



Delivery of Aerosolized Drugs Through Continuous Positive Airway Pressure (CPAP)

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CLIENT

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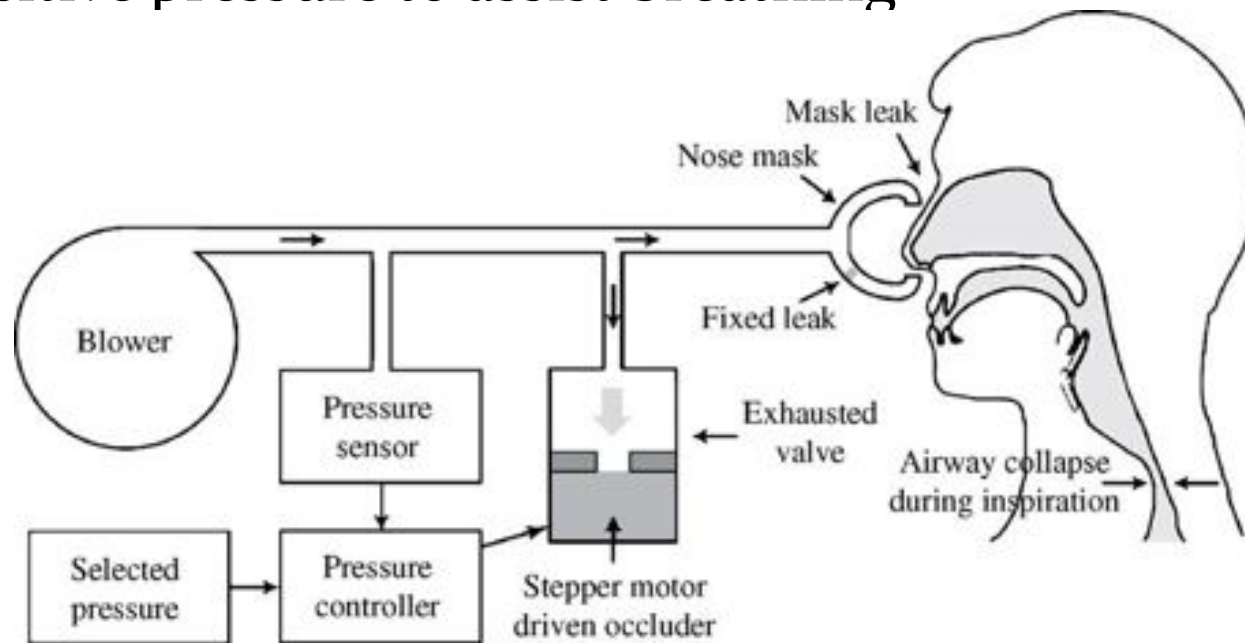


Problem Statement

- A device is needed to automatically deliver bronchodilating drugs, such as Albuterol Sulfate, in line with a CPAP machine.
- Automated delivery should occur at timed intervals during the sleep cycle.
- The device should also be compatible with a hospital ventilator.

Background - CPAP

- Continuous Positive Airway Pressure (CPAP)
 - For sleep apnea and asthma patients
 - Positive pressure to assist breathing

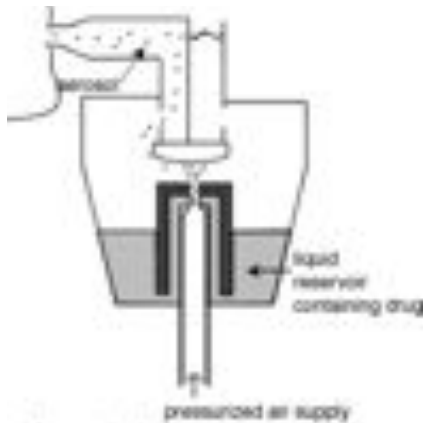


Background - Nebulizers

- Transform liquid medication into mist
- 2 types:

