Q&A: Updating pulse oximeters

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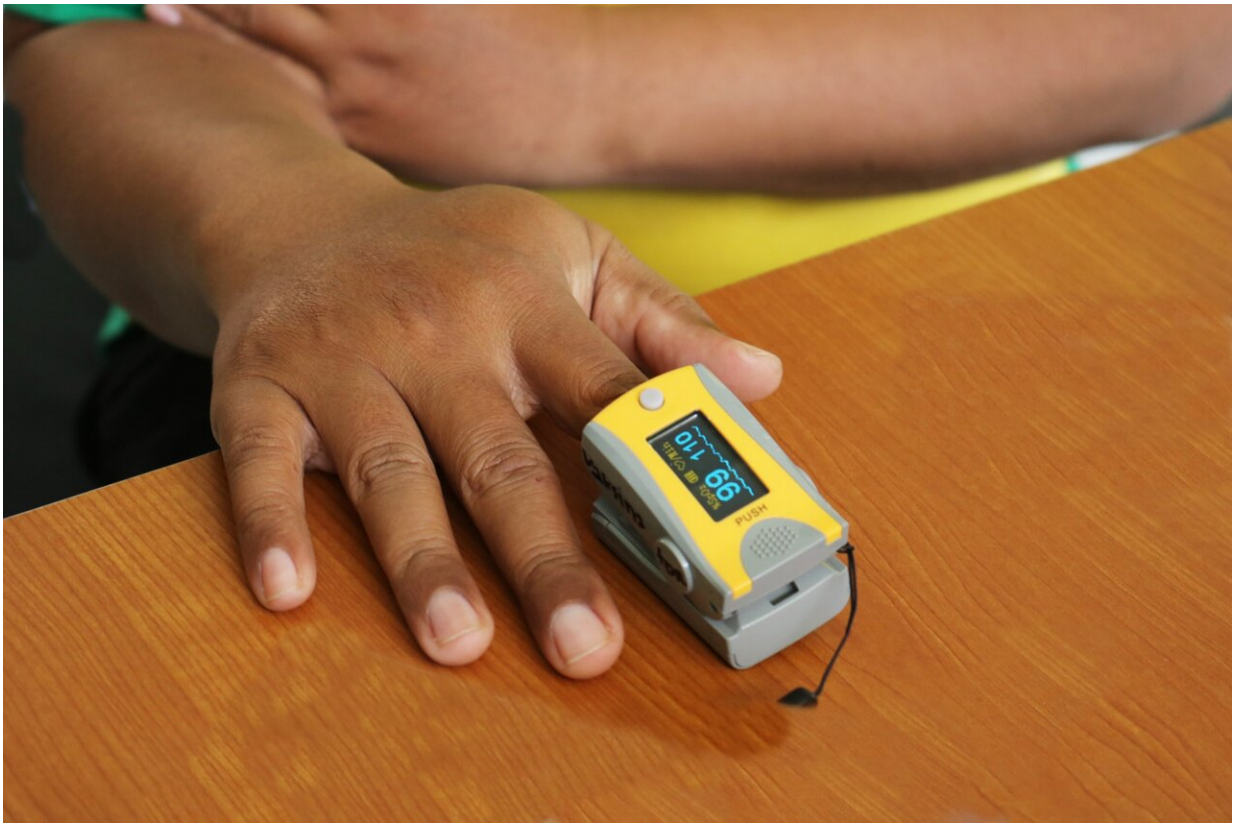

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A portable device used to detect blood oxygen levels revolutionized the medical field 50 years ago and is now receiving essential updates.

Efforts to improve the accuracy of pulse oximetry readings for diverse groups of patients and in multiple settings are underway. Joel Moss,

M.D., Ph.D., a senior investigator in NHLBI's Laboratory of Translational Research, and Bennett Yang, a postbaccalaureate fellow in Dr. Moss's lab, describe this process and the future of pulse oximetry research.

Q: Why are portable pulse oximeters important?

Bennett Yang: The cells that make up the human body depend on oxygen for survival. Within minutes of oxygen desaturation, tissue starts to die. So, the importance of monitoring a patient's blood oxygen levels, especially if they are low, such as during surgery or if a person has COVID-19 or pneumonia, cannot be understated. The pulse oximeter, or pulse ox, was created to rapidly and noninvasively estimate a patient's blood oxygen saturation so that patients and physicians can monitor and adjust for an individual's oxygen needs.

