

Thesis Project Portfolio

**Non-invasive Ventilation and the VM-2000: Improving the Versatility of an Affordable,
Easy-to-Use Emergency Ventilator**

(Technical Report)

The Effect of Automation in Healthcare on Patient Outcomes

(STS Research Paper)

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Executive Summary

Medical technologies are constantly evolving and developing to meet our every need and the potential for a completely automated emergency response is significant. They are promoting the advancement of healthcare, improving patient outcomes, and transforming the way medical conditions are diagnosed, treated, and managed. From innovative devices and equipment to cutting-edge diagnostic tools and therapies, medical technology encompasses a broad spectrum of advancements that aim to enhance medical interventions and optimize patient care. 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. The weight put upon the future creators of modern medical technology cannot be understated. How we balance efficiency and cost-effectiveness with safety and ethical concerns becomes a drastically more arduous task when assessing the tools that will be put in the hands of the people we have entrusted to save lives. How do we as engineers ensure that in creating these tools, we are providing the best solution and not causing additional harm?

Ventis Medical is developing an affordable, easy-to-use emergency ventilator called the VM-2000 aimed at expanding accessibility of ventilator technology. The VM-2000 is intended to replace rudimentary bag-valve masks and existing transport ventilators, which are expensive, cumbersome, and complex. In this project, a mask attachment system and non-invasive ventilation (NIV) feature were developed for the VM-2000, expanding the versatility of the device by allowing it to be used without intubating the patient, a procedure that can be difficult to perform in emergency situations. First, a variety of existing respiratory masks were evaluated for the creation of a mask attachment. Second, an NIV mode developed by Ventis Medical was evaluated for its performance and used to assess these masks. Third, an initial 3D model was

built for a neck prop that could be used to help easily maintain an open airway in the patient during NIV. The VM-2000 is currently in the process of receiving FDA clearance, and in the future this NIV feature will be incorporated into the device and its operation to create a safer, more effective, and easier alternative to prior methods of ventilation.

Implementing automation in healthcare has had a lot of benefits and encompasses a wide range of applications. It has immense potential for improving accuracy, efficiency, and patient outcomes by reducing human error. It also has the capacity to free up healthcare professionals' time, allowing them to focus on complex tasks and direct patient care. However, it is important to strike a balance between automation and maintaining a human touch in healthcare to ensure patient-centered care and preserve the doctor-patient relationship. Utilizing an in-depth review of the literature on the topic I sought to better understand this complex relationship and provide some understanding on the way in which the tools we use can affect us unexpectedly. From this analysis I determined that advances in technology have caused changes in the healthcare system that are responsible for the deterioration of a patient's personal connection and trust with their doctors and/or other care providers. The use of certain automated technologies has left patients unsatisfied and unhappy with their care despite the providers finding their work easier because of it. Ultimately it is clear that automated systems in the medical world are eliciting a negative response from patients, the question of whether it is significant enough to counteract the benefits provided by their use is still unanswered.

The conclusion of both of these projects leaves me with a great deal of satisfaction with what we sought out to do and achieved. Working with Ventis Medical was deeply gratifying and provided me with lessons and experiences that I will never forget and continue to utilize in my near and distant future. My team members and I accomplished the goals that we set out and I

hope to see the fruits of our labor when the VM-2000 gains FDA approval. Evaluating the ways medical technologies affect people in unforeseen ways was a topic I enjoyed delving into and hope to explore further in my career. It was at times difficult to find quantifiable data on how automation in healthcare has had negative impacts and as I said previously, I cannot conclude either way that the harm caused by some of these technologies is counterbalanced by the benefits that they do provide. A more definitive answer to this is something I would have liked to find but for now is something left for future work.

I would like to thank my team members for their hard work throughout this year as well as my advisors Dr. Glenn Laub and Dr. Kent Wayland for providing me with this opportunity and guiding me through my research.