Jet Nebulizer

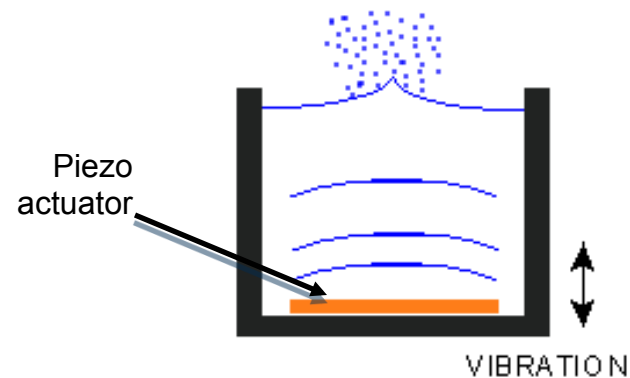
- ▣ Uses Pressurized Air
- ▣ Efficiency 39+/-3%**



www.mece.ualberta.ca/arla/tutorial.htm

Ultrasonic Nebulizer

- ▣ Uses ultrasonic waves
- ▣ Efficiency 86+/-5%**



www.sonozap.com/nebulizer.htm

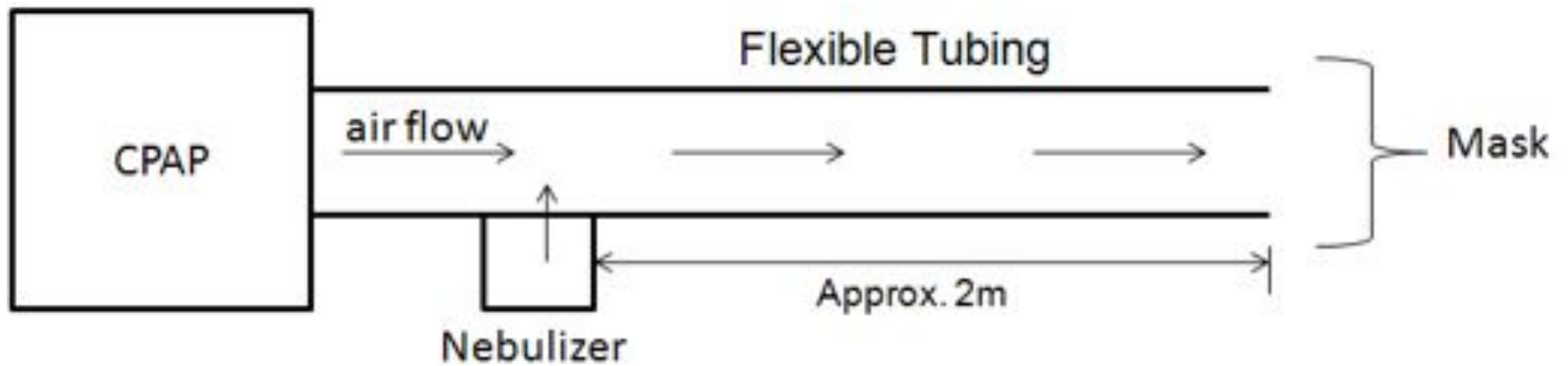
** Gessler T; Schmehl T; Hoepfer M M; Rose F; Ghofrani H A; Olschewski H; Grimminger F; Seeger W. 2001. Ultrasonic versus jet nebulization of iloprost in severe pulmonary hypertension. *The European respiratory journal : official journal of the European Society for Clinical Respiratory Physiology* 2001;17(1):14-9.



