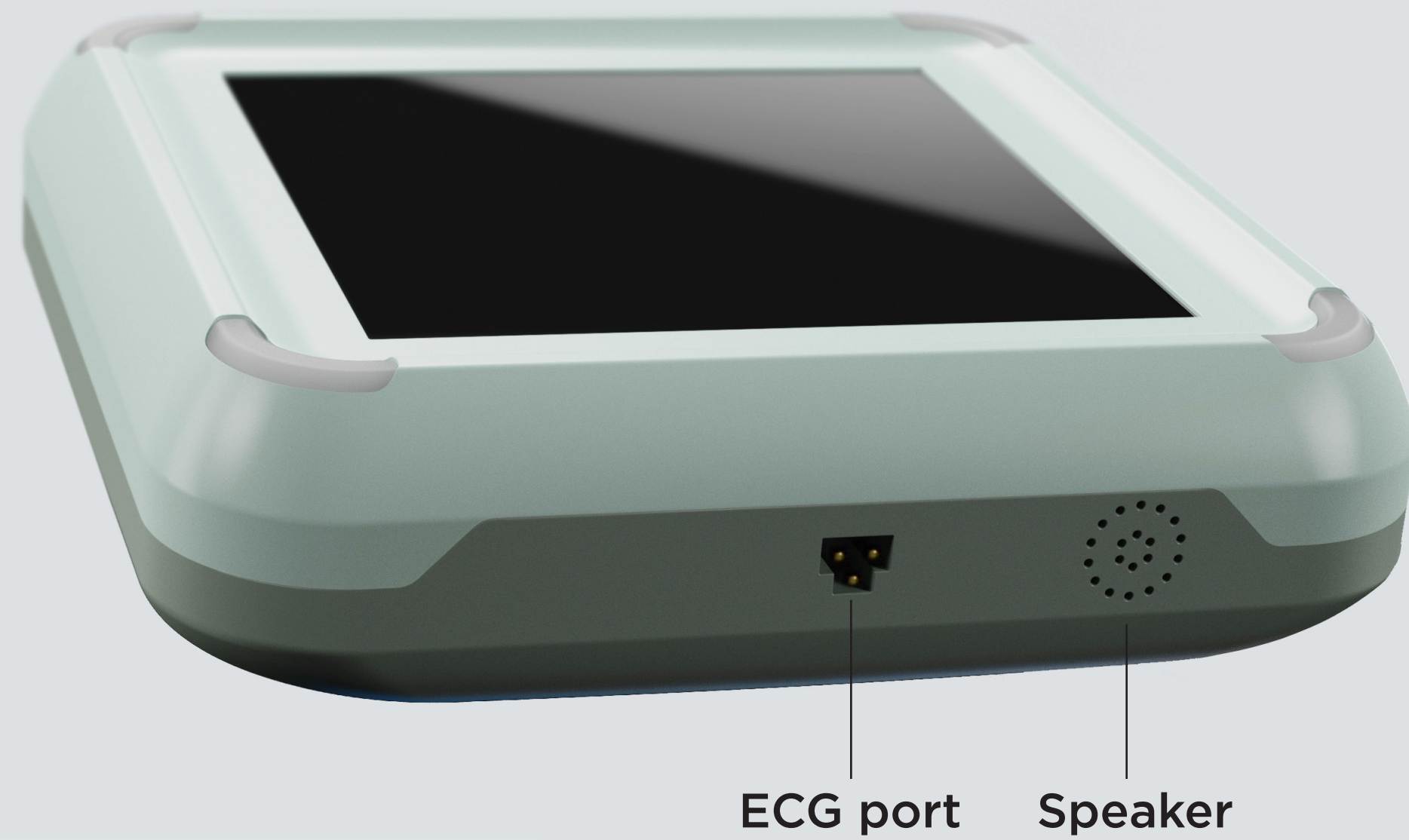
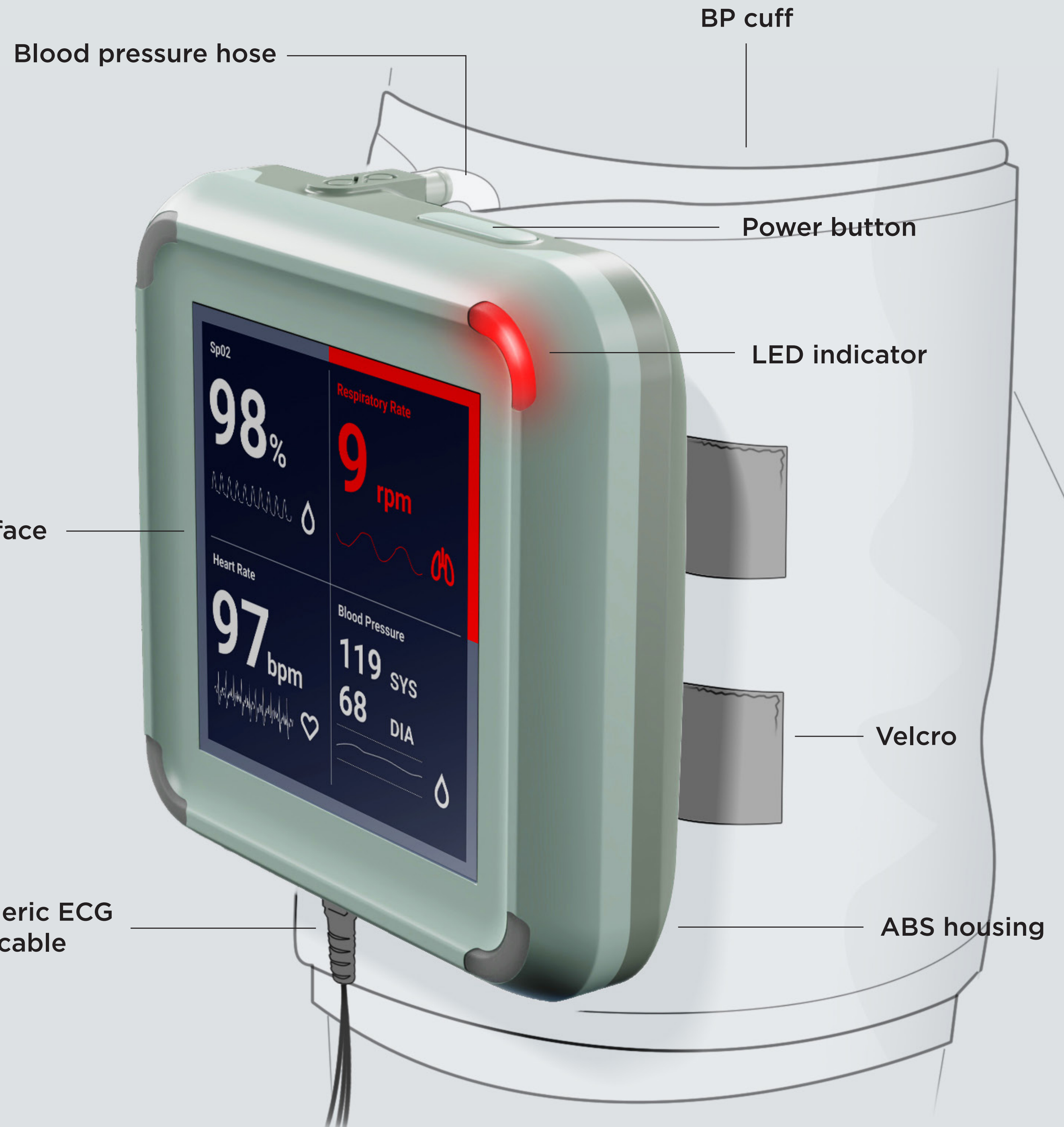
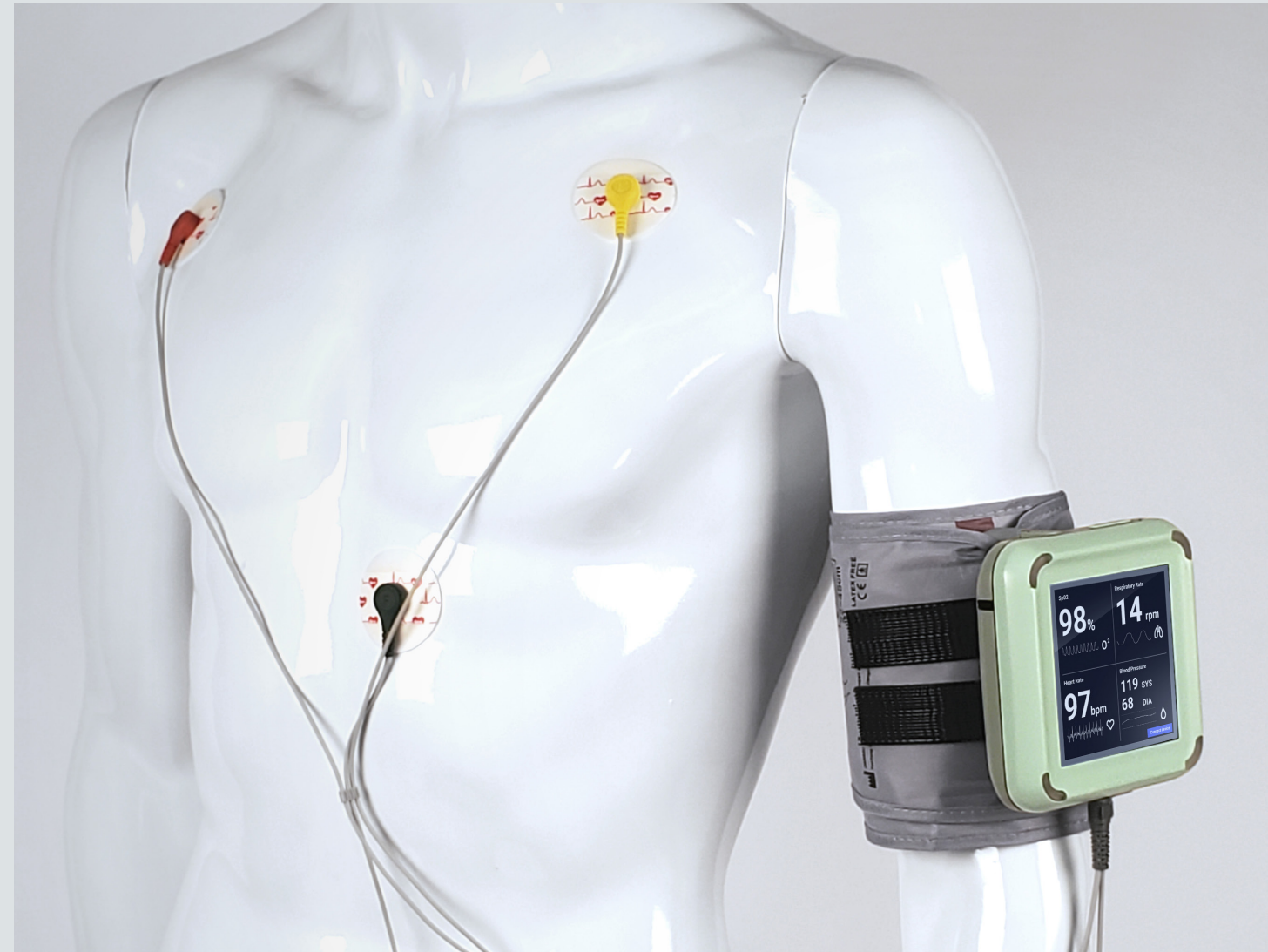
Four quadrant vital sign layout

