



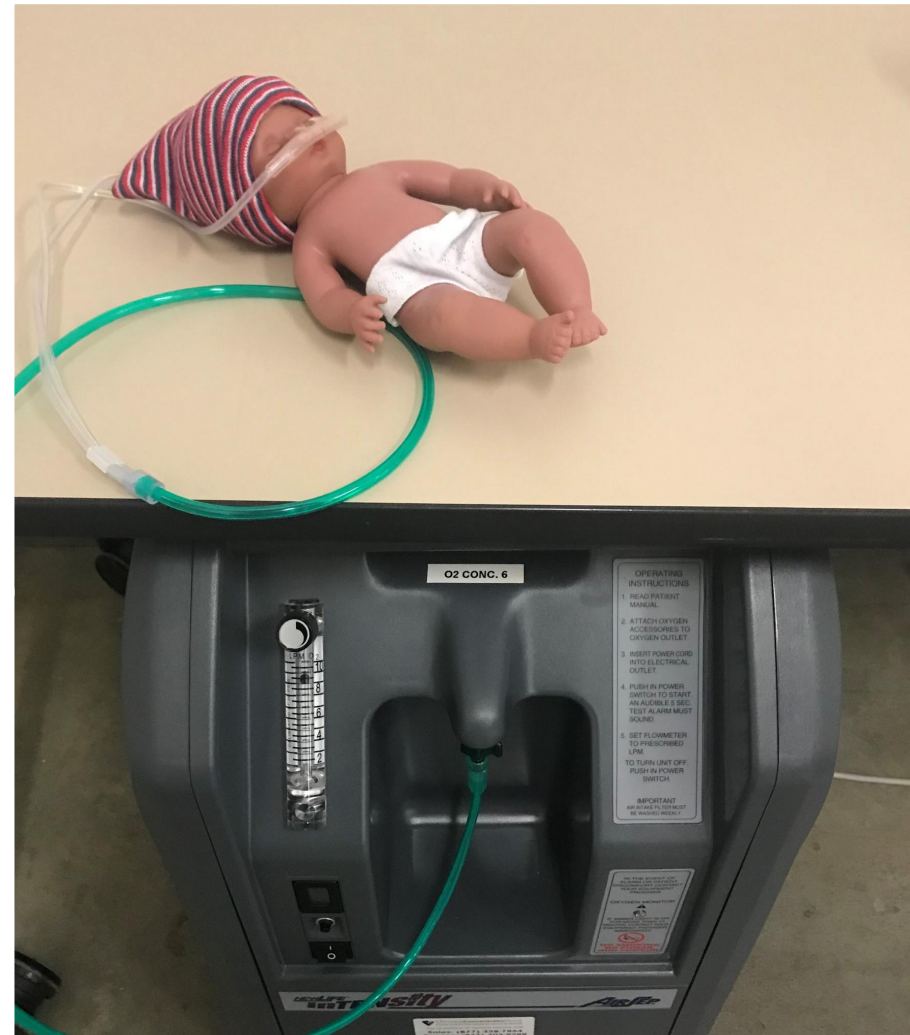
# ArtemisHFNC

## Team Let's Get This Breath

Hannah Andersen, Keeler Gonzales, Dora Huang,  
Carrigan Hudgins, Eric Torres, Hoang Vu

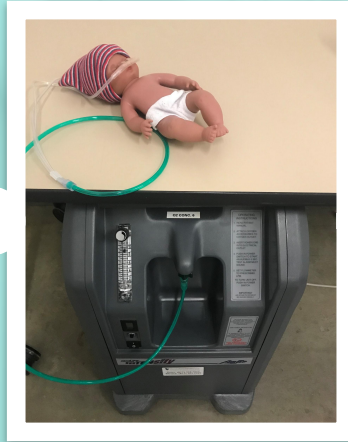
Sponsored by Dr. Rohith Malya





Low Flow Therapy





High Income

High Flow Therapy



Low Income





# 2 million

annual pediatric  
deaths from  
pneumonia



**~ 1 million**  
in Sub-Saharan Africa



# High Income Countries **Have** Oxygen Therapy Infrastructure





# High Income Countries **Have** Oxygen Therapy Infrastructure



High Flow Nasal  
Cannula (HFNC)

# HFNCs can treat severe respiratory illnesses

## Issues with current systems:

- Reliance on centralized oxygen infrastructure
- Expensive (\$4,000/unit)



# Low Income Countries **Lack** Oxygen Therapy Infrastructure



# Low Income Countries **Lack** Oxygen Therapy Infrastructure



Oxygen Concentrator



Oxygen Cylinder

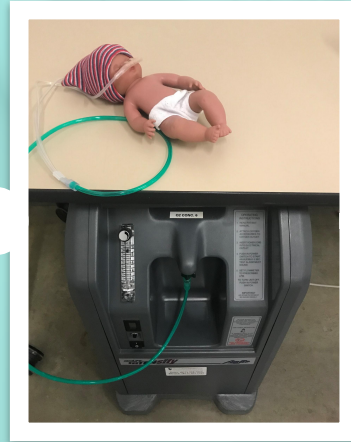




# ArtemisHFNC

- Cost: \$500
- Compatible with any oxygen source





High Income

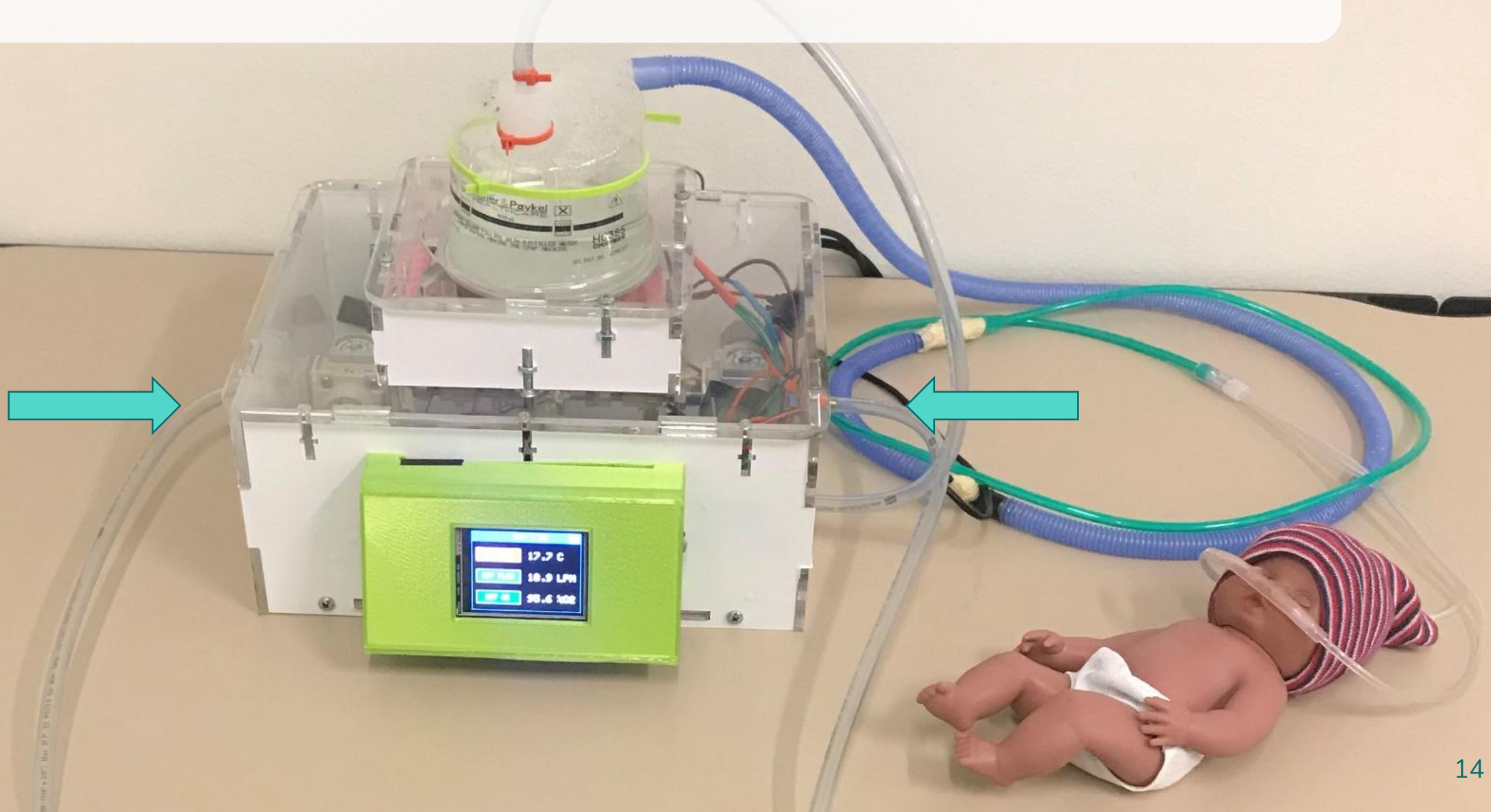


Low Income

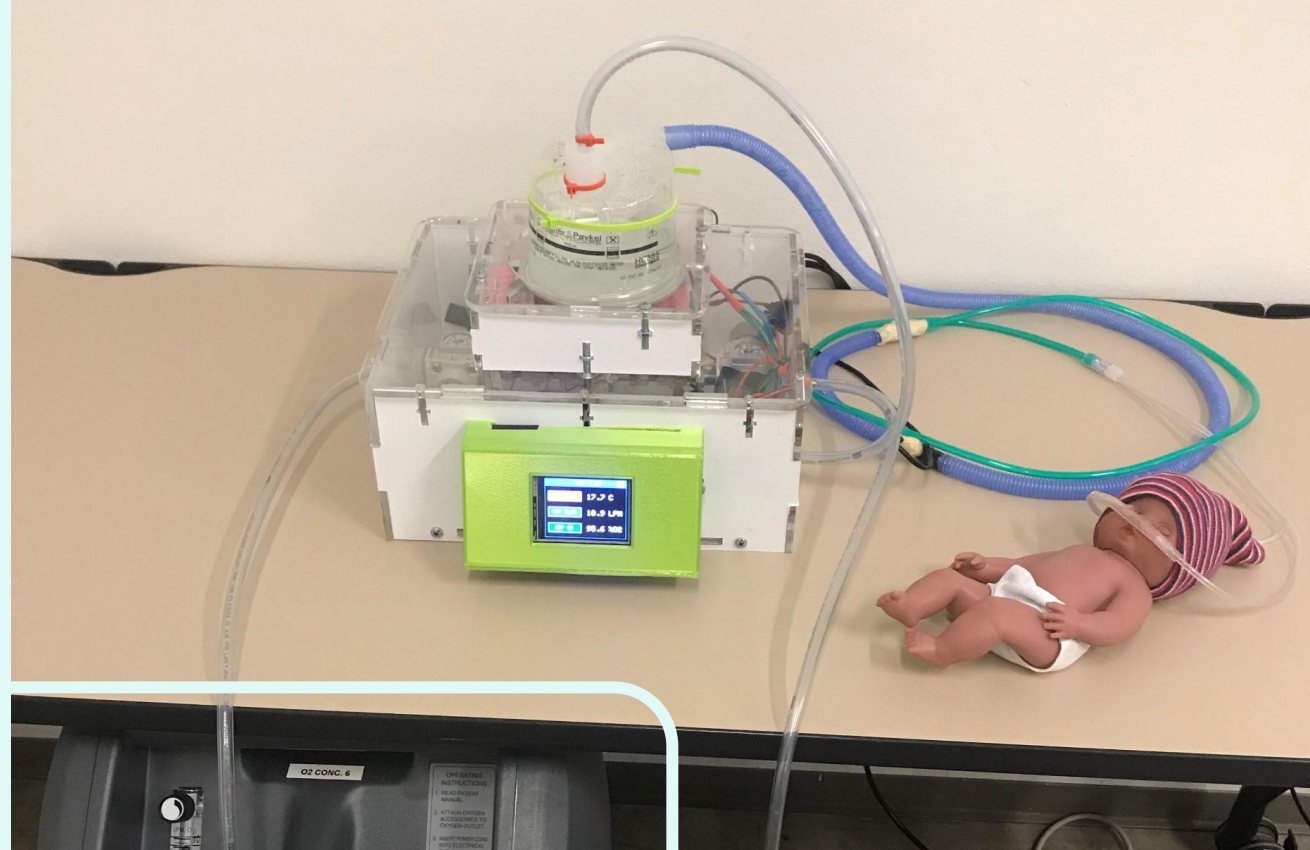




Connect an air source and oxygen source



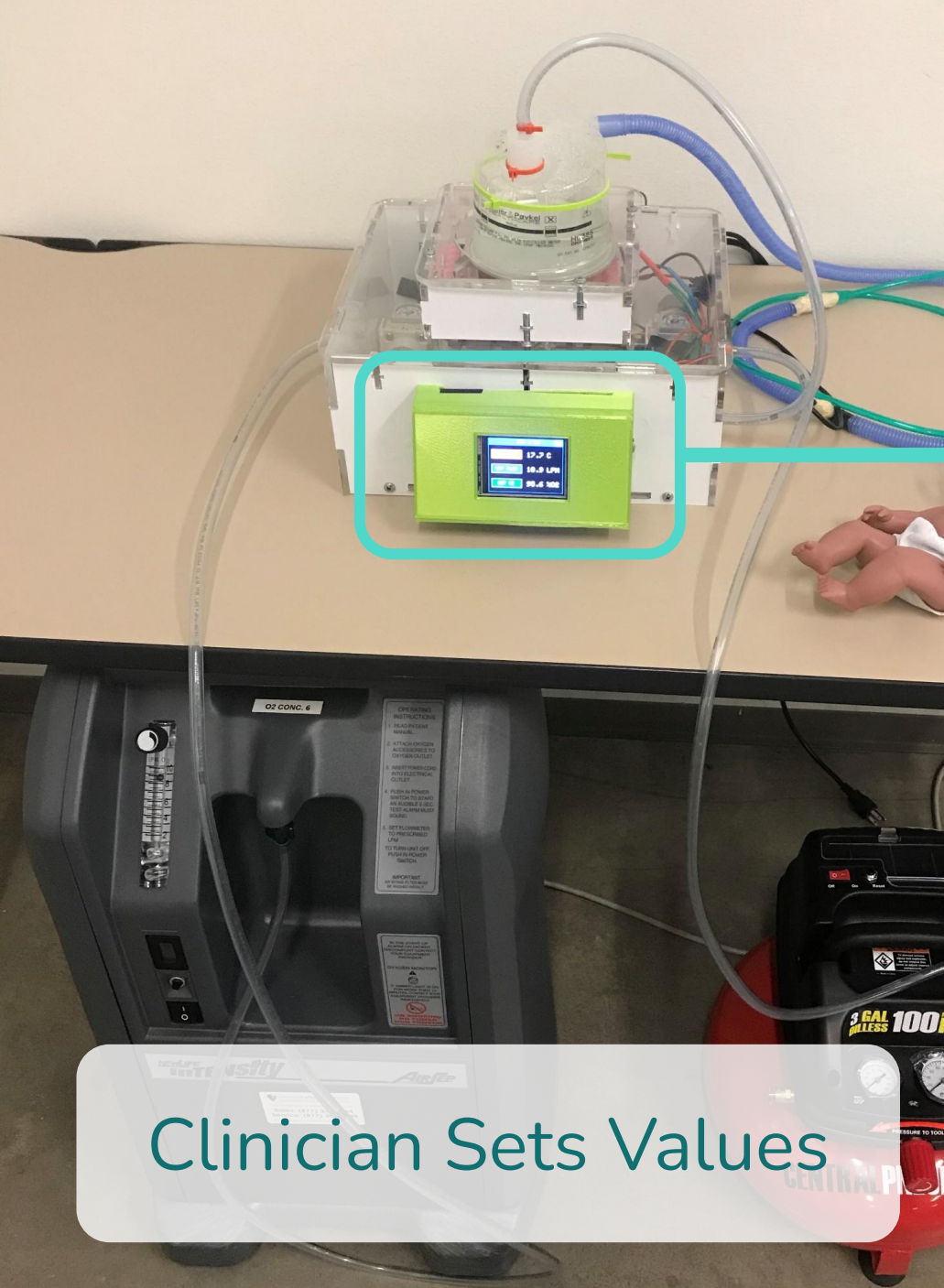
Oxygen  
Concentrator



Air Compressor







Clinician Sets Values





20 LPM

40% O<sub>2</sub>

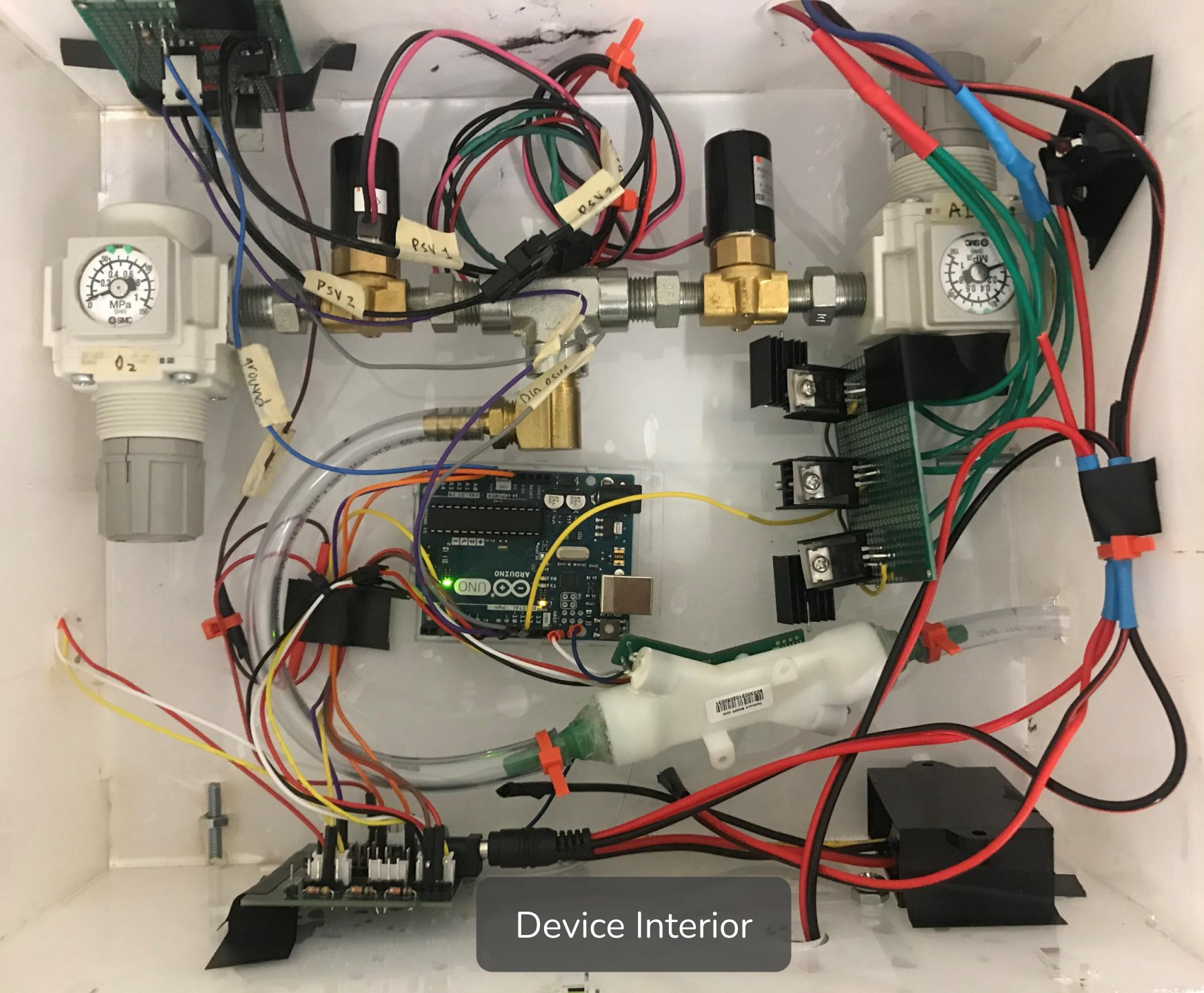
A newborn baby is lying on a blue surface, wearing a red and white striped hat and a white diaper. A clear plastic tube is inserted into the baby's mouth. In the background, there is medical equipment, including a green device with a screen and various tubes and wires.

