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EDITORIAL COMMENT

# Extracting Vocal Biomarkers for Pulmonary Congestion With a Smartphone App*

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Pulmonary congestion is the principal admission reason in patients with acute decompensated heart failure (ADHF), and persistent pulmonary congestion portends poor post-hospitalization outcomes (1). Tracking fluid retention over the course of HF may prevent ADHF hospitalization and improve the quality of inpatient care. However, objectively tracking congestion cheaply, frequently, and accurately remains challenging.

Machine learning (ML) has accelerated "nonclinical" adoption of automated and functional speech recognition systems broadly, but it remains to be seen whether these systems can be used to track physiologic variables like pulmonary congestion for clinical use. A number of studies have taken advantage of the smartphone, a pervasive and noninvasive device for patient data collection, and studies have also shown a relationship between fluid retention and vocal cord vibration (2,3). Amir et al (4) explore the possibility of monitoring pulmonary congestion through voice analysis using a smartphone app. In this commentary, we highlight implications this study may have on HF management, discuss potential alternative approaches, and highlight some cautionary notes regarding equity in use of such technology with respect to vulnerable populations.

## CHALLENGES WITH VOCAL BIOMARKER TRACKING AND ALERTING

Congestion may be easier for clinicians to verify, interpret, and intervene on in a targeted manner than a global indicator of HF status such as New York Heart Association functional class, simply because the spectrum of congestion is lower dimensional (3). The HearO app, as presented by Amir and et al (4), requires a patient to read specific phrases into their smartphone. Using a number of fixed analytic measures, the app reports differences between a patient's current speech characteristics and those in a reference state, such as euvolemia. The authors show that there are significant differences in the app's voice analysis findings at hospital admission vs discharge.

However, there are several important limitations to this approach. For example, patients are required to engage the app and read the appropriate phrase for the app to be useful. Inconsistencies in adherence to many nonpharmacologic self-care recommendations for patients with HF suggest that engagement with a system like the HearO app may be suboptimal.

Another important limitation of the HearO app is that it may be difficult to true euvolemia over the course of hospitalization. ADHF itself is also highly variable in presentation, and pulmonary congestion may not be the ideal clinical reference point in many scenarios (1). Given these factors, a more holistic monitoring approach, such as using always-on virtual assistants like Alexa or Siri, may be more effective for individualization of clinical alerts. However, development will require large, rich data sets to develop and train effective ML models (5), and use of passive,

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continuous listening, of course, raises additional privacy concerns. For example, challenges persist in how to limit language and dialect bias, and thus, the use of smartphone technology in the clinic requires careful design during development.

## BROADENING THE POTENTIAL OF VOCAL BIOMARKER TRACKING IN THE CLINIC

In clinical practice, individuals often present with similar symptoms each time they develop ADHF. Speech changes associated with ADHF could be learned over time for an individual patient, which could improve both the accuracy of alerts and the timing of advance notification. For example, rather than relying on speech measures only at admission or discharge to indicate congestion, as is the case with the HearO app, speech measures could be made more granular and diverse. For example, phrase length and actual word content could supplement vocal cord vibration by assessing different symptom types. However, although a response to a single concerning signal such as vocal cord vibration may be as simple as prompting a formal clinical assessment, an abundance of concerning signals may complicate already involved clinical workflows. If use of smartphones in ADHF management, as with the HearO app, is to be scaled, it will be important to discern what steps to take based on the nature of the warning signal to allow cheap, frequent, and accurate volume assessments on a specific schedule and AD hoc basis without compromising quality of care and contributing to provider burnout.

## TECH IN MEDICINE: A CAUTIONARY NOTE

Artificial intelligence is plagued by bias, which has unfortunately only recently been given extensive attention (3,6). Algorithms rely on developers to make choices in modeling and data, both of which allow for the introduction of bias and reinforcing systemic bias. The development of software, especially in safety-critical environments, should involve careful consideration of fairness, operational tolerances, and adverse influences on vulnerable populations.

Many types of bias may affect vocal biomarker detection, including representational, measurement, omitted variable, algorithmic, and social biases (6). In addition to standard requirements for efficacy, any patient-monitoring technology should ensure demographic parity, equalized odds, equal opportunity, treatment equality, and fairness. The HearO app highlights that limited access to new smartphones (eg, the latest iPhone or Android devices) may affect quality of care in the future, because voice recording quality could be stratified according to socioeconomic status. As more fields of medicine collect data with these devices, the HF community should think carefully about how such disparities might adversely affect our patients.

## CONCLUSION

Active speech analysis as described by Dr Amir et al (4) is an important advance toward expanding the tools available to assess patients with HF. Although nascent, use of commonly available mobile technologies suggests potential for wide use compared with highly invasive strategies requiring dedicated hardware. Extensive development and validation are required before clinical use, but success in a use case such as HearO may pave the way for even more convenient and generalizable strategies.

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