# Develop Prototyping



# OSSO

## Final Product

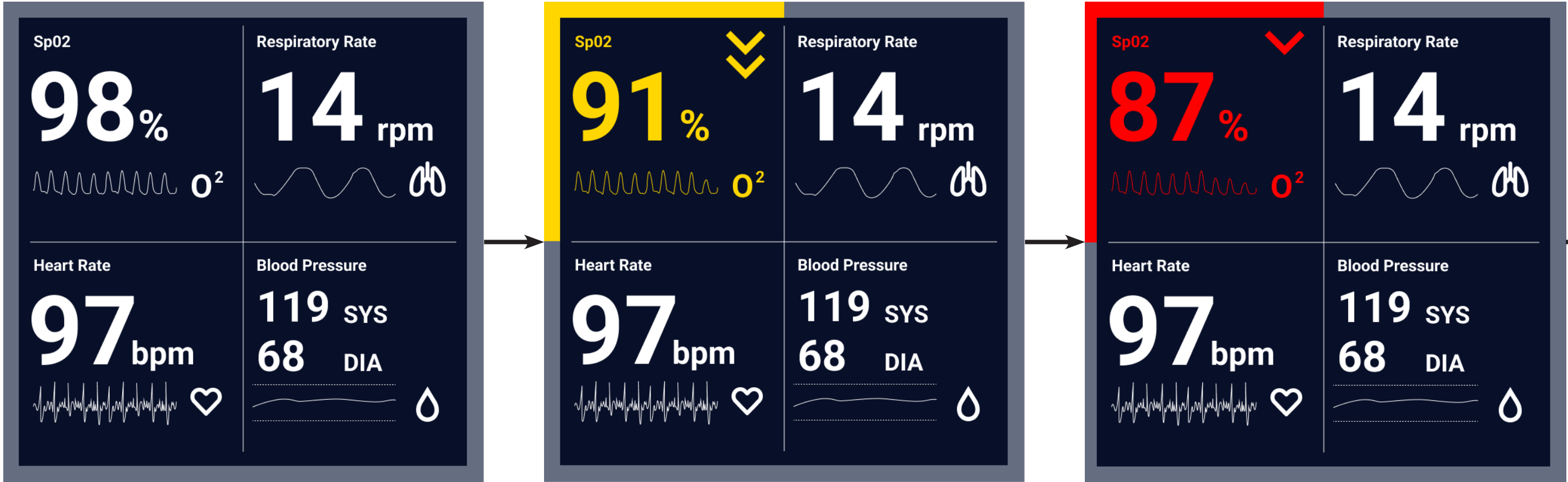




# Product Innovation

## Four Quadrant Mapping

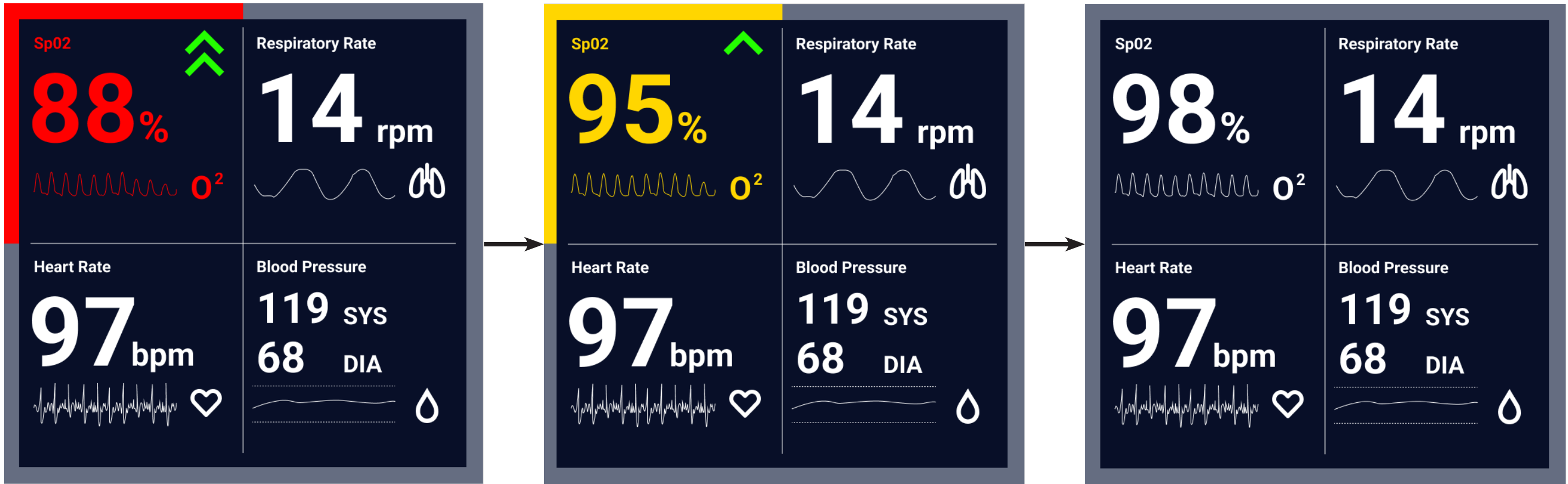
Patient trending negatively



LED indicator lights up



Patient recovering

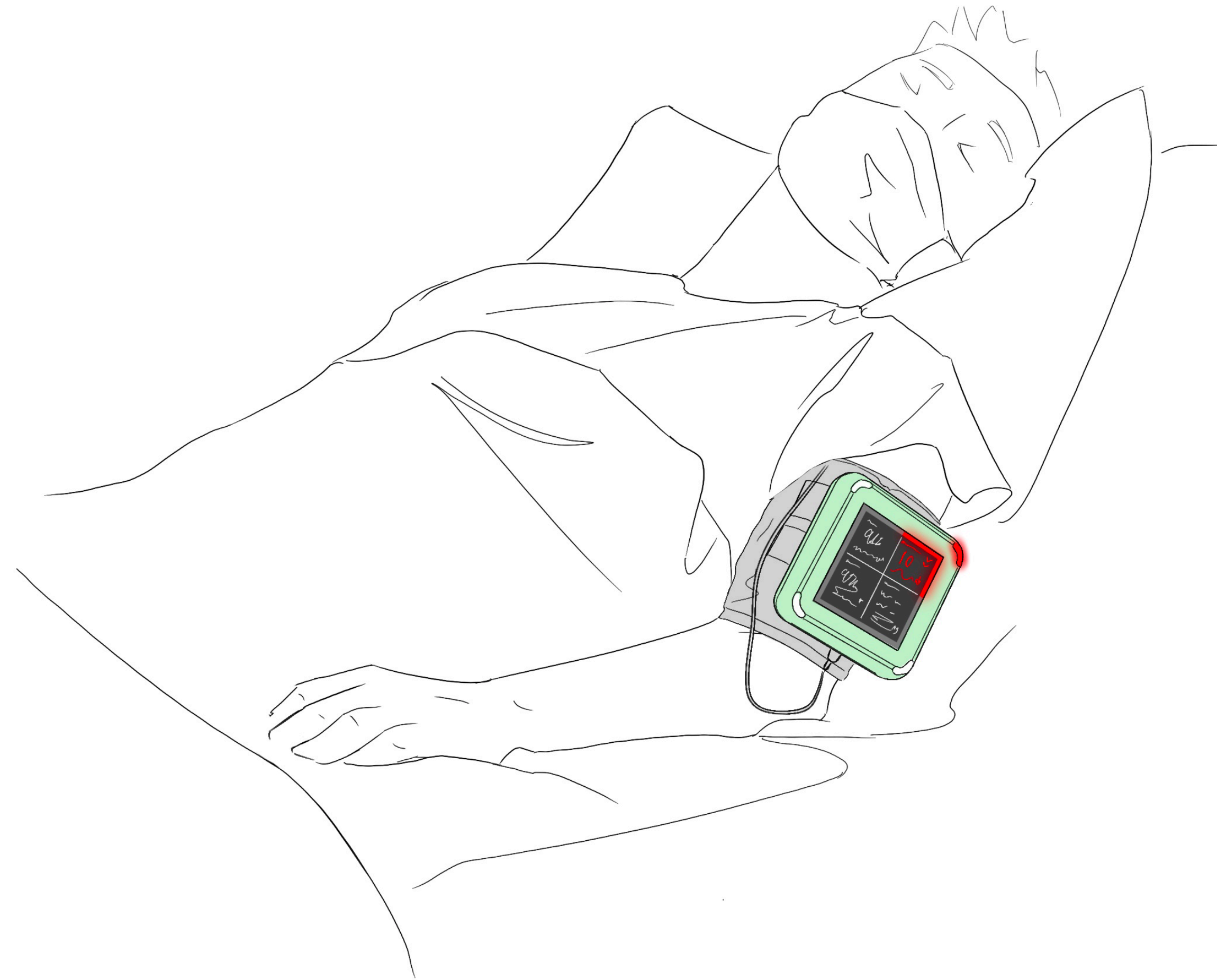


User Journey  
**Alert is Received**



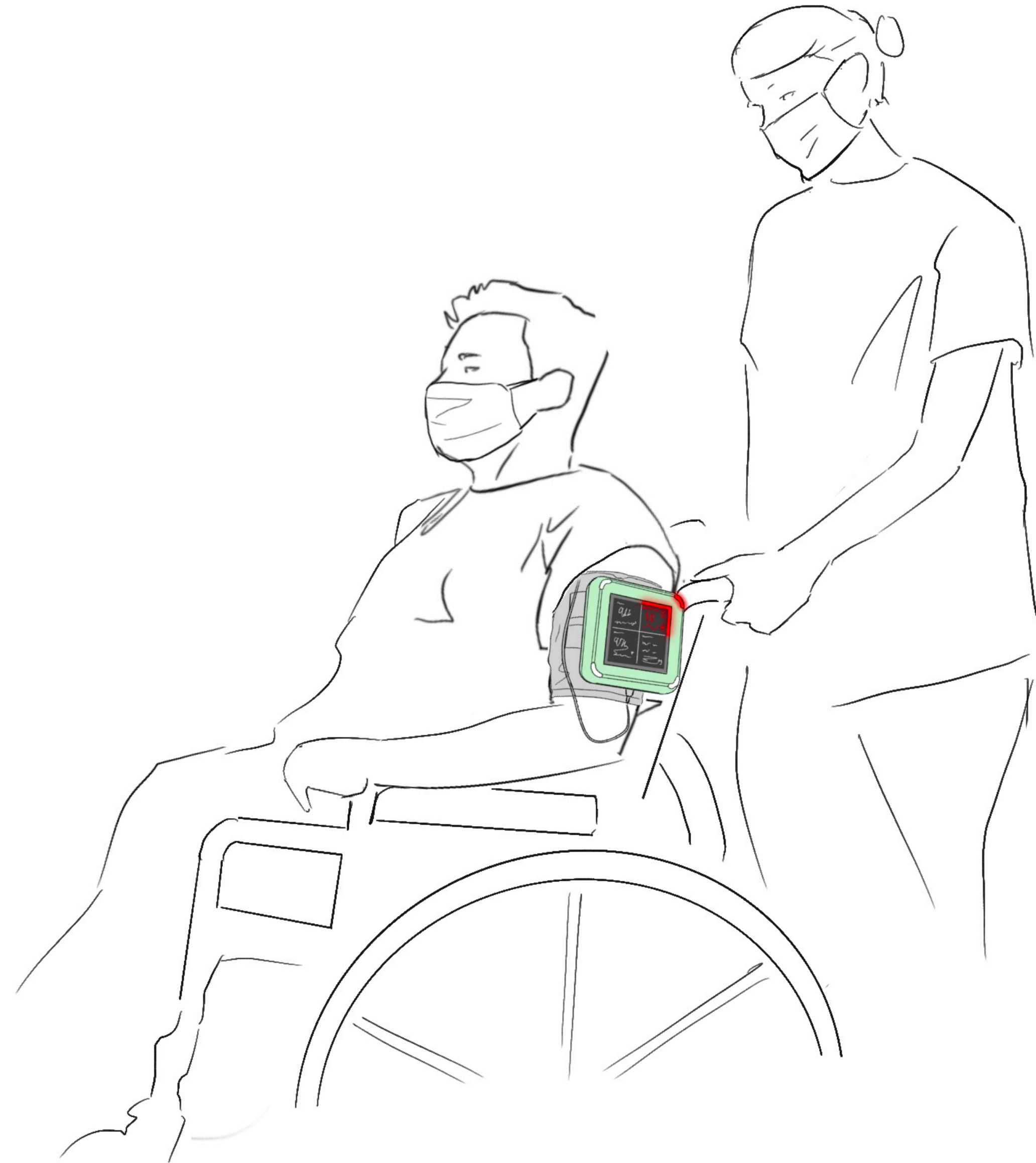
# User Journey

## Patient Assessment



# User Journey

## Patient Transport



User Journey

# Nurse Treats Patient



# OSSO Wearable Vital Sign Monitor

## How does OSSO mitigate alarm fatigue?

Mitigates **noise fatigue** by leveraging secondary monitors (smartphones/watches)

Reduced **false alarms** and alleviates **cable management** through wearable architecture

Improves **patient transportation** through integrated display

Improves **visual communication** through four quadrant display

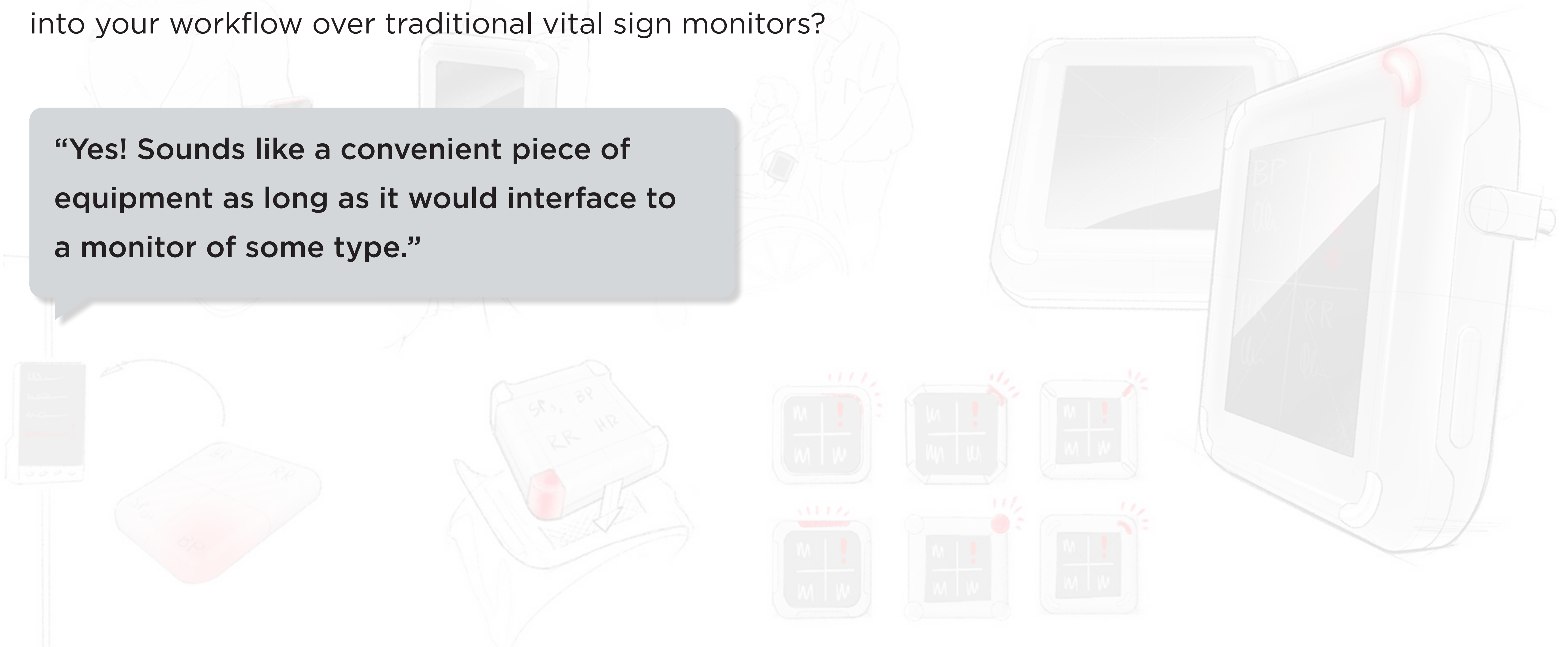


# User Testing

## Concept Feedback

If it were up to you, would you be interested in integrating a product like this into your workflow over traditional vital sign monitors?

“Yes! Sounds like a convenient piece of equipment as long as it would interface to a monitor of some type.”



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**“Absolutely.  
Especially for transport to/from imaging  
with trauma/stroke patients.”**



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**“Yes!”**

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**“Absolutely.  
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**“Yes!” (x10)**

Next Steps

## Founder's Day



MVP Founder's Day May 10th



