Chapter 51
Understanding and Evaluating the Needs of a Respiratory Assessment Device for Community Health

Nibedit Dey and Priyabrata Rautray

Abstract In public health settings, most of the patients with respiratory-related complaints come with chronic conditions, where the disease has already developed to a chronic stage that requires immediate care. As per the Global Asthma Report (2018), more than one billion patients suffer from chronic respiratory diseases (CRD). Pneumonia is considered the single most significant cause of mortality in children worldwide with over 2 million deaths. Factors such as malnourishment, low zinc intake, overcrowding, exposure to parental smoking, indoor air pollution play an essential role in increasing children's susceptibility to respiratory infections. Due to the lack of pulmonologists in primary care centres and lack of time, patients remain undiagnosed, which leads to a rise in the number of chronic cases. The problem is worse for babies suffering from pneumonia, where any delayed diagnosis can be fatal. In a crowded and noisy atmosphere, it is challenging to hear the sound of congested lungs through a regular stethoscope. To improve our understanding of the screening process and gather clinicians' perspectives, several face-to-face interviews and online surveys were conducted. We also documented the existing diagnosis methods and tests prescribed by clinicians to detect pneumonia. This research paper documents and highlights the need for a respiratory assessment device. The research paper is divided into three segments; firstly, it highlights the existing diagnosis methods for respiratory disease and issues related to it, and secondly, recording and analysis of clinicians' perspectives and challenges. Finally, conceptualizing a novel solution to assist clinicians in the diagnosis of respiratory diseases.

N. Dey
Ibrum Technologies, Bangalore, India
e-mail: nibedit@ibrum.tech

P. Rautray (✉)
Indian Institute of Technology, Hyderabad, India
e-mail: md17resch11001@iith.ac.in

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51.1 Introduction

In the twenty-first century, respiratory disease is the foremost cause of death and illness worldwide, affecting all age groups and especially infants are more vulnerable. The respiratory of the disease varies from severe infections to prolonged non-communicable diseases. Acute respiratory infections (ARI), tuberculosis (TB), asthma, chronic obstructive pulmonary disease (COPD), and lung cancer are five prevalent respiratory diseases identified by the Forum of International Respiratory Societies (FIRS) [1]. Every year, nearly 1.3 million children die due to pneumonia, and with early detection, most of the death could be averted. One in five children below the age of five dies due to pneumonia each year [2]. Currently, asthma is one of the widespread non-communicable diseases in case of children worldwide [3]. In 2016, it was assessed that more than 339 million people were affected by asthma globally [4]. According to WHO estimates, there were 417,918 deaths due to asthma at the global level and 24.8 million Disability-Adjusted Life Years (DALYs) attributable to asthma in 2016 [5]. Globally, around 5% of death is from COPD compounding to more than 3 million in number. As per WHO estimates, COPD will be the third leading cause of death in the year 2030 [6].

India, with its massive population, chronic respiratory diseases are adding to an already overly burdened healthcare system. As a country, we lack an overall understanding of the prevalence of chronic respiratory diseases for individual states [7]. As per the global asthma report 2018, about 2% of adults and 6% of children have asthma in India [4]. Asthma affects over 30 million and with a high mortality rate of 18.1 death per 100,000 people. ARI accounted for 69% of the total cases of infectious diseases and caused 23% of deaths in 2017 [8]. In 2018, the National Health Profile (NHP) of India recorded 41,996,260 ARI cases and 3740 deaths.

This research paper on understanding and evaluating the needs of a respiratory assessment device for community health is divided into four sections. Section 51.1 introduced the background for the paper and established the need for the research project. A detailed literature review to understand the existing respiratory assessment for diagnosis of different lungs conditions was done as elaborated in Sect. 51.2. Section 51.3 documents the methodologies used for clinical immersions, interviews and online survey. It also includes illustrated data sets, data interpretations and finding. Finally, Sect. 51.4 gave a summary of the problem and methods to overcome it. This paper is an effort to initiate further research and development of novel medical devices.

51.2 Literature Review

Literature related to physical observation, respiratory assessment and computerized lung sounds analysis (CLSA) to detect respiratory disorders were studied. The traditional way of physical observation and examination has a lower accuracy in identifying pneumonia cases. Research says that even with a specialist doctor, physical diagnosis sensitivity is between 47 and 69% and specificity is between 58 and 75% [9]. A respiratory assessment is a physical examination that includes evaluation of the respiratory rate, chest movements and breathing pattern. The assessment consists of inspection, palpation, percussion and auscultation along with the patient health history as explained in Fig. 51.1 [10]. Once a doctor assesses the patient's medical history and general appearance, physical assessment is done. Palpation provides vital information about respiratory health conditions. The clinician measures body temperature looks for abnormal sounds, checks alignment of trachea, excursion and percussion. Auscultation is the final critical component of a respiratory assessment, i.e. listening to chest sounds [11].

