**PROJECT REPORT**
**On**

**Title : PORTABLE VENTILATOR IN HEALTHCARE**

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# "PORTABLE VENTILATOR IN Healthcare "


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## Section :

# Abstact :

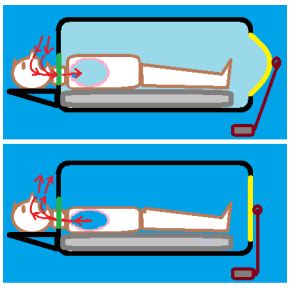
The current COVID-19 pandemic has heavily impacted the healthcare system in the United States and elsewhere. The need for patients to have access to a hospital with a ventilator along with a shortage of ventilators for recovery and at-home care as a result of minimal hospital vacancy for patients has been greatly stressed. The presented problem is both an unmet demand and supply of portable and effective ventilators.

The solution is to design a ventilator which can meet the symptoms and strains which COVID-19 can put on various individuals, should they not have access to a commercial ventilator as an economic constraint, or have restricted access to a medical facility attributed to the influx of patients. This means that a portable ventilator targeted for lower risks patients to be the ideal ventilator design. This ventilator would allow for short term out-patient care of low risk patients, thus allowing hospitals to focus on high risk patients.

The ventilator would include wireless communication, smartphone integration, and a portable power system which would allow consumers to relocate the ventilator as needed and have back-up power in the event of a power outage.

# Background :

A ventilator is a machine that uses mechanical ventilation to help patients breathe and provide oxygen when their own body is not able to do this correctly. The first widely used ventilators were during the polio epidemics,1920s and 1930s, and called iron lungs. These were large noninvasive devices that required most of the patient's body to be in a box. Then it used negative pressure to expand/contract the patient's chest and thus also the lungs, drawing air.



In the following years, the ventilators were constantly improved to function better, minimize maintenance, and increase reliability. However, the next big revolution in ventilator design did not occur until the introduction of microprocessors. This third generation of ventilators started with the Drager EV-A and finally allowed for monitoring of patients on a 3 screen. Immediately following, were the Puritan Bennett 7200, the Bear 1000, the Servo 300, and the Hamilton Veolar models.

# Product/Project Description :

The Portable Ventilator is a mechanical ventilation device designed to tackle one of the biggest problems with current ventilators, their restrictiveness. Currently patients are required to either be hospitalized and occupy an ICU room risking contracting disease or forgoing care. This leaves many patients with milder symptoms to have two bad options. Along with this, hospitals are also at a loss. Every patient with milder symptoms that is hospitalized is one less ICU room available for other patients with more severe symptoms. This also puts a strain on the limited resources hospitals have, such as nurses.


The Portable Ventilator seeks to solve these problems by providing a third option to patients and hospitals. This is the ability to provide out-patient care for mild cases that require help breathing and oxygen intake. This would be done by designing the Portable Ventilator to be lighter, smartphone compatible, automatic monitoring and adjustment, and a simpler interface for controlling the device. This would allow the ventilator to be used at the patients home with no need for professional monitoring. This would meet both the patient's need to be provided care without hospitalization and the hospital's need to keep available rooms and staff.

# Product Research :

Today most of the ventilators in the market and in use are designed for hospital use and to address specific medical needs. This means that an ICU ventilator may not be able to be used for neonatal ventilation. Having a many different types of ventilators allows most patients to be treated for whatever condition they may get. Modern ventilators include many health safety features to ensure that the patient remains safe even when there is an error.

This includes alarms for dangerous changes in patients' biometrics. Another safety feature is the monitoring and displaying of both patient and device conditions. One of the most important features of current ventilators is the ability to change the settings and provide precise control of the device. However, this means that to operate a ventilator not only requires accurate ventilator knowledge but also accurate medical knowledge. This causes ventilators to require professional monitoring and administering.

# Technology Research :

Ventilators are controlled by microprocessors. These microprocessors are responsible for controlling and communicating with various components. These components include the sensors, compressors, pumps, displays, and etc. For the Portable Ventilator design we would need a microprocessor that can perform those same duties using I2C communication protocol along with having wireless capability. A Raspberry Pi 4 microprocessor is capable . The sensors needed are many, with flow rate, temperature, humidity, and O2 being a few. There are many available sensors that could be used which are both small and require little power.