**Thank You!**

Dane Hart

**OSSO Wearable Vital Sign Monitor**



# Appendix

Dane Hart

**OSSO Wearable Vital Sign Monitor**

# Discover Affinity Mapping

### Administrative Insights

- System team committed resources dedicated to making AI in the OR
- Standardization would be greatly beneficial to the hospital environment
- Monitors are replaced when old equipment ends its lifecycle
- Digital infrastructure is essential to supporting high tech monitors systems
- Detail parameters are set through representative of the OR teams and will depend on location or kind of instrumentation
- Procedure dictated by Goal 6 of the National Patient Safety Goals
- Information highway
- Tech such as telemetry must be supported by infrastructure

### Operational Insights

- 80%-90% Meaningless alarms
- Respiratory alarm often fails due to patient movement
- Surgical units are very busy leading to excess noise
- Blood pressure monitors are challenging when in transport, have to be repaired for the minute
- Code Blue are one of the most actionable alarms
- Cardiac monitors will have setting for infants, kids, and adults
- Secondary monitors (Phones) are utilized
- Patient baselines are essential to accurate monitoring
- IV pumps are particularly convoluted and difficult to design for
- If an essential alarm is not silenced it will be broadcast in the hospital
- O2 alarm is particularly memorable
- Rooms can have 12-15 monitors in them
- Alarms can be shut off in the OR
- Ventilator alarms tend to be the worst
- Effective alarms reduce response needed to keep an eye on patients