The portability of the pulse ox, such as those that can clip on fingertips, has made it more accessible and valuable, both within the hospital and at home. The pulse ox works by emitting red and near infrared light from one surface of the finger to a detector on the other side. Oxygenated and deoxygenated blood absorb these lights differently, which allows the pulse ox to calculate oxygen saturation based on these ratios.

Q: What limitations have researchers found with pulse oximeters?

Yang: The pulse ox has revolutionized medicine, but, like any device, it has limitations. For example, pulse ox accuracy tends to decrease as oxygen saturation levels drop, which could lead to inaccurate readings. This, unfortunately, is when oxygen detection is critical.

Additionally, the pulse ox does not perform well if a patient has poor

blood flow in their fingertips or if they are wearing nail polish. Blood loss, constricted blood vessels, and conditions, ranging from heart failure to Raynaud's disease, a rare condition that disrupts blood flow, can all contribute to decreased accuracy.

Physical motion can also disturb pulse ox readings. This is called motion artifact. This is especially a problem for patients who have normal oxygen saturation levels at rest but desaturate when they start to move or during daily activities.

Finally, and critically important, the pulse ox tends to overestimate oxygen saturation in patients with darker skin tones. The reason lies in melanin, which is the skin pigment. Melanin's job is primarily to block ultraviolet light to protect tissues from underlying damage. And it does this well.

But, it also absorbs across a range of wavelengths, including red and near infrared, which are the lights emitted from the pulse oximeter. It tends to do this with differing intensities. The overall effect of this is that it skews measurements upwards in patients with darker skin tones.

Q: What did the COVID-19 pandemic reveal about health disparities related to inaccurate pulse oximetry readings?

Yang: The pitfalls of the pulse ox are not new ideas to the clinic, but the pandemic has raised more concerns about the device's accuracy. Data from the last three years has made it painfully clear that communities of color as well as socioeconomically disadvantaged populations have disproportionately suffered from COVID. This includes more frequent oxygen desaturation.

Remember, the pulse oximeter tends to overestimate true saturation for these patients. So, not only would these patients require medical intervention more often, but recent research has shown they have also been victim to systemic delays in receiving interventions because the pulse ox is essentially telling physicians that these patients are doing better than they actually are. Hence, health disparities are compounded by the pulse ox's inaccuracies.

Q: How are researchers studying ways to update this technology?

Yang: Updating the pulse ox will help physicians make the best choices for their patients. Thankfully, several projects are underway. One includes a new green-light pulse ox, which is being studied by researchers in Texas.

Their device is based on the principle that the difference in absorbance between oxygenated and deoxygenated blood is largest in the green-light range. Also, green light does not penetrate through the finger as well as red and near infrared light. The pulse ox instead measures reflection off of the skin rather than being transmitted through it. A benefit is that the light does not have to pass through two layers of skin and two layers of melanin, which also helps avoid any deeper sources of tissue error.

The researchers also calibrated their device using a skin pigment color scale. Therefore, the pulse ox could adjust for the skin color of each patient being monitored.

Q: How is NHLBI's small business innovation research program supporting translational aspects of this research?

Dr. Moss: The NHLBI small business and innovation research (SBIR) program was established to fund businesses developing devices and technologies that align with NHLBI goals. Specifically, our SBIR topic 114 is part of an effort to support a company in developing a wireless, user-friendly, pulse ox that can interface with mobile devices.

The idea is that patients who need to continuously monitor their oxygen saturation, such as patients with lung disease, should be able to do so during daily activities and with technology that can automatically record their data. The SBIR explicitly mentions the need to recruit a diverse population for clinical study, which will strengthen the pulse ox's accuracy.

We hope to have two companies compete for a phase 1 award, perhaps with clinical testing, within the next 3-4 years. A developed prototype from one company would advance to a phase 2 clinical trial leading to FDA approval.

Again, the objective is to have a wireless pulse oximeter that measures oxygen levels during exercise, regardless of skin color, and interfaces with mobile devices.

The research is published in the journal *CHEST*.

More information: Bennett Yang et al, Evolution of the Pulse Ox, *CHEST* (2023). DOI: 10.1016/j.chest.2022.12.042

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