A stethoscope is used to listen to respiratory sounds, also known as lung sounds or breath sounds. Normal lung sounds can be heard throughout the chest area, which includes the area below of the rib cage and above the collarbones. The clinician may listen to the normal, decreased or absent, and abnormal chest sounds using a stethoscope [12]. The four most common types of abnormal breath sounds are rales,

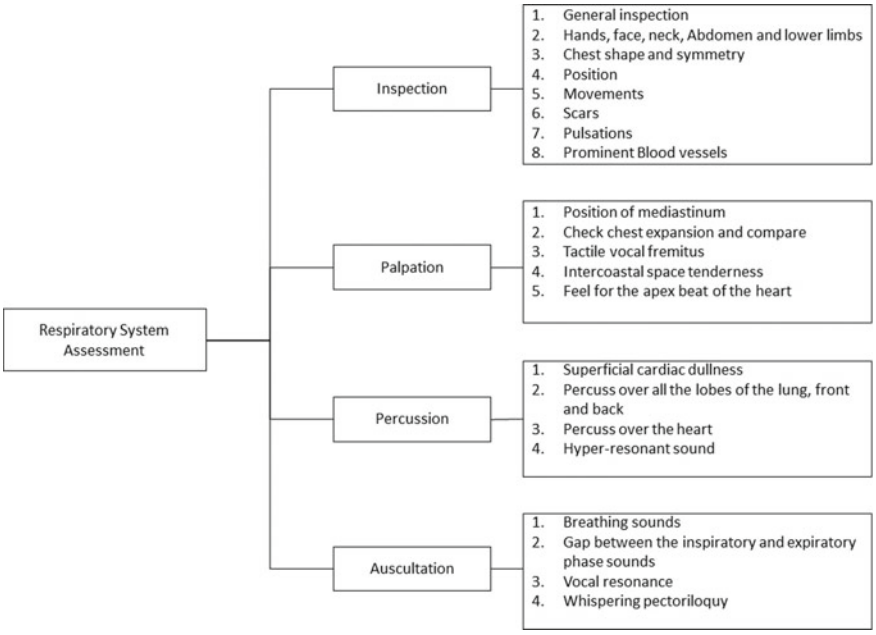

Fig. 51.1 Respiratory assessment procedure

rhonchi, stridor and wheezing [13]. Abnormal chest sounds may indicate underlying health conditions like asthma, bronchitis, pneumonia, emphysema, interstitial lung disease, bronchiectasis, etc.

Auscultation is a very skilful procedure and gained by practice. Therefore, most of the clinicians require confirmation using blood tests and medical imaging modalities like X-rays or CT scans [14]. The user's listening skills limit the capabilities of traditional stethoscopes for chest auscultation. Auscultation using electronic stethoscopes and machine learning-based classification of lung sounds may bridge these shortcomings. In one of the studies, the sensitivity of CLSA for the detection of crackles or wheezes was at 80%, and specificity was 85% [15]. 2D visualization of lungs sounds has the edge over traditional stethoscopes. 3D visualization of lungs sounds may help in localizing the infection. Unlike traditional stethoscopes that provide access to only one site information, sensor arrays can provide a 2D or 3D visualization of the lungs. However, existing sensor array-based solutions are not preferred by clinicians as they are not user friendly, expensive and bulky [16]. As per the study conducted by Marques et al., computerized respiratory sound analysis has shown potential in monitoring respiratory health in COPD patients. The researchers found that the quality of lungs sounds from standardized anatomic locations was excellent and reliable. The usefulness of computerized respiratory sound assessments in evaluating disease severity and response to treatment may be improved by using these standardized anatomical locations [17].

51.2.1 Respiratory Assessment Process

To understand a patient's respiratory health condition, the clinician evaluates the current physiological status. Any abnormal respiratory pattern may indicate the possibility of an underlying illness or metabolic disorders. A respiratory assessment begins with a detailed medical history of the patient. Clinicians ask about their earlier respiratory diseases, chronic conditions and cardiovascular health. If the patient has a history of cardiopulmonary conditions, then the clinician tries to get as many details as possible about previous hospitalization, post-emergency events and vaccination history [11].

