

**DEVELOPMENT OF AN AUTOMATED RESPIRATOR FOR EMERGENCY USE  
THE EFFECT OF AUTOMATION IN HEALTHCARE ON PATIENT OUTCOMES**

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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## **General Research Problem**

*How do automated medical technologies and a reduction in human input make for a safer society?*

Automation has been a benefit to technological efficiency since its pioneering by Henry Ford in 1913 during the assembly of his first automobile, and our society has continued that legacy in introducing automation in every viable aspect of our lives. Automation has led to faster collection, assembly, and distribution of everything from food, to weapons of war on a global scale and in recent years it is an increasingly common aspect of the medical field. The potential of a completely automated emergency response is immense, as it would leave no room for human error or delay, a diagnosis could be made instantaneously and appropriate care immediately given. Everyday we grow closer to making this a reality with countless new devices that can deliver treatment being developed and proposed. One such device is the focus of the technical aspect of this paper, an automated ventilator that is being developed by Ventis Medical. The success and distribution of which would fill an important need in today's society. Currently if an emergency responder in the United States encounters a patient that is unable to breathe on their own then they must use a manually operated ventilator that requires constant input and care that almost encourages human error. The development of this device that myself and my project collaborators will work on would reduce this potential error allowing for a safer and more successful user experience. However, while an automated device such as this does reduce the likelihood of human error it does not remove the existence of failure entirely, rather it simply moves it to a different source. For that reason, I will be examining the potential consequences of implementing automation in the field of medicine and weighing it up against current treatment methods to determine its net benefit or detriment.

## **Advancing the Design of the VM-2000 Automated Ventilator by Ventis**

### **Medical**

*How can non-invasive respiratory techniques be applied to the existing VM-2000 device?*

Annually, prehospital mechanical ventilation is delivered in 1.2 million (*Office of EMS: NEMSIS*, n.d.) emergency medical service activations in the United States (Stephens et al., 2019). In the case of out-of-hospital cardiac arrests, less than 40% of patients that required mechanical ventilation will survive hospital discharge (Grieco et al., 2022), a mortality rate that is often a direct consequence of ventilator-induced lung injury (VILI). In these patients that are mechanically ventilated the primary cause of VILI is an excess amount of stress and strain in the aerated lung, an unfortunate by-product of ventilation that is much more difficult to prevent when using manual ventilation versus automatic (Stephens et al., 2019). Currently, if an emergency responder found it necessary to provide an individual with ventilation, most likely due to them not being able to breathe of their own power, they would utilize a manual bag valve ventilation device. These devices are portable and disposable but their biggest drawback is that they require constant and consistent manual operation to keep the patient breathing. A typical ambulance in the United States operates with two EMTs, a driver and someone to monitor their patient in the back, (Brown et al., 1996) therefore, during a potentially long ride to a hospital the responder in the back of the vehicle will need to be applying measured squeezes to the large bag of the device at frequent intervals for an extended period of time completely on their own. The room for error during this time period is immense as the operator could apply too much pressure resulting in VILI or could grow too tired to apply constant pressure, potentially shortening the patient of oxygen to the brain and killing them. An automated ventilator however, would

eliminate this potential error while also providing the operator the time and the hands to perform other essential tasks to keep the patient stable until they can reach a hospital.

In a 2005 study, the usefulness of an automatic transport ventilator (ATV) was compared with bag valve (BV) ventilation for intubated patients. The Emergency Medical Technicians-Paramedics (EMT-P) that participated in the study cohesively agreed in favor of the ATV due to their better ability to accomplish more tasks, and ability to document and provide better patient care than when using the bag valve (Weiss et al., 2005). Automatic ventilation is a safer and more reliable tool, yet current ATVs are not optimized for prehospital emergency use because they are often considered to be too bulky, complicated, and expensive. Due to these flaws' ATVs are rarely seen on emergency response transport vehicles.

In response to this need Ventis Medical has designed the VM-2000, a cutting edge product that is more successful in its portability, usability, and affordability (troselaub, 2022) than all other current designs. As it stands, the product is currently undergoing testing for FDA approval, which would allow it to be distributed to hospitals and emergency transport vehicles nationwide. The distribution of this product would eliminate so much potential for human error during the critical juncture of getting a patient into a hospital, however it is lacking in one key design aspect. Currently the VM-2000 requires patient intubation in order to operate correctly. The process of feeding tubing through a person's mouth or nose and into their trachea is extremely invasive and also requires proper training in order to do properly without injury or complication. This process really only works well for patients that are nonresponsive or unconscious but that is certainly not going to be the case in every emergency situation. The goal that myself and my teammates hope to achieve is to iterate upon the existing design to create a non-invasive mask for the VM-2000. This would allow it to be used nationwide on emergency transports without

the need for intubation, improving the efficiency, safety, and ease of use of the device, qualities that could all mean the difference between life and death in an emergency situation.

