1 Problem & Research

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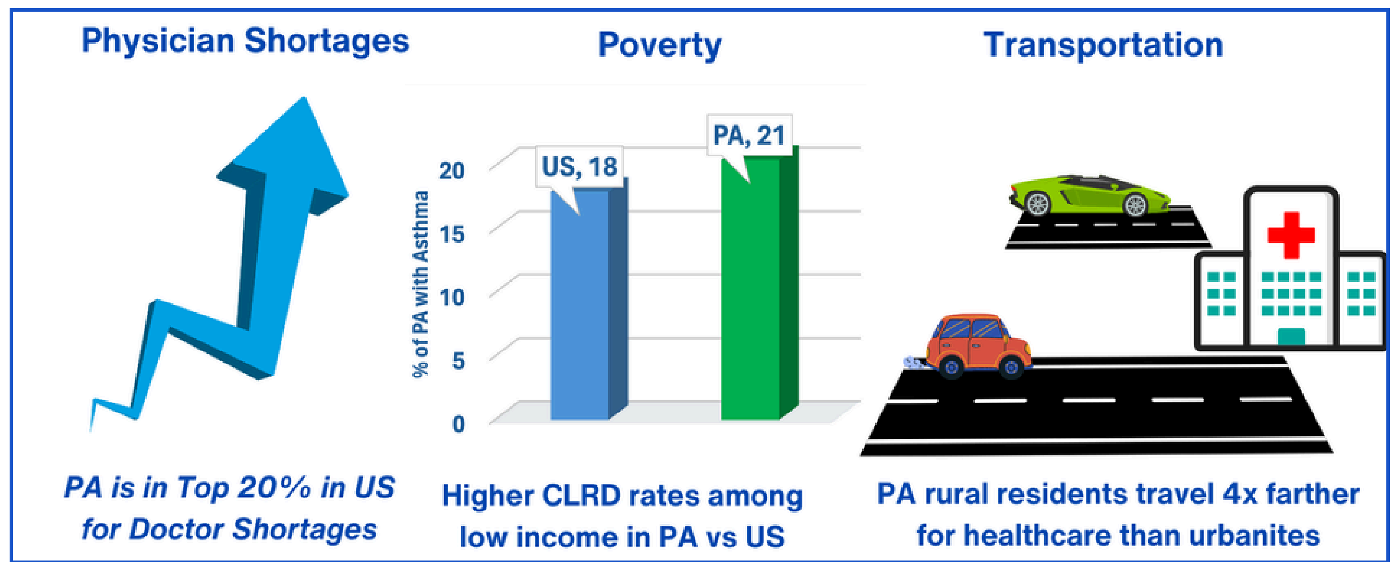
The integration of Telemedicine as a popular medical platform has accentuated two critical issues for public health in Pennsylvania.

While **Telemedicine** can broaden access to healthcare, it can also hinder equitable care (Haimi, 2023; Huang, 2023).

- Healthcare providers are not able to directly measure key vital signs for PA patients via Telemedicine platforms.
- This requires that some patients, especially those with chronic illnesses to go beyond Telemedicine and seek clinic based testing.
- In-person care poses **barriers** for PA elderly, disabled, and low-income residents, such as cost, lack of transportation, and doctor shortages (DiMaria-Ghalili, 2023).

Pennsylvania Case Study



(Source: PA DOH, 2023)

*Figure 1. Case Study (**LEARN MORE**)*

2 Goals

We developed a **Timeline** for project pacing. Next, we created project goals for designing a **Mid-Fidelity Prototype**. **IRB** approved the the Project.

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1. Integrate advancements in science and engineering, such as **nanotechnology**, to develop a **Biomedical Engineering Prototype**.
2. Accurately measure key vital signs for overall health:

Respiration Rate (RR)	Forced Vital Capacity (FVC)
Heart Rate (HR)	Blood Oxygen Saturation (SpO2)

3. Adhere to **Universal Design Principles**, including comfort, low cost, accessible, durable, and sustainable.
4. Integrate **Artificial Intelligence** (AI) for customizations.
5. Use Universal Design Principles to create a mobile application that securely transmits and displays physiological functions using Wi-Fi and **IoMT** networking.

This digital poster provides an interactive experience for readers by including links to Team BioTech's website. Click on any image or underlined term to connect to our website.