20 LPM

40% O<sub>2</sub>

Optimize therapy and  
patient comfort





Device Interior

Blends air and  
oxygen sources  
to achieve:

**10-40 LPM**

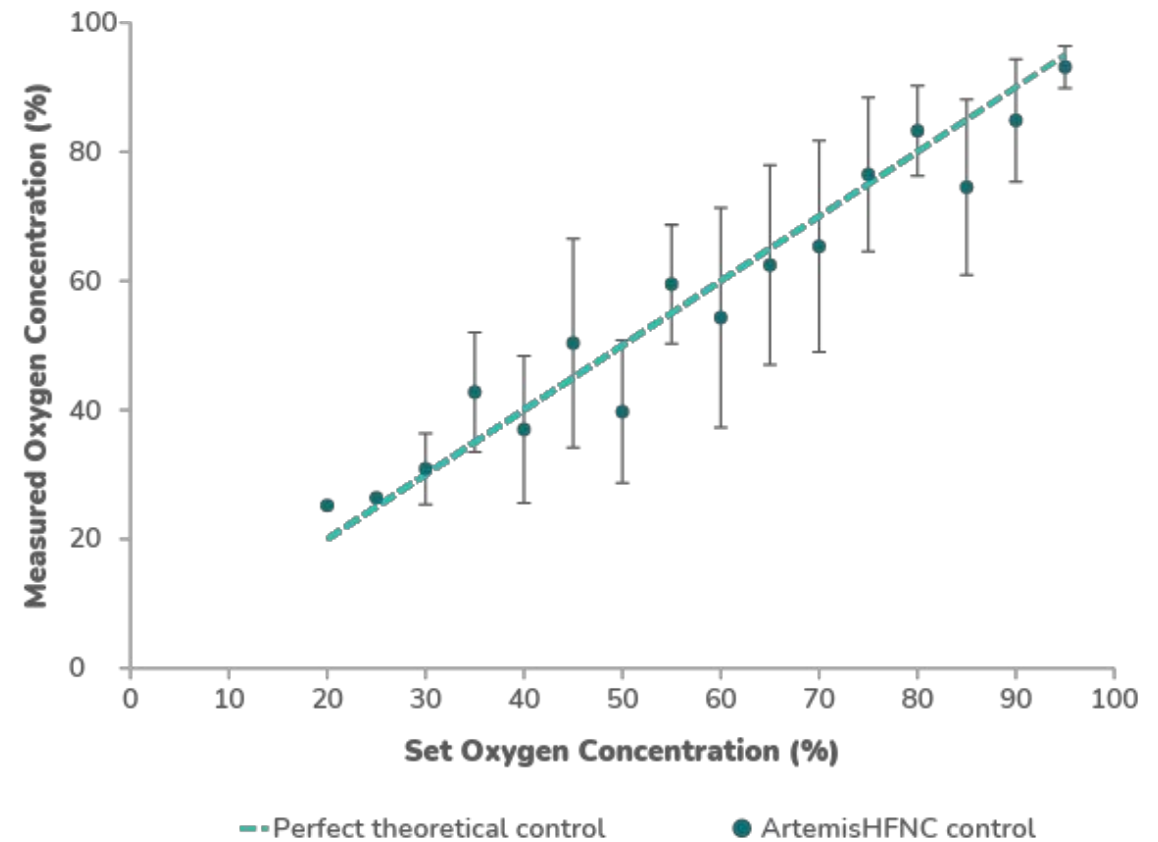
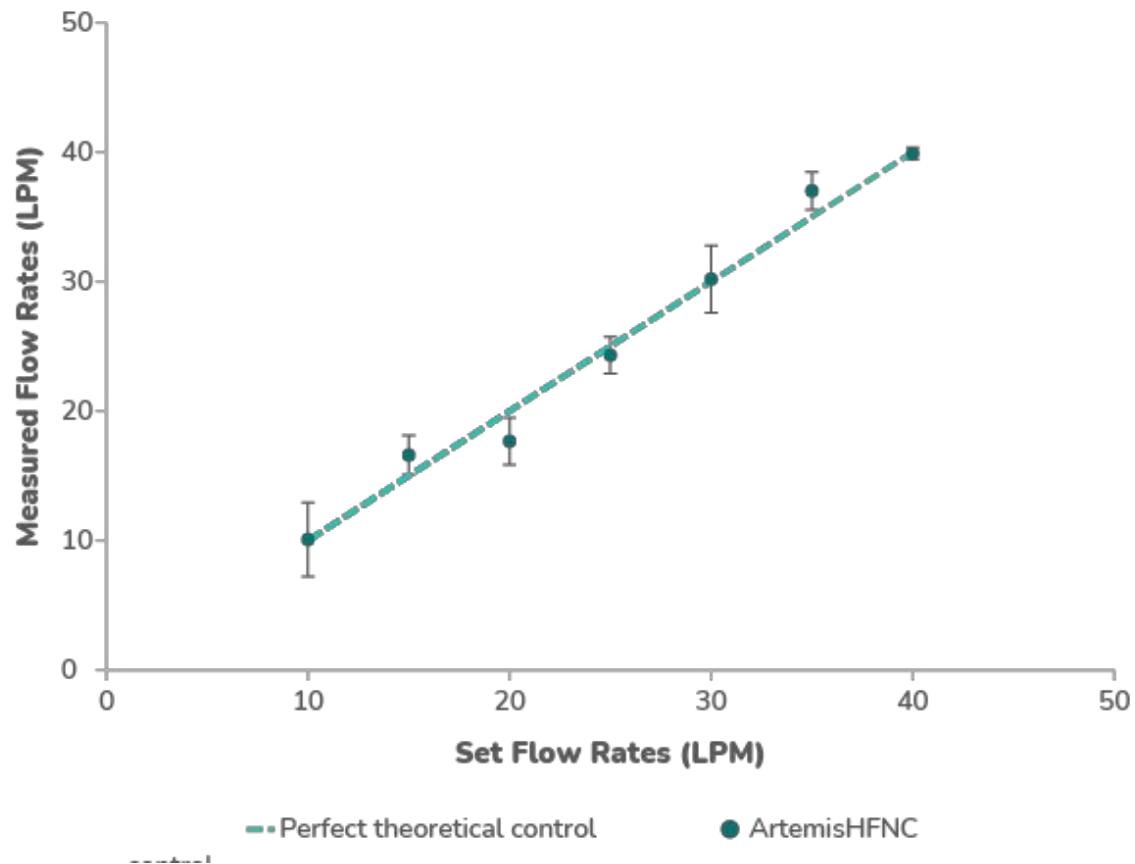
**20-95% O<sub>2</sub>**

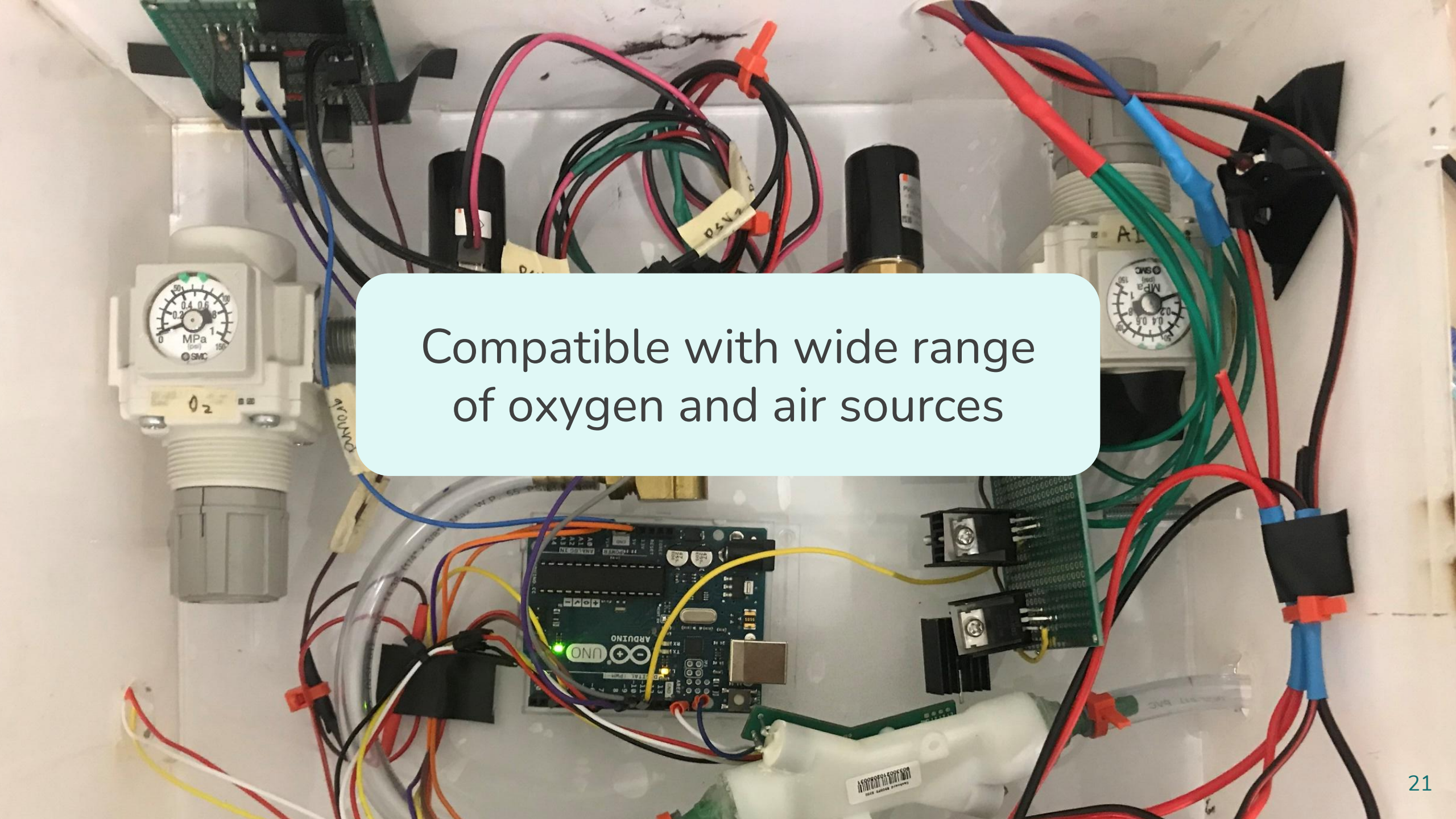


Testing data demonstrates ability to achieve:

10-40 LPM

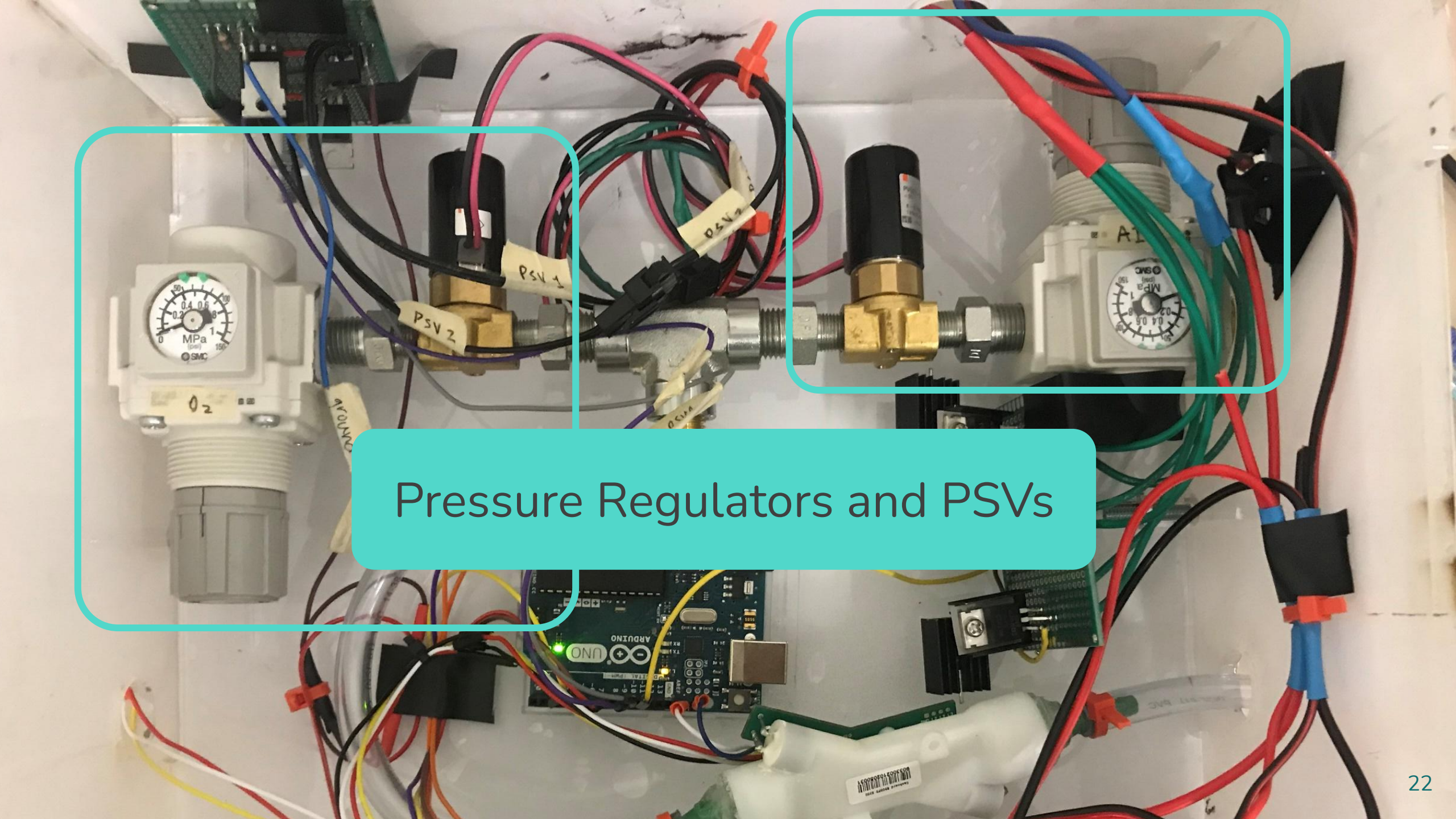
20-95% O<sub>2</sub>





Compatible with wide range  
of oxygen and air sources

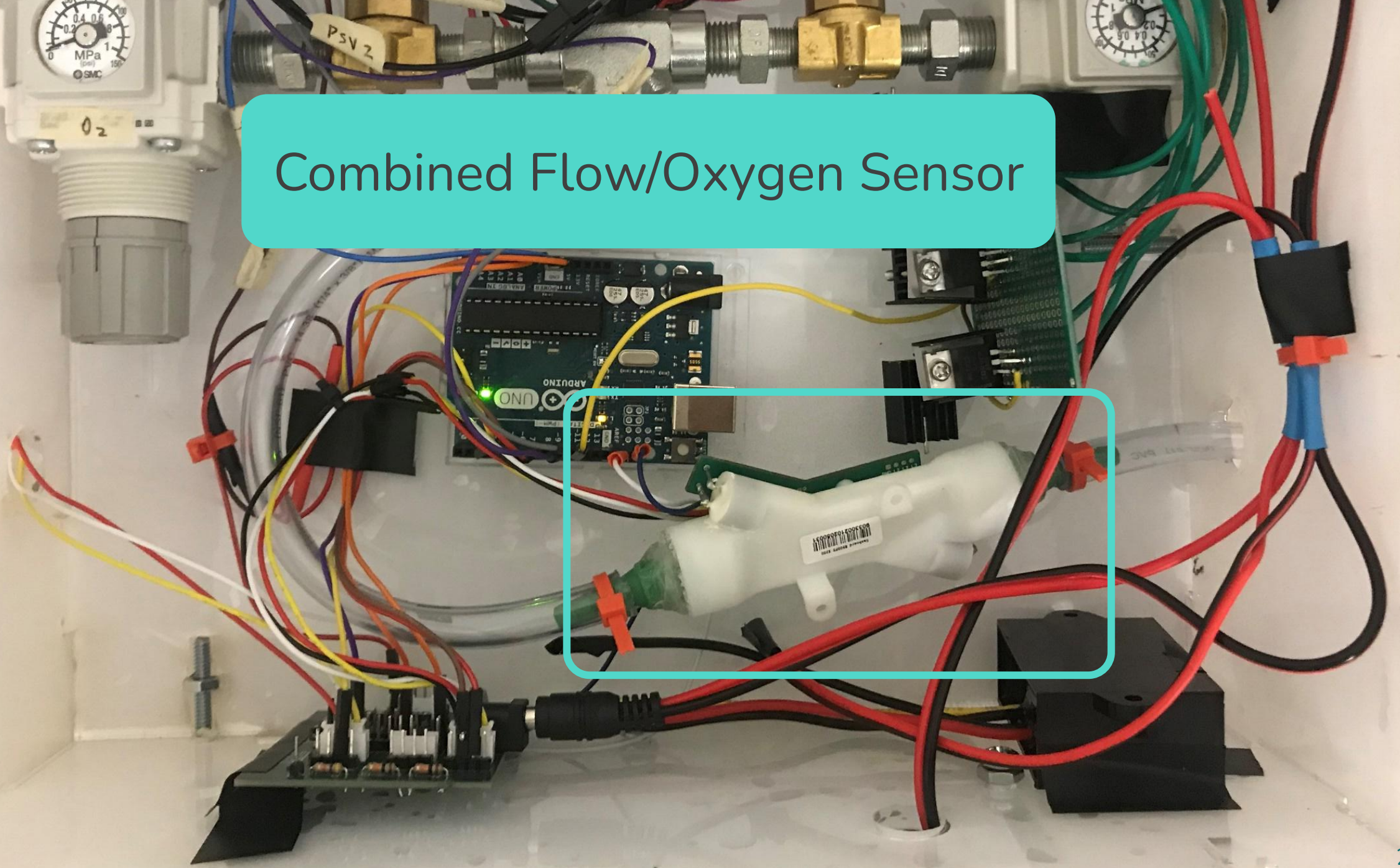




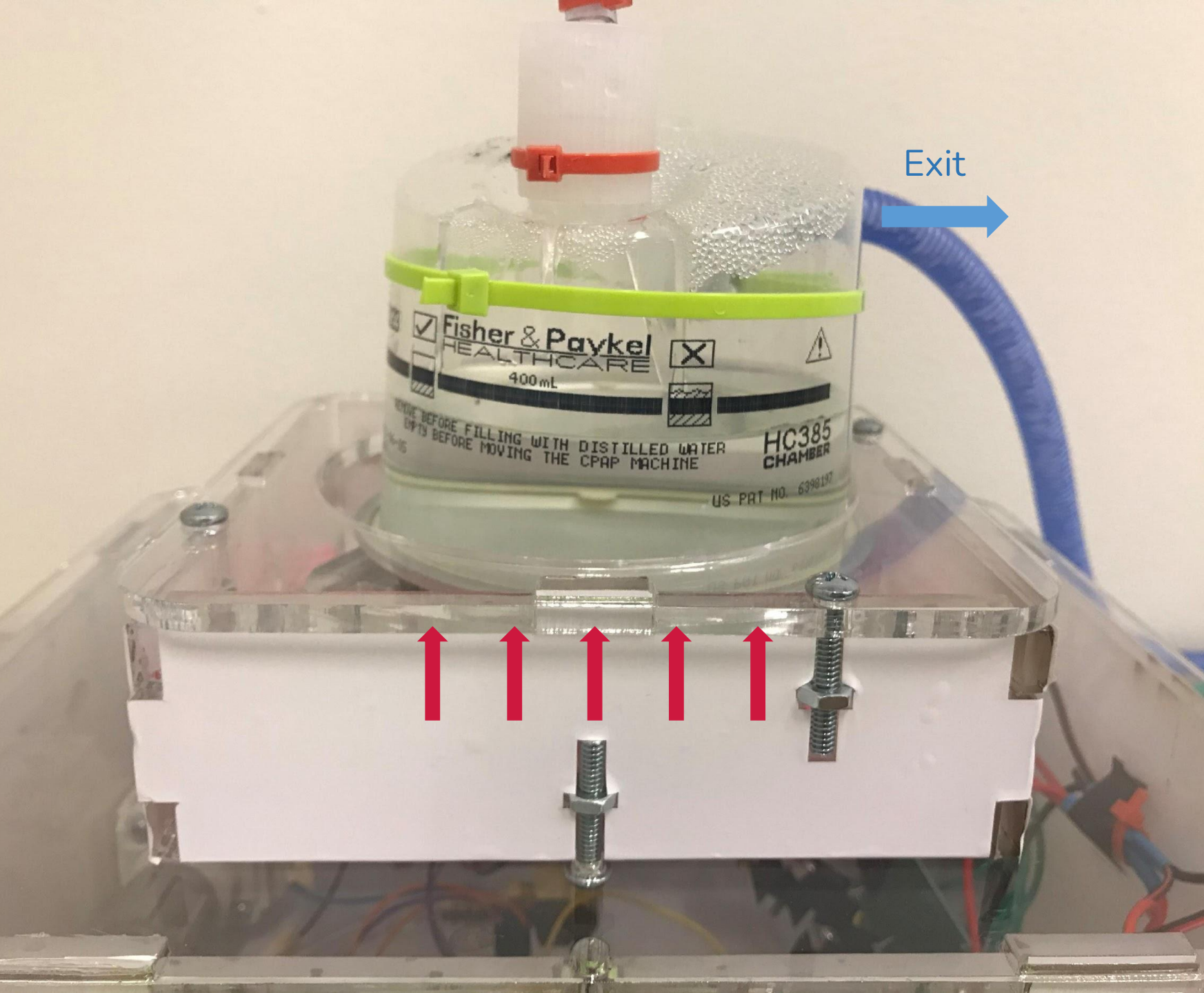
## Pressure Regulators and PSVs



## Combined Flow/Oxygen Sensor







Heats air to

$37^{\circ}\text{C}$

Humidifies air to

$>12\text{ mg/L}$



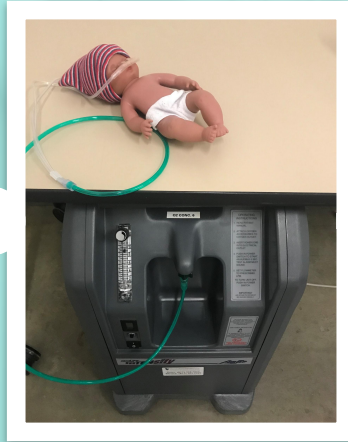


# ArtemisHFNC

- Intuitive user interface
- Novel blending system
- Heater/humidifier system





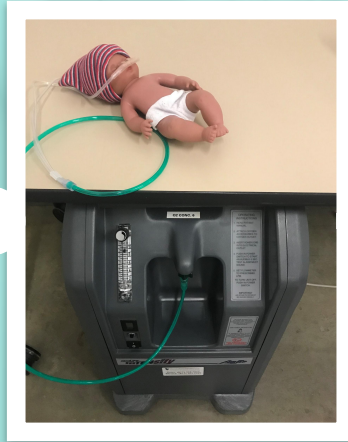


High Income



Low Income





High Income



Low Income





The  
United  
States  
of  
America

The Director of the United States  
Patent and Trademark Office

Has received an application for a patent for a  
new and useful invention. The title and descrip-  
tion of the invention are enclosed. The require-  
ments of law have been complied with, and it  
has been determined that a patent on the in-  
vention shall be granted under the law.

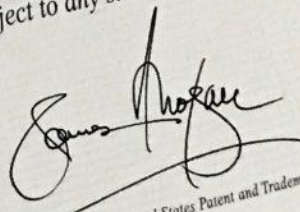
Therefore, this

### United States Patent

Grants to the person(s) having title to this patent  
the right to exclude others from making, using,  
offering for sale, or selling the invention  
throughout the United States of America or im-  
porting the invention into the United States of  
America for the term set forth below, subject  
to the payment of maintenance fees as provided  
by law.

If this application was filed prior to June 8,  
1995, the term of this patent is the longer of  
this term or twenty years from the date of grant of this  
patent or twenty years from the date of filing of the ap-  
plication, whichever is longer, subject  
to any statutory extension.

If this application was filed on or after June 8,  
1995, the term of this patent is twenty years from  
the U.S. filing date, subject to any statutory ex-  
tension. If the application contains a specific  
reference to an earlier filed application or ap-  
plications under 35 U.S.C. 120, 121 or 365(c),  
the term of the patent is twenty years from the  
date on which the earliest application was filed,  
subject to any statutory extensions.



Director of the United States Patent and Trademark Office



# Provisional Patent

# Industry Partnership



We would like to give a special thanks to the following for their help and support.

**Advisors:**

Dr. Rohith Malya  
Dr. Sabia Abidi  
Scout Dittmar

**Collaborators:**

Rice 360° Institute  
for Global Health  
Rice Bioengineering  
Department



RICE ENGINEERING  
Bioengineering

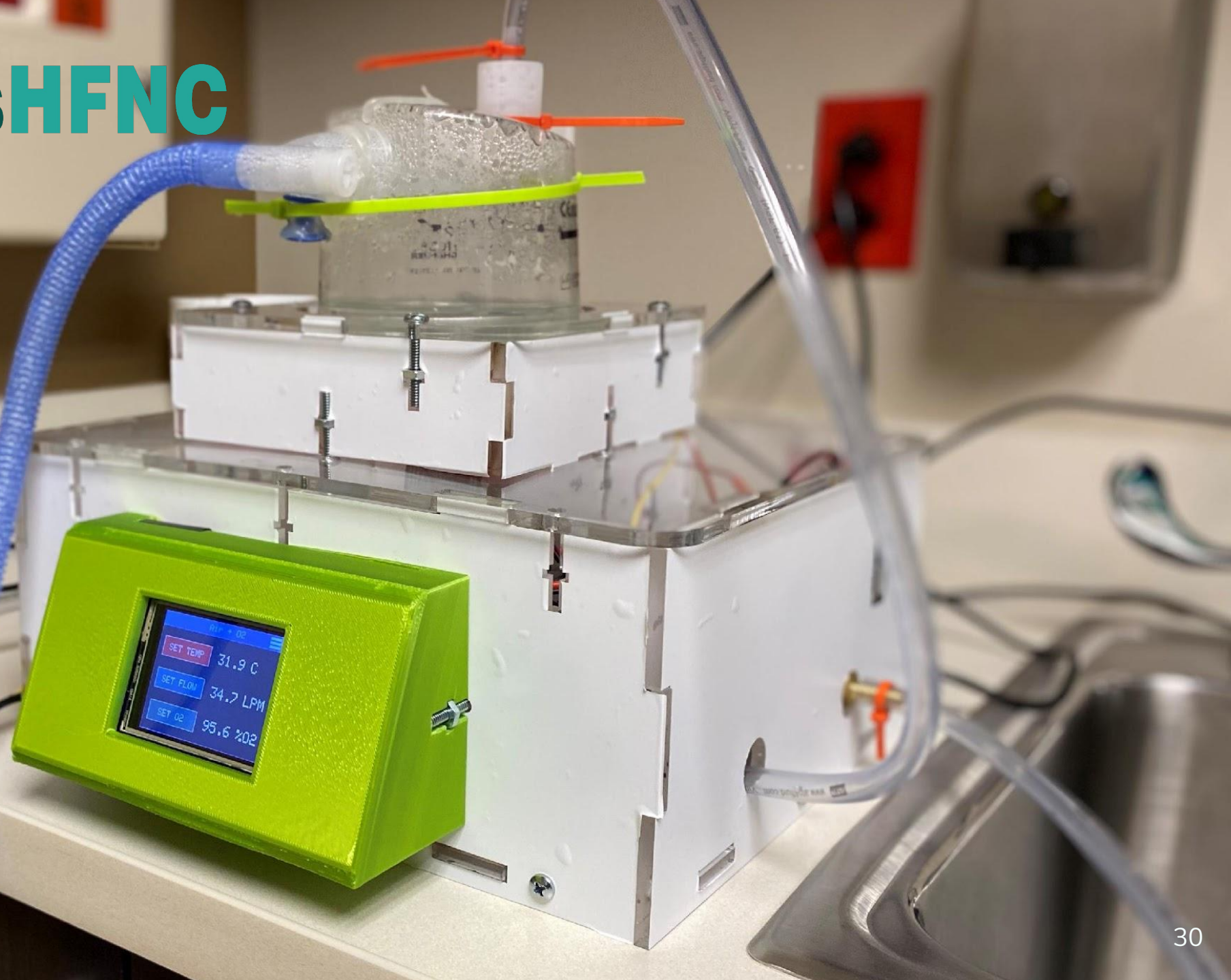


**ArtemisHFNC**





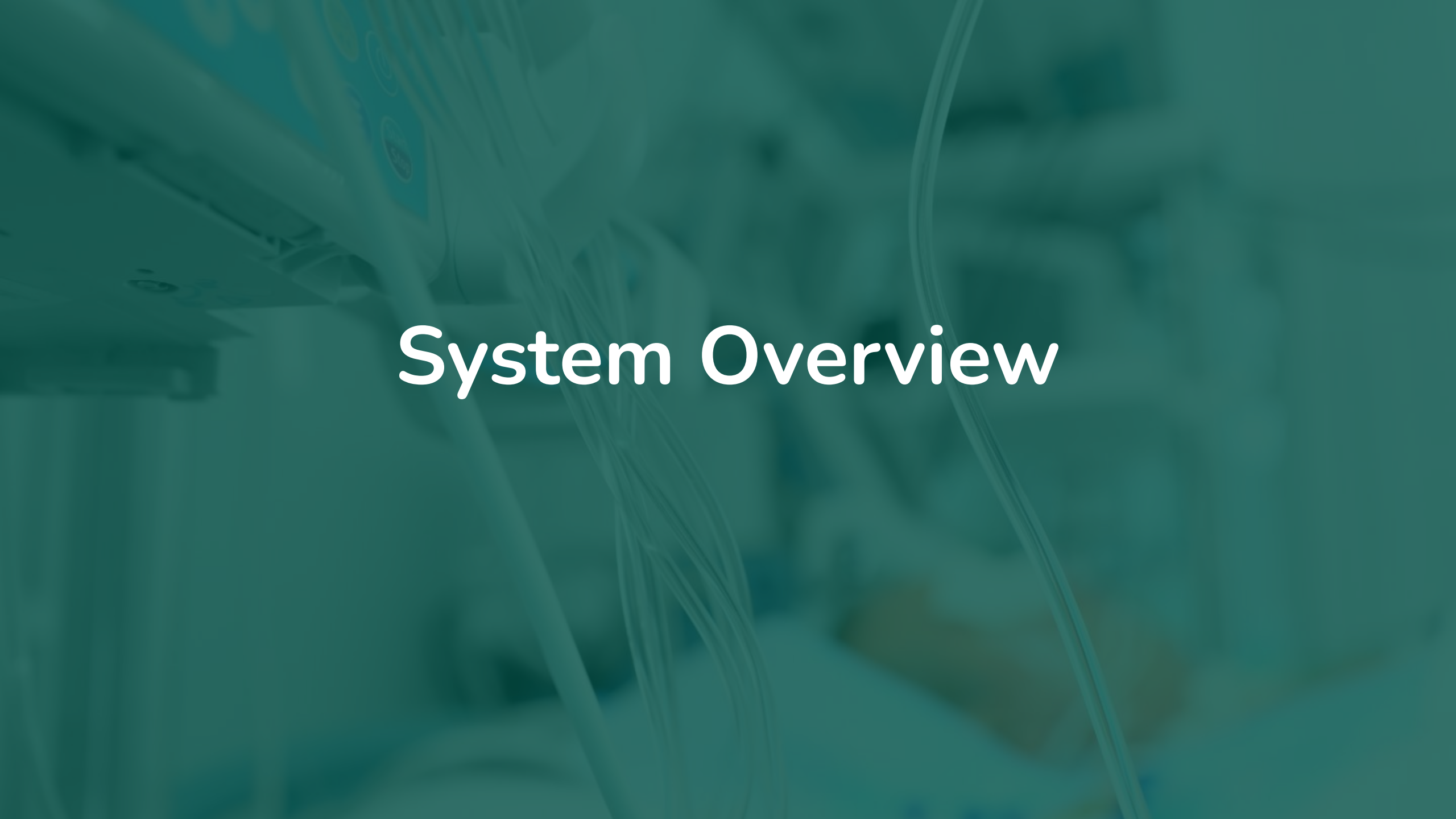
# ArtemisHFNC



The background of the slide features a blurred image of medical equipment, including what appears to be a patient bed with various tubes and sensors. A semi-transparent teal overlay covers the entire image, creating a professional and clinical aesthetic.

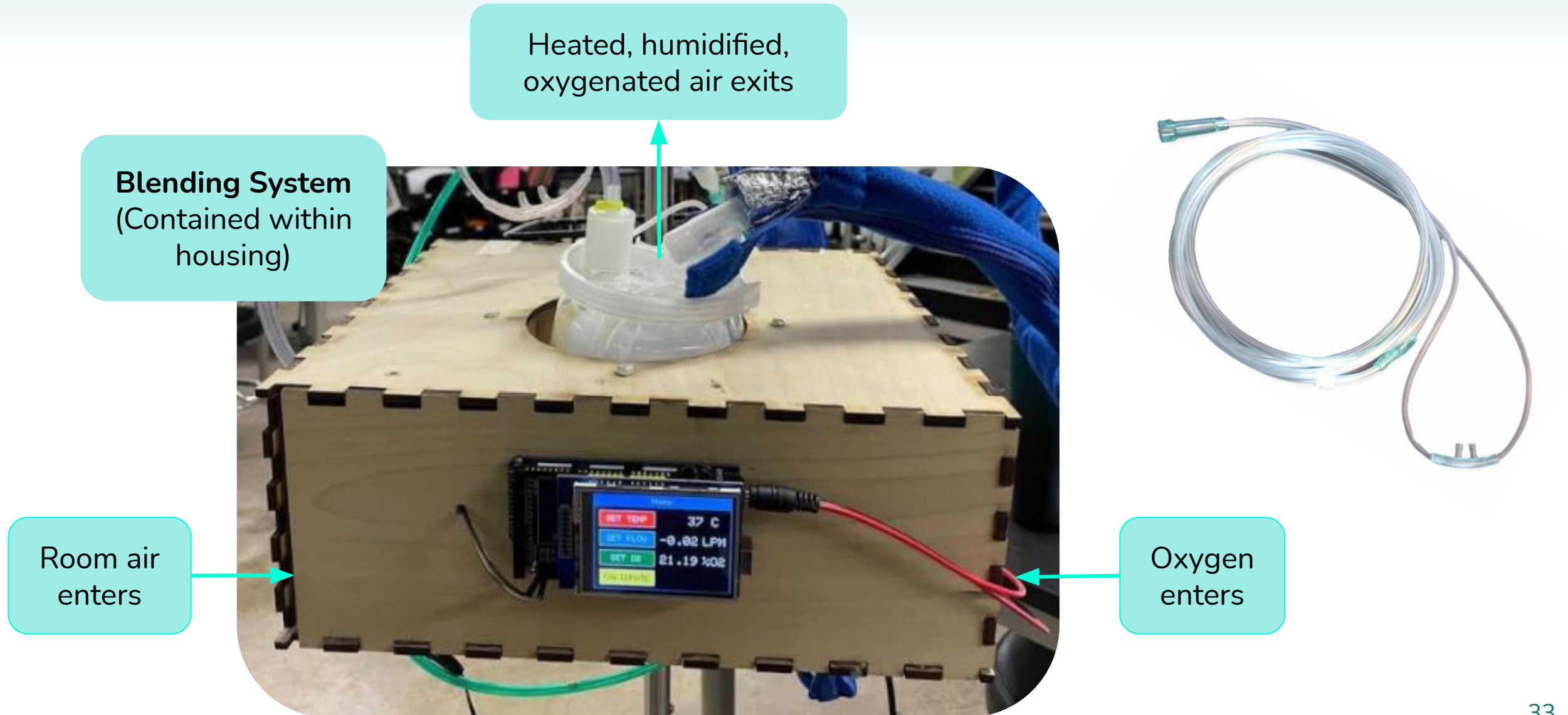
# Appendix



The background of the slide features a blurred image of a medical device, possibly a ventilator or a similar piece of equipment, with various tubes and components visible. A semi-transparent teal overlay covers the entire image, creating a professional and clinical aesthetic.

