# MINDFUL HEALTH
## Simplifying outpatient management with wireless pulse oximetry, fluid web tools, and data driven health insights

Olivia Rice, Christopher Fernandez ,Geoff Cohen ,Brandon Jonen, Jared Buckner, & Nick Glattard
*Advisors: Dr. Fred Robertson & Dr. Kris Saha*

UWHealth
University of Wisconsin Hospital and Clinics

UW BME Design

## Scientific & Clinical Background

### Congestive Heart Failure (CHF)

- Congestive heart failure occurs when the heart is unable to pump blood efficiently throughout the body and thus is unable to deliver sufficient amounts of oxygen and nutrients that the body needs
- **Heart failure is the leading cause of hospitalizations in people older than 65**
- 6 million people are affected by heart failure in the U.S.
- Pulse oximetry is a leading indicator of heart failure decompensations

## Design Motivation

### Affordable Care Act: Readmission Reduction Program

- The Center for Medicare & Medicaid Service will no longer pay for CHF related hospital readmissions within 30 days of departure
- **In 2013 alone, Medicare levied $227 million in fines** for these avoidable readmissions in 2,225 hospitals across the country

### Current CHF Patient Management Process

- Readmissions could be avoided with efficient home monitoring, however, **patient compliance is a significant issue**, which makes current processes ineffective

### Telehealth Efficacy & Adoption

- One of the largest telehealth studies to date was conducted by the UK department of health over two years with more than 6000 CHF, COPD and diabetes patients. The results of this study showed a **substantial reduction in a variety of clinical admissions**, as well as a **45% reduction in mortality rates** for telehealth equipped patients
- Telehealth remote monitoring has yet to be highly adopted in the U.S. due to the tedious process of electronic health record (**EHR**) entry that accompanies current remote monitoring processes

EHR
Electronic Health Record

Current Process    Telehealth

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RRA
Readmission Reduction Act

CHF
Congestive Heart Failure

ACA
Affordable Care Act

**Figure A:** Mindful Health seeks to simplify care processes, integrate telehealth into standard EHRs, and improve patient outcomes.

## pulseMobile Device & Cloud Application

### pulseMobile Device

**Figure B:** The prototype pulseMobile (left) and the next generation concept model (right)

- **Automatically collects and sends clinical grade pulse oximetry data through the cellular network to the cloud**
- Smith's Medical FDA approved OEM pulse oximetry processor
- Seeedstudio GSM shield sends data through GSM network
- Current prototype is the size of a pager but the next iteration will be miniaturized into the form factor of a hearing aid

### pulseMobile Cloud Application

**Figure C:** A critical care dashboard (above) and individual patient page displaying pulse oximetry data (below)

- **A clinical decision making tool that enables early interventions to prevent avoidable readmissions**
- Responsive alerts and notifications when patients cross clinician-defined vital thresholds
- Actionable vital and trend data visualizations/analytics
- Automated patient severity categorization based on the most recent patient vitals
- Platform agnostic design enables access through any web enabled computer, tablet, or smartphone device

## Testing & Results

### Pulse Oximeter Accuracy

- Recorded 60 simultaneous SpO2 and Heart Rate measurements from 4 individuals using pulseMobile and a standard pulse oximeter at the UW Madison VA Hospital
- Recorded 120 measurements from a severe CHF patient using the same experimental protocol
- Using a non-directional dependent t-test for paired samples, **pulseMobile was observed to have no statistical difference from the standard pulse oximeter with a p-value $< 0.005$**
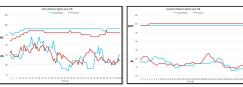
**Figure D:** SpO2 and HR data collected from a severe CHF patient (left) and healthy control (right)
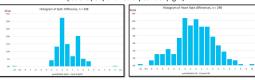
**Figure E:** Histograms for the pulseMobile – Control difference in observed HR (left) and SpO2 (right) for n = 298 measurements

### Test Driven Software Development

- Red, Green, Refactor: tests are written before features, tests are run to show failure, features are correctly developed, then tests pass
- **pulseMobile cloud application passes all 72 tests** that validate functionality for data models, controllers, interface elements, etc.

## Future Work

- Patient compliance validation test: deploy minimum prototype to CHF patients through home care providers
- Healthcare provider 'pain point' validation test: secure pilot study
- Execute device redesign for manufacturability
- Distribute mobile and tablet applications using PhoneGap
- Migrate from Heroku to Amazon Web Services for HIPAA

## Acknowledgements

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