### Magic Wand Solutions

- Magic wand: Business driven alarm prioritization
- Magic wand: single manufacturer compatible monitors
- Need wand solution: Cardiac parameter monitor which gets information from ICU monitor

### Administrative Painpoints

- New monitor systems take approximately 3.5 years to implement
- Monitor software UI often needs to be edited for end user
- Equipment can be incompatible on a number of technological levels
- Infrastructure compatibility plays a big role in choosing vendors

### Operational Painpoints

- Patients are unmonitored during transit
- Reducing alarm fatigue via training is time consuming
- There are sometimes needed to transport equipment between units
- The hospital uses the overhead speaker for code blue and parking violations
- Various alarms have similarities with other noises
- Many hospital rooms do not have enough electrical plugs for the equipment
- It can take years to dig through between essential alarms versus nonessential
- The ICU is the hardest unit to transport patients
- Equipment has to be manually supported, resulting in a lot of time and frustration
- If monitor errors get out of hand, additional procedures are required
- Staff can be hard of hearing

### Emotional Painpoints

- Noises from hospitals tend to stick with clinicians
- Incompatible wires between equipment is frustrating
- False alarms can lead to unnecessary interruptions
- Inaccurate alarms can harm patient outcome

### Improvement Roadblocks

- Nurse afraid of setting parameters
- Each Hospital department has different needs
- Patients privacy interferes with alarm efficacy
- UI needs to be audited from the vendor
- EMI (Electro magnet interference)
- Time is one of the biggest barriers to torque management
- As monitors advance, difficulties advance

### Operational Behavior

- Parameters are set to suite patient
- Monitor watchers keep an eye on the central monitoring unit
- No one resets monitor parameters when transporting
- Charge nurses rely on primary nurse to watch over patients
- Cables need to be managed
- "Doing Spaghetti" the act of untangling monitor cables
- Code Reds (Fire alert) are ignored

### Alarm Design Insights

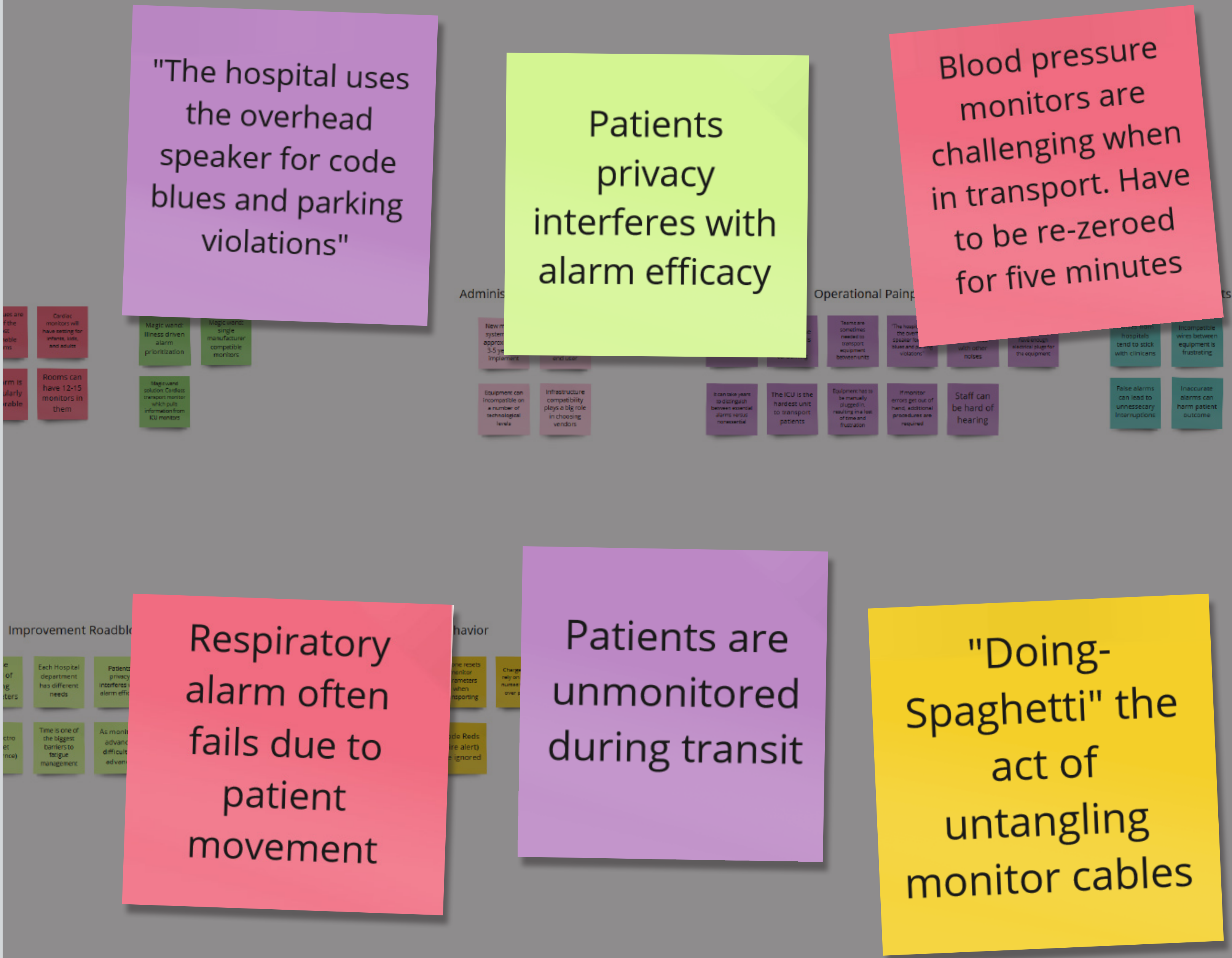
- Good alarms are actionable
- Patients' expectations play a large role in appropriate monitor usage
- Light is utilized in place of noises
- Alarms are accurate but unhelpful
- Monitor communication is essential, allows for more safety when critical for smaller and quiet
- Tone and speed are important as characteristics

# Insights

## Affinity Mapping

Clinicians reported that current patient monitoring systems cause all sorts of added stress.

Not only do patient monitors create unneeded **noise**, but they also create patient **transporting, privacy**, and **device management** challenges.