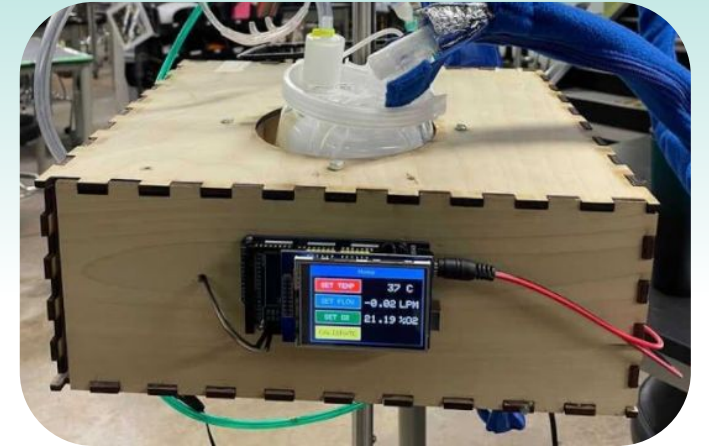
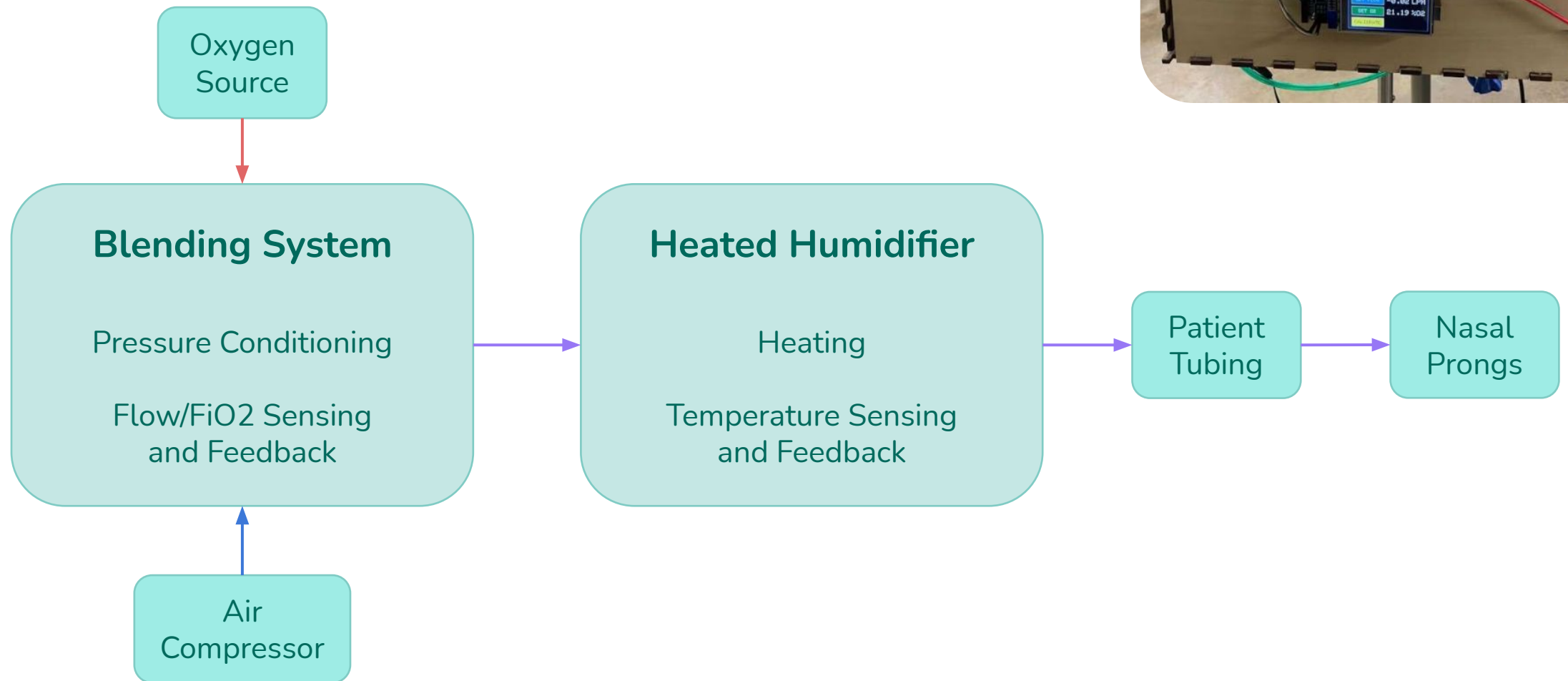
# System Overview

# Integrated System Overview

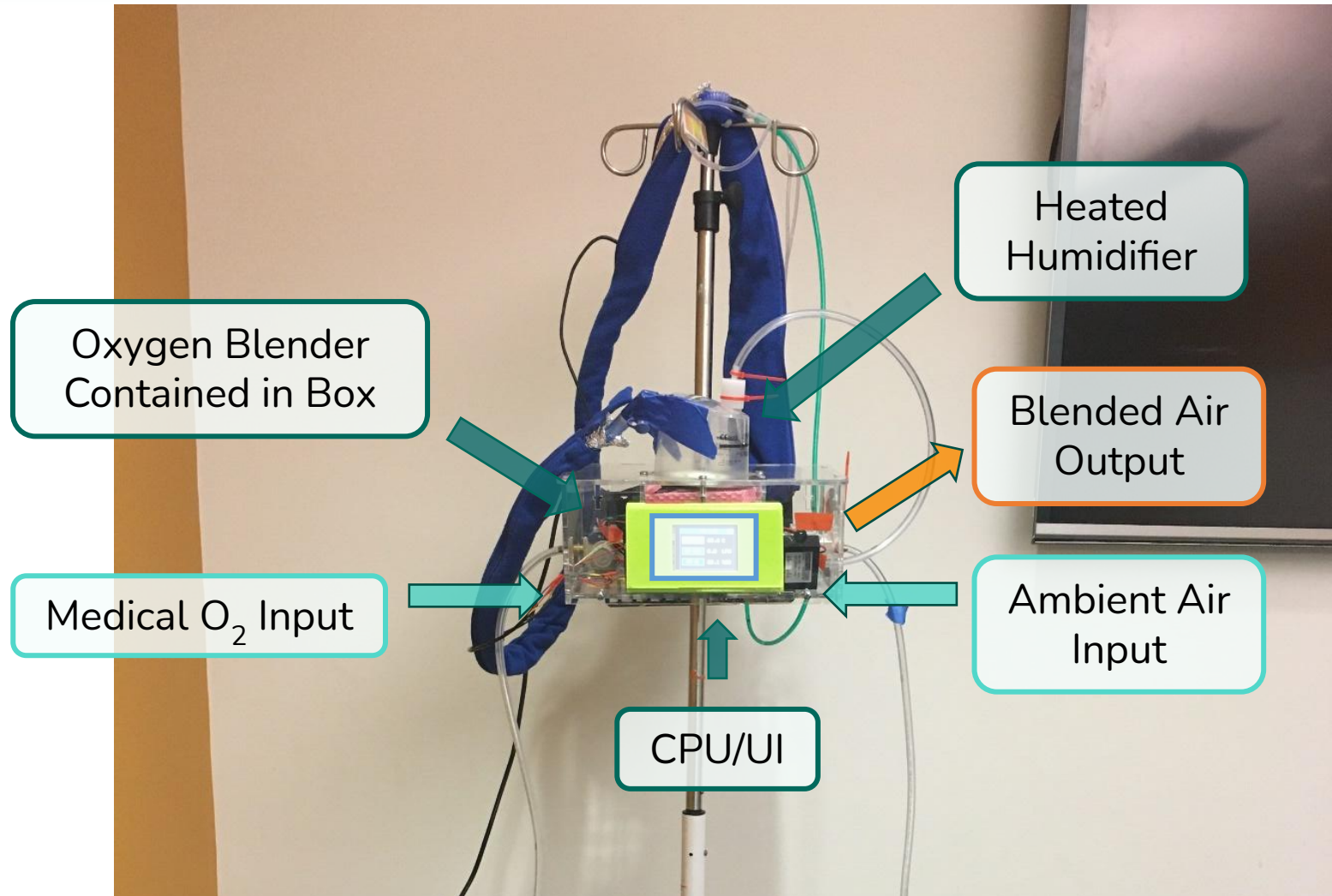




# Integrated System Overview

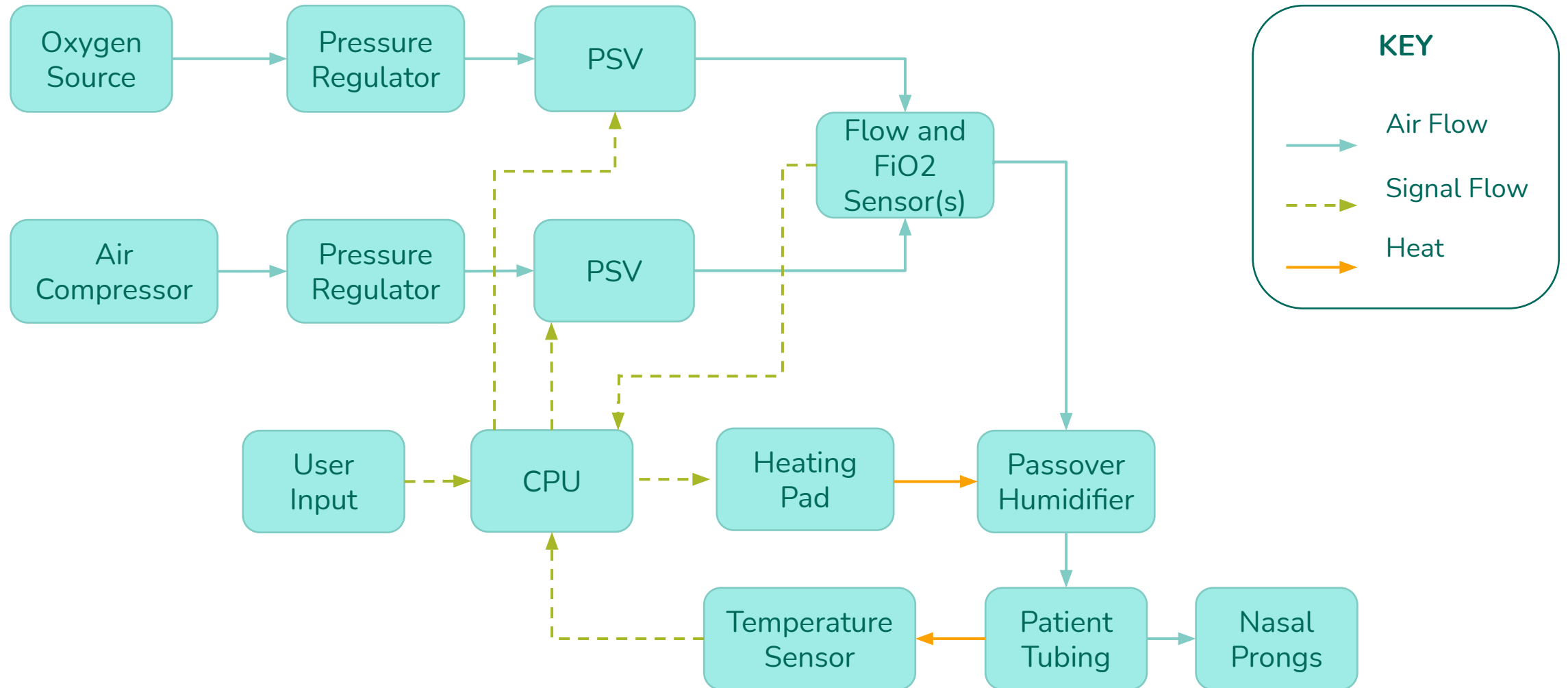


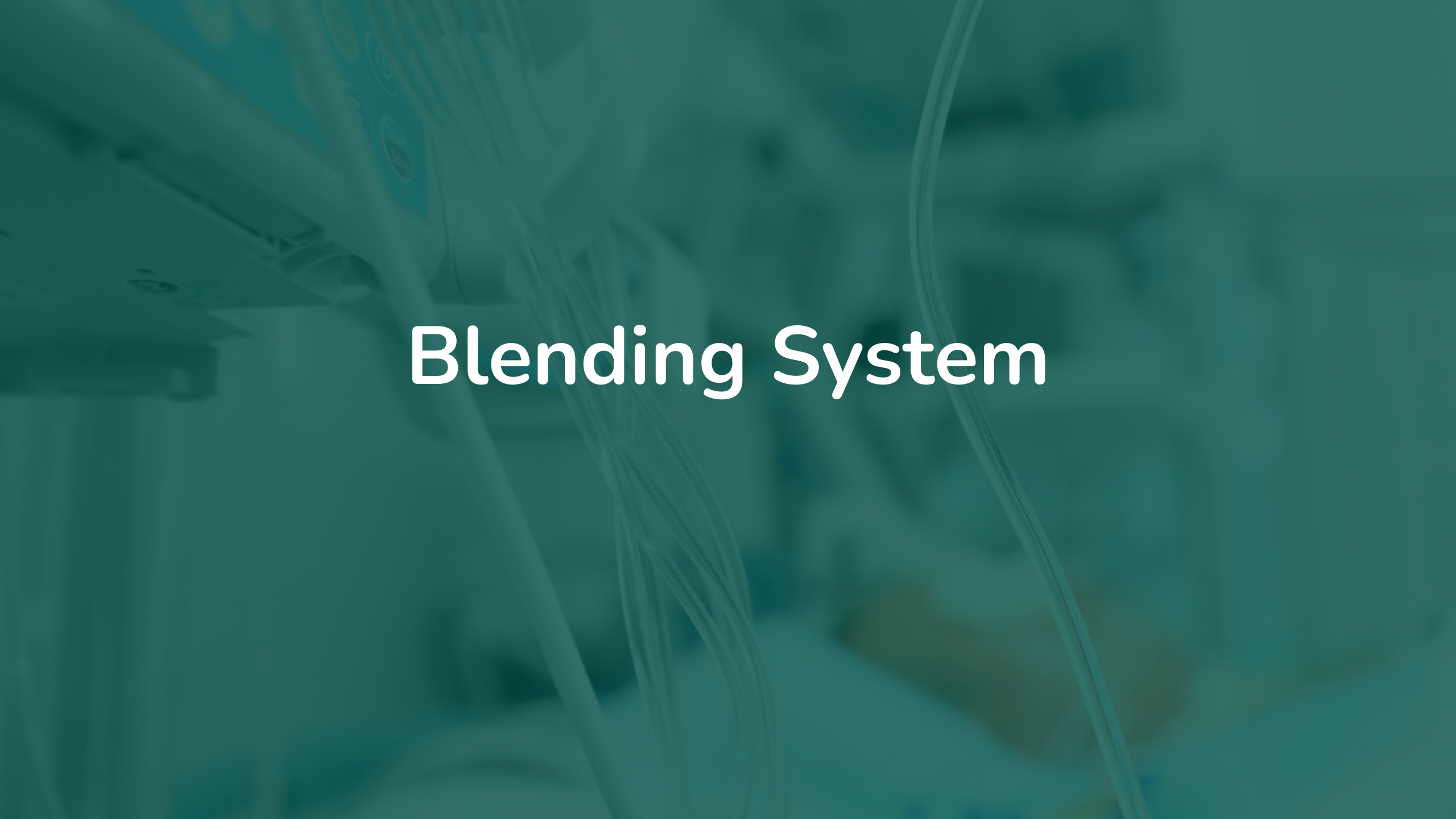
# Integrated System Overview





# System Block Diagram



The background of the slide is a teal-colored overlay on a blurred image of industrial equipment, likely a blending system. The equipment features various pipes, valves, and a control panel with several buttons and a small display screen. The overall aesthetic is clean and professional, typical of a technical presentation.

