



# Svasth Healthcare

Comfort Mat System(CMS)

**ENSC 305/440 Capstone Project**  
**2014 Dec 10th**

# Outline

- Team Members
  - Motivation
    - Problem
    - Existing Solutions
  - Project Details
    - Schedule
    - Financial
  - System Overview
    - Hardware
    - Software
  - Market
  - Future Development
  - Conclusion
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# Team Members and Roles

- **JabarJung Sandhu**

- Smartphone Application

- **Wei Lu**

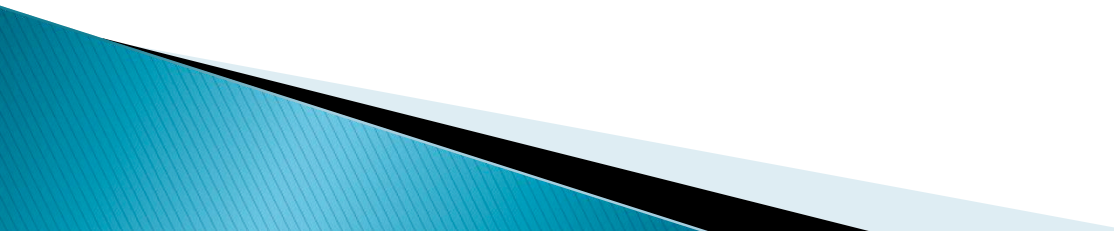
- Circuit Design
- PCB Layout
- Temperature/Humidity Sensor

# Team Members and Roles

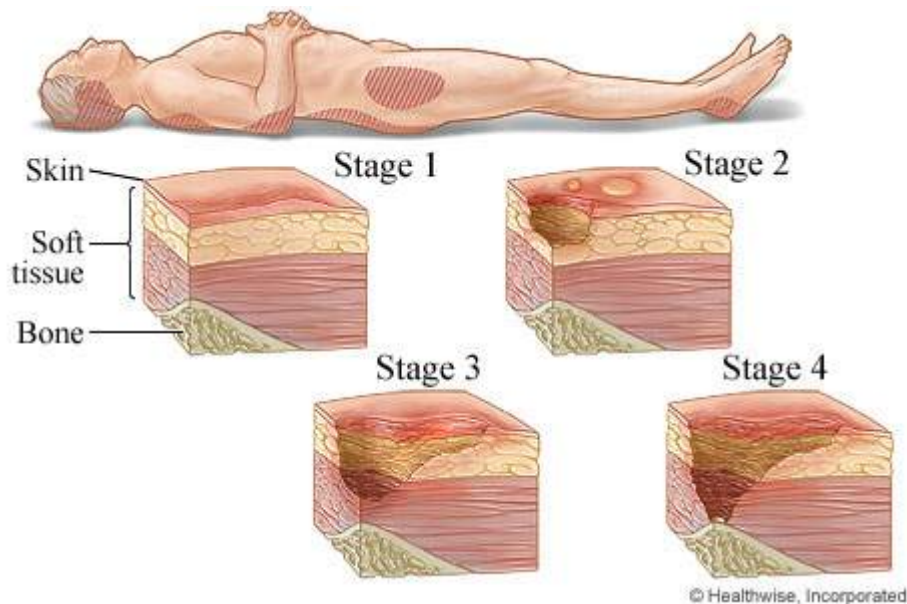
## ➤ **Di Luo**

- Hardware Coding
- Cushion Design
- Vibration Motors

## ➤ **Henson Truong**

- Pressure Sensing Mat
  - Matlab User Interface
  - System Integration
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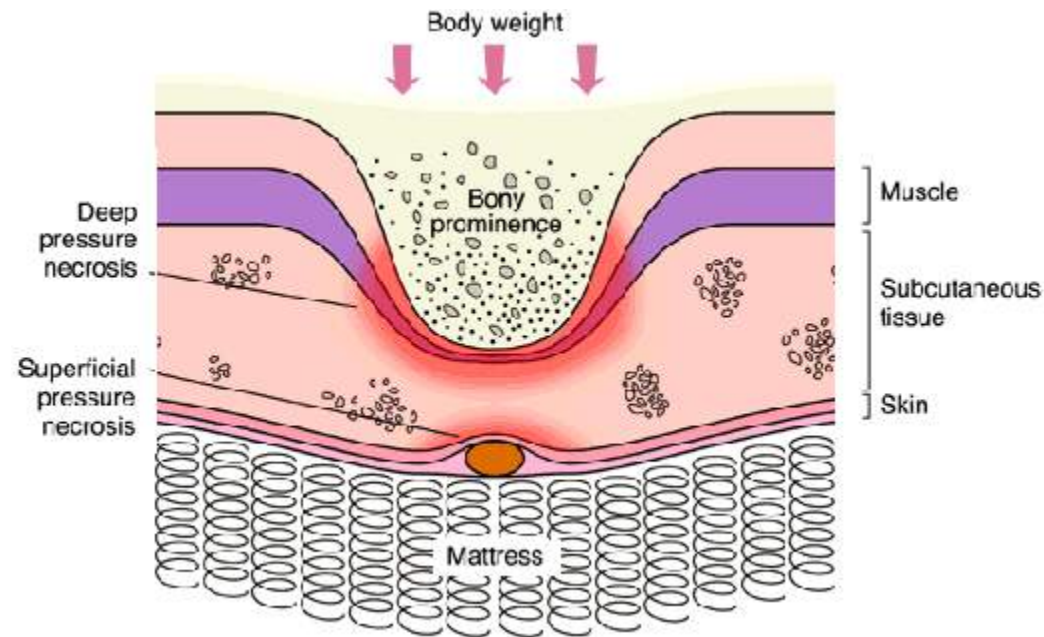
# Motivation



- A pressure sore (also known as bed sores) is the breakdown of the skin and the underlying tissues
- It starts as an area of skin damage, then spreads to the tissues underlying the skin (which then can cause permanent damage to muscle or bone underneath the skin)

# What Causes Pressure Sores?

- Long lasting pressure pressed against skin
- Increased temperature and humidity speeds up the rate at which pressure sores develop

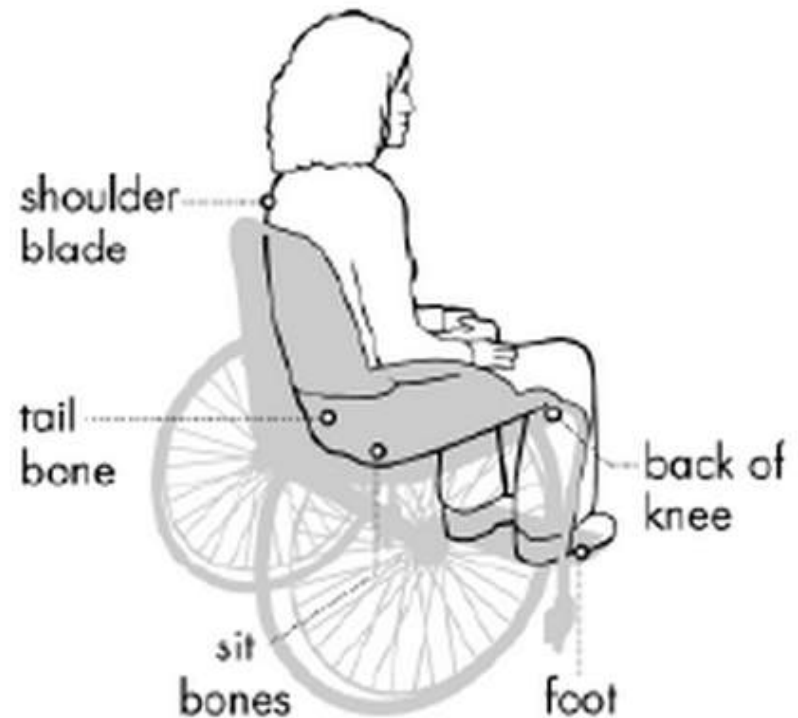


# Who is Affected?

- People who are not able to change their body position frequently (such as people who are hospitalized)
- People who sit in wheelchairs for long periods of time

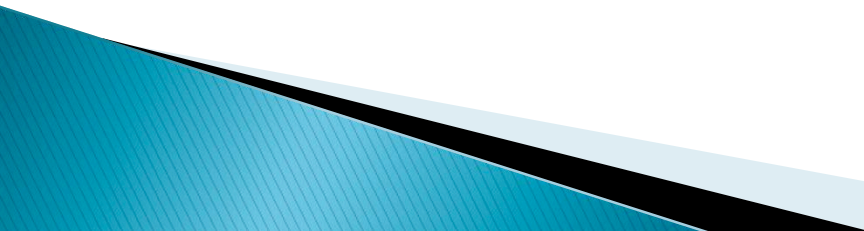
# Common Areas Where Pressure Sores Develop