"The hospital uses the overhead speaker for code blues and parking violations"

Patients privacy interferes with alarm efficacy

Blood pressure monitors are challenging when in transport. Have to be re-zeroed for five minutes

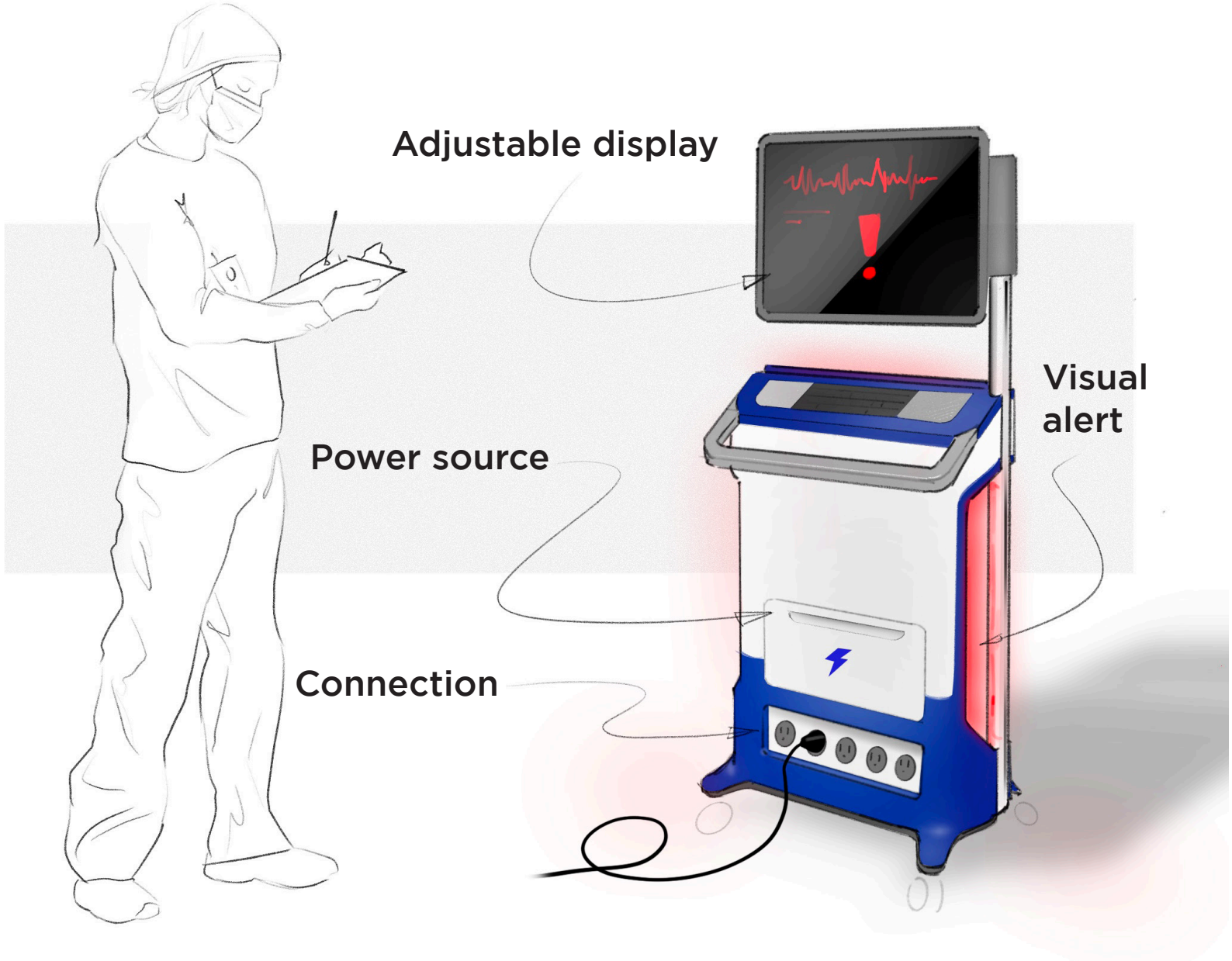
Respiratory alarm often fails due to patient movement