# Blending System





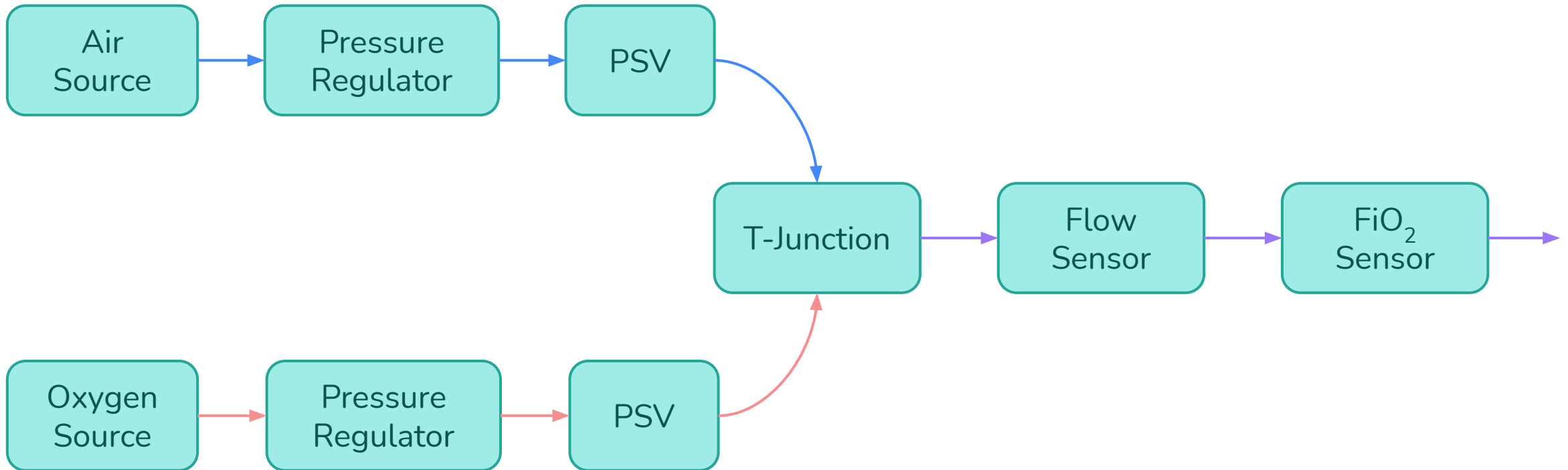
20 LPM

40% O<sub>2</sub>



# ArtemisHFNC

## Blending

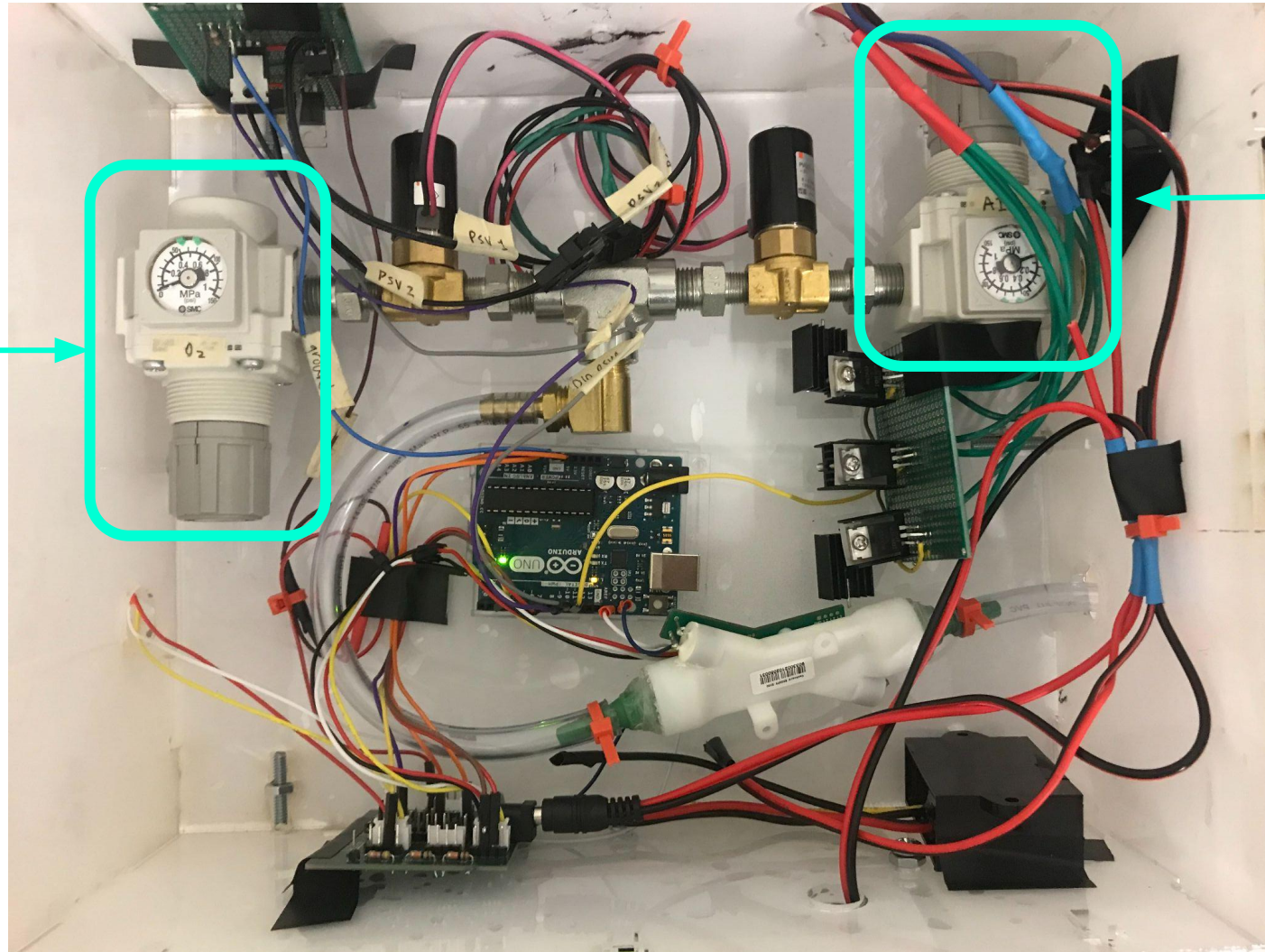




# Pressure Regulation for Compatibility with Any Oxygen Source



Pressure  
regulator for  
air source



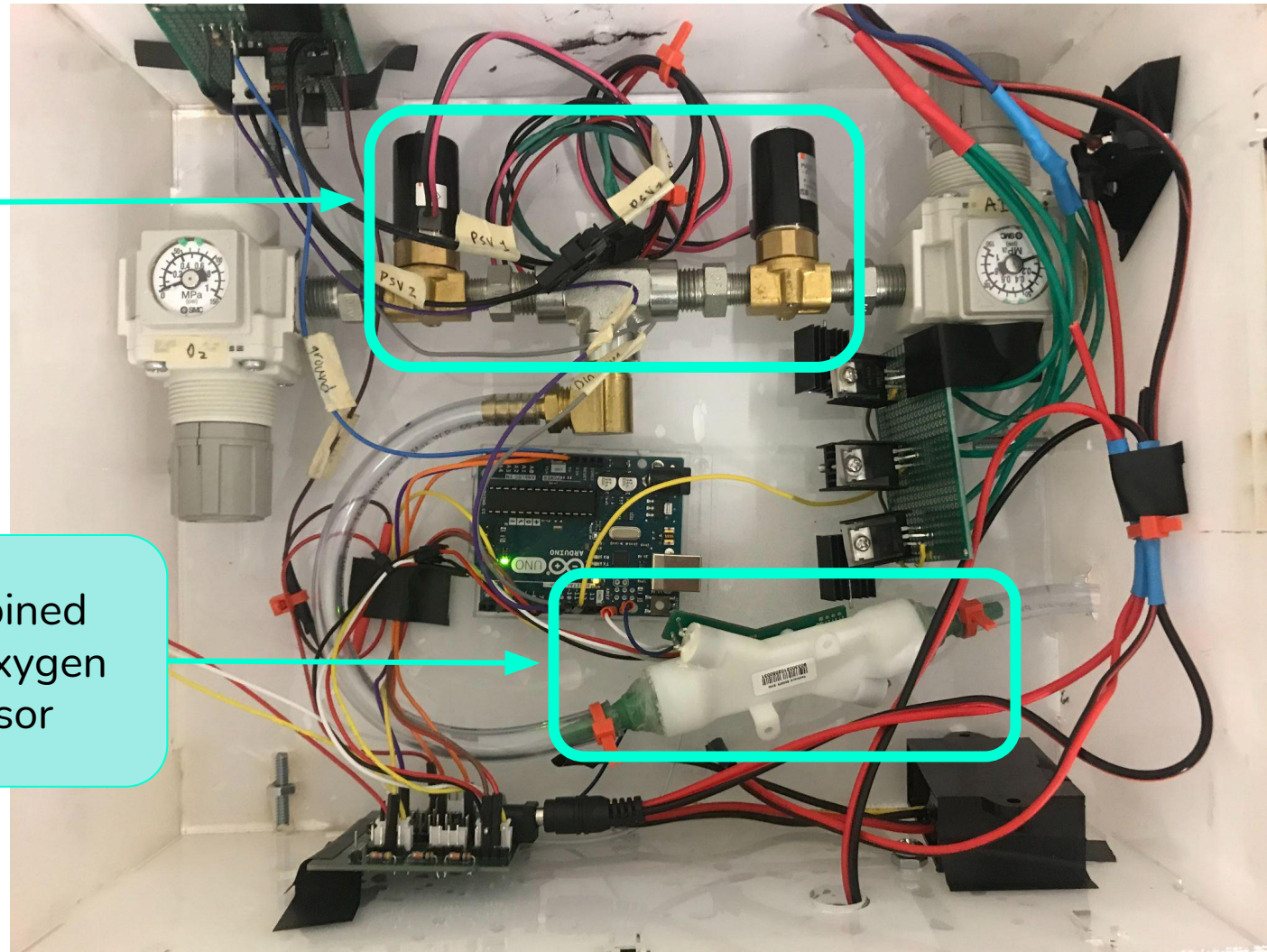
Pressure  
regulator  
for oxygen  
source

# Novel Control Algorithm Using Minimal Sensors and System of Equations



Proportional  
Solenoid  
Valves (PSVs)

Combined  
flow/oxygen  
sensor





# Novel Control Algorithm Using Minimal Sensors and System of Equations



## Algorithm

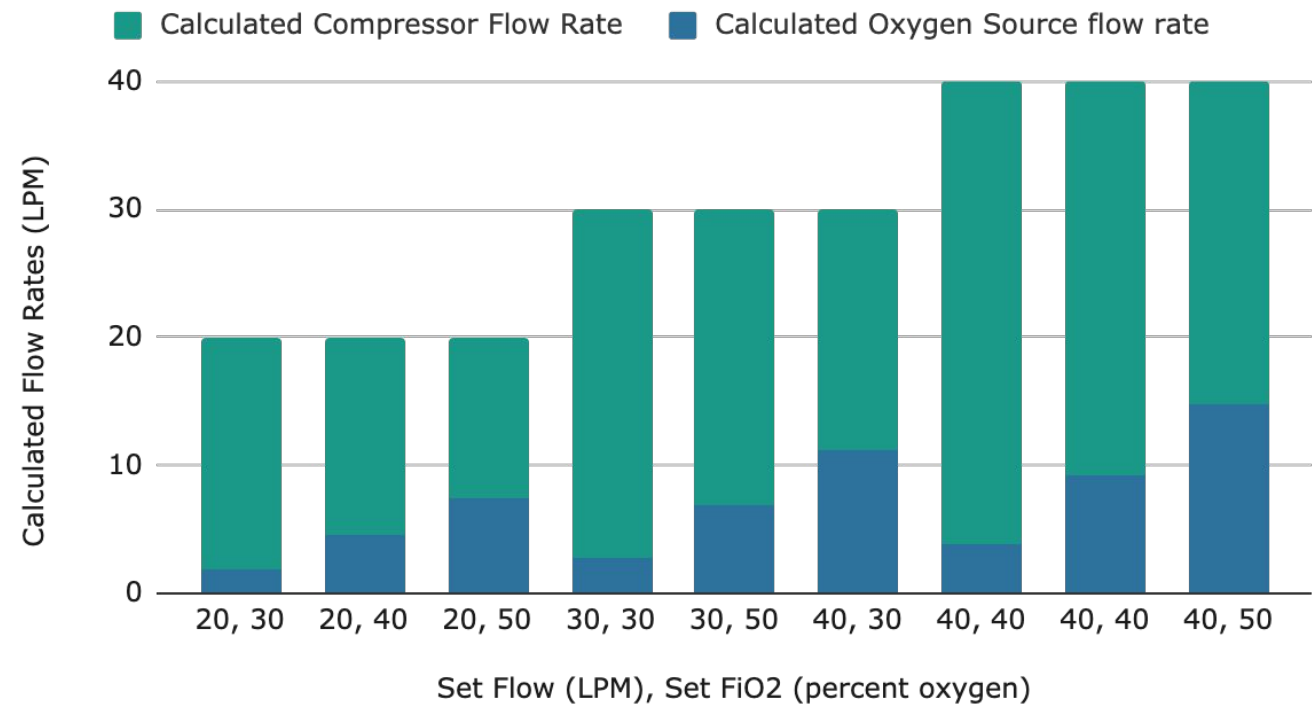
(1)

$$\text{flow}_{\text{o}_2} + \text{flow}_{\text{room}} = \text{flow}_{\text{total}}$$

(2)

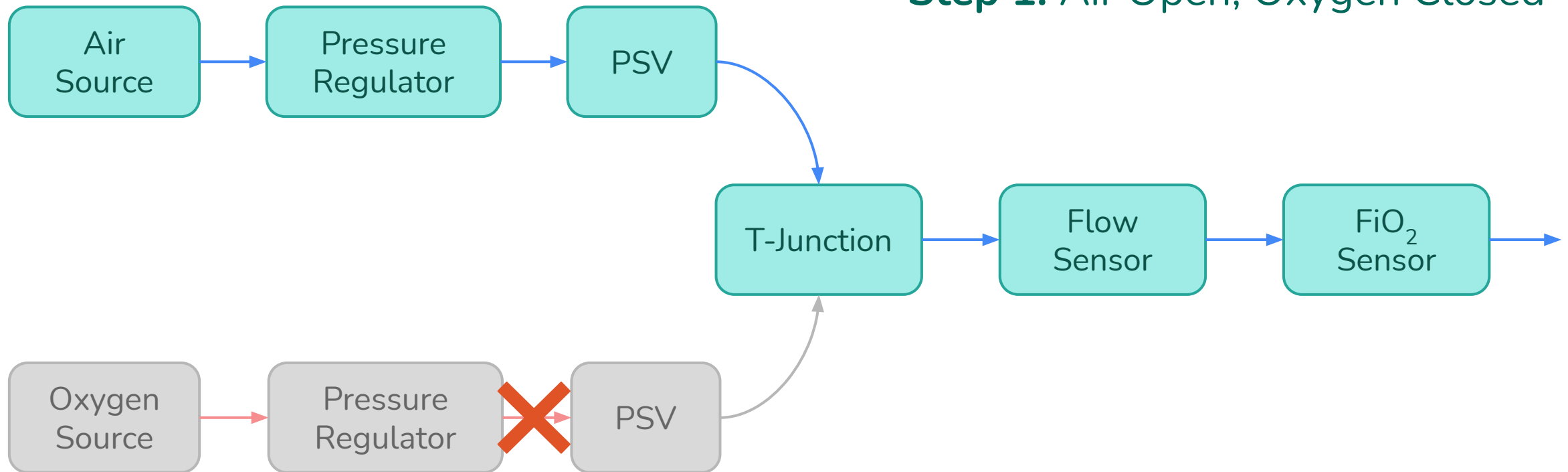
$$\frac{(\text{flow}_{\text{o}_2} \times \text{conc}_{\text{o}_2}) + (\text{flow}_{\text{room}} \times \text{conc}_{\text{room}})}{\text{flow}_{\text{total}}} = \text{fiO2}_{\text{total}}$$

## Calculated Flow Rates vs Set Flow and FiO2



# Calibration Setup

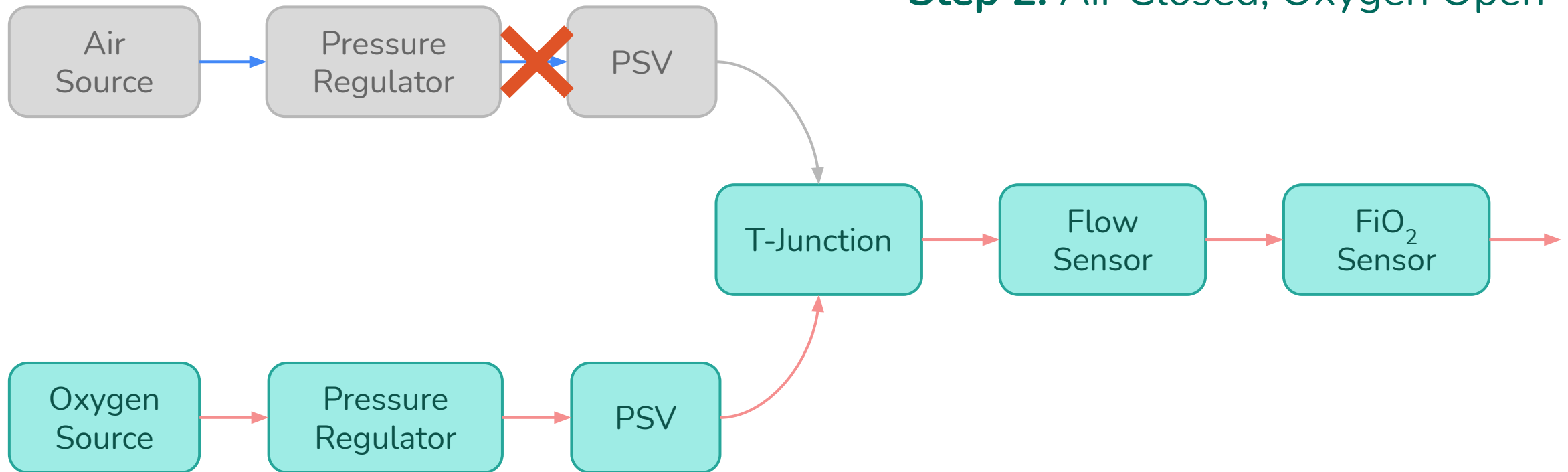
**Step 1: Air Open, Oxygen Closed**





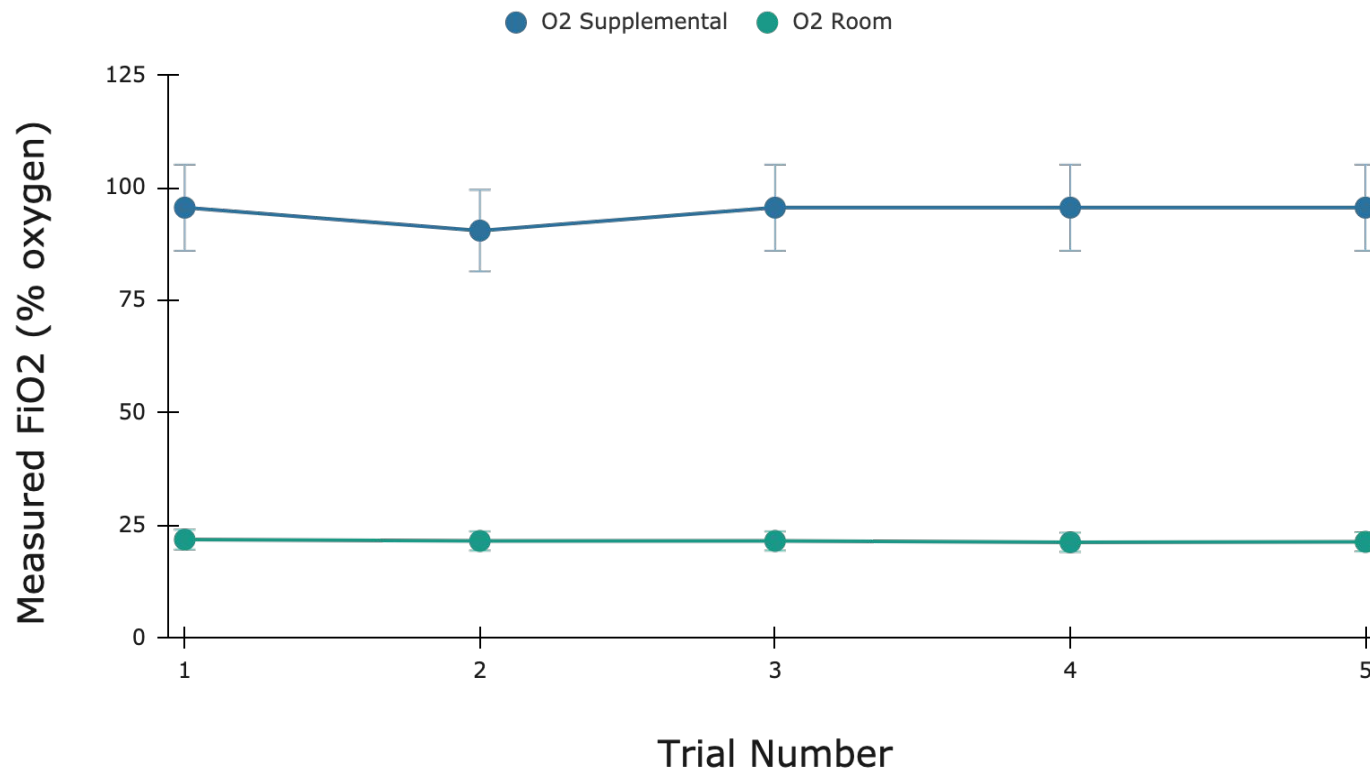
# Calibration Setup

**Step 2: Air Closed, Oxygen Open**



# Calibration Results

## Calibration Testing, $t = 5$ sec



%O<sub>2</sub> Supp.