- Pressure sores are injuries to the skin and tissues over a bony area
  - Back of the heels
  - Buttocks
  - Backbone
  - Shoulder blades



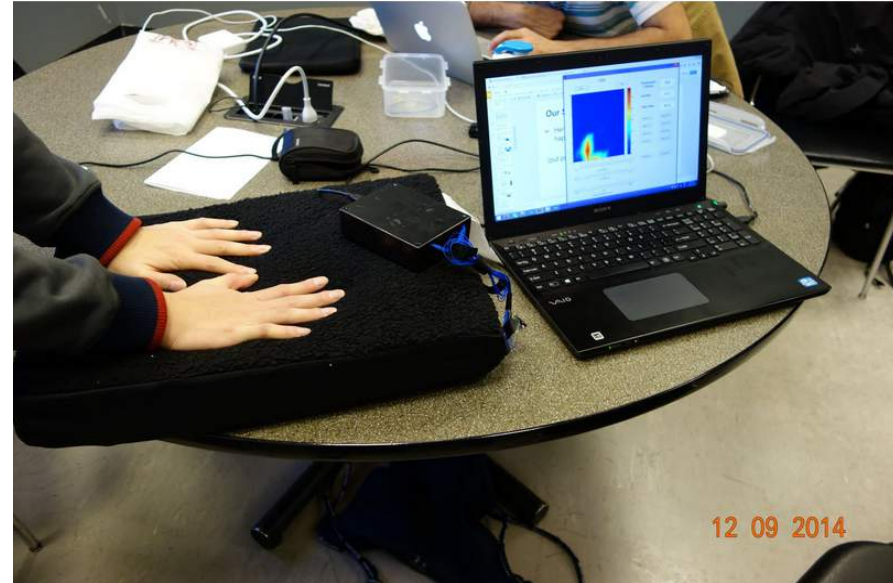
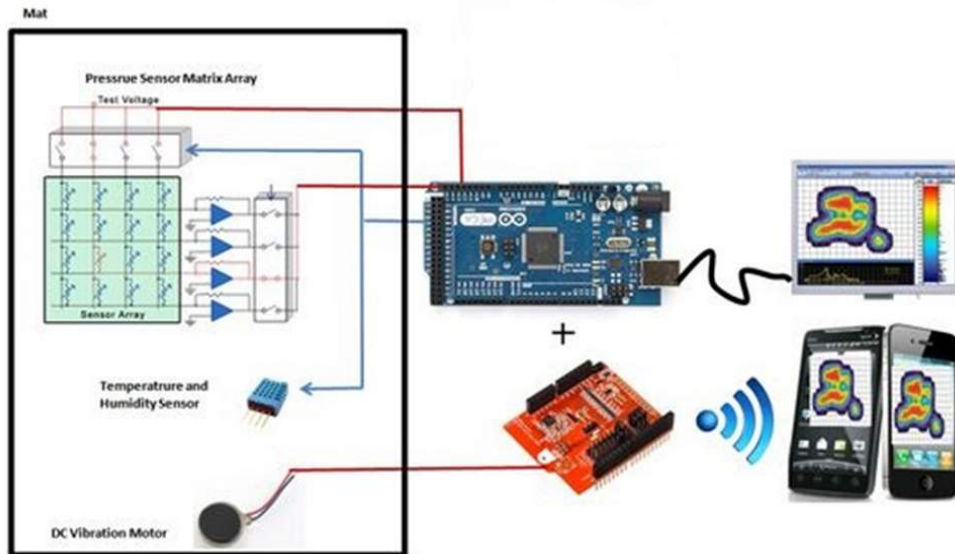


# Treatment of Pressure Sores

- Need to manage the load put on the affected area
  - Need to keep the affected area clean and dry
  - Most stage 1 and stage 2 pressure sores will heal within several months, while stage 3 and stage 4 pressure sores can take months to heal
  - Basically, it takes a lot of care, effort, and time to treat pressure sores
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# Our Solution

- Helps prevent pressure sores before it happens (not treat it)