The respiratory assessment process may vary for patients with special needs. For example, preterm babies have weaker respiratory muscles than children and adults, while babies and young children have a higher respiration rate. The clinician has to change the assessment based on the age and unique needs of the patient [10]. The clinician observes the patient for different respiratory clues such as respiration rate, abnormality in the shape of the chest, signs of laboured breathing, patient's pulse, blood pressure and oxygen saturation. If oxygen saturation is below 90%, the patient may require oxygen. In the case of infants and new-borns, clinicians may check for flaring nostrils, which indicates breathing problems. Any retractions or bulging of the muscles between the ribs may indicate an emergency condition with lack of enough air [18]. Respiratory assessment can be challenging for patients with

pneumonia as the symptoms are similar to patients with colds or the flu. People often ignore pneumonia until the illness lasts longer than the other conditions. The clinician diagnoses pneumonia based on the patient's medical history, a respiratory assessment examination, chest X-ray and laboratory test results. Pneumonia has four stages, namely consolidation, red hepatization, grey hepatization and resolution. Most of the pneumonia cases are reported at the later stages.

Clinicians usually follow below parameters for pneumonia diagnosis:

- CXR (Chest x-ray) to confirm the presence of pulmonary infiltrate or two or more of the following:
- Fever > 100.4 °F (Oral)
- SpO2 < 92% in normal room condition
- RR > 24 breaths per minute (bpm)
- Evidence of focal pulmonary consolidation on respiratory assessment, including auscultation results.

Similarly, clinician usually follows the below parameters for COPD/Asthma diagnosis:

- CXR showing COPD with hyper-inflated lungs and no infiltrates and two or more of the following:
- Symptoms of shortness of breath, wheezing or increased sputum production
- SpO2 < 92% in normal room condition
- Acute reduction in peak flow or FEV1 in spirometry
- Respiratory rate > 24 bpm.

51.3 Clinical Survey

This section includes our efforts in clinical immersions and needs validation following Stanford Biodesign methodology. After our initial personal interviews with doctors from the selected hospitals, we conducted an online survey to increase the data set and to have a broader perspective.

51.3.1 Personal Interviews

Initial clinical studies were conducted in 15 hospitals, and the current methods of diagnosis were studied. We identified a few focus clusters based on our observations during phase 1 clinical immersion. To gain further insights, we discussed our views with doctors during phase 2 focused immersion. It was found that it is difficult for an undergraduate doctor or alternative medicine practitioners to identify abnormalities in lungs sounds in the noisy environment of primary care. There were many patients with complaints of sneezing and cold, which are diagnosed as allergic rhinitis.

Following are the observations documented during our interviews with doctors. They mentioned that chronic allergy cases convert to asthma. Asthma is prevalent, and patients require regular treatment. Doctors regularly persuade asthmatic patients to stop smoking to avoid asthma attacks. Most of the days, people come early in the morning for nebulization. People do not keep inhalers and depend on PHC. The condition can be critical at midnight. Villages are far away and no proper transport available at night. Patients do not visit hospitals until the situation goes out of control and believe that allopathic treatment will make them dependent on drugs. The doctor said the early treatment could cure and reduce the progress of asthma. In case of patients coming with breathing difficulty, the doctor does not have tools to differentiate between asthma, COPD, pneumonia and other disorders. In one of the PHCs, there were 2275 outpatients during the month, and 1579 laboratory tests were done. Tuberculosis was common among the villagers. Twelve patients were getting treated for TB with DOTS. From the clinical immersion, we found that pneumonia is prevalent among children and often treated late causing the casualties. From the discussions with the doctors, we concluded that there is a need for a tool for quick diagnosis of patients in primary care.

51.3.2 Online Survey

After the discussion with primary care doctors, we discussed with doctors from different specializations to increase the unique data sets and to have a better understanding of the issue. An online survey was conducted where 29 doctors responded from various specialties.

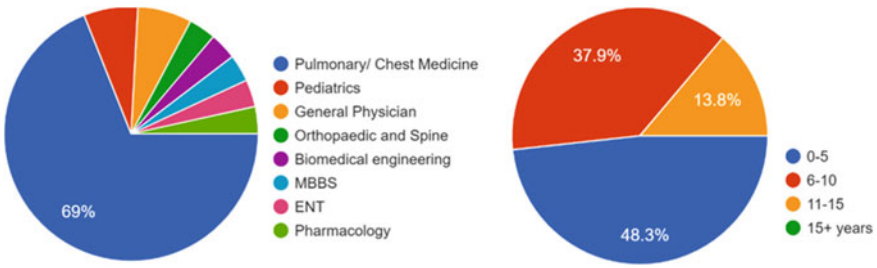

Fig. 51.2 Specifications of participant and years of experience

51.3.3 Data Visualization

Figure 51.2 highlights the specializations of the doctors who participated in the online survey and their experience in years. Around 69% of the doctors were specialized in pulmonology and with a fair amount of experience, which gave us in-depth insights.

The next figure explains the frequency of most common lungs' diseases and the number of asthma case handled by participants every month, as shown in Fig. 51.3.

Figure. 51.4 shows the number of pneumonia cases handled every month by doctors and the methods used to detect them.