Client Requirements

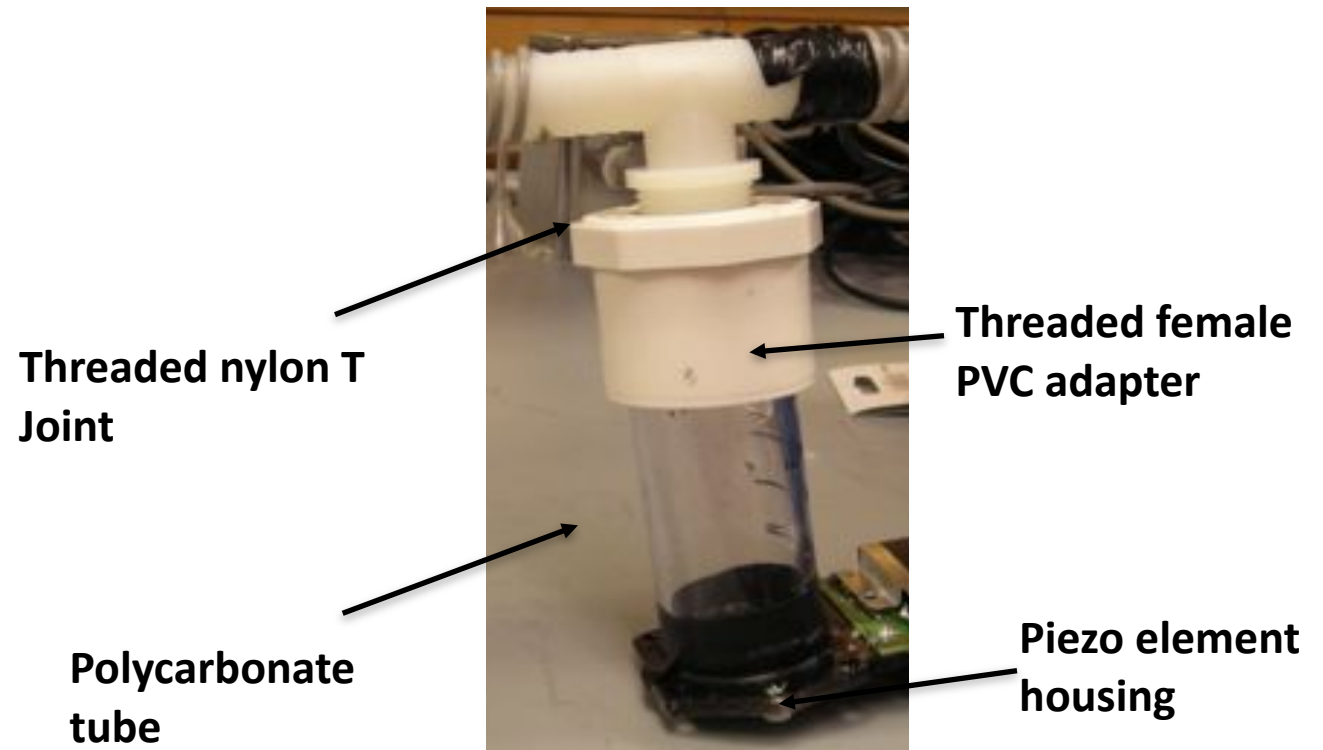
- Automatic drug delivery
- Compatible with CPAP and hospital ventilator
- Adjustable amount of drug delivery
- Cannot compromise quality of sleep
- Computer interface for user input
- Design for clinical trials
- Eventually for at-home use

