Low-cost, easy-to-build ventilator performs similarly to high-quality commercial device

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Low-cost, easy to build prototype ventilator during use. The ventilator can be used to support COVID-19 treatment in low income regions of where ventilator supplies are limited. Credit: Prof. Ramon Farré.

A low-cost, easy-to-build non-invasive ventilator aimed at supporting the breathing of patients with respiratory failure performs similarly to conventional commercial devices, according to new research published in the *European Respiratory Journal*.

Non-invasive ventilators are used to treat patients with breathing difficulty and respiratory failure, a common symptom of more severe coronavirus disease. Non-invasive ventilation is delivered using facemasks or nasal masks, which push a set amount of pressurised air into the lungs. This supports the natural breathing process when disease has caused the lungs to fail, enabling the body to fight infection and get better.

The research paper provides a free to replicate, open source description for how to build the ventilator. The researchers say the prototype ventilator could support treatment of coronavirus and other severe respiratory diseases in low income regions or where ventilator supplies are limited.

The study was led by Ramon Farré, Professor of Physiology in the Unit of Biophysics and Bioengineering at the School of Medicine of the University of Barcelona, Spain. He said: "In light of the ongoing coronavirus pandemic and the escalating need for respiratory support devices around the world, we designed a ventilator that can be built at a low cost using off-the-shelf components. The ventilator is intended to support hospitals and health systems that are struggling to meet the demand for ventilatory support due to coronavirus and other severe lung diseases."

The research team designed, built and tested the low-cost non-invasive ventilator with a small high-pressure blower, two pressure transducers and a controller with a digital display, which are available at a retail cost of less than $75 USD (equivalent to £60 GBP / €67 EUR).

Display panel for the low-cost, easy to build prototype ventilator, which could be used to support COVID-19 treatment in low income regions or where ventilator supplies are limited. Credit: Prof. Ramon Farré.

To assess the effectiveness of the ventilator prototype compared with a commercial ventilator, the research team tested the device using 12 healthy volunteers. The participants' breathing was partially hindered by having them wear bands around the chest, mimicking obstruction at the upper airways to simulate different levels of chest tightness and breathing difficulty caused by disease.

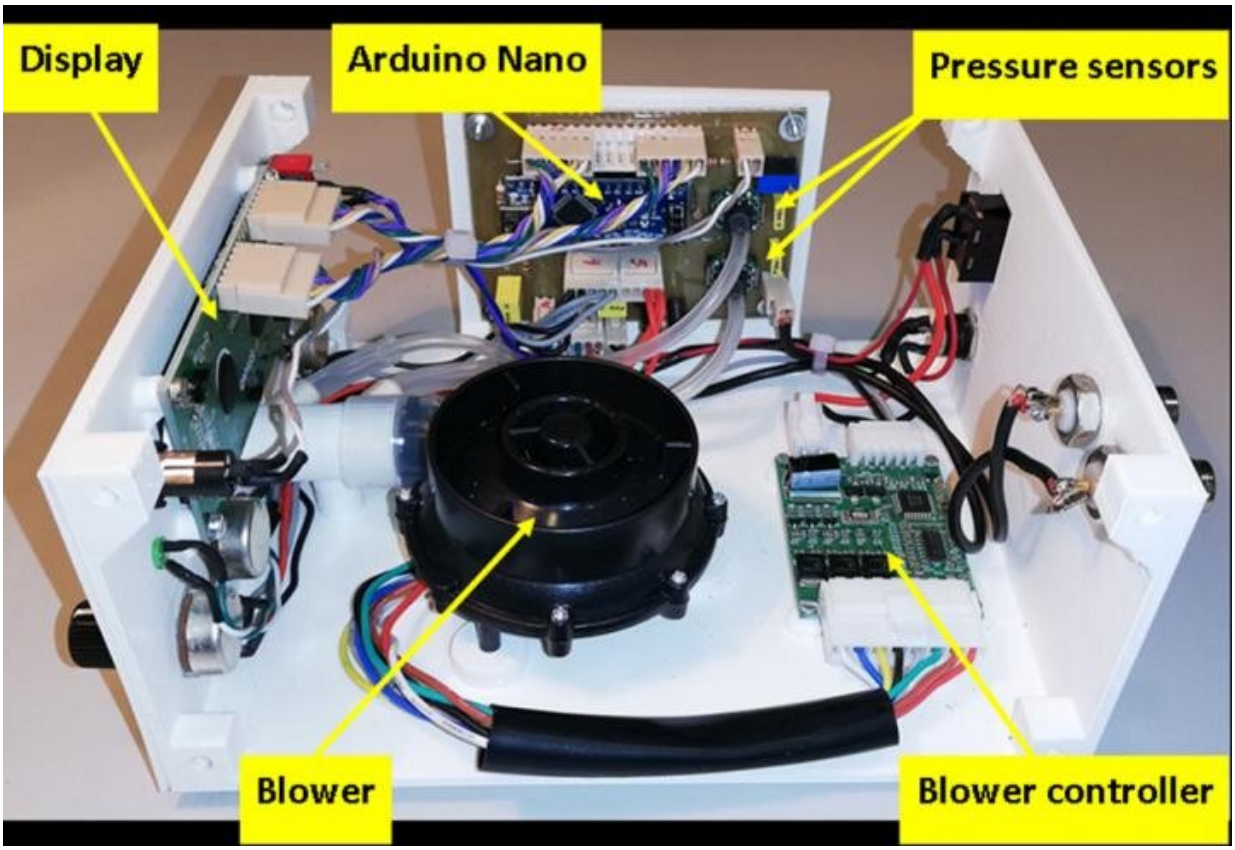
The participants wore face masks fitted over the nose to facilitate