Focusing on mild symptom/low risk patients could allow the Portable Ventilator to be designed without an air compressor and reduce the cost and complexity of it. Due to the widespread use of advanced smartphones, the Portable Ventilator can use an app to easily communicate with the user and allow the user to easily adjust the ventilator.

The most important feature of modern ventilators are the alarms and failsafe features to protect the patient. This is done through the monitoring of the patient's biometrics and ventilator conditions. Any problem encountered by the ventilators would cause the alarms to set off and failsafe features to activate, if needed, until a nurse can attend to the patient[9]. With the use of an app, the portable ventilator can guide the patient or family member on the steps needed when there is a problem and automatically call for medical attention.

## Market Research :

The ventilator market is a growing market due to both an increase in the geriatric population and the COVID-19 pandemic.[10] The COVID-19 pandemic rapidly increased the demand for ventilators and companies responded by increasing production of ventilators. However, this increase in production was for ICU ventilators. This led to a saturation in the market as the number of ventilators that can be used is limited by the number of ICU rooms available. Therefore, the largest reason for patients not receiving the necessary ventilation they need is not caused by a lack of ventilators but a lack of hospital space and medical staff. This leaves a need

for hospitals to alleviate their in-patient care and increase out-patient care. The Portable Ventilator is designed to meet that need and fill that market. Along with opening up hospital space, the Portable Ventilator will also fulfill the need for patients to remain active and comfortable. Presenting this new option should cause many current patients to opt into using the Portable Ventilator over the current one they are using. While the current demand is being driven mainly by the current pandemic, the demand will continue to increase for years due to the geriatric population. The limitations for this increase are due to high cost and operating requirements . The Portable Ventilator would address these issues by presenting a cheaper, lighter, and accessible alternative for out-patient care in both nursing and private homes.

# Market Description :

The portable ventilator aims to create an avenue for hospitals to provide out-patient care so that they may increase the amount of rooms available for patients with more severe respiratory symptoms while still administering adequate out-patient care for those with less-severe symptoms. The ventilator will be driven with a desire to make sure all patients with respiratory symptoms may receive the care they need appropriate to their symptom severity. This is much inspired by the 2019 outbreak of COVID-19 and its impact on hospitals with a focus on the United States. To penetrate the market, serious capital would have to be invested into getting this device FDA approved, patent the device, visit trade shows and hospitals to talk with hospital business administrators, and designing and building a working prototype. This will require a minimum of 25,000 of funding to provide for the materials to produce a ventilator unit, for the labor of the team, for the applications towards patents and FDA approval, and for travel to trade shows and hospitals. The time investment would be large for the team involved. Due to the small team, it could take around 20 hours per person in order to get a unit functional. It also may take two years to get all of the approvals and begin to enter the market.

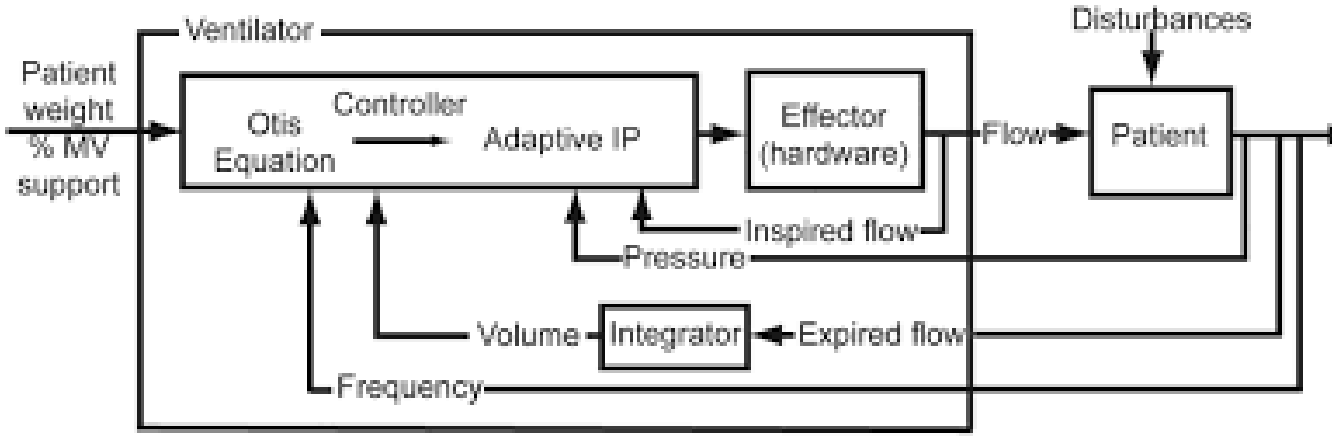
## Marketing Requirements :

The Portable Ventilator will be designed to include features that will solve the current problem with available ventilators. Similar to current ventilators, the Portable Ventilator will provide breathing and oxygen intake assistance to low risk patients. The differentiator between current ventilators and the Portable Ventilator will be the greater accessibility, mobility, and 16 comfort the Portable Ventilator will provide to patients. This will be done by designing the ventilator to be light, run on a battery, and be easy to use.

The Portable Ventilator places higher importance on features that add to the functionality of the device. If there is a choice between a higher cost or a lower functionality of a smartphone integration, the ventilator will have to receive the higher cost in order to provide the extra service to the customer. This is necessary to stand out versus other portable ventilators on the market. Without many of these beneficial design features, this device would not be able to break through the market.

## Block Diagram :

The high(0th) level block diagram for the ventilator displays the necessary inputs and outputs for the system. The inputs for the system are the patient's biometrics, patient input, air, and a charger. The patient's biometrics must be accurately measured to provide feedback to the ventilator so it can adjust to provide the needed enriched air. The patient input sets and changes the settings for the ventilator and defines how the ventilator will be used(e.g. high flow rate). The air input is used by the system to provide the air flow rate and is enriched with oxygen to create the enriched air for the patient. The charger input is necessary to charge the ventilator's battery and allow the ventilator to be portable. The outputs for the system are the enriched air and the measured biometrics. The enriched air is humid, pressurized, oxygen-enriched air that is supplied to the patient. The enriched air's conditions must be carefully and accurately met to provide the patients needs. The measured biometrics must be clearly and readily available to the patient.




This will require both a functional and usability test. The functional test will be a check that the phone/app is correctly communicating to the Raspberry Pi and the phone/app is correctly displaying information. The usability test is to ensure that the ventilator's setting can be easily set and managed. This test will be done by having people outside the project use the app to set the ventilator's setting according to what they are told they should be.

A notable thing about the block diagram is that the Lion Battery and Voltage regulator will connect and provide the power to the various components. The feedback for the system is provided through the combination of the sensors and the Raspberry Pi. The pulse oximeter and watch both measure the patient's biometrics with the pulse oximeter being the back up.

# Conclusion :

Various portable ventilators are available, driven by demands for equipment suitable for different clinical situations and environments. Their design reflects availability of gas and electrical supplies and the modes of ventilatory support required by the patient population. When transporting critical care patients, provision for estimated gas and electrical requirements should be made. A ventilatory mode suited to the patient's clinical condition should be selected and trialled before departure.

An appreciation of how different portable ventilators function, preferably supported by comparative data, can help when an organization purchases such equipment. Understanding the strengths and weaknesses of a specific ventilator and breathing circuit may help anticipate and prevent complications during transfer.

A portable ventilator should be lightweight, robust, and able to function in demanding environments with little maintenance.

Most portable ventilators display the oxygen concentrations selected by the operator, and do not measure that delivered by the ventilator.

Portable ventilators may not provide identical support to the ICU machine in use despite apparently similar settings; a trial period should always be allowed before moving the patient.

Portable ventilators that assist spontaneously breathing patients are more complex and generally require microprocessor control.

Alternatives to oxygen cylinders such as oxygen concentrators and liquid oxygen should be considered for prolonged use outside of hospital.

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