Patients are unmonitored during transit

"Doing-Spaghetti" the act of untangling monitor cables

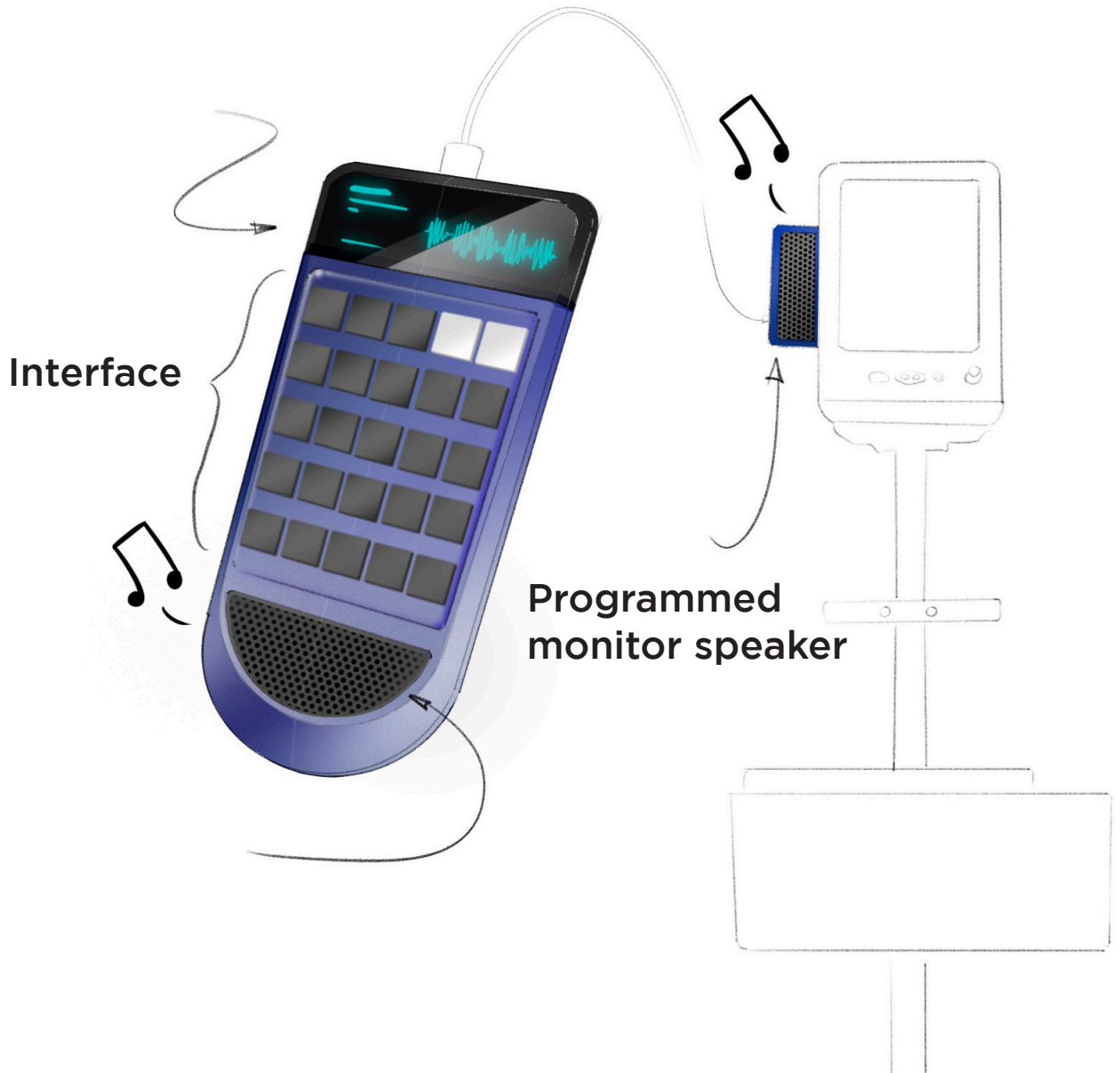
# Define Preliminary Concepts

## The Monitor's Monitor



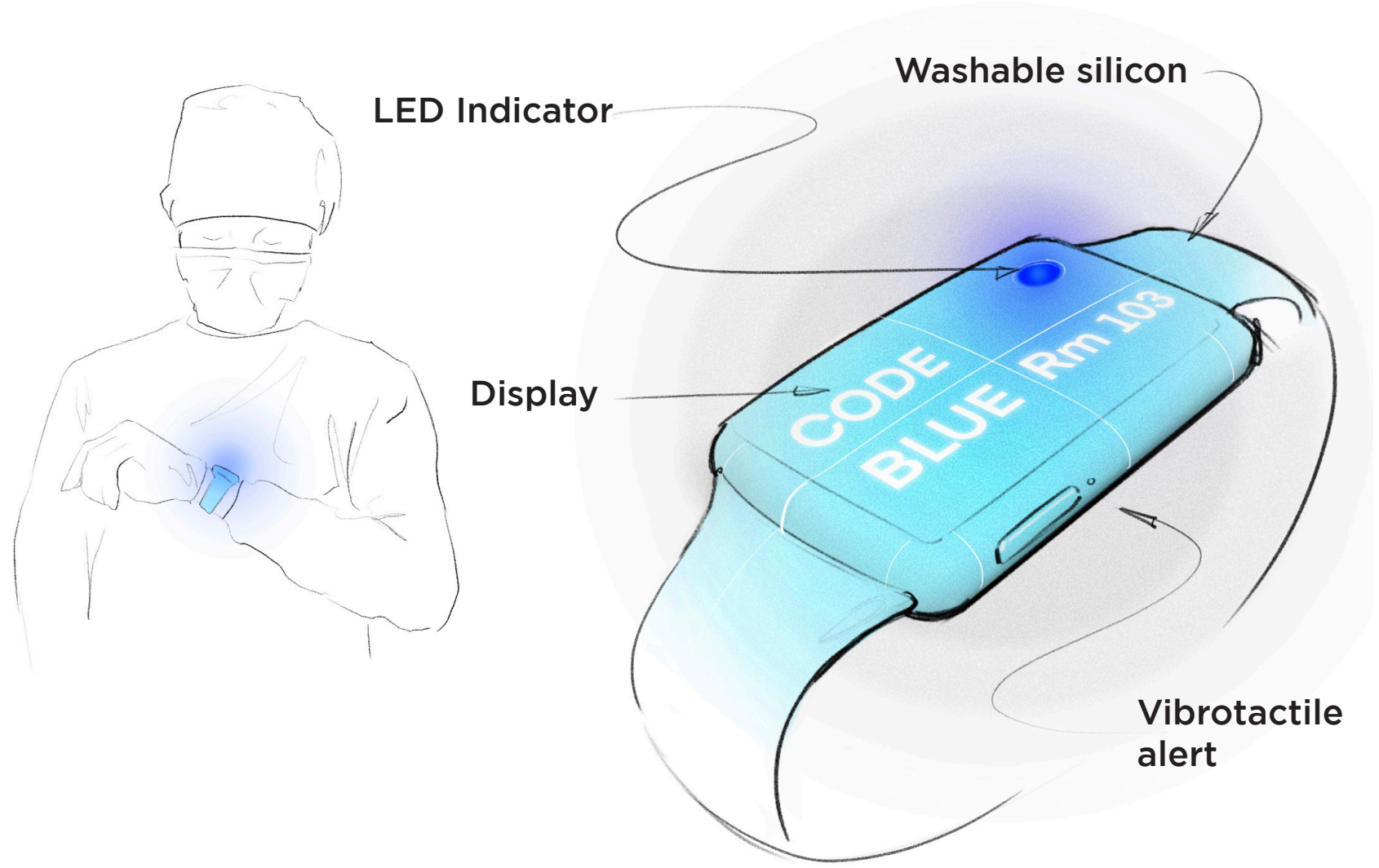
“Adjusting patient baseline’s would be essential to making monitors more meaningful”

## Beat's by Doc



“Doctors are like artists, they don't like standardization”

## Clinician Wearable



“When patients want privacy, it can be difficult to monitor their condition”