Fig. 51.3 Most common lungs diseases and the number of asthma cases per month

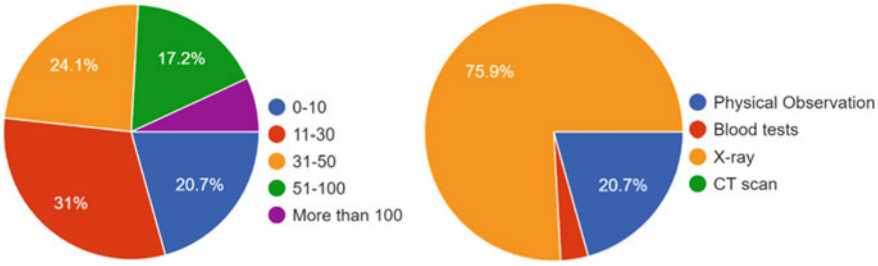

Fig. 51.4 Number of pneumonia case per month and methods used in the diagnosis

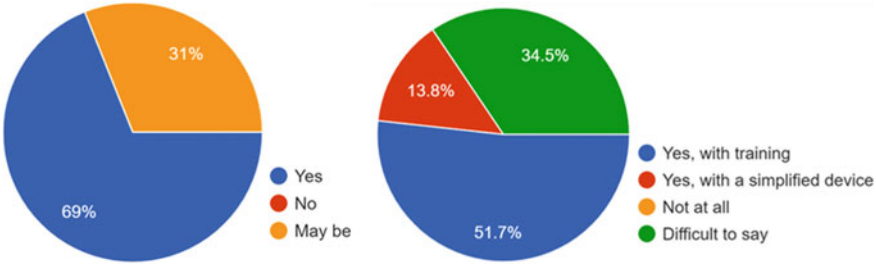

Fig. 51.5 Need for assistive respiratory assessment system and ease of use by semi-skilled healthcare user

In Fig. 51.5, validate the need for an assistive respiratory assessment system for primary care and ease of use by semi-skilled healthcare user.

Thus, after analysing the data from our online survey, we found that most of the cases, the participants came across were cough-related problems followed by asthma and COPD. The important findings are mentioned below:

- 75.9% of participants responded that they rely on X-rays for pneumonia diagnosis.
- 75.9% clinician also mentioned that they come across more than five pneumonia cases per month.
- 20% of doctors with specialization in pulmonology and chest medicine mentioned that there is a chance of identifying and missing crackles through traditional stethoscopes.
- Overall, 24.1% of doctors were not confident identifying a crackle with conventional auscultation.
- 69% clinicians said that a respiratory assessment device could assist doctors in screening pneumonia in PHCs.
- 44.8% clinicians said they require assistance with lung sound analysis.
- 51.7% clinicians agreed that paramedical staff like nurses, ANMs and Asha workers could identify childhood pneumonia cases with a skilling program or with the help of a simple respiratory assessment system.

51.3.4 Analysis and Interpretation

From the clinical immersion and discussions with the clinicians and the survey, it is clear that there is a need for a respiratory assessment system for community health. Majority of respiratory cases come at a chronic stage and require assessment by a specialist doctor. Chest X-rays are not usually done in the primary healthcare centres due to unavailability of the X-ray machine or the technician and due to poor economic condition of patients. In several cases, the rural healthcare centres are managed by ayush doctors or by paramedical staffs who are not trained to do a respiratory assessment and prescribe treatment. Over usage of antibiotics without proper diagnosis is leading to anti-microbial drug resistance. It is observed that essential equipment such as pulse oximeter, infrared thermometer and spirometer were not present in primary care centres. It was also found that telemedicine was not available to the patients in government-run healthcare centres and life support systems such as ventilators are only available in tertiary care centres. It is leading to delay in diagnosis and treatment in most of the cases. Hence, there is a need for a respiratory assessment system to enhance clinical decision making, which should not create an additional diagnostic cost to the patients.

51.4 Conclusion

Due to lack of access to the healthcare facilities, vaccines and medicines, millions of people die every year. These deaths are preventable, and community spread can be stopped. Availability of a respiratory assessment system can help in identifying underlying respiratory conditions early, and patients can be treated before it becomes an emergency. It can also assist in decision making about the next treatment steps and avoid any guesswork. Children can be protected from pneumonia with a simple respiratory health assessment device and can be treated with low-cost medication and care. Thus, from our literature reviews, clinical and online surveys, we found that there is an unmet need for the development of a respiratory assessment system that can be used with existing telemedicine platforms. These devices will become the first line of defence in preventing respiratory disease related to mortality. Due to remote locations and a massive rural population of our country, these innovative devices based on latest technologies will go a long way in providing early detection and last-mile healthcare services to the people. We hope our research findings will help to inspire and push for the development of such novel medical devices that are not only cost effective but easy to use.

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