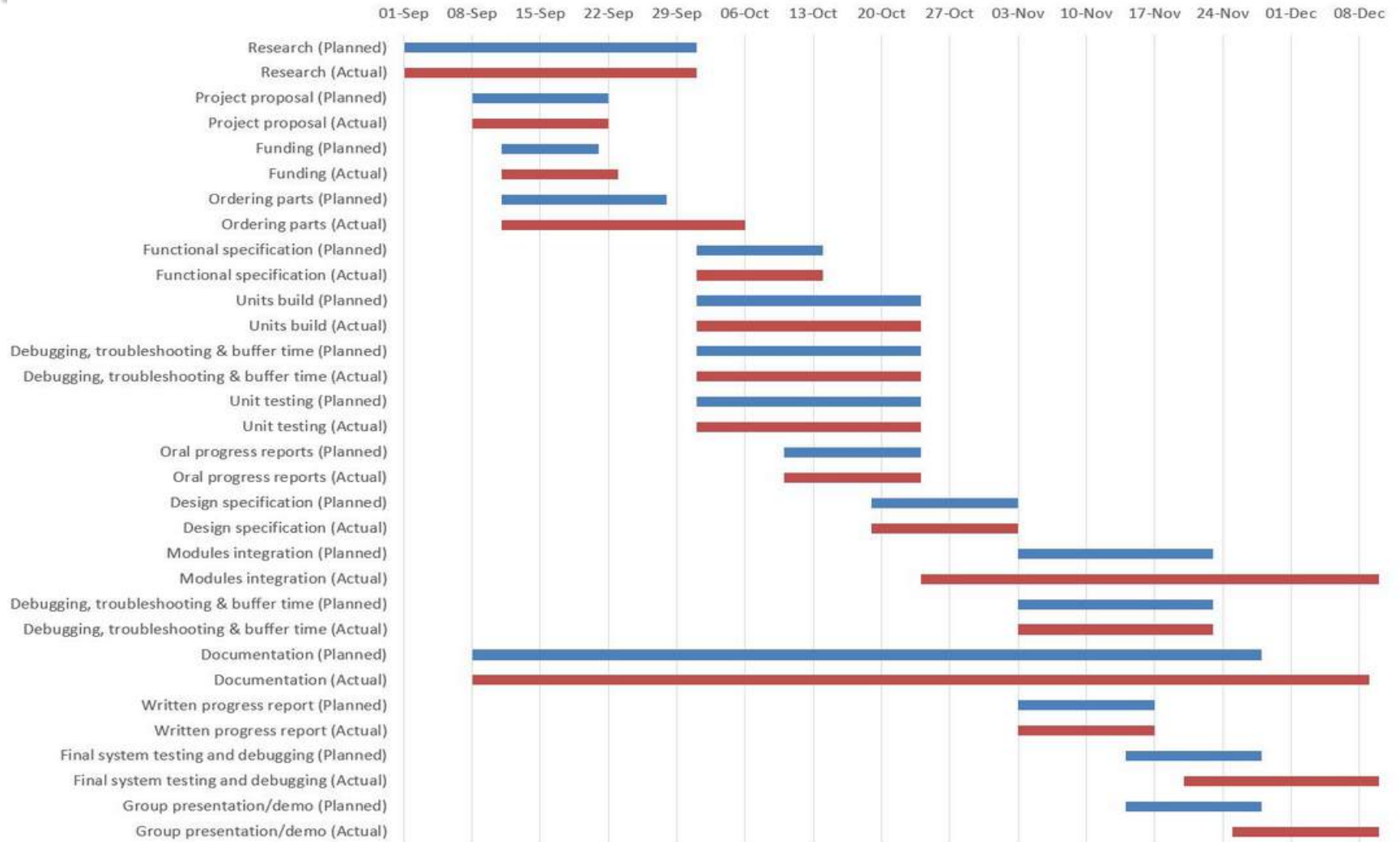


# Financial

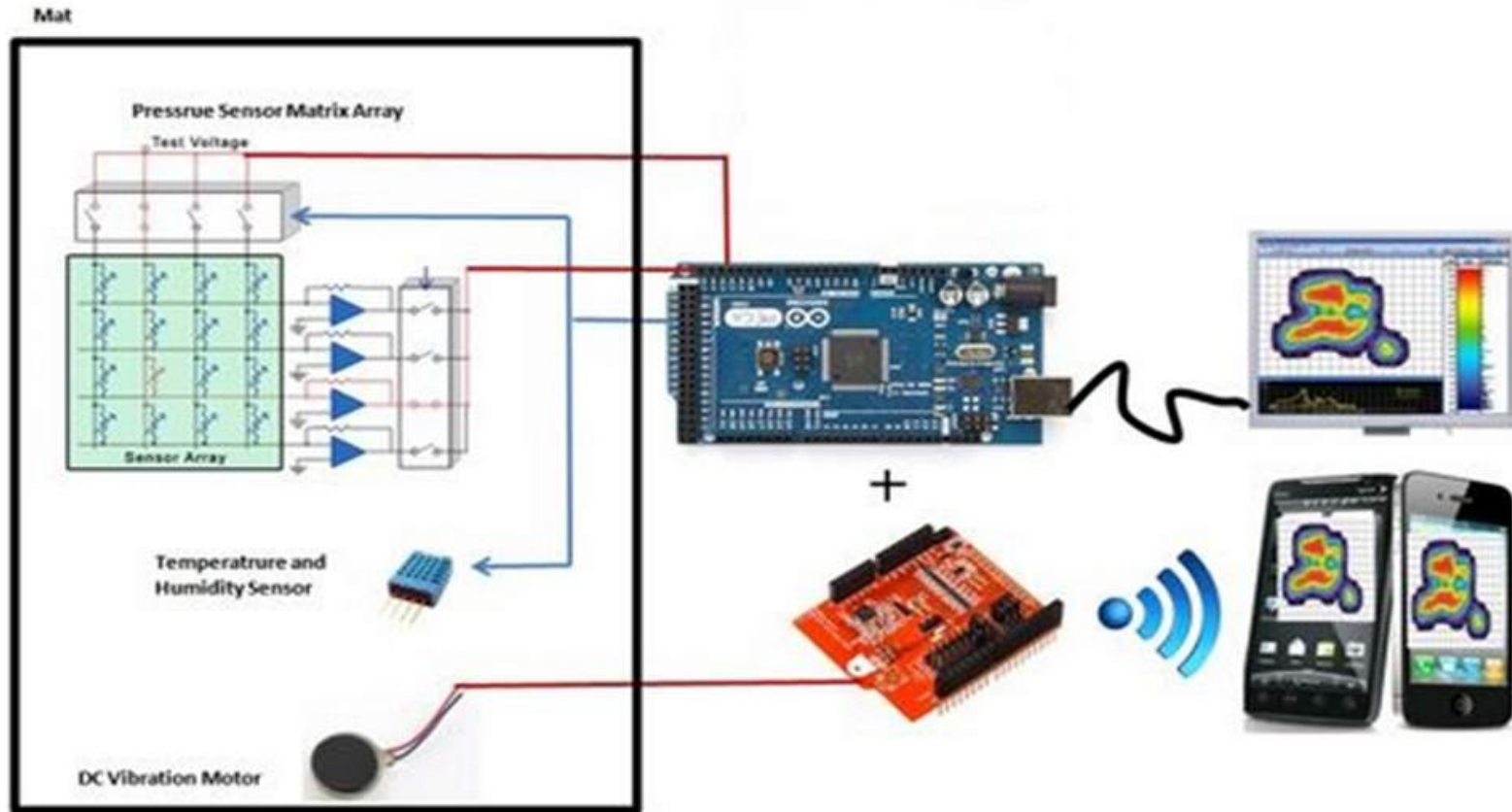
- We received \$650 from the ESSEF
- This amount was almost enough to cover our entire project
- We managed to borrow some parts to further reduce the cost of our project

Component	Estimated Cost	Actual Cost
Arduino Mega 2560 R3 board	80	74.8
Temp. and Humidity Sensor	15	15
Copper Foil Tape	12	12
Vibration motor	30	22
Multiplexer 4051N	1.5	do not need
Shift register 74HCT595N	1.5	1.5
Bluetooth 4.0 low energy – BLE Shield	30	30
DMI Med Convuluted Foam Chair Pad	20	41
FSR 402 0.5"	384	352
Jump wires (Male and Female)	40	40
Conductive wire	30	30
Resistor	Free	Free
Battery Connector	5	5
Plexiglass Sheet	20	10
Touchscreen LCD	75	do not need
L293D Motor Driver IC	20	18.4
<b>Total Cost</b>	<b>\$750</b>	<b>\$653.2</b>

# Timeline and Schedule



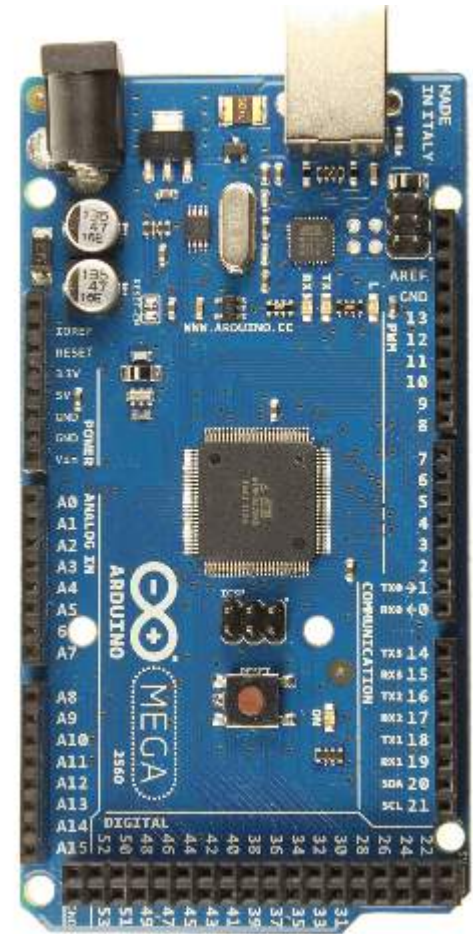
# Hardware System Overview



# Microcontroller Board

## ➤ Arduino Mega 2560 R3

- Lots of input/output connectivity for our large amount of sensors
- Small and portable, so it can be carried around with the CMS
- Open source software and easy for programming( C language)
- Can be powered by battery or USB

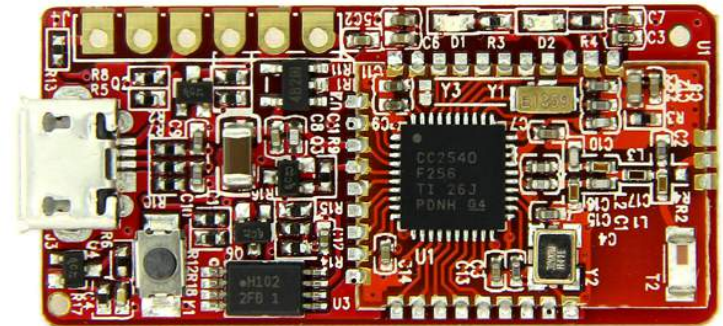


# Bluetooth Adapter



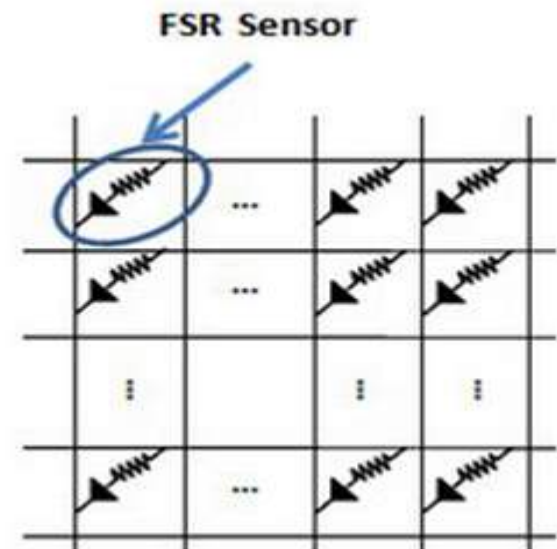
## ➤ BLE mini

- Using Bluetooth 4.0 low energy
- Only require a serial port for communication
- Easy to integrate with Arduino Mega Microcontroller Board