breathing and were asked to score the level of comfort or discomfort they experienced both with and without ventilatory support.

The researchers observed no faulty triggering of changes to the levels of air pushed from the ventilator during use, and the team says it effectively supported spontaneous breathing rhythm, suggesting that the prototype assists natural breathing well. Further, they found that the feeling of breathing relief provided by the prototype was virtually the same as what was reported using the commercial ventilator.

The team also carried out respiratory "bench testing", where lung modelling is used to assess how well the ventilator supports the breathing of patients with different levels of airflow obstruction or restriction. The ventilator prototype was tested under 16 different simulated conditions, covering real life settings where non-invasive ventilation is used in clinical practice.

The bench test showed that, across all simulated conditions, the prototype ventilator worked effectively to support the lungs to operate efficiently and there was no faulty triggering.



The internal build of the ventilator prototype with labels indicating the off-the-shelf components, including the blower and controller, display panel and pressure transducers. Credit: Prof. Ramon Farré.

Professor Farré said: "Our tests showed that the prototype would perform similarly to a conventional, high-quality device when providing breathing support for patients who, although with great difficulty, can try to breathe by themselves. This low-cost device could be used to treat patients if commercial devices are not available, and it provides clinicians with a therapeutic tool for treating patients who otherwise would remain untreated."

The researchers highlight that the prototype is a non-invasive ventilator;

it is not intended for the most severely diseased patients in intensive care units, who are intubated and require a mechanical ventilator to take full control of the patients' breathing, as the prototype only provides breathing support.

Professor Leo Heunks is an expert in intensive care medicine from the European Respiratory Society and was not involved in the study. He said: "World Health Organization data suggests that around 80% of people who get coronavirus recover without needing hospital treatment, but those who do develop severe symptoms can experience breathing difficulties, which is distressing and puts health systems under additional pressure. Low-cost solutions like the ventilator described in this paper could provide treatment for those patients, potentially improving outcomes and helping to alleviate pressure on health systems by reducing the need for more invasive types of ventilatory support."

An open source description with full technical details on how to build the non-invasive ventilator is included in the research paper. The authors say that to build the device no prior knowledge of ventilation is required, and only basic engineering skills are needed.

More information: Onintza Garmendia et al, Low-cost, easy-to-build non-invasive pressure support ventilator for under-resourced regions: open source hardware description, performance and feasibility testing, *European Respiratory Journal* (2020). DOI: 10.1183/13993003.00846-2020

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