



Published in final edited form as:

CHEST Pulm. 2025 March ; 3(1): . doi:10.1016/j.chpulm.2024.100129.

Association of Oxygen Saturation on Home Pulse Oximetry With Telephone Triage Decision:

A Retrospective Single-Center Study

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Abstract

BACKGROUND: Given limited tools for objective assessment during telephone triage, home pulse oximeters may augment clinical decision-making in patients with respiratory conditions. However, there are well-documented concerns about clinically significant, race-discrepant pulse oximetry error.

RESEARCH QUESTION: Is home pulse oximetry incorporated into telephone triage decision-making and is it associated with triage disposition?

STUDY DESIGN AND METHODS: In this retrospective study, we reviewed electronic medical record documentation regarding telephone calls to the pulmonary clinic triage line at a university-affiliated tertiary care center. All adults who called the triage line with an acute complaint between May 1, 2023, and October 31, 2023, were included. We tested the association between reported abnormal oxygen saturation and triage decision.

RESULTS: A total of 118 telephone triage notes were reviewed. Median patient age was 50 years (interquartile range, 34–62), with 85 calls (72%) from White patients and 24 calls (20%)

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Author contributions: D. C. B. takes full responsibility for the content of this manuscript, co-designed the study, acquired data, performed data analysis, co-wrote the first draft of the manuscript, and critically revised the version of the manuscript submitted for publication. T. B. contributed to acquisition of data and critically revised the version of the manuscript submitted for publication. A. F. was involved in interpretation of the data and critically revised the version of the manuscript submitted for publication. T. J. I. co-designed the study, supervised the data analysis, and critically revised the version of the manuscript submitted for publication. M. R. conceived of and co-designed the study, co-wrote the first draft of the manuscript, and critically revised the version of the manuscript submitted for publication. All authors have read and approved the final manuscript.

Financial/Nonfinancial Disclosures

None declared.

Disclaimer: The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

Part of this article has been presented at the American Thoracic Society International Conference, May 20, 2024, San Diego, CA; and the AcademyHealth Conference, June 30, 2024, Baltimore, MD.

from Black patients. Of the calls, 70% (n = 83) were for respiratory symptoms. Pulse oximeter use was reported in 29 notes. No notes documented consideration of factors that might influence pulse oximeter accuracy. Among calls for respiratory symptoms, 24 (29%) discussed home pulse oximetry. Twenty-one calls (18%) were referred to the emergency department or hospital, and 12 (10%) were referred for an urgent visit. In multivariable analysis, patients with respiratory symptoms and peripheral oxygen saturation < 90% had 22.3 times the odds (95% CI, 1.9–258.9; $P = .01$) of being triaged to in-person care.

INTERPRETATION: In this study, providers documented home pulse oximetry readings in 1 in 3 patients calling the pulmonary triage line with respiratory symptoms. Patients with abnormal oxygen saturation were more likely to be triaged to in-person evaluation. Given the current state of widely available, variably accurate, and racially biased pulse oximeters, there is an opportunity for standardization of how triaging providers assess home pulse oximetry data and counsel patients on their limitations.

Keywords

occult hypoxemia; pulse oximetry; telephone triage

Telephone triage systems embedded in ambulatory practices can be associated with benefits such as a reduction in unnecessary emergency department (ED) use, appropriate triage of patients to in-person care, improved patient satisfaction, and decreased patient anxiety.^{1,2} The use of remote monitoring systems and telephone triage during the COVID-19 pandemic illustrated some of these benefits on a large scale.^{3,4} On the other hand, telephone-based triage systems can result in delayed care when a patient's complaint is triaged to a lower level of urgency than is warranted.⁵ Efforts to understand the drivers of triage decisions have shown that they can be influenced by clinician experience and reliance on heuristics, and patient age, gender, vocal cues, and socioeconomic status.^{6–10} Triage systems vary with respect to staffing, and triage decisions can be inconsistent between clinicians.^{11,12}

There has been increased advocacy for incorporation of objective data (eg, measurements from home pulse oximeters) into triage as a means of enhancing clinical decision-making, particularly in patients with acute and chronic respiratory conditions.^{13–15} Furthermore, evidence suggests high uptake of home pulse oximetry among the public since the COVID-19 pandemic began, with a 500% increase in the purchasing of home pulse oximeters.¹⁶ A qualitative study of 30 individuals with chronic lung disease in Australia found that 73.4% had either self-initiated use of home pulse oximetry or initiated it based on the recommendation of a family member or peer.¹⁷ Notably, about one-half of those participants purchased devices from the internet, and most were unsure about the brand or type of pulse oximeter they owned; however, almost all reported some adjustment in behavior based on pulse oximeter readings.¹⁷ Context from systematic study in the United States is limited.

Since the start of the COVID-19 pandemic, there has been an increase in both telehealth implementation by health care systems and the use of home pulse oximeters by patients.^{4,16,18} However, to our knowledge, there are currently no systematic studies evaluating how home pulse oximetry data are integrated into routine outpatient pulmonary

telephone triage practices. To assess how frequently and to what extent data from home pulse oximeters are incorporated into telephone triage decision-making, we conducted a retrospective review of triage notes written by pulmonary on-call clinicians at a single university-affiliated tertiary care center. We assessed the association between reported home pulse oximeter readings and triage decision.

Study Design and Methods

This retrospective study was performed at a large university-affiliated tertiary care center. We included all patients of the institution's pulmonary clinics (including the general pulmonary clinic and subspecialty pulmonary clinics [ie, cystic fibrosis, interstitial lung disease, interventional pulmonology, and pulmonary hypertension clinics]) who called the adult pulmonary triage line with an acute complaint between May 1, 2023, and October 31, 2023. Calls to this line are fielded by a trained pulmonary clinic nurse (registered nurse [RN]) or nurse practitioner (NP) during the day and an on-call pulmonary fellow (doctor of medicine [MD]) overnight and on weekends. Patient calls were identified with assistance from the institutional Telecom Service Center Operators. No patients were excluded. Electronic health records of the patients identified in this manner were reviewed for any telephone notes documented by pulmonary department clinicians written in response to a call initiated by the patient for an acute symptom between January 1, 2023, and October 31, 2023. All telephone notes were independently abstracted by 2 abstractors (D. C. B. and T. B.) into a prespecified survey form in a REDCap¹⁹ database, and any discrepancies were resolved by discussion. This study was conducted in accordance with the amended Declaration of Helsinki. It was approved by the Johns Hopkins institutional review board (IRB00383780) with a waiver for informed consent.

We calculated descriptive statistics regarding the patient's primary pulmonary diagnosis, the proportion of calls where pulse oximeter readings