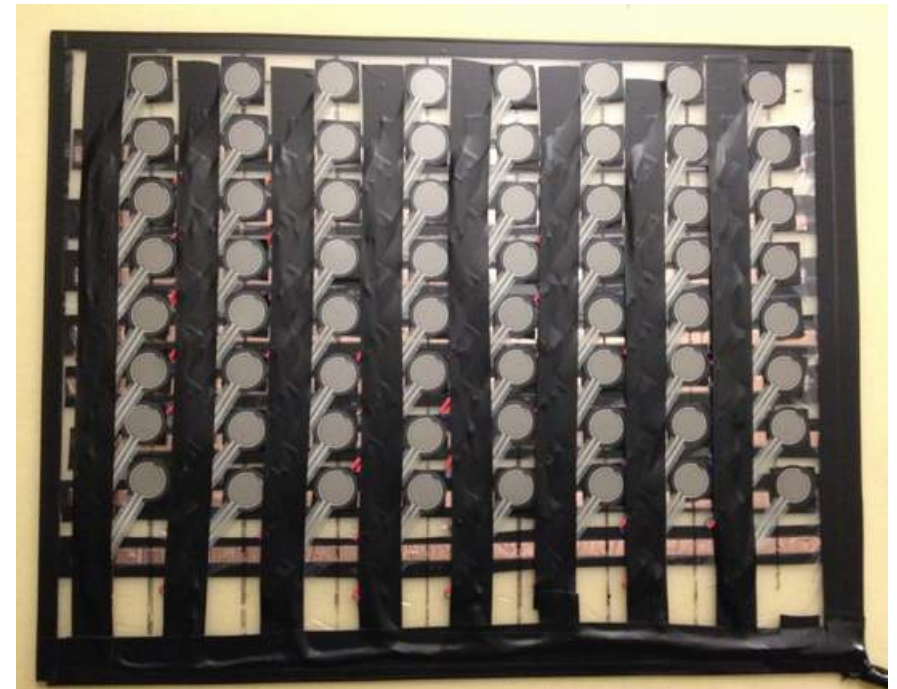
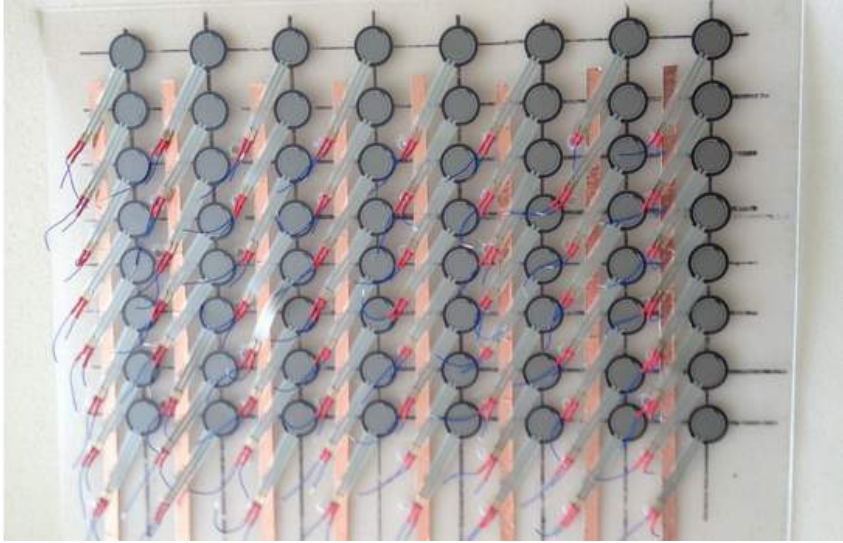
# FSR Sensors Matrix Array

- Used Force Sensitive Resistors (FSR) in a 8x8 Matrix Array
- FSR reading can be obtained by enabling both row and column at same time
- Mounted the FSRs on Plexiglass, then placed them within the seat cushion





# FSR Sensors Matrix Array (Con't)



# Temperature and Humidity Sensor

- Continuously monitor temperature and humidity of the environment inside the cushion
- **RHT 22**
  - Humidity: 0-100% readings with 2-5% accuracy
  - Temperature: -40°- 80°C with  $\pm 0.5^\circ\text{C}$  accuracy
  - Advantage: comes in a plastic enclosure
  - Disadvantage: slow data collecting period (2 seconds)



# Vibration Motors



- 4 Individual DC vibration motors are placed inside the CMS
- Improving user's blood circulation
- But more importantly, it also act as alarm to warn the user of long lasting high pressure values were detected, which need to release the pressure
- L293D to provide and increase bidirectional drive currents

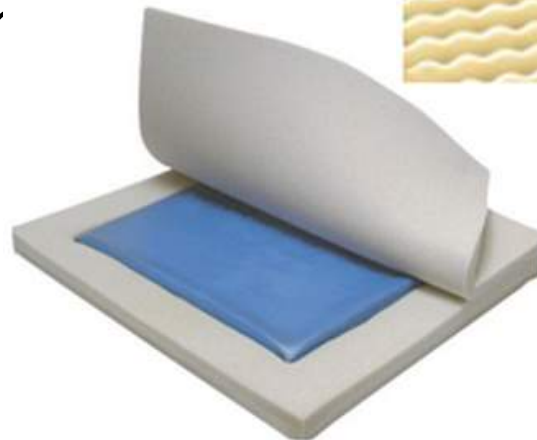
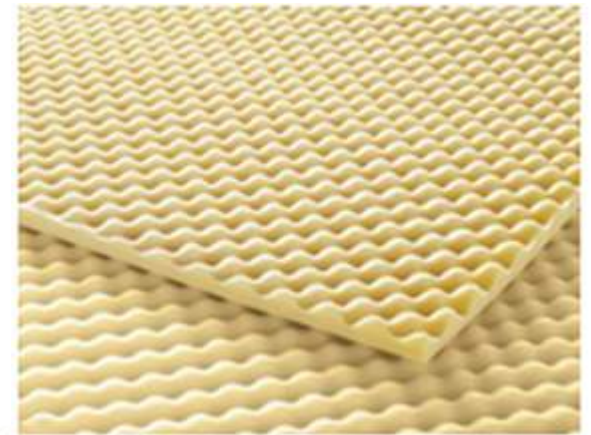
# Pressure Relief Cushion and Cover

## ➤ **Cushion Cover**

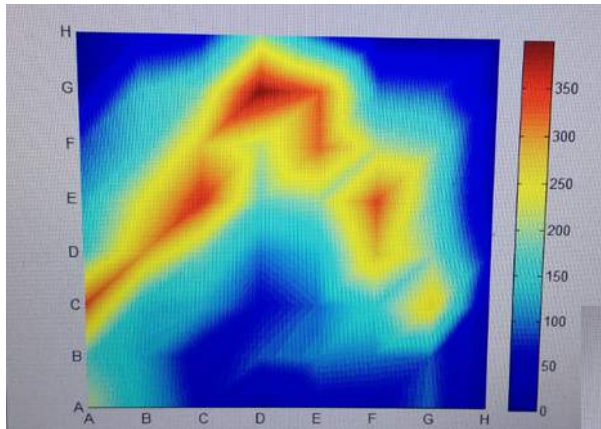
- Breathable fabric cover wrapping over the pressure relief cushion