Integrating E-Textiles, Nano-Technology, and AI to Enhance Physiological Data Acquisition

Emma A. Simmons & Sarah C. Simmons

3 Design & Build

Designed using Universal Design Principles. Schematics (Fig, 2 & 4) were drawn and components were assembled (Fig. 3) and evaluated.

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Microprocessor: Arduino Nano operates sensors with unique code.

Coding: Novel C++ code written to program sensors.

Conductive Fabric: Utilized as RR and FVC sensors to measure changes in voltage with breathing. **Graphene** was added for durability and enhanced conductivity.

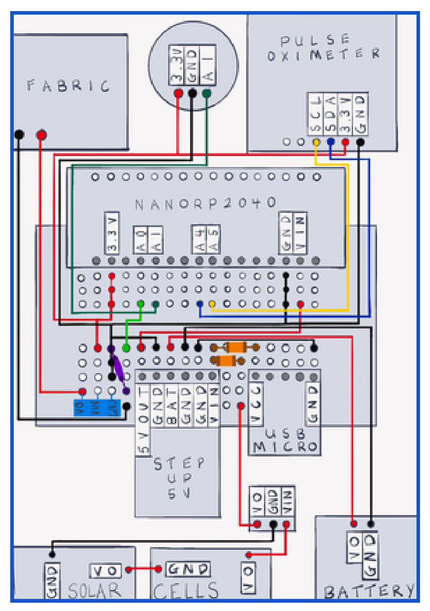

Figure 2: Wiring schematic

Inertia Measurement sensor and AI: measures move-ment and distinguishes between typical and atypical RR patterns in the wearer.

Spectral Sensors: **Photoplethysmography** for HR and SpO2.

IoMT Mobile Application: Vital signs displayed and transmitted to healthcare providers using Blynk.

Power Source: Li-Po battery provides power to the Prototype. **Solar cells** offer a secondary power option.

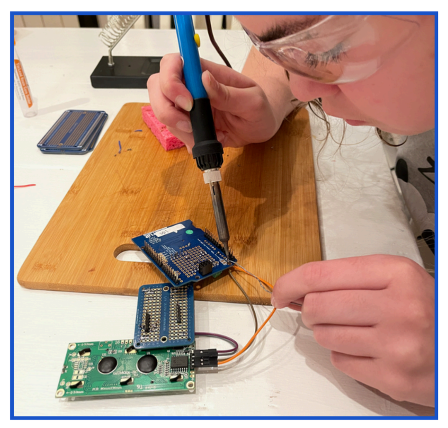

Figure 3. Building circuitry

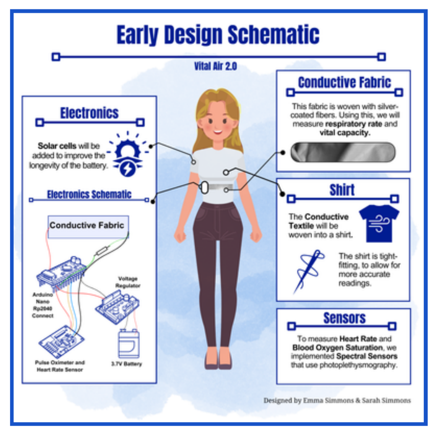

Figure 4. Design schematic

4 Testing & Iterations

Figure 5: Testing the Prototype in the lab

We tested the Prototype's sensor system to determine accuracy and ease of use. **Learn More about Testing**.

1. **Treatments:** Team Member engaged in 3 treatments: Sitting, Standing, and Climbing Stairs. Second member recorded data from Mobile App.
2. **Test 1**: In this test, a team member wore Vital Air 2.0 while the Treatments were applied.
3. **Test 2**: Conducted with Team member using commercial grade equipment, a BioPac **Spirometer** and **ECG** and a Santamedical SpO2 monitor (Fig. 5).
4. **Iterations:** Prototype accuracy was improved by revising the FVC and RR equations. HR was improved by increasing sampling rate and changing sensor location. Several iterations were undertaken to optimize functionality. **Learn More.**
5. **Graphene:** A graphene epoxy was applied to the conductive fabric to improve durability and protect conductivity, especially with washing. (Rohen, 2024). We washed the fabric and a control 20 times, testing after each washing with a tensile meter (Kuphalt, 2023) and a 2000x digital microscope. **Learn More.**

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5 Findings & Analysis

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Sensor Findings: For the RR sensor, we selected the conductive fabric woven with silver-coated fibers, which showed the largest change in resistance when stretched. We also tested conductive fabric as electrodes for ECG, but we found that a spectral heart rate sensor was more accurate.

