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Low-cost, easy-to-build noninvasive pressure support ventilator for under-resourced regions: open source hardware description, performance and feasibility testing

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Patients in under-resourced areas cannot be treated by mechanical ventilation given the unaffordable cost of conventional devices; here a low-cost, easy-to-build ventilator with open access details for free replication is designed and tested https://bit.ly/34UcbWp

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ABSTRACT

Aim: Current pricing of commercial mechanical ventilators in low-/middle-income countries (LMICs) markedly restricts their availability, and consequently a considerable number of patients with acute/chronic respiratory failure cannot be adequately treated. Our aim was to design and test an affordable and easy-to-build noninvasive bilevel pressure ventilator to allow a reduction in the serious shortage of ventilators in LMICs.

Methods: The ventilator was built using off-the-shelf materials available *via* e-commerce and was based on a high-pressure blower, two pressure transducers and an Arduino Nano controller with a digital display (total retail cost <75 USD), with construction details provided open source for free replication. The ventilator was evaluated, and compared with a commercially available device (Lumis 150 ventilator; Resmed, San Diego, CA, USA): 1) in the bench setting using an actively breathing patient simulator mimicking a range of obstructive/restrictive diseases; and b) in 12 healthy volunteers wearing high airway resistance and thoracic/abdominal bands to mimic obstructive/restrictive patients.

Results: The designed ventilator provided inspiratory/expiratory pressures up to 20/10 cmH_2O,

respectively, with no faulty triggering or cycling; both in the bench test and in volunteers. The breathing difficulty score rated (1–10 scale) by the loaded breathing subjects was significantly ($p<0.005$) decreased from 5.45±1.68 without support to 2.83±1.66 when using the prototype ventilator, which showed no difference with the commercial device (2.80±1.48; $p=1.000$).

Conclusion: The low-cost, easy-to-build noninvasive ventilator performs similarly to a high-quality commercial device, with its open-source hardware description, which will allow for free replication and use in LMICs, facilitating application of this life-saving therapy to patients who otherwise could not be treated.