## ➤ **Pressure Relief Cushion**

- Foam with egg-tray shape
- Foam with gel cushion

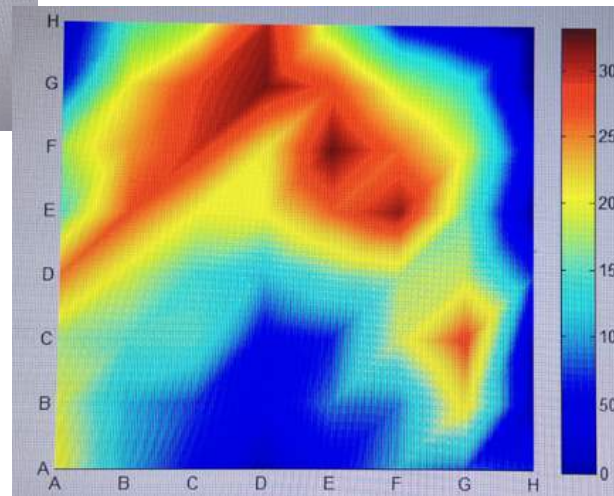


# Pressure Relief Cushion and Cover



## No Cushion

- Sharp and no distribution
- Highest pressure value >350

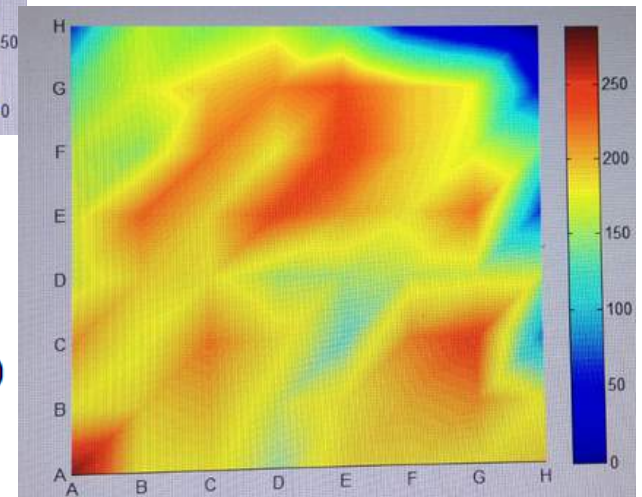


## Foam Cushion

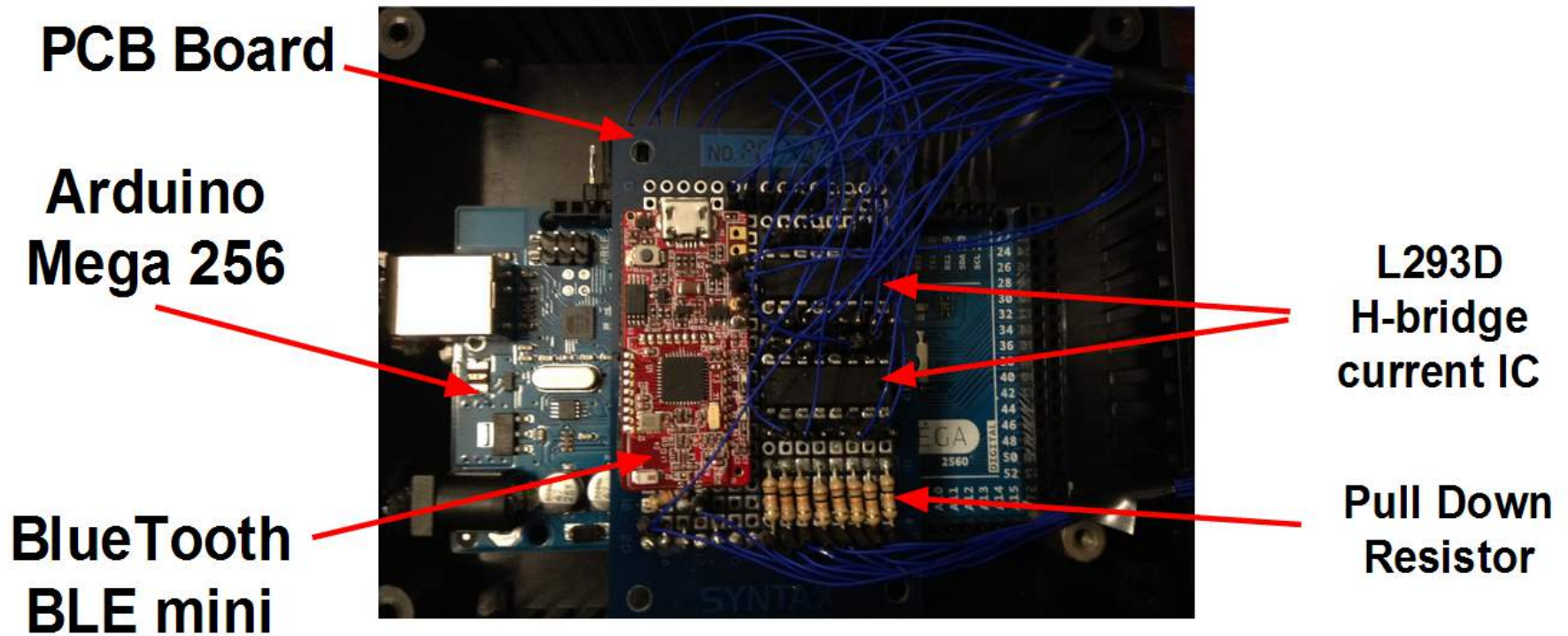
- More distribution picture
- High pressure value >300 but <350

## Foam + Gel Cushion

- Most distribution picture
- High pressure value >250 but <300



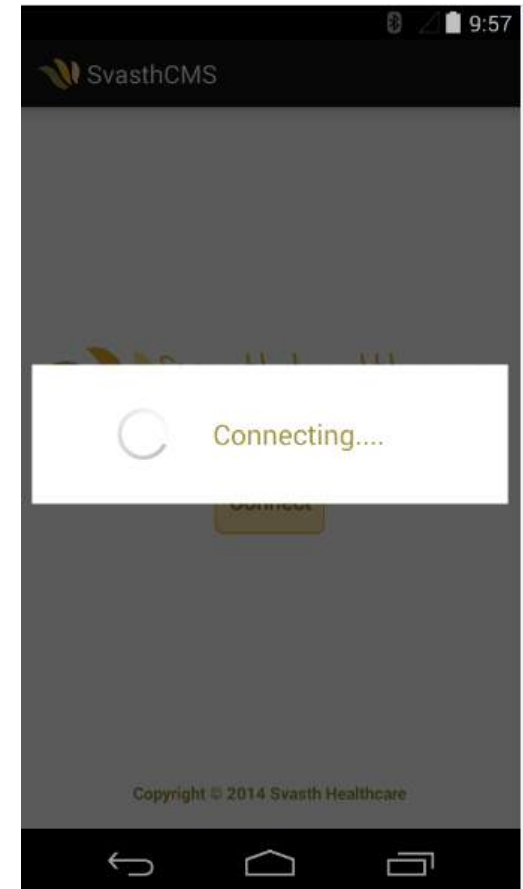
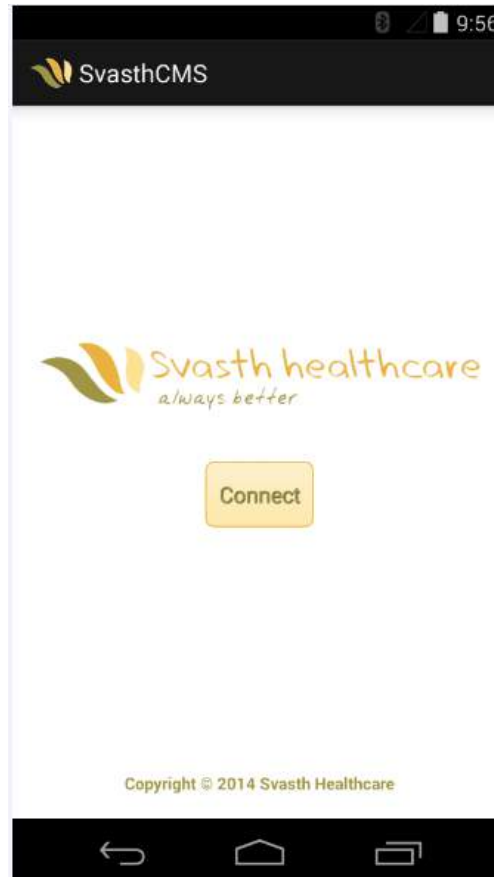
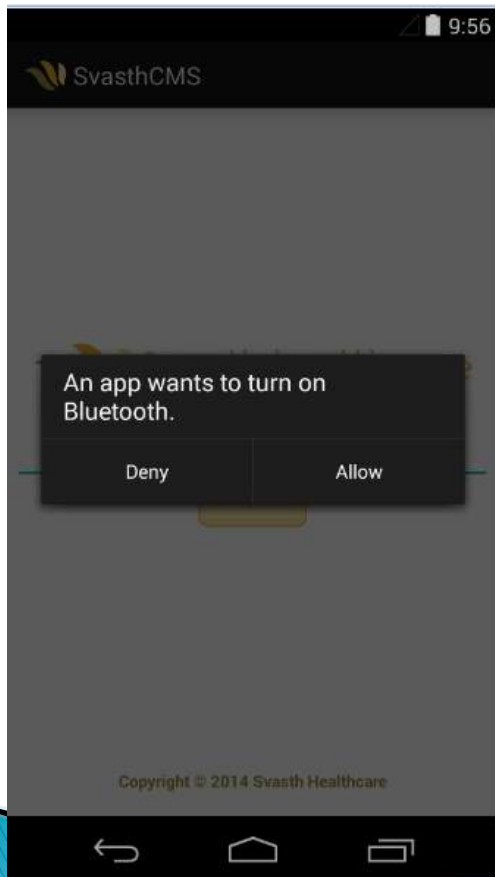
# System Integration