Basic Mechanical Design



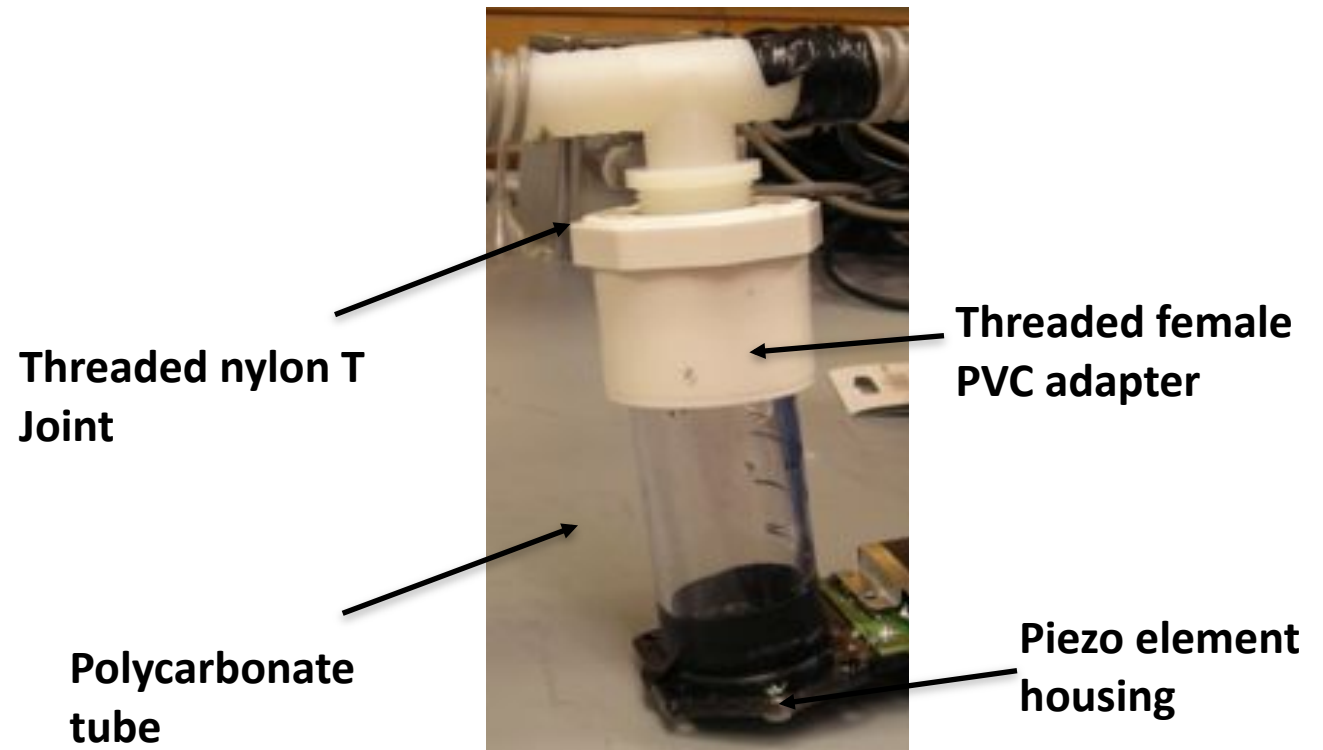
Previous Mechanical Design

- Problems
 - Low yield
 - Inefficient
 - Splashing



Previous Mechanical Design

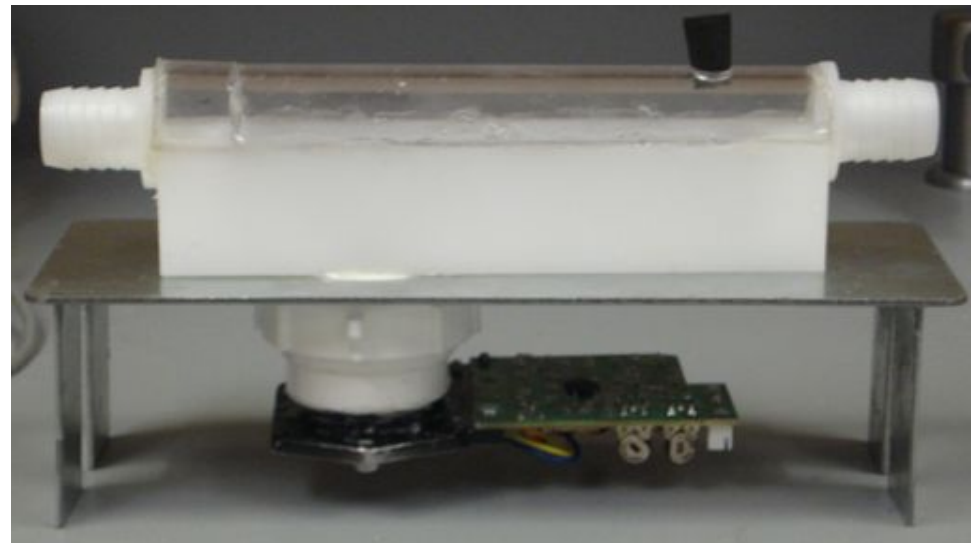
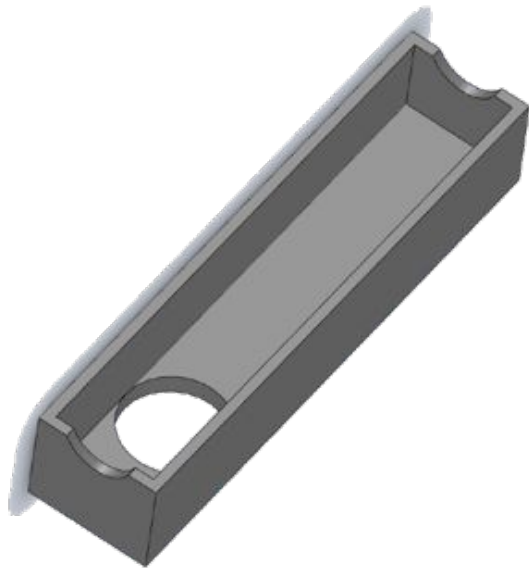
- Problems
 - Low yield
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New reservoir design necessary