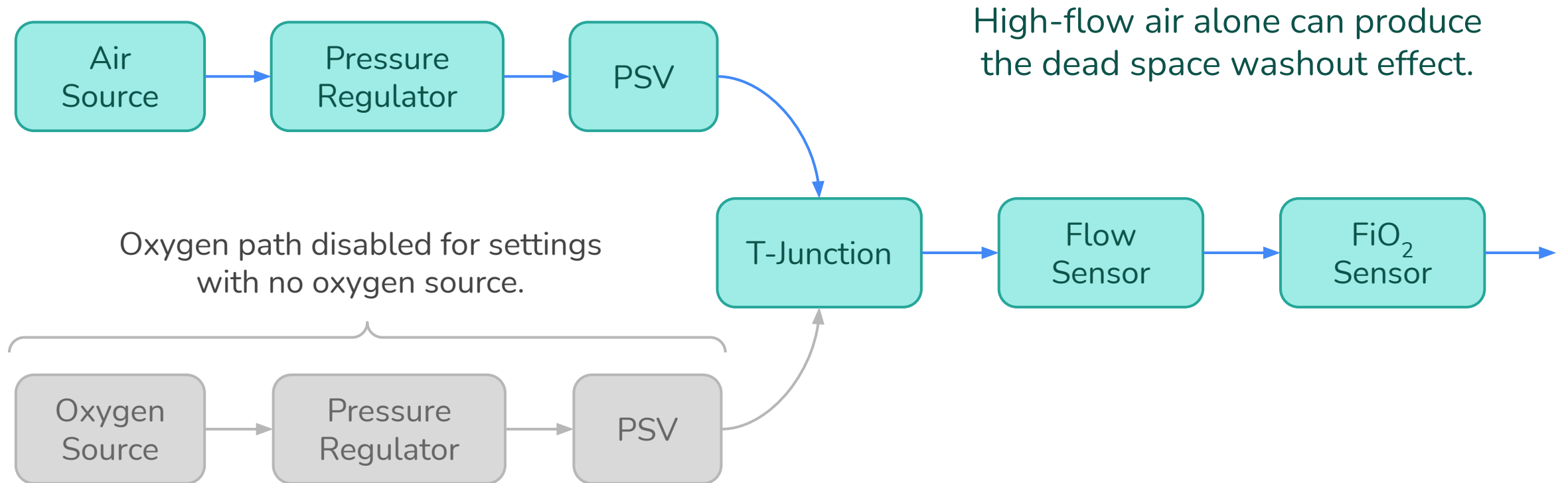
94.58 ± 2.28

%O<sub>2</sub> Room  
(Air Source)

21.56 ± 0.23

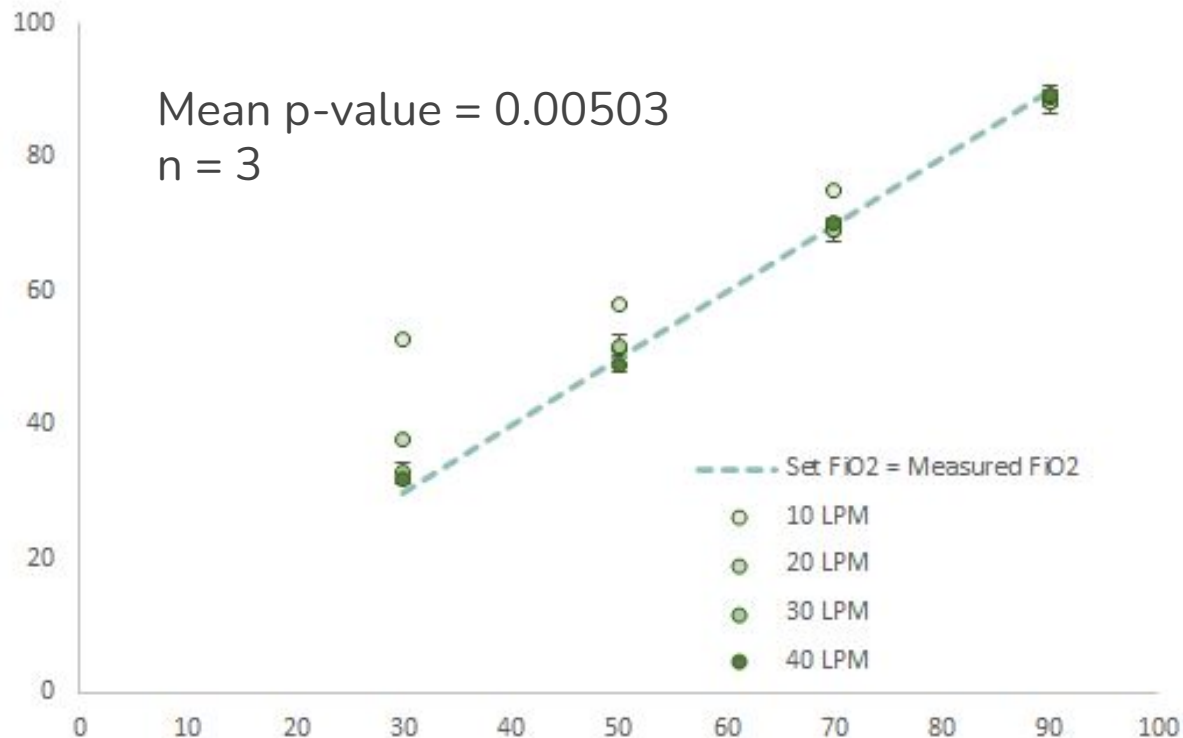


# Need for Air Only Control Mode

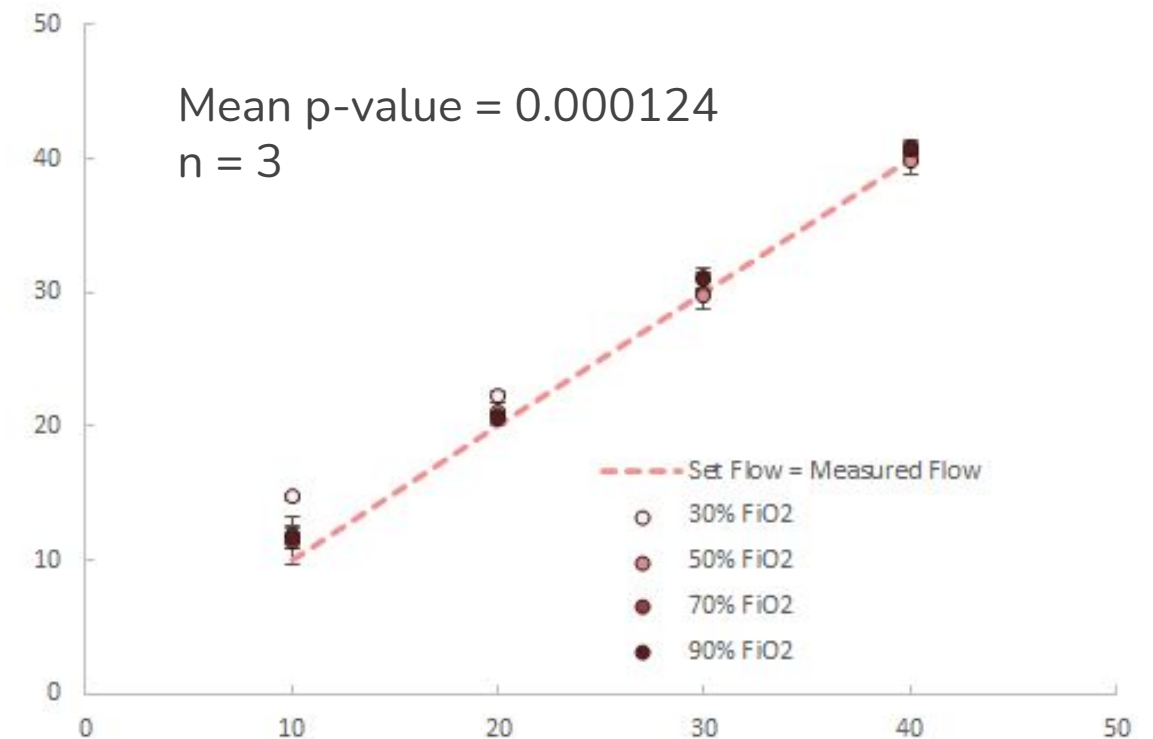


# Success: ArtemisHFNC Accurate Over Range of FiO<sub>2</sub> and Flow

## FiO<sub>2</sub> Set Value vs. Measured Value



## Flow Rate Set Value vs. Measured Value

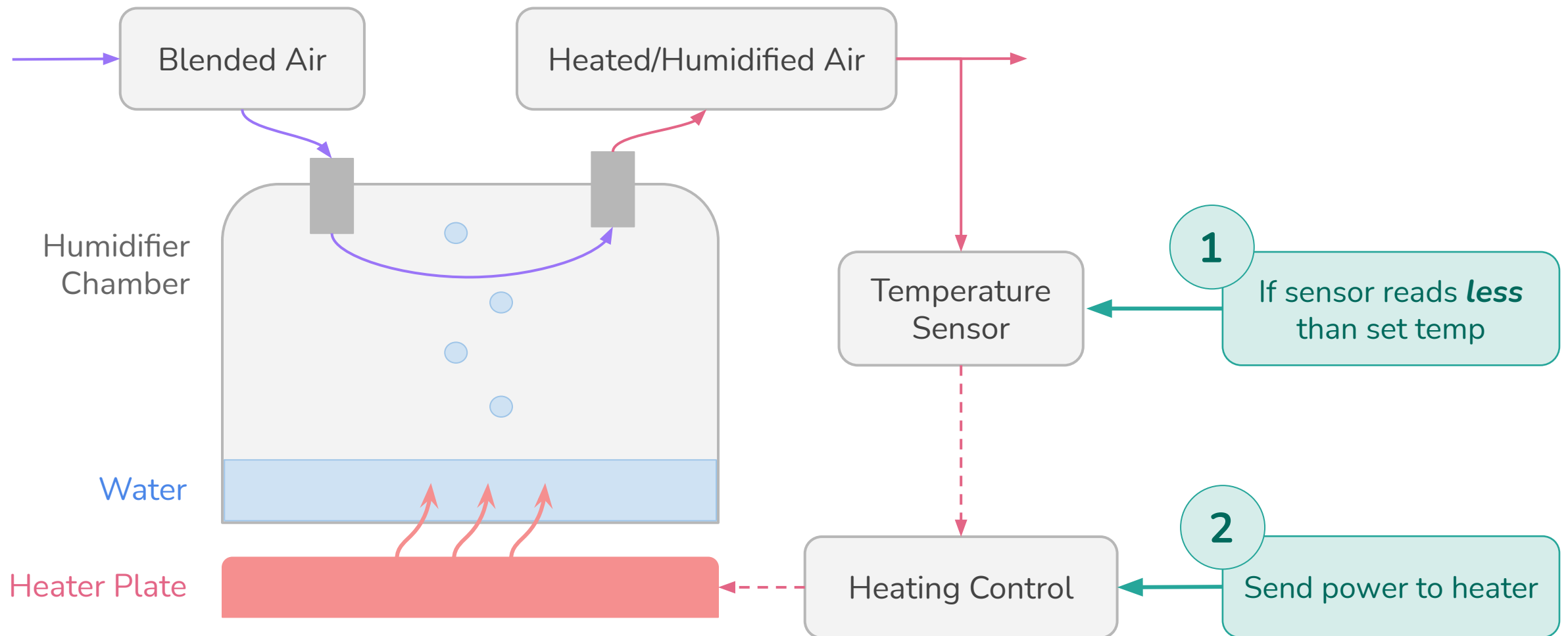


The background of the slide is a teal-colored overlay on a blurred photograph of medical equipment, specifically a ventilator with various tubes and connectors. The text "Heater/Humidifier" is centered in a large, white, sans-serif font.