Prototype Findings: Pearson-r analysis indicated that Vital Air 2.0 produced vital biofunction measurements comparable to commercial equipment (Charts 1 & 2) with p-values ranging from <0.01 to 0.1 (Table 1).

Vital BioFunction	Prototype	Commercial	Pearson r	p-value
Respiration Rate (breaths per min)	16.0	17.3	0.99	$p < 0.05$
Forced Lung Capacity (liters)	2.46	2.51	0.66	$p < 0.05$
Blood Oxygen Saturation (% SpO2)	97.5%	98.5%	0.77	$p < 0.1$
Heart Rate (beats per min)	90.0	90.1	0.96	$p < 0.01$

Table 1. Vital Air 2.0 is comparable in accuracy to commercial devices. (Learn More)

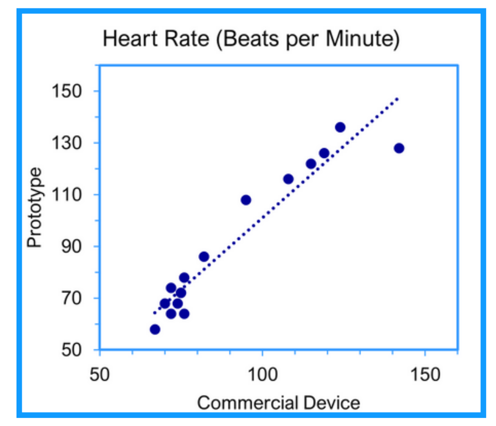

Chart 1. HR Comparison (MORE)

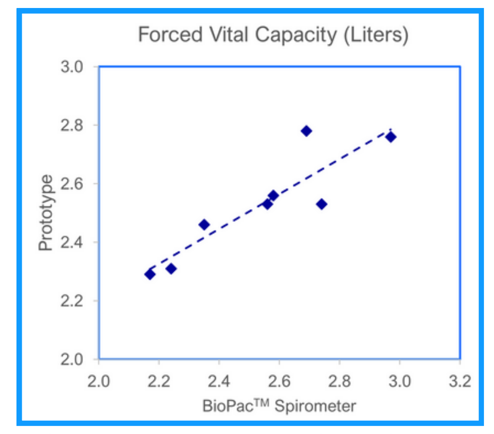

Chart 2. FVC comparison (MORE)

Graphene Findings: We found that there were no significant differences between the graphene-coated fabric and the control conductive fabric. (Chart 3). We concluded the graphene would not improve the Prototype, and so it was not used. (**Learn More**)

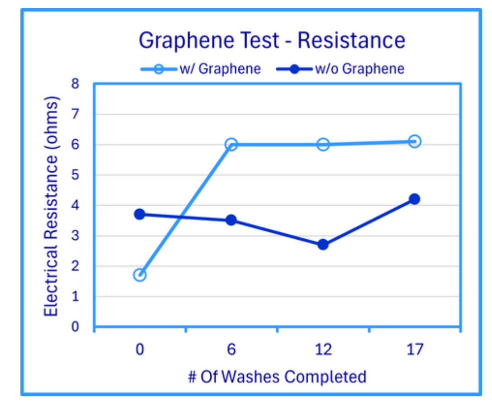

Chart 3. Graphene Test (MORE)

6 Conclusions

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IMPROVES TELEMEDICINE — **VITAL AIR 2.0** Telemedicine doctors can measure vital signs in real-time.

COMPARABLE ACCURACY — **VITAL AIR 2.0** offers comparably accurate and lower cost alternative to commercial testing equipment that requires clinic visits. (**Learn More**)

EQUITABLE HEALTHCARE — **VITAL AIR 2.0** removes barriers to healthcare for PA residents by offering low-cost, accessible, remote way to send key medical data to doctors.

***Learn More** about the Comparability of Vital Air 2.0 and Commercial Equipment*