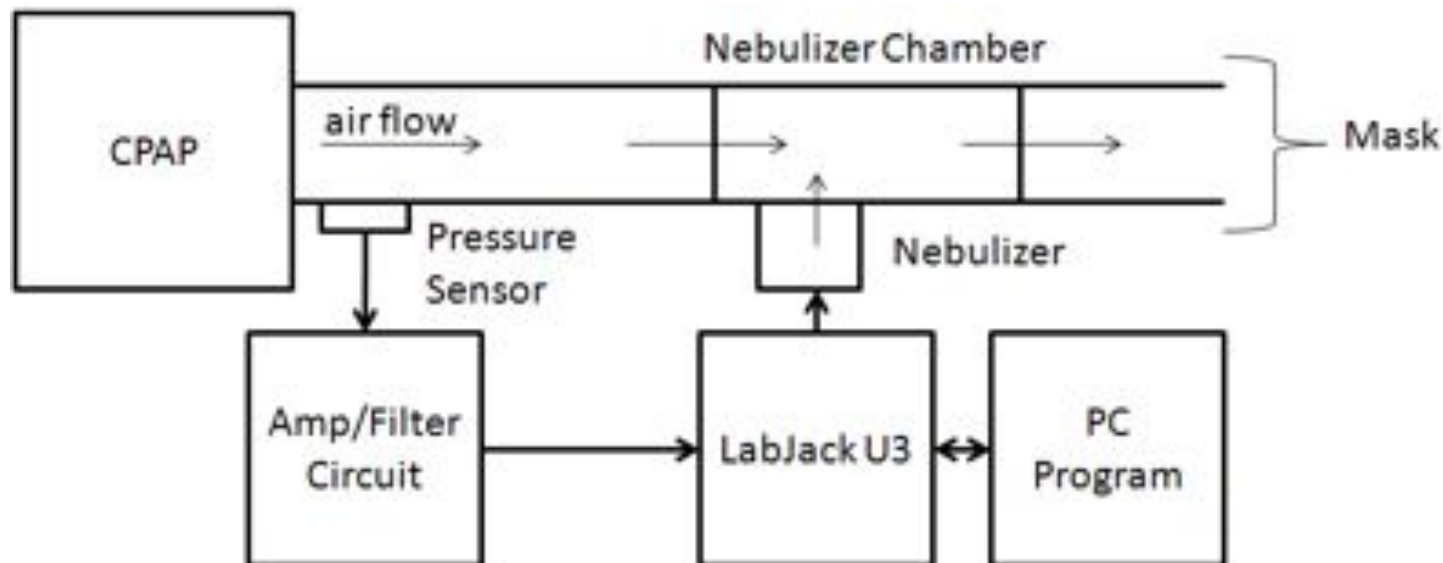
New Mechanical Design

- Goes in-line with CPAP
- Holds ~100 mL of liquid
- Minimizes splashing effect
- Allows maximum aerosol transport into main flow