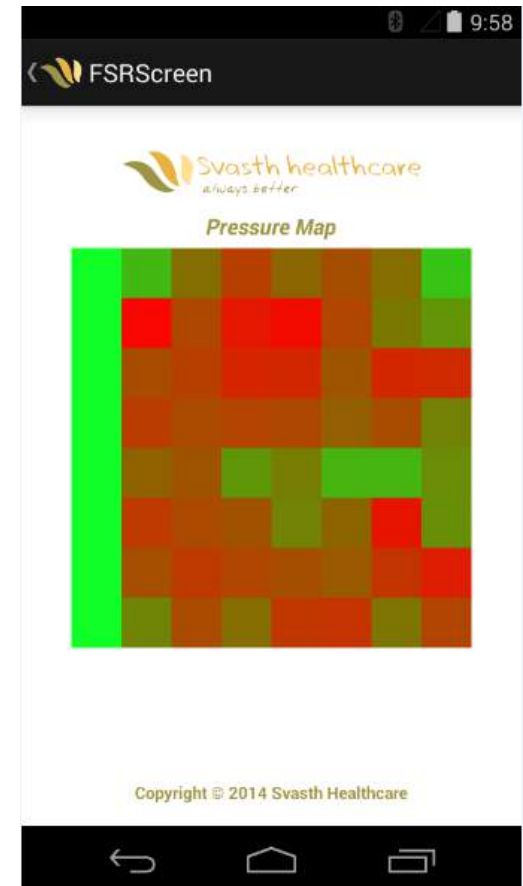
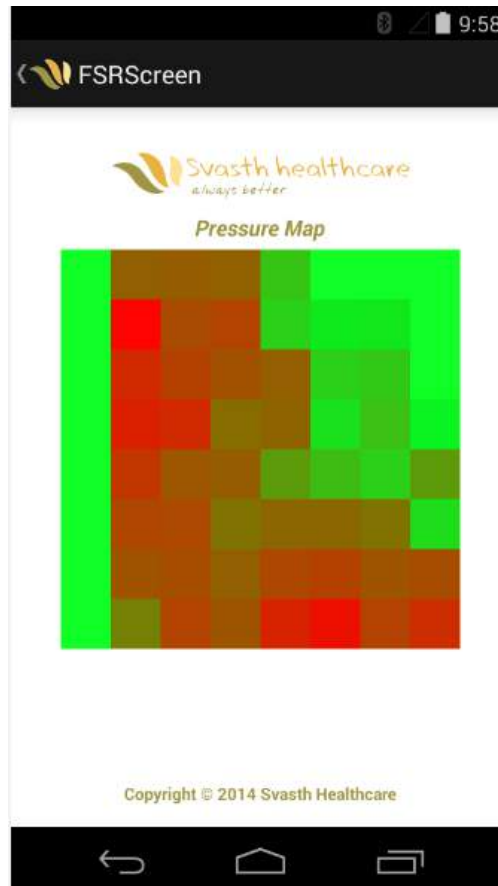
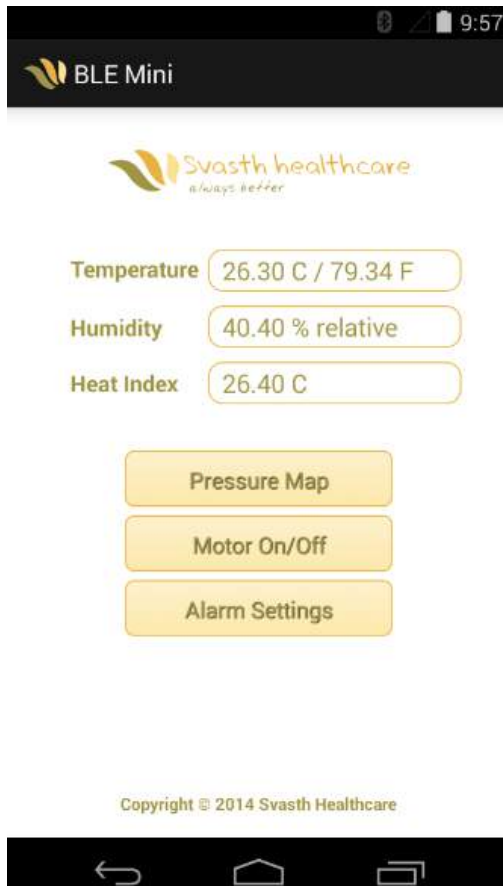
# Smartphone Application

## ▶ Bluetooth Connectivity

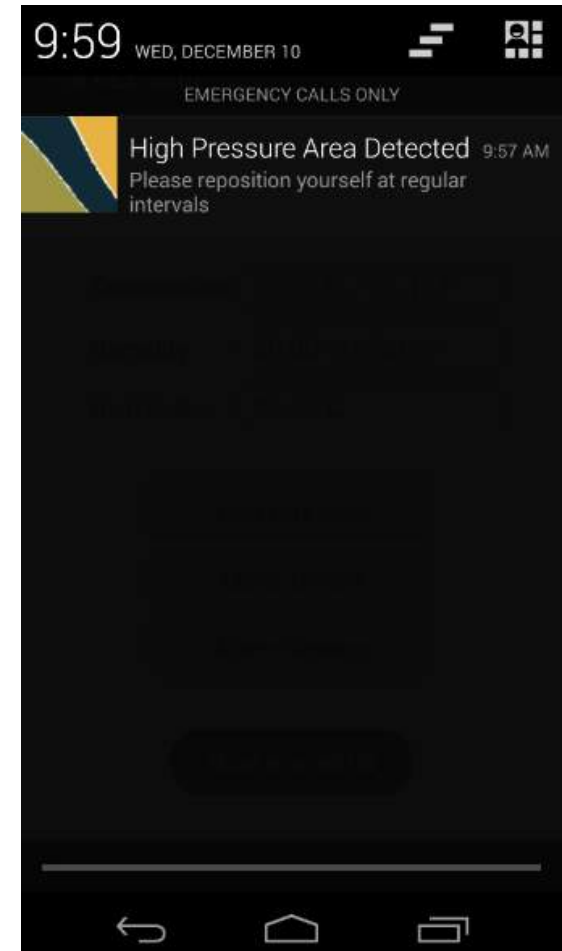
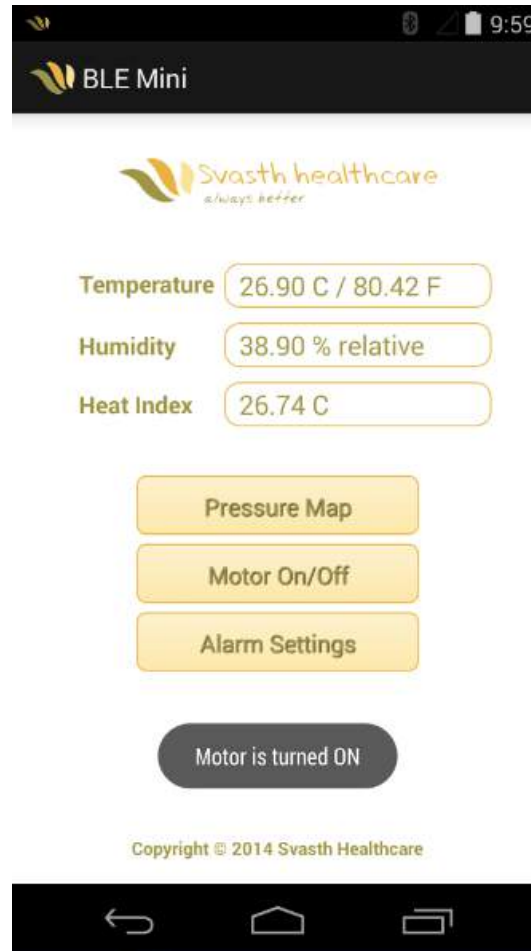
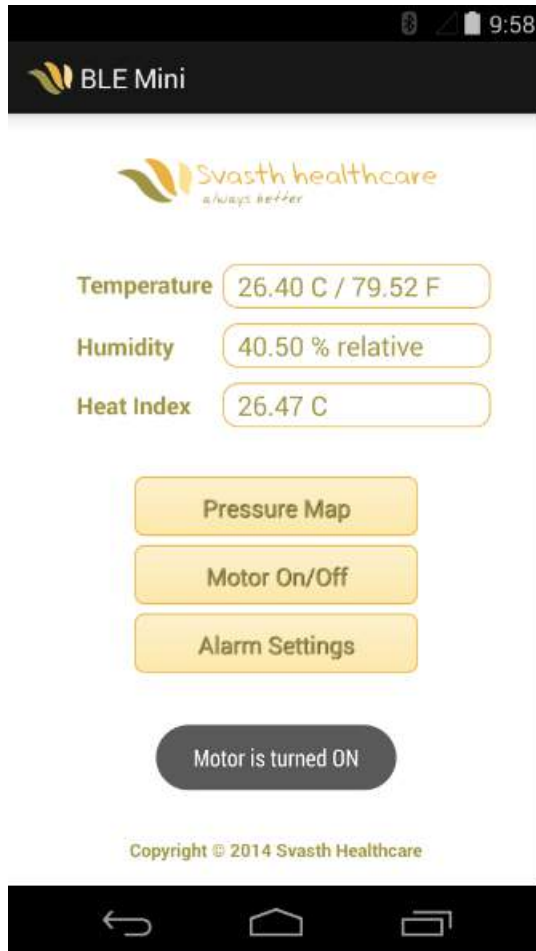