**Nurse-Facing Wearable**

**Patient Facing Wearable Vital Monitor**



Silicone construction

Backlit interactive  
E-Ink Display

Notetaking stylus

Infrared thermometer

Vibrotactile alert

LED visual alert

Adjustable armband

Zigbee connection

patient vital overview

heart rate  
102

SpO<sub>2</sub>  
90

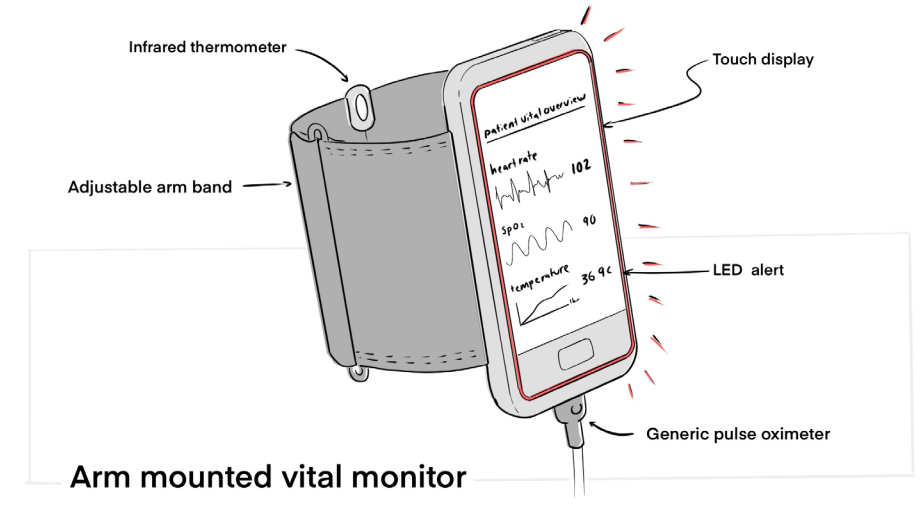
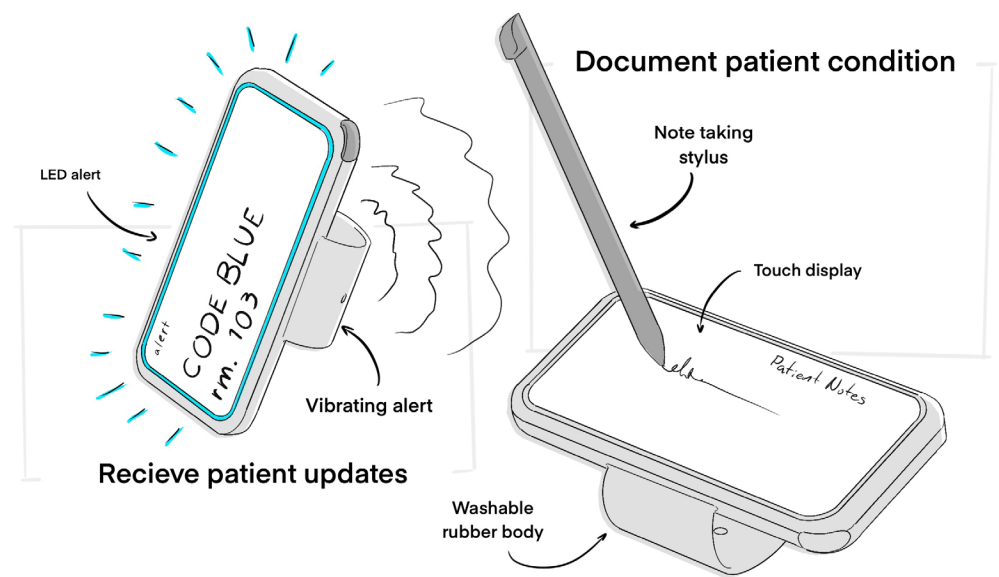
temperature  
36.9c