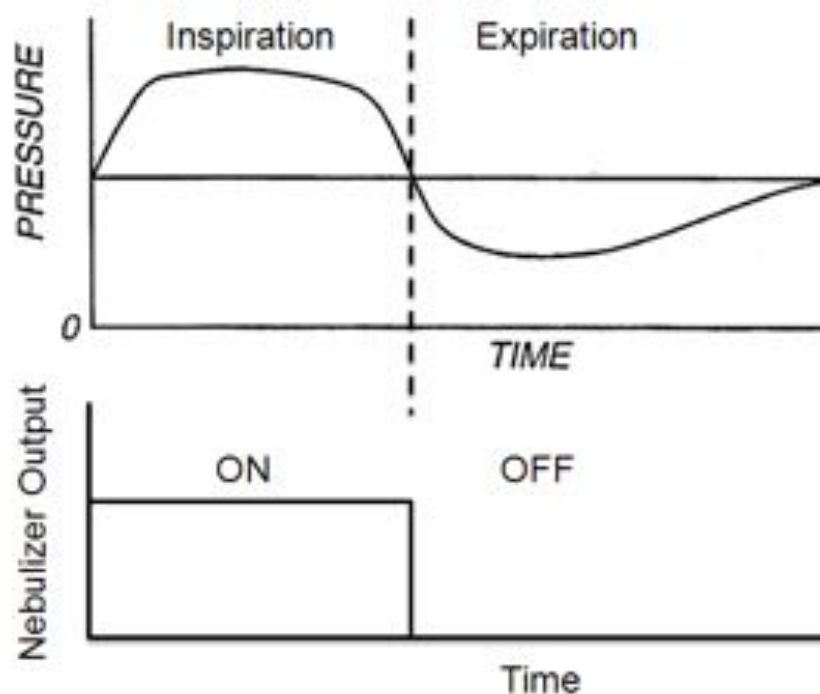
Automation

- Pressure sensor detects breathing cycle
- Sends signal to LabJack U3 device via amplifier/filter circuit
- LabJack U3 relays information to LabVIEW program
- Program turns nebulizer ON/OFF based on time during breathing cycle



Automation Waveforms

- Maximizes drug intake while inhaling
- Minimizes drug waste while exhaling
- Pressure sensor detects time during breathing cycle
- Program turns nebulizer ON/OFF based on breathing cycle



Device in Use





Before Going to Sleep

- Pre-mixed Albuterol solutions provided for the patient/doctor to put into the reservoir.
- Drug delivery settings controllable only by qualified medical personnel.
- At Home: Patient will simply push a start button before going to sleep.
- At Hospital: Reduced man-hours

USER INPUT

Clinical Trials and Final Design User input

| Dose Number | Dose Start Time | Dose Duration (min=15min) |
|-------------|-----------------|---------------------------|
| 1 | USER INPUT | USER INPUT |
| 2 | USER INPUT | USER INPUT |
| 3 | USER INPUT | USER INPUT |

Additional User Input for Clinical Trials

| | |
|---|------------|
| Reservoir Fluid Volume | USER INPUT |
| Mg Albuterol | USER INPUT |
| Patient Information (for research purposes) | USER INPUT |
| Comments | USER INPUT |



User Interface: Cleaning

- Removable parts will expedite cleaning.
- **Clinical Trials** – Thorough cleaning needed after each subject.
- **In Home Setting: Daily Maintenance** – Replace fluid in reservoir.
- **Weekly Maintenance** – A more thorough cleaning
- **Hospital use** – Thorough cleaning and replace tubing after each patient.

Budget

| Item | Vendor | Purpose | Unit Cost | Cost |
|---------------------------------|--------------|--|-----------------|-----------------|
| Total from last semester | Various | Used to develop effective prototype designs | \$159.61 | \$224.68 |
| HDPE Plastic block | McMaster | Machined into nebulizer reservoir base | \$3.00 | \$12.00 |
| Polycarbonate tube | McMaster | Cut and epoxy to form nebulizer chamber | \$2.19 | \$17.53 |
| Tubing and adaptors | ACE Hardware | Non-corrugated substitute for CPAP tubing and adaptors to connect to nebulizer | \$13.06 | \$13.06 |
| Plumbing kit | ACE Hardware | Fix to nebulizer making reservoir removable | \$5.26 | \$5.26 |
| CPAP unit | UW-Hospital | Used to test feasibility of prototype ideas | \$0 | Donated |
| Albuterol Nebulizer Doses | UW-Hospital | Used to test feasibility of prototype ideas | \$0 | Donated |
| Total from this semester | | | | \$47.85 |
| Total overall | | | \$183.12 | \$272.53 |



Future Work

- **Testing** to determine:
 - Rate of albuterol sulfate aerosol formation
 - Efficiency of aerosolized medication delivery to CPAP mask
 - Efficacy of pressure sensor with nebulizer and delivery programming
- **Create user interface** with adjustable dosage settings based on results of testing
- **Submit Disclosure Form** for Patent Application
- Submit paper to *Respiratory Medicine*
- **Conduct clinical trials** in Dr. Teodorescu's sleep research lab.

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Questions?