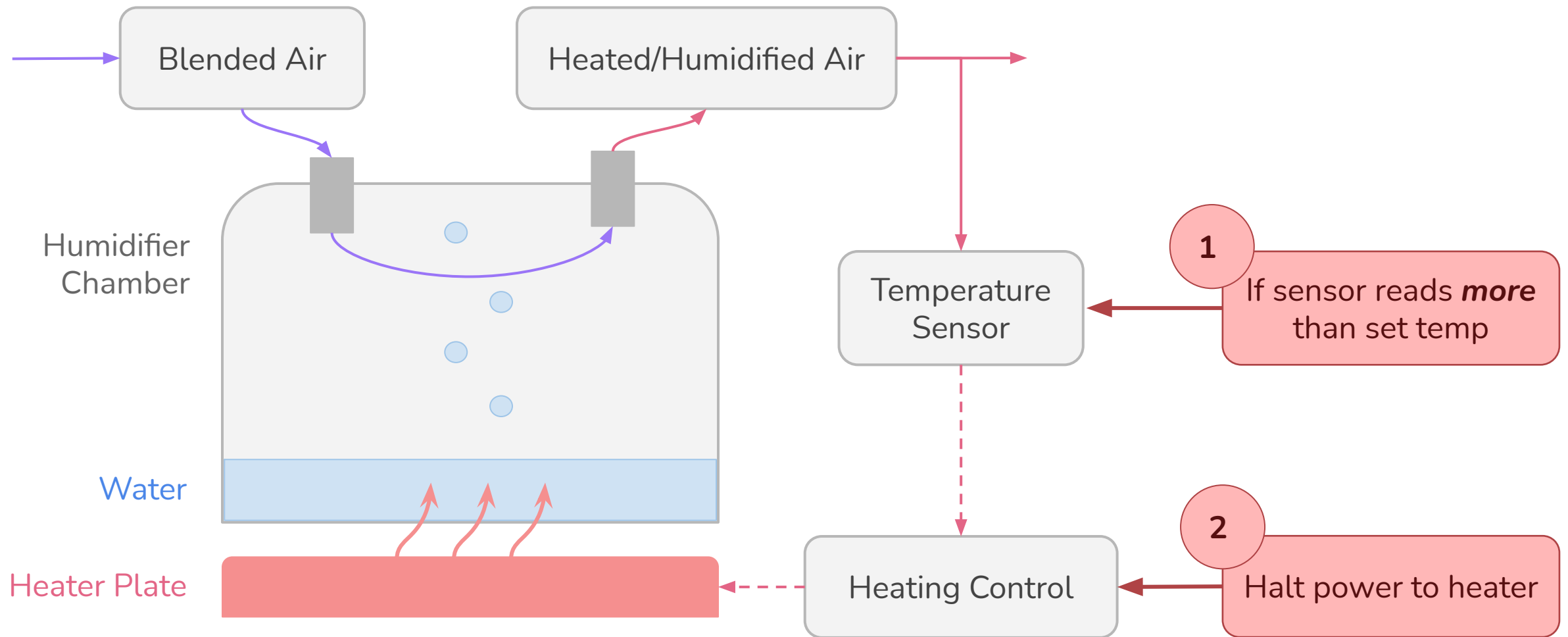
# Heater/Humidifier



# Heater Control Algorithm

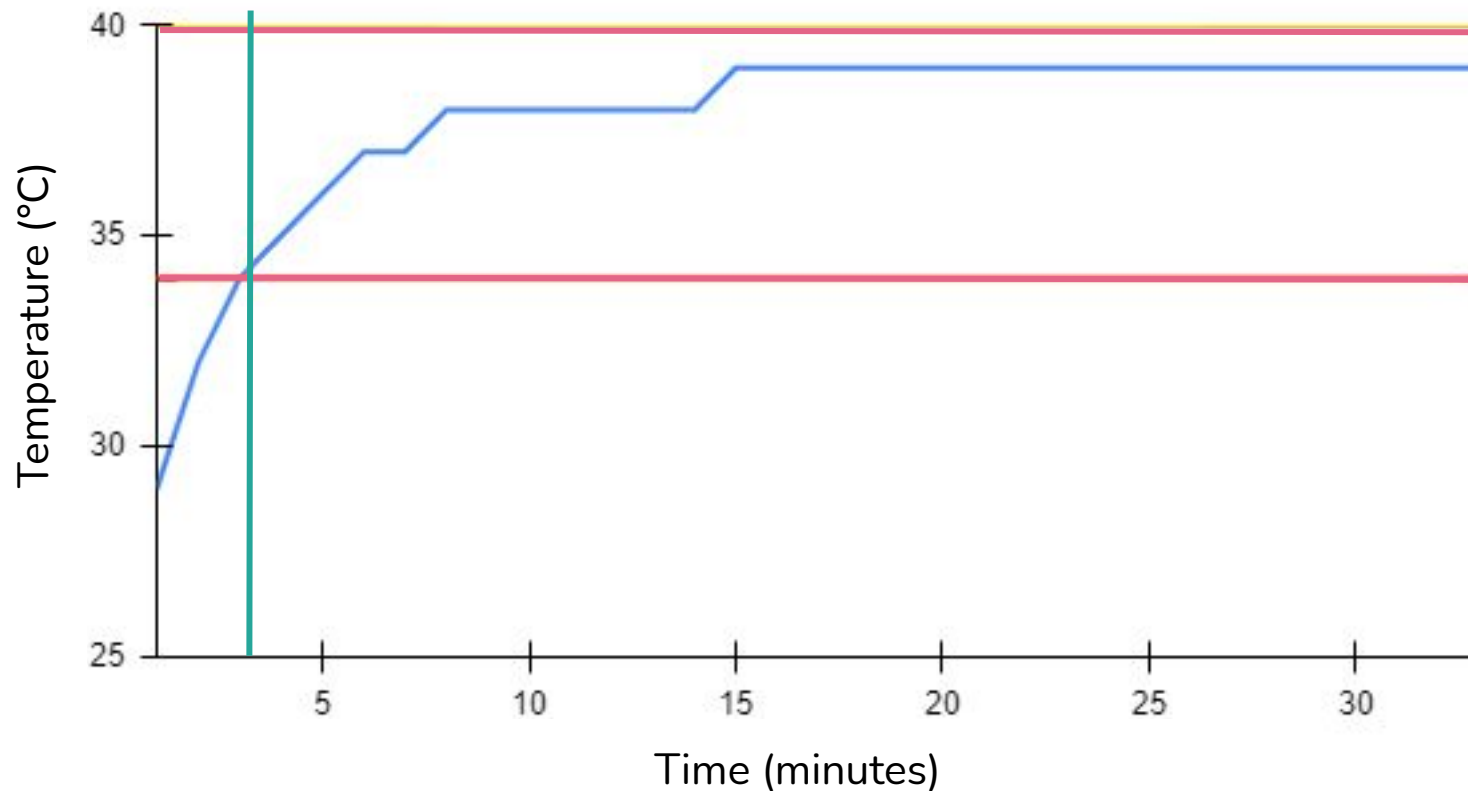


# Heater Control Algorithm



# Heater Control: Data Collection

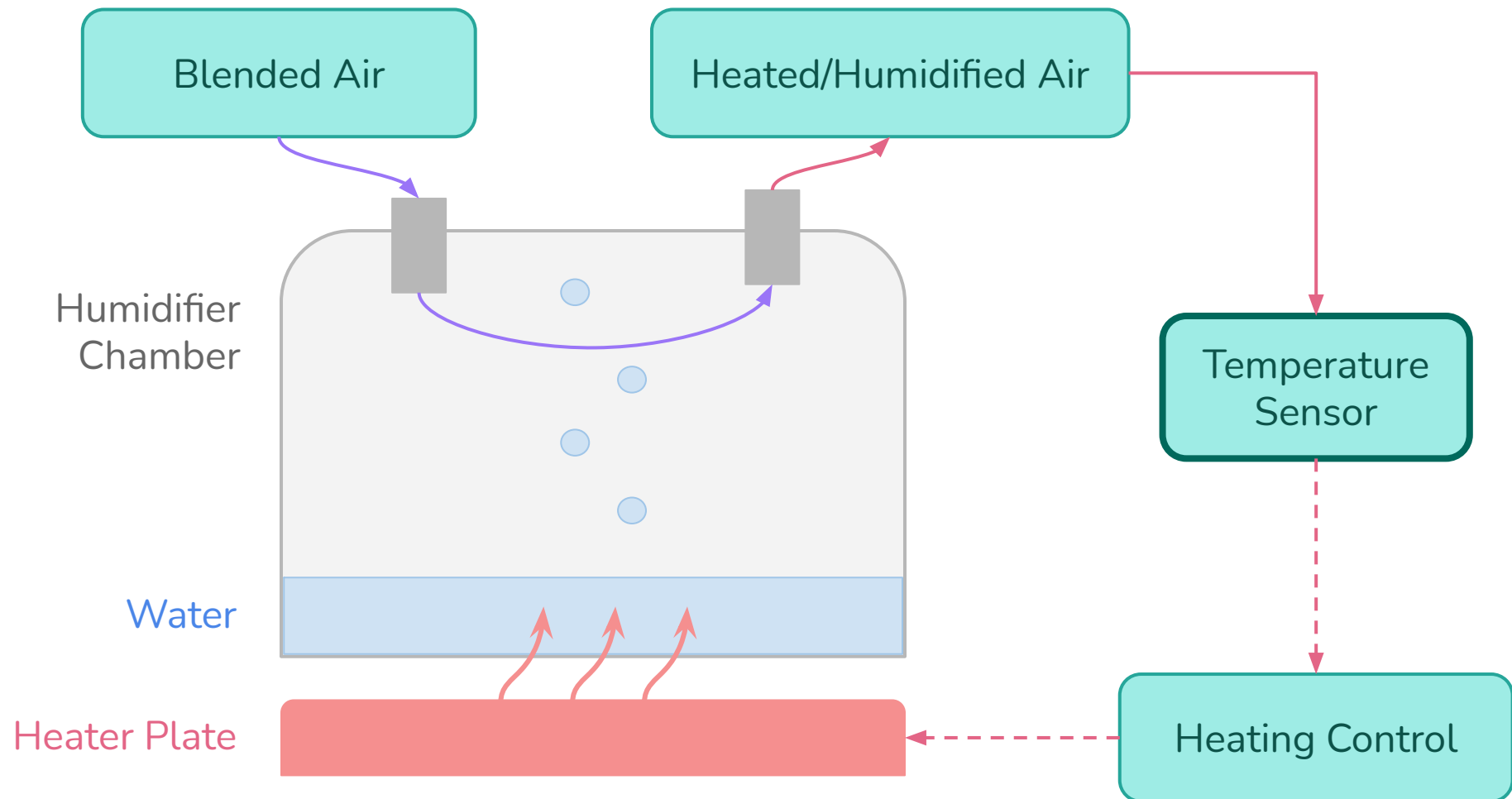
## Temperature Controlled Over Time



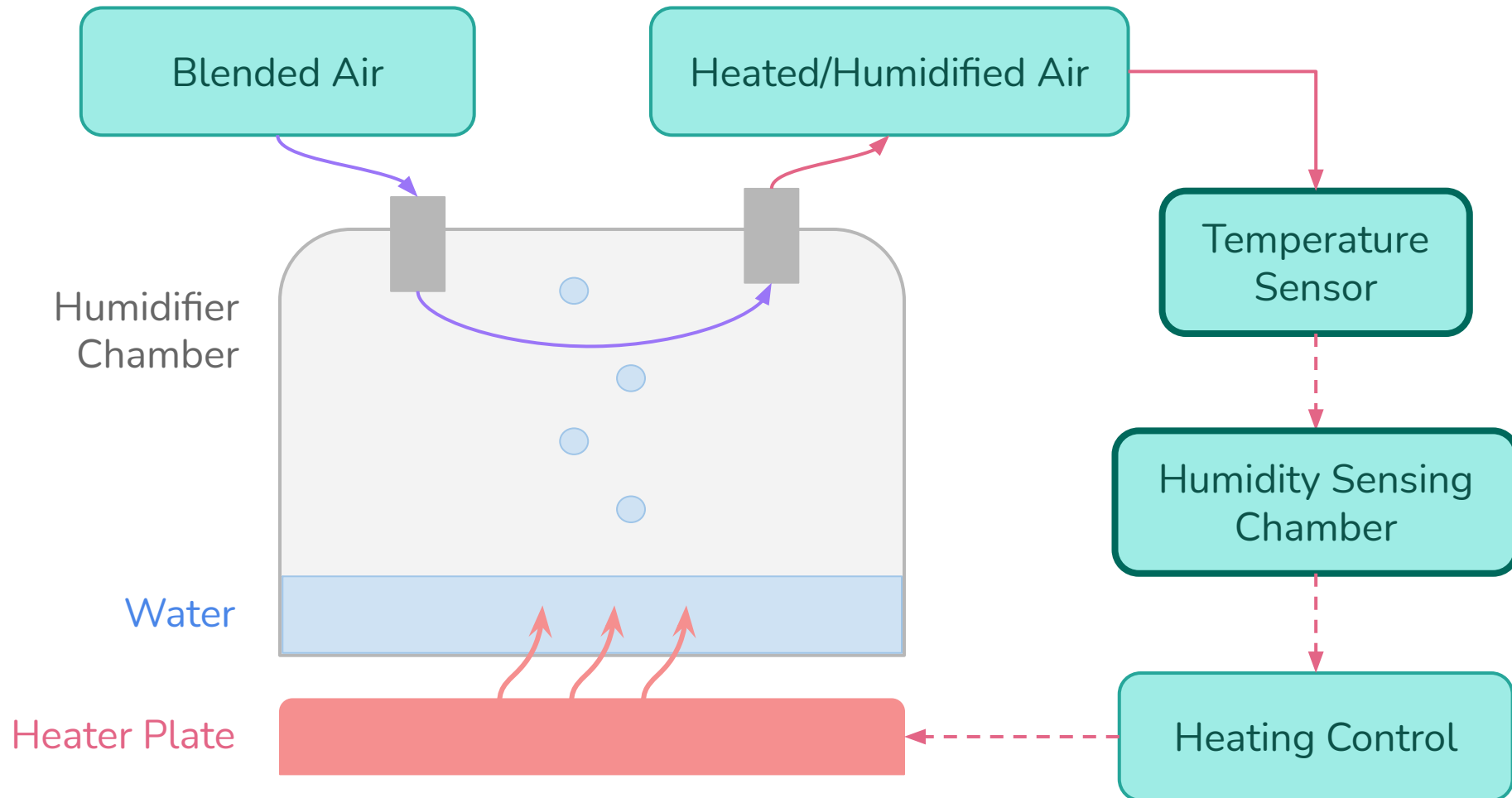
- Temp data
- Desired range of temperature ( $37 \pm 3$ )
- Time at which desired range was achieved (3 min)



# Humidification Verification Setup

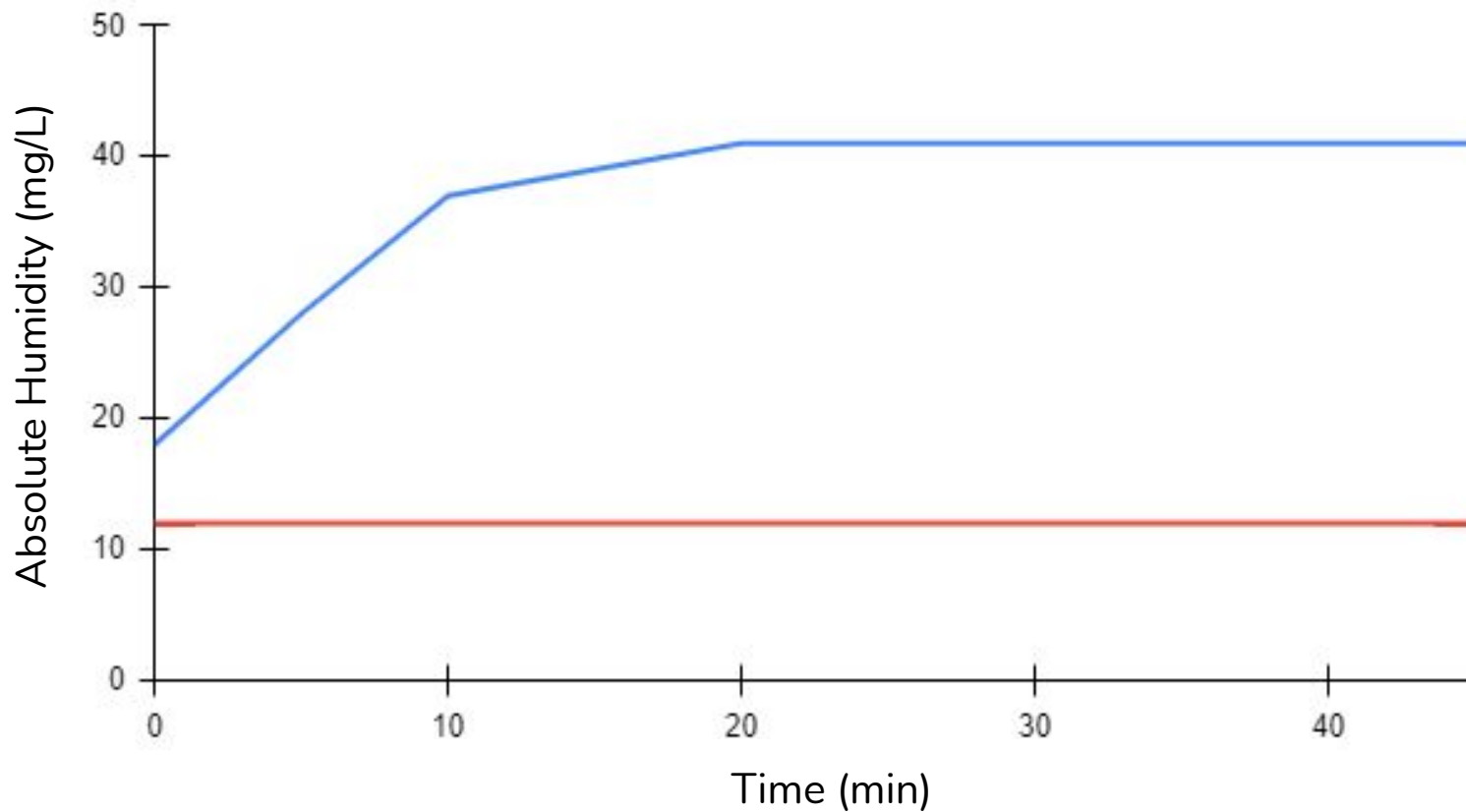


# Humidification Verification Setup



# Humidification: Data Collection

## Absolute Humidity Over Time



Recorded humidity

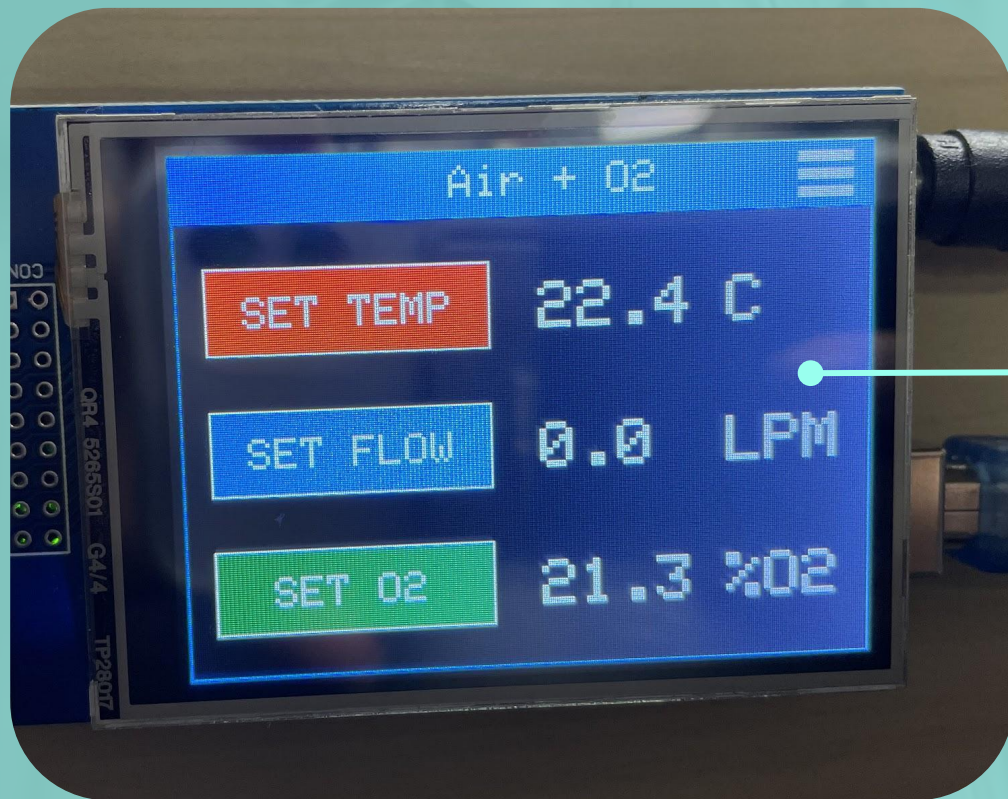
Humidity Constraint:  
minimally acceptable  
value



The background of the slide is a blurred photograph of a medical device, possibly a ventilator or a similar life-support machine. It features various tubes, wires, and mechanical components. A semi-transparent teal overlay covers the entire image, creating a professional and clinical aesthetic.

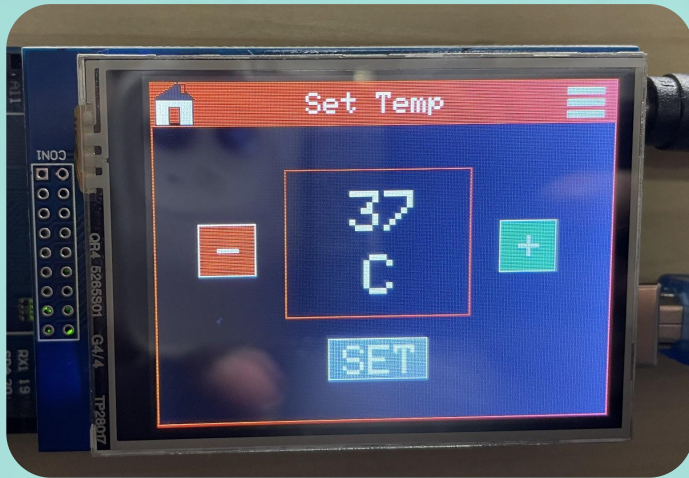
# User Interface

# Displaying Sensor Readings

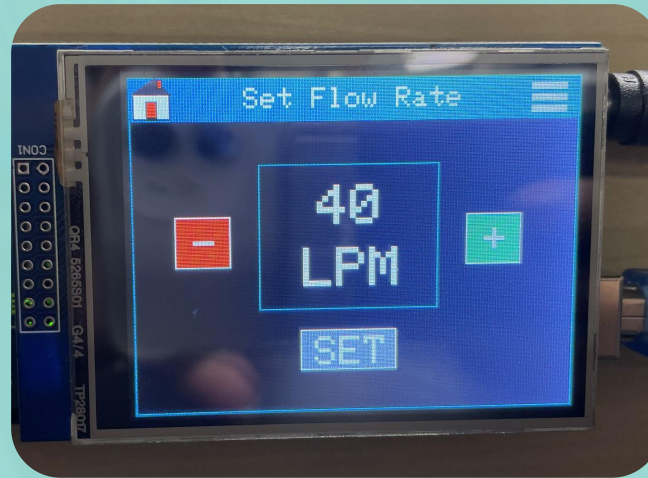


Temperature, Flow, and  $\text{FiO}_2$   
Sensor readings updated **every 1**  
**second** on the home screen

# Controlling Parameters



*Temperature control between  
31°C and 40°C*



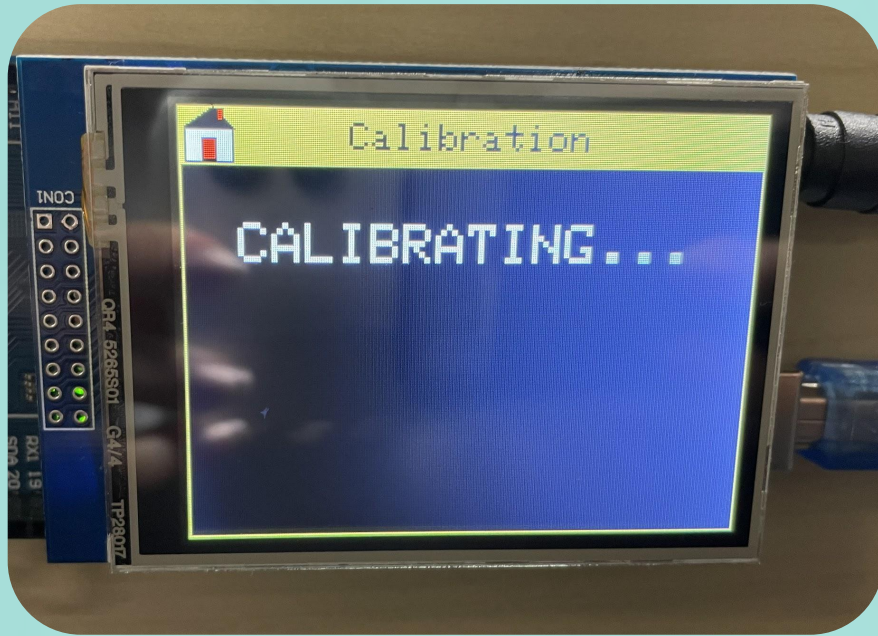
*Flow Rate control between  
10 LPM and 40 LPM*



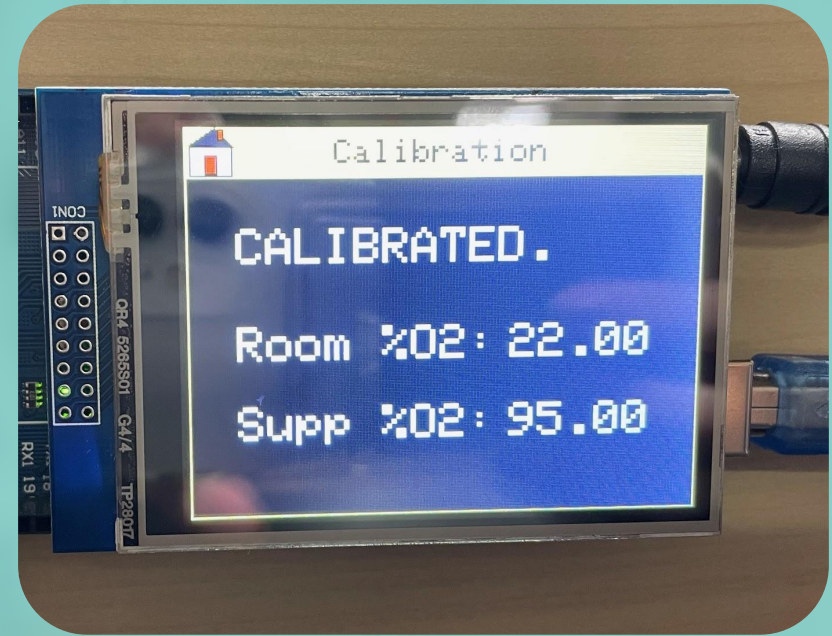
*FiO<sub>2</sub> control between  
20% and 95%*