# Define

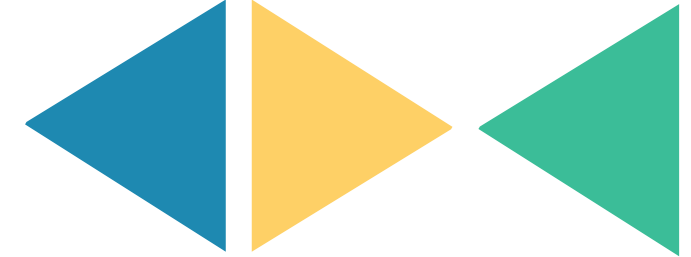
## UMN Product Design Showcase



### Feedback from Nurses and Industry



Leverage pre-existing systems



Continue exploration

# Develop Requirements and Heuristics

Product requirements, heuristics, and additional human factor considerations were leverage to better develop the product's design.

| No. | Metric   | Imp. | Unit   | Marginal Value | Ideal Value |
|-----|--|------|--------|----------------|-------------|
| 1   | Adjustable armband   | 5    | In     |                | Subj.       |
| 2   | Lightweight  | 3    | g      | <60g           | >30g        |
| 3   | Durable material   | 3    | ksi    | >0.348         | <0.797708   |
| 4   | Sized appropriately for bicep  | 3    | Subj.  | >3             | >5          |
| 5   | Non-porous material  | 5    | nm     | <2             | <2          |
| 6   | Water resistant  | 3    | Bar    | >.5            | >1          |
| 7   | Interactive display  | 5    | Binary | Pass           | Pass        |
| 8   | High resolution display  | 3    | Pixel  | <720           | <1080       |
| 9   | Color blind friendly   | 2    | Binary | Pass           | Pass        |
| 10  | Accessible interface   | 3    | Subj.  | >3             | >5          |
| 11  | Bright LED notification  | 5    | Lumens | >70            | <100        |
| 12  | Communicate with other devices such as the clinician-facing wearable | 5    | Binary | Pass           | Pass        |
| 13  | Rechargeable battery   | 5    | Binary | Pass           | Pass        |
| 14  | Long battery life  | 3    | Hours  | >8             | >12         |
| 15  | Easy to Clean  | 5    | Subj.  | >3             | >5          |
| 16  | Compatible with off-the-shelf pulse oximeter                         | 5    | Binary | Pass           | Pass        |
| 17  | Accurately measures patient's axillary temperature                   | 5    | Binary | Pass           | Pass        |
| 18  | Accurately measures patient's blood oxygen                           | 5    | Binary | Pass           | Pass        |
| 19  | Accurately measures patient's heart rate                             | 5    | Binary | Pass           | Pass        |

|                          |   |
|--------------------------|---|
| <b>Hick's Law</b>        | This concept will reduce the amount of time needed for the user to take action by better reflecting the patient's condition and therefore allowing the clinician to react more quickly.               |
| <b>Miller's Law</b>      | This concept will consider less than seven pieces of information by only exposing the user to the patient's four primary vital signs and their condition in relation to the patient's set parameters. |
| <b>Fitts' Law</b>        | The touch targets of my concept will be large enough to be selected.  |
| <b>Interface Effects</b> | Because perception differs from representation, I will have to conduct usability tests to better understand how the information on the screen is perceived.   |

|                    |  |
|--------------------|--|
| <b>Match</b>       | <p>The patient monitor leverages a digital touch screen in a way similar to that of a common tablet/electronic.</p> <p>The monitor can be interfaced with pre-existing secondary monitor interfaces such as smart watches and phones.</p> <p>The experience of the common consumer of electronics will have to be understood in all details, such as charging.</p> |
| <b>Anticipate</b>  | The concept would provide real time and historical information of the patient's condition.   |
| <b>Complexity</b>  | The physical architecture of the patient monitor concept leverages a user experience similar to an armband blood pressure monitor.   |
| <b>Consistency</b> | The interface of the patient monitor will be consistent with the interface of the clinician facing app.  |
| <b>Place</b>       | The user experience of this product concept is all about place. The concept provides a sense of place by allowing clinicians to readily identify patient condition through the device's interface and their secondary monitor anywhere in the hospital.  |
| <b>Constraints</b> | This concept prevents misuse through visual product semantics which psychologically imply how the product is used.   |
| <b>Aesthetics</b>  | The concept leverages aesthetics which are appropriate for a medical environment. The form and CMF of the product will reflect the hygienic aesthetic of a medical product and allow for easy sanitation.  |
| <b>Language</b>    | The language implemented into this concept will reflect the most essential information necessary to convey in the user's experience of the product. This information includes descriptions of patient condition, and vital parameters.   |
| <b>Feedback</b>    | As a monitor, the concept will provide feedback to the users regarding the patient's condition. The feedback will be translated through LED lights and primary and secondary monitor displays.   |
| <b>Errors</b>      | The device will work towards preventing errors through non-permanent user interfaces. Patient parameters can be edited by the clinician and app screens can be navigated in a way which allows the user to access all pertinent information.   |

# Develop Feasibility

Feasibility has been assured through market research as well as through the development of a detailed bill of materials.

| Number             | Qt. | Cost per Unit   | Part   | Part Description  | Material   |
|--------------------|-----|-----------------|--|---|------------|
| 1                  | 1   | \$8,644.00      | *Tooling for Enclosure   | Injection mold tooling required to manufacture the main housing of the device             | Steel      |
| 2                  | 1   | \$10.00         | Plastic Enclosure  | The plastic housing which contains the devices electronics                                | ABS        |
| 3                  | 1   | \$25.00         | Blood Pressure Cuff  | Cuff that measures blood pressure, also secures the device to the patient                 | Purchased  |
| 4                  | 1   | \$0.25          | Rectangular Buckle Ring  | A buckle which when built into the armband, allows users to adjust the device's tightness | ABS        |
| 5                  | 1   | \$2.00          | Velcro   | Velcro which when built into the armband, allows users to adjust the device's tightness   | Velcro     |
| 6                  | 1   | \$20.00         | Lithium Ion Battery  | A rechargeable battery that powers the device   | Electronic |
| 7                  | 2   | \$1.25          | ECG Electrode Foam Pad   | The foam pads which holds the ECG leads to the patient                                    | Electronic |
| 8                  | 1   | \$50.00         | ECG Lead Cable   | ECG allows for the monitoring of all nessecary vital signs                                | Electronic |
| 9                  | 1   | \$50.00         | 4" Capacitive Touch AOMLED Display                               | A screen which allows users to digitally interact with the device                         | Electronic |
| 10                 | 1   | \$10.00         | Air Pump   | Used to inflate blood pressure cuff   | Electronic |
| 11                 | 1   | \$25.00         | ECG Connection   | Recieves ECG leads to the PCB board   | Electronic |
| 12                 | 1   | \$35.00         | Custom PCB board   | The custom circuit board which acts as the device's computer                              | Electronic |
| 13                 | 2   | \$0.25          | Push Button  | Allows users to interface with the device   | Purchased  |
| 14                 | 4   | \$0.10          | Fasteners  | Connects the PCB board to the housing   | Purchased  |
| 15                 | 1   | \$0.10          | 2" rubber tubing   | Connects the air pump to the blood pressure cuff  | Purchased  |
| <b>Total Price</b> |     | <b>\$228.85</b> | <b>*Tooling is not included in total cost of parts in device</b> |   |            |

# User Journey Storyboard



Alert is received across the hospital



Nurse arrives to patient, quickly assessing condition



Nurse is able to treat patient