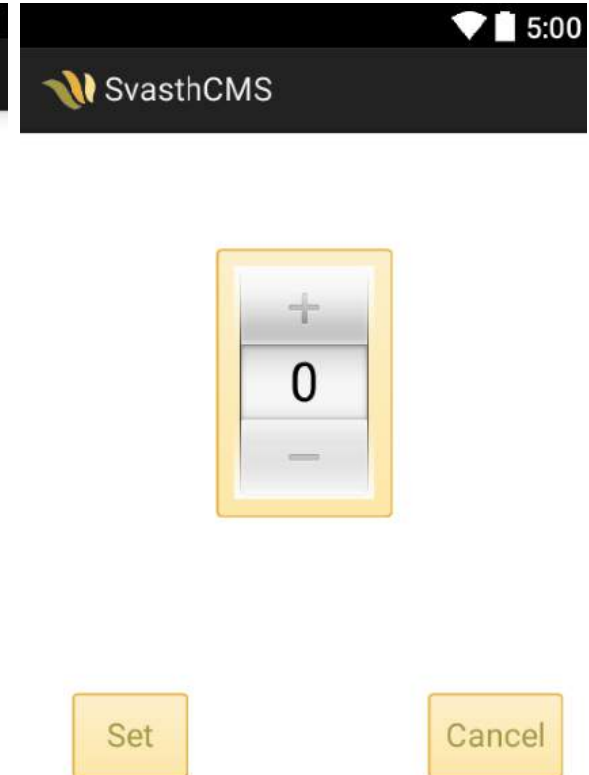
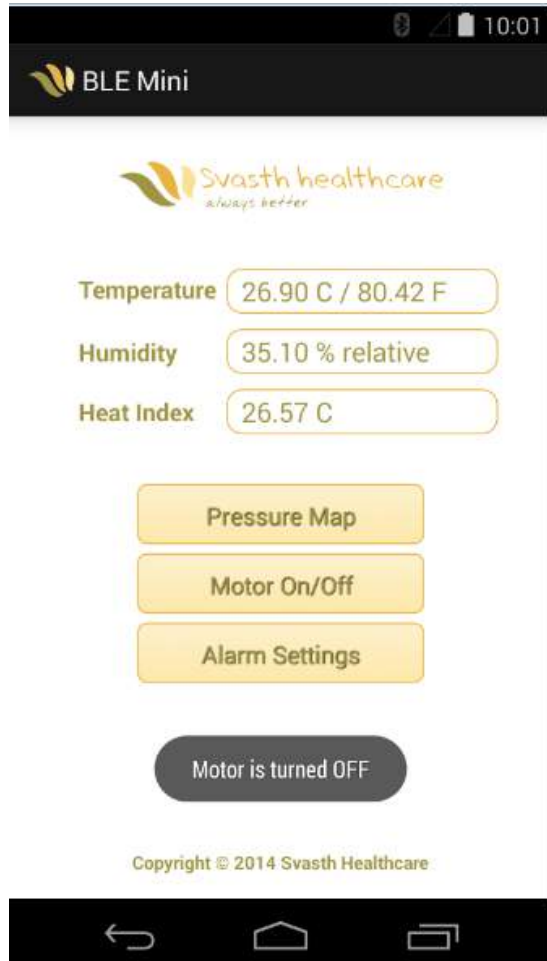
## ▶ Main Menu & Pressure Mapping



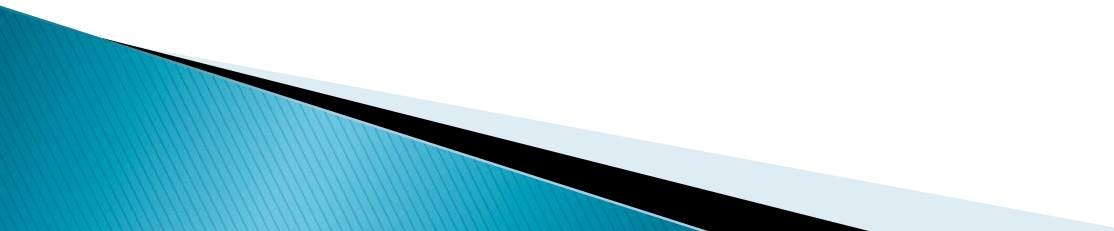
## ▶ High Pressure Detected and Motor Turns ON



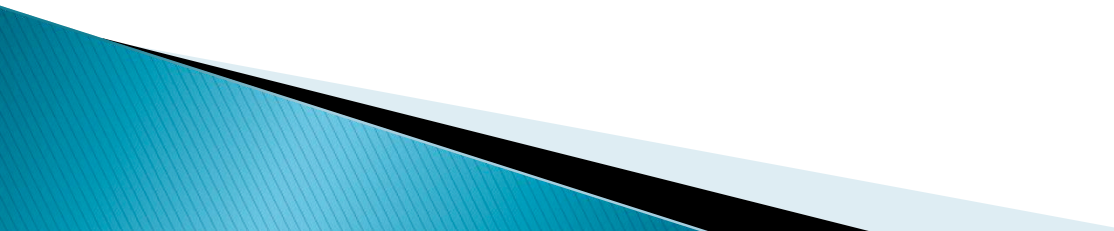
## ▶ Turn Motor Off and Trigger Value Setting



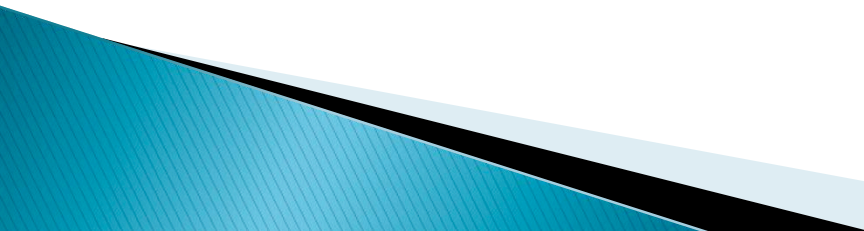
# Future additions to the App

- ▶ Run the app in the background in the Service mode so that the conditions are monitored round the clock and alarms are raised
  - ▶ As that will generate more data as compared to current version so a data transfer feature could also be added
  - ▶ Individual motor control
  - ▶ Uploading the data to the server
- 

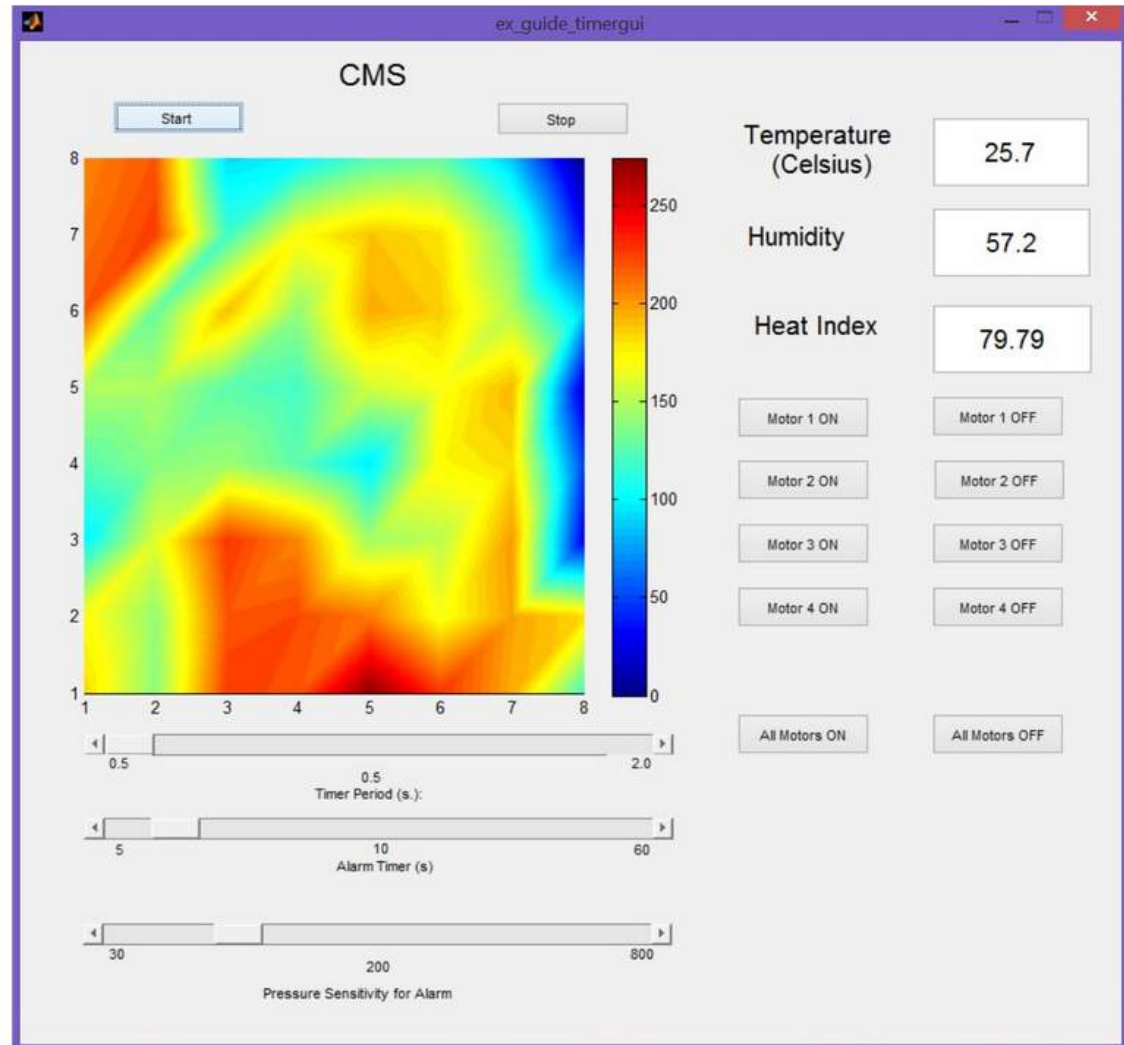
# Communicating with the Arduino

- Use serial communication protocol to communicate with both Matlab and phone application via Bluetooth connectivity
  - Read all 8X8 matrix FSRs from the customized circuit
  - Read Temperature & Humidity index
  - Motor control (waiting for inputs from GUIs)
- 