# Integrating Calibration

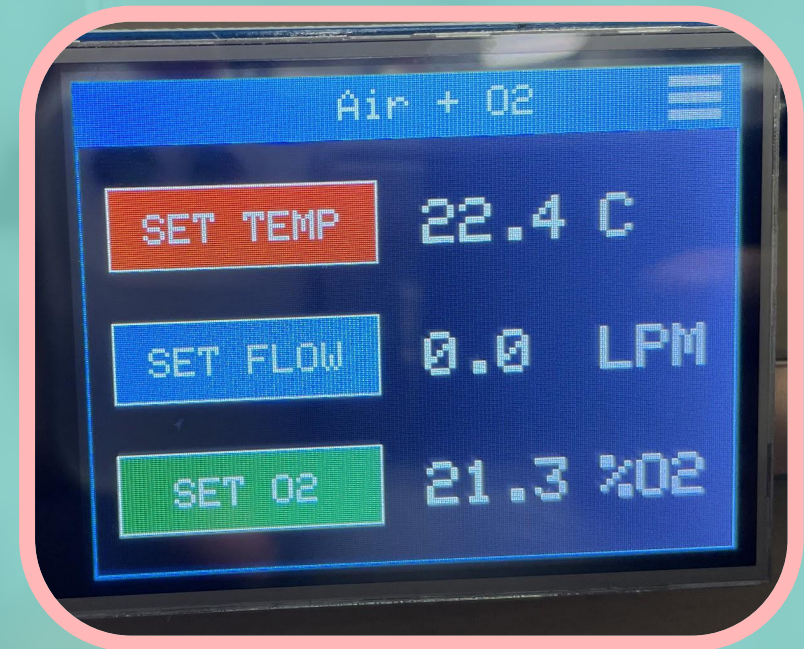
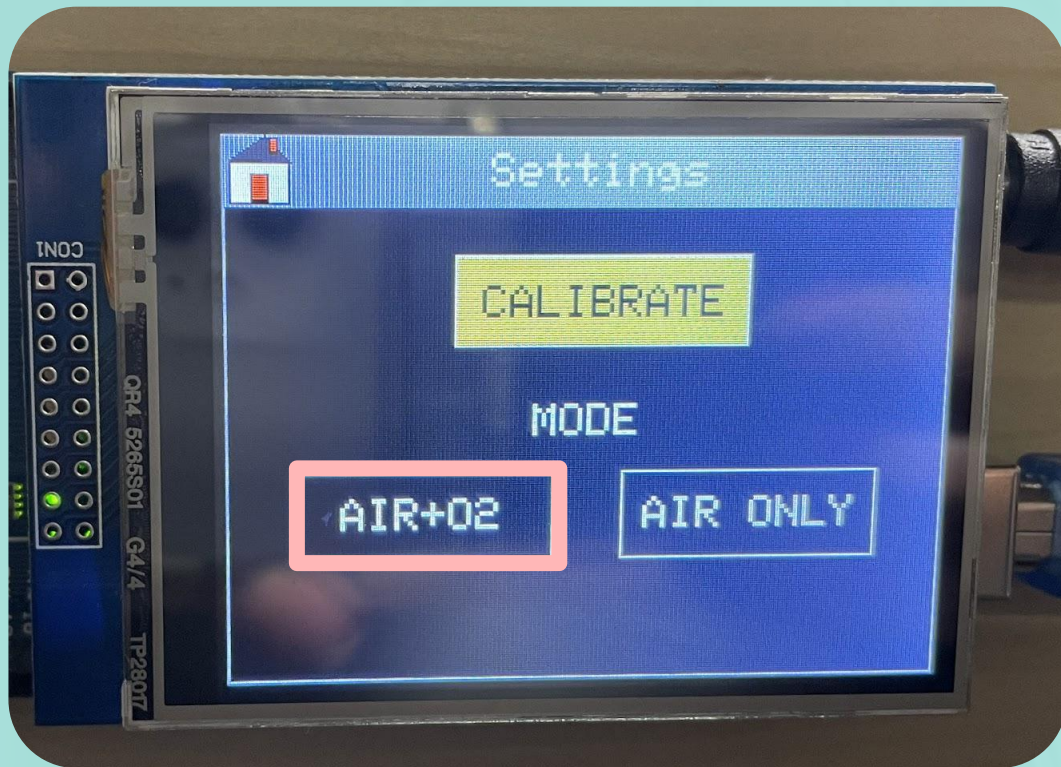


The oxygen and air branches alternate between a fully open and fully closed state for 5 seconds each.



FiO<sub>2</sub> values for each branch are displayed.

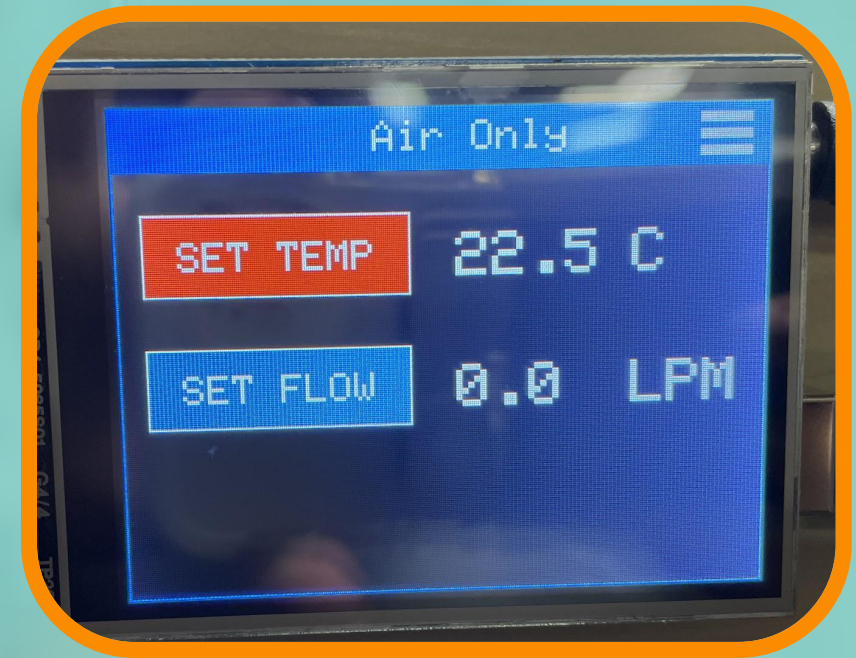
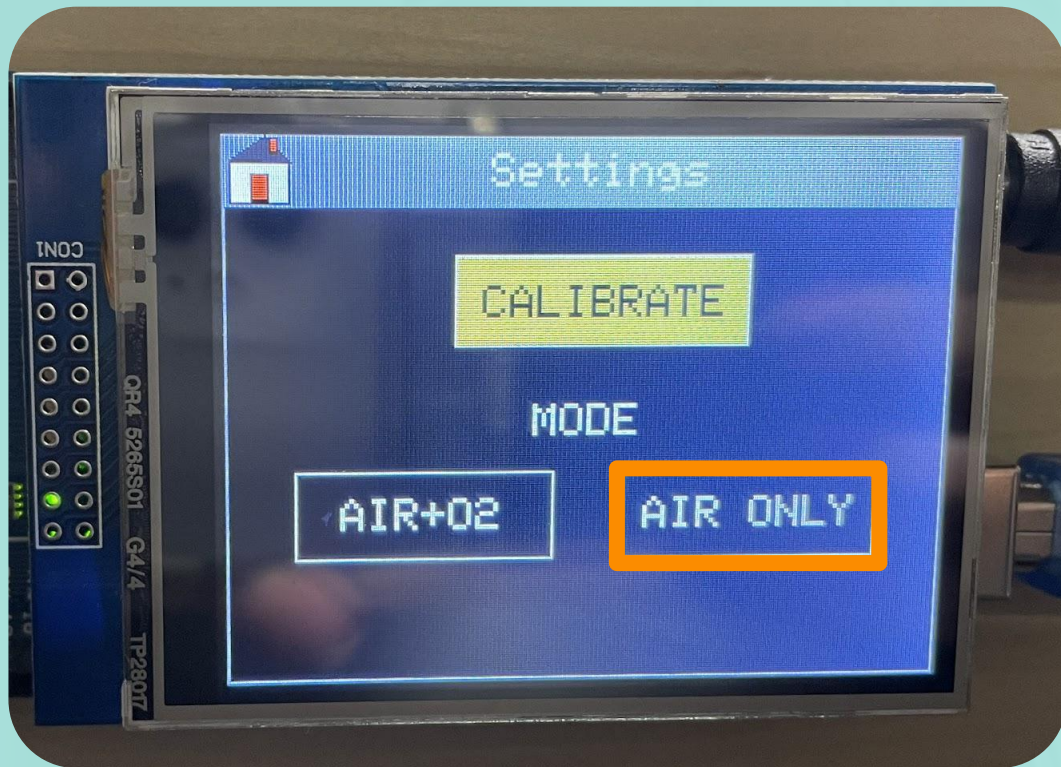
# Settings Menu to Select Mode



*Air + O<sub>2</sub> mode allows user to set and monitor temperature, flow rate, and FiO<sub>2</sub>*



# Settings Menu to Select Mode

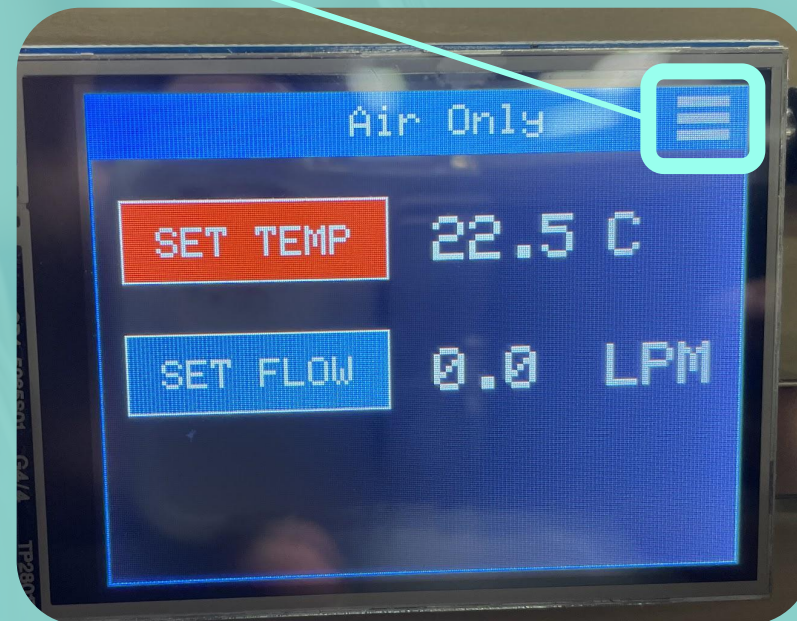
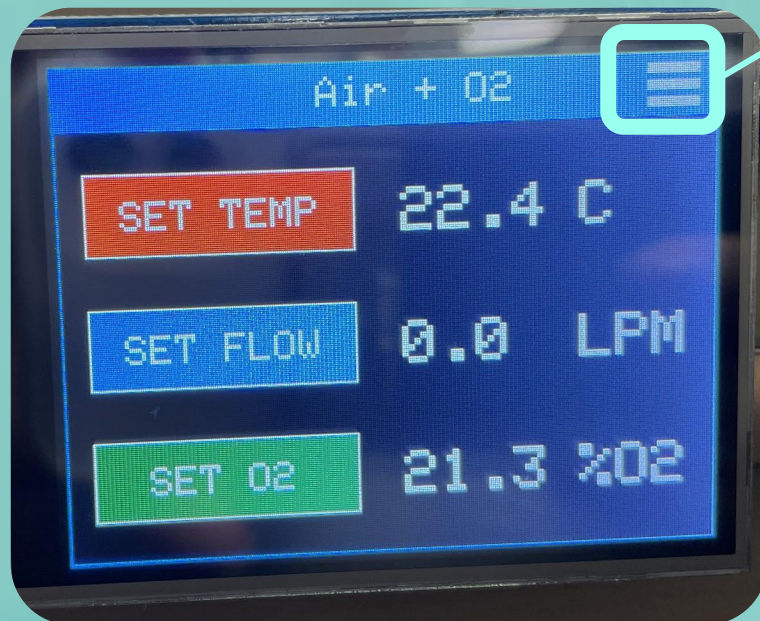


*Air Only mode allows user to set and monitor temperature and flow rate*



# Accessing Settings Menu

User can access **settings menu** to toggle between Air + O2 mode and Air Only mode or re-calibrate



The background of the slide is a teal-colored overlay on a blurred image of medical equipment, including various tubes and wires, suggesting a healthcare or medical technology context.

# Market and Future Plans

# Options for Respiratory Support

---

|                             | Concentrators/<br>Canisters                                                                                                                                                                                                                                   | Bubble CPAP                                                                                                                                                                                                                                                       | High Flow<br>Oxygen (HFNCs)                                                                                                                                                                                                                                       |
|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Affordable                  |          |          |          |
| Accessible                  |          |          |          |
| Range of Cases<br>Coverable |    |    |    |



# Proprietary Tubing Make HFNCs Inaccessible

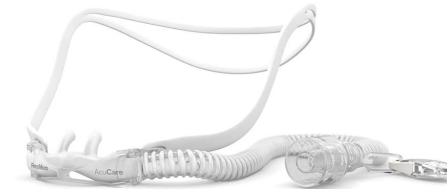
Standard  
Cannula



Flexicare  
High-Flow  
Cannula



ResMed Acucare



Fisher & Paykel  
Optiflow



Max Flow:

6 LPM

40 LPM

60 LPM

60 LPM

Features:

Universal adapter

Universal adapter

Double-strap design

Facial pads

Cost:

\$3.25

~\$11

~\$50

~\$128

# Current Systems are Expensive

Flexicare FL-900U



Max Flow: 60L/min  
Temperature: 36-40°C  
Humidity: >33 mg/L  
  
Cost: ~\$3,200

Vapotherm Precision Flow Plus



40L/min  
33-43°C  
>12 mg/L  
  
~\$4,500

Fisher & Paykel Airvo 2



60L/min  
31- 43°C  
>33 mg/L  
  
~\$4,900

# Current Systems are Expensive

Flexicare FL-900U



Max Flow: 60 L/min

Cost: ~\$3,200

Vapotherm Precision Flow Plus



40 L/min

~\$4,500

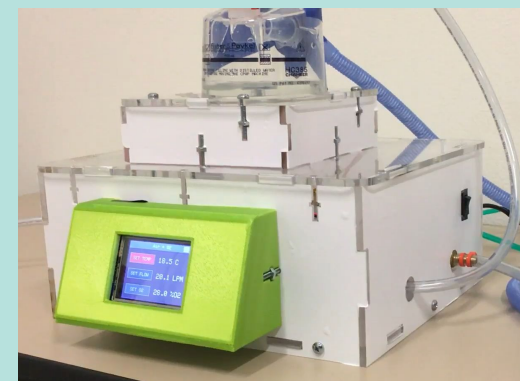
Fisher & Paykel Airvo 2



60 L/min

~\$4,900

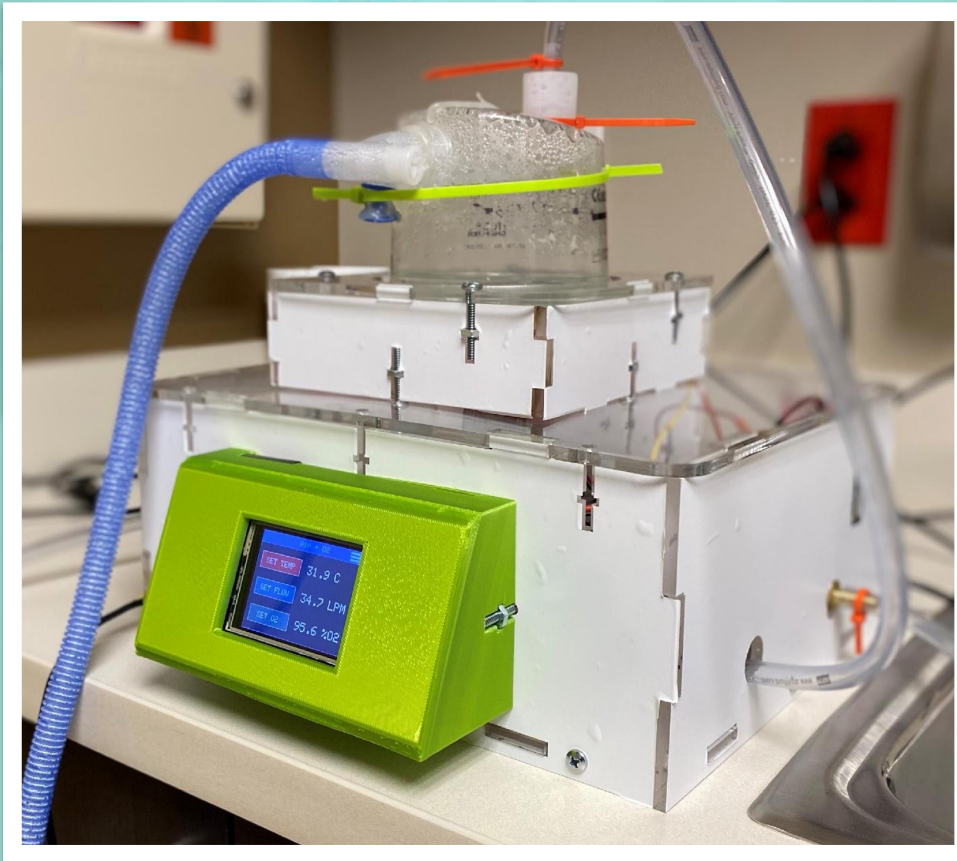
ArtemisHFNC



40 L/min

< \$1,500





\$1000

# ICUs

\$2 million market



Malawi  
Tanzania  
Kenya  
Nigeria





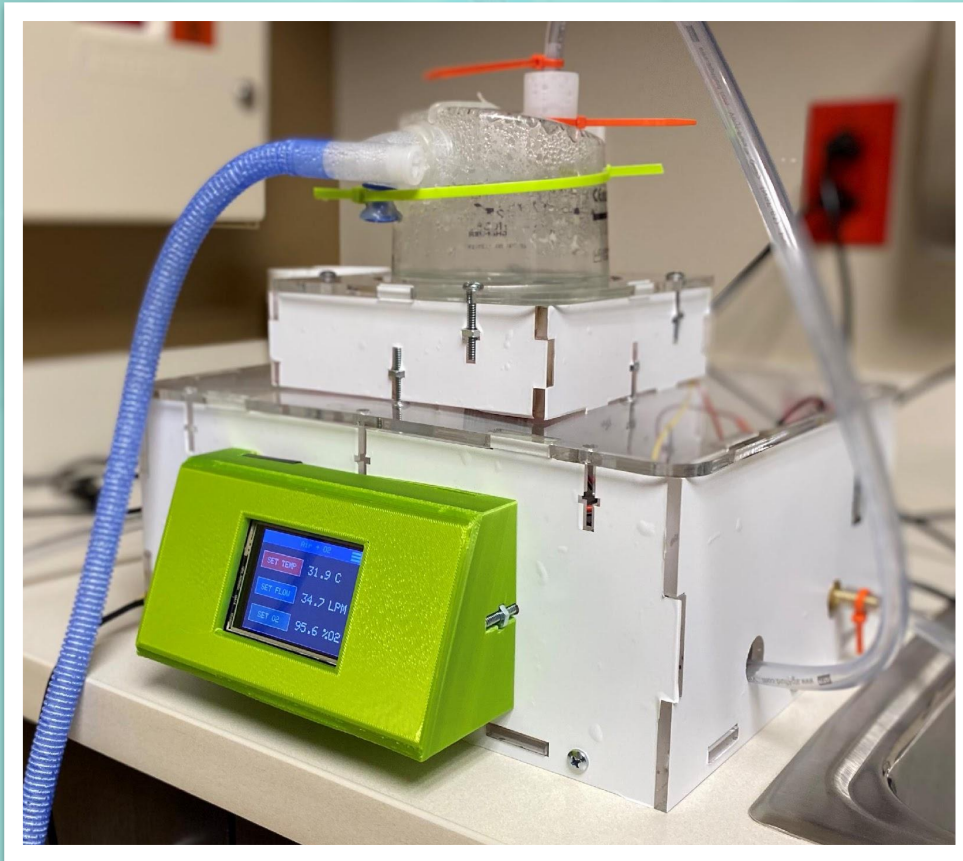


# ArtemisHFNC

Seeking  
**\$10,000** in  
funding

Build 5  
**high-fidelity**  
prototypes

Test  
prototypes  
in **Malawi**



## Limitations:

- Sensor is a prototype
- Medical air compressor is loud
- Pneumatic connections
- Humidity chamber (partnerships)
- High flow cannula procurement