Clinical importance of remote monitoring of respiratory function

- Weakness of respiratory muscles in neurological conditions like Parkinson’s Disease or Amyotrophic Lateral Sclerosis may result in dysarthria.
- Respiratory function is key to efficient speech production and an objective measure for disease diagnosis and management.
- Current clinical standard is a spirometry test; patients exhale forcefully into a device that measures the flow of exhaled air.
- Telemedicine has been gaining traction; current COVID-19 pandemic highlights the need to make clinical tests available to patients at home.
- Unmet need for remote spirometry to allow on-demand remote monitoring of patients’ respiratory function.

NEMSI bridges this gap!

- NEurological and Mental health Screening Instrument (NEMSI)
- cloud-based multimodal dialogue system that conducts automated screening interviews by engaging with conversational AI over a device of the user’s choice (smartphone, tablet, laptop) from the comfort of their home.
- Deployed in an automatically scalable cloud environment allowing it to serve an arbitrary number of end users at a very small cost per interaction.
- Natively equipped with real-time speech and video analytics modules that extract a variety of features of direct relevance to clinicians, thus allowing for measurement of multiple subsystems (motoric, phonatory) in conjunction with lung function.

Flowchart for a remote spirometry call

Figure 1: Example call

- Users call a secure web link to start the interview.
- Users are guided to set up their webcam and microphone and greeted by an AI agent (Figure 1).
- After asking for details like age, sex, height and weight, the AI agent instructs users to exhale forcefully into the microphone of their device.
- AI agent helps users fill out relevant questionnaires (Figure 2).

Figure 2: Questionnaires

Figure 3: Dashboard

Figure 4: Volume vs Time plots

- (A) Slow exhalation, (B) Incomplete exhalation, (C) Microphone held far away, (D) No user errors.
- Note: The axes are not uniform across panels.

Analysis of metrics

- The work presented here is currently still in early stages of development and has only undergone internal testing.
- We attempted to standardize various aspects of data collection like mic type and mic-to-mouth distance.
- However, as in clinical spirometry, poor user adherence to instructions and resulting user errors are a major hurdle.
- Slow exhalation (as opposed to a forced burst) may result in an overestimation of FVC values and underestimation of FEV, values (see Figure 4A) whereas incomplete exhalation results in an underestimation of FEV, and FVC values (see Figure 4B).
- Not holding the microphone at the recommended distance causes the audio signal to be too quiet resulting in incorrect FEV1 and FVC values but an accurate FEV1/FVC ratio (see Figure 4C).
- In the absence of user errors, all estimated metrics fall within the range of predicted values for the user’s age, sex and height (see Figure 4D) as specified in reference charts.

Next steps

- Our cloud-based multimodal dialogue system provides an integrated scalable solution to remote diagnosis and monitoring of respiratory function in patients with respiratory muscle weakness and dysarthric speech.
- However, there are several limitations that need to be overcome before the solution can be implemented.
- We look forward to working with the research community on the following points:
  1. Ideas on ensuring user adherence by means of user training and intelligent feedback.
  2. Developing a reliable method to calibrate microphones.
  3. Collection of preliminary data from patient populations and healthy cohorts to validate and verify our methods.
- Remote spirometry is not a replacement for clinical spirometry but provides a valuable telehealth and telemedicine tool.

References