# Matlab Graphical User Interface

- Dynamic pressure mapping from pressure sensor matrix array
  - Temperature and Humidity sensor readings
  - Alarm system triggers the vibration motors when long lasting high pressure is detected
  - Option to adjust pressure sensitivity level for alarm
  - Option to adjust the duration of long lasting pressure detected before the alarm goes off
  - Individual motor controls
- 

# Matlab - Graphical User Interface



# System Limitations

- Refresh rate is a bit slow
  - around 0.5 seconds for Matlab
  - around 0.5 second for smartphone application

so really quick movements cannot be detected

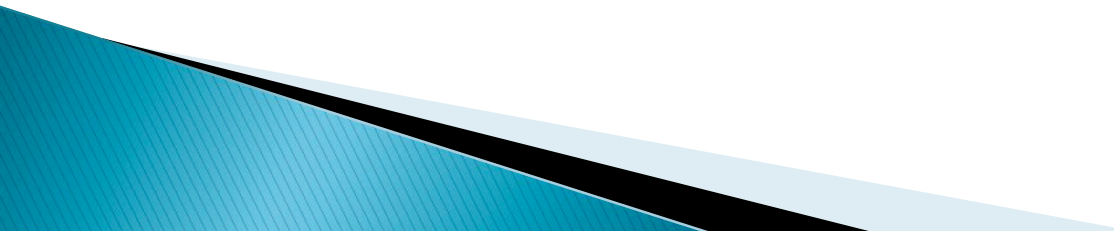




# Market

- Wound care management
  - In 2006, the total cost is \$11 billion global wide
  - Expect to increase to \$19.6 billion in 2016
- Market in Canada
  - 25% of people in acute-care settings (e.g., hospital) develop pressure sores
  - This number increase to 30% in non-acute care settings (e.g., nursing house)

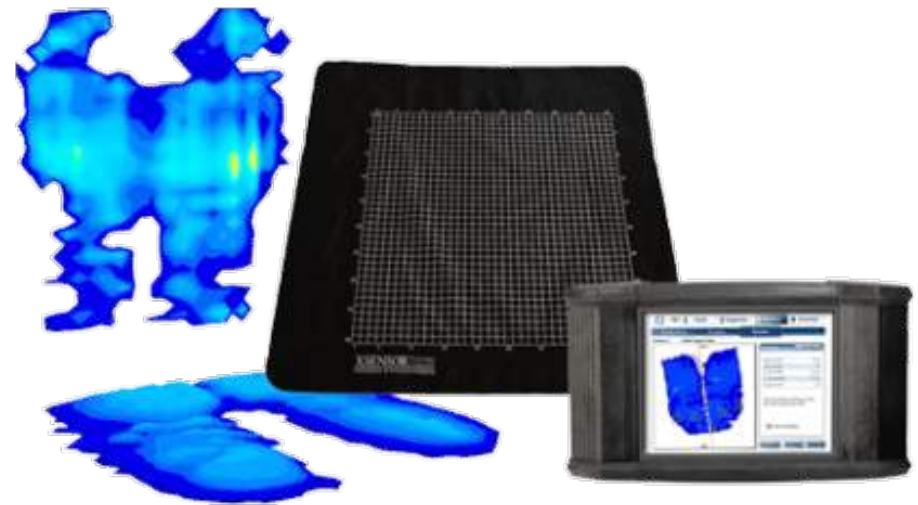
# Competition on the market

- Similar pressure mapping products on the market
  - Advantages of CMS over other products
    - More GUI options: PC and phone application
    - Automatically alarm
    - Detect current environmental condition (Temperature, humidity and heat index)
- 

# Other Products

## -X3 Medical Wheelchair Seat System

- Limits user to computer
- A wireless touchscreen display available as an add-on
- Very Expensive



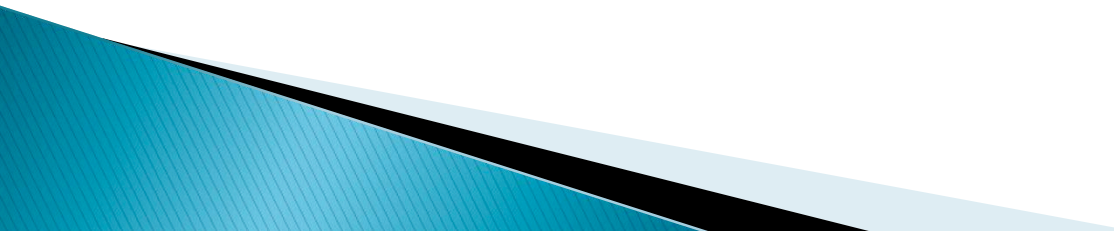
# Other Products

## -FSA Rehab Seating Assessment System

- Pressure mat requires calibration unit
- Limited to use with computer
- Does not alert user when long lasting pressure is detected (just shows information on computer)

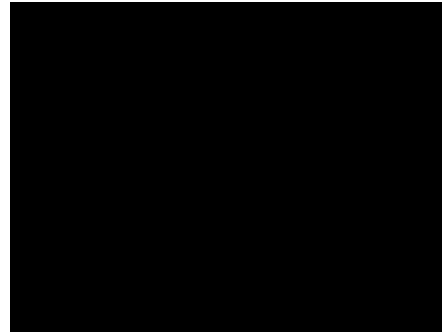


# Future Developments

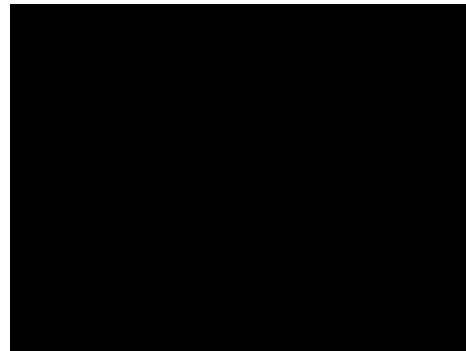
- Stronger vibration motors
  - Easy to integrate with different sizes of mat
  - Increase the resolution of matrix array
  - Try out different types of cushions such as Jay-cushion
  - Faster refresh rate
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# Video

- ▶ Matlab GUI and Phone App



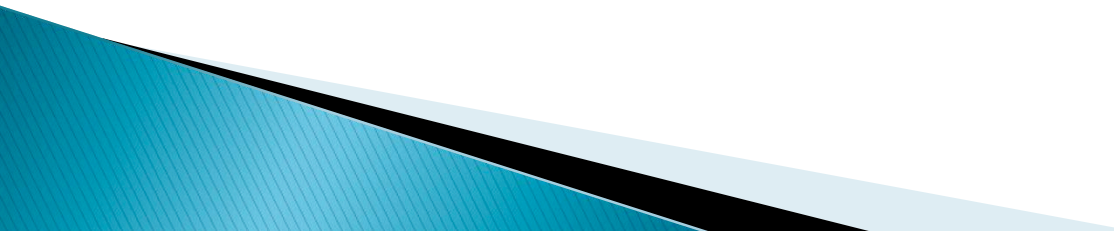
- ▶ Alarm and Alarm Setting on Phone App



# Conclusion

- Achieved the goal of Comfort Mat System, which helps prevent pressure sores

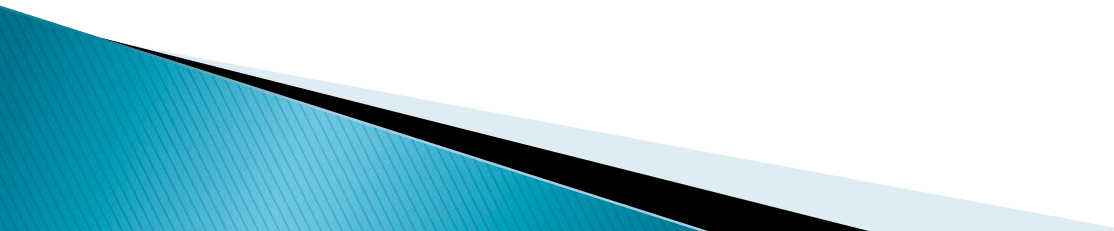
# What We Learned

- Teamwork
  - Time management (commitments to deadlines)
  - Writing technical documents
  - Attention to details
  - Working with Arduino Microcontroller Board
  - Troubleshooting and debugging skills
- 



# Acknowledgments

Thanks to:

- Dr. Andrew Rawicz
  - Steve Whitmore
  - Lukas-Karim Merhi
  - Jamal Bahari
  - Mona Rahbar
  - ESSEF Endowment
- 

# References

- <http://www.webmd.com/skin-problems-and-treatments/four-stages-of-pressure-sores>
- <http://www.hospitalmanagement.net/features/feature97878/>
- <http://www.spinal-injury.net/spinal-injury-network/images/applied-pressure.gif>



**Questions???**