## **Comparing Automated and Manual Healthcare**

*How has moving further towards automatic medical machinery affected the wellbeing of individuals in critical care?*

### *Background*

Human beings are inherently social creatures, cooperation with one another lies at the very heart of human society and we rely on it to survive and thrive (“The Cooperative Human,” 2018). Complete social isolation is such a fundamental aspect of being human that it can be detrimental to one’s health to the point of being deadly if severe enough. Considering this essential need that all humans have I think that there is significant reason to doubt the benefits of our ever-increasing push towards automation making its way into the business of healthcare. The problem is not one with a clear answer however, despite the potential negative impacts of automation in healthcare, there are also many obvious benefits. As referenced in the technical description above, EMT-Ps found an automated ventilator to be easier to operate and more beneficial for their overall care of the patient than the manually operated alternative. This example is certainly not an outlier nor is it unique to just healthcare, automation has made workplaces safer, and more productive while also increasing the value of human labor (*10 Ways Automation Is Improving Human Lives - Technology Org*, 2019). One can simply look at the price of a machine-brewed cup of coffee from a vending machine and the hand-made cup from a local barista to see the proof of the matter. However, while the role of constant monitors and automated devices unquestionably makes the jobs of our health care professionals easier, the

potentially harmful consequences of having your medical care being operated by a machine rather than another person needs to be considered.

### *Literature Review*

Automation in health care has its benefits, but with it runs the risk of neglecting the social needs of the patients it should be aiding. With advances in robotics, and artificial intelligence, our healthcare is changing and with it has come “the rise of the data-driven physician” (*Stanford Medicine’s 2020 Health Trends Report spotlights the rise of the data-driven physician*, n.d.).

Our current and future doctors are now being trained and re-trained to provide care in addition to navigating a sea of data that is collected about every aspect of our lives. This means that more and more diagnoses will be done automatically without the need for human interaction. These diagnoses will soon be much quicker and more accurate than that of a medical professional but they also become lonelier, and there lies the problem. Recent studies have shown that “social isolation significantly increased a person’s risk of premature death from all causes, a risk that may rival those of smoking, obesity, and physical inactivity” as well as being “associated with about a 50% percent increased risk of dementia” (*Loneliness and Social Isolation Linked to Serious Health Conditions*, 2021). These health risks are significant and while they bring up an altogether different problem in how we abandon our elderly, these risks are extremely relevant in how we should be treating patients. For example, the Continuous Cardiac Monitor (CCM) was first introduced in the 1960s and is now an essential tool in any hospital to monitor a patient’s heart rate, allowing nurses and doctors to have constant detector of irregularities in heart rate. What this has also done is allow a patient to be monitored without human interaction, allowing hospital staff to see to other needs, and check on a patient much less frequently. Current practice suggests a patient’s vital signs should be checked every 4 hours, as with modern technology such

as the CCM a higher frequency is not necessary. However, what needs to be considered is that “loneliness among heart failure patients was associated with a nearly 4 times increased risk of death, 68% increased risk of hospitalization, and 57% increased risk of emergency department visits” (National Academies of Sciences, 2020). Automating our healthcare system will require a delicate balance that needs to be studied further before full implementation.

### *Theoretical Framework and Methods*

The process of further implementing automation in our hospitals and the general healthcare system requires a more in-depth assessment of the lasting impacts before moving any further. The goal of reducing human labor in hospitals is a good one as our healthcare professionals are overworked to the extreme and making their jobs easier should always be in everyone’s best interest. That goal needs to be taken alongside that of ensuring patients are given the care needed to uphold their mental health, not just their physical, a balance that requires a deep evaluation of the literature available to come to a valid assessment of what can be done moving forward. Utilizing a thorough literature review I will first determine to what degree automated techniques has improved patient outcomes and then do a further analysis into whether these techniques have resulted in a significant decrease in patient-professional interactions and to what degree that may be worsening patient outcomes.

### **Conclusion**

At the end of my research and analysis I hope to have a clearer picture of the benefits automating our healthcare industry may have alongside a deeper understanding of the consequences such reliance on technology could have on the wellbeing of those being cared for. The process of the medical industry becoming more automated is not one that can, will, or maybe even should be

stopped. As technology advances so too will the level of care our hospitals can administer, however from this project I hope to glean how to balance the level of automation we use to ensure physical health with the level of human interaction required to ensure mental health. While the STS focus of my research will be primarily on the potential consequence of too much automation in healthcare, I hope to still gain an appreciation and understanding of the function and benefit of automated devices through my technical research. The successful development of the automated ventilator designed by Ventis Medical has life-saving potential as well as a general improvement to the quality of care given by emergency responders. In being a part of that process, I will be able to see the direct benefits of such advancements in the medical field as well as being able to see how such a device can be used without disregarding human treatment as well. Through these two focuses of research the general question of how automated technologies make for a safer society will be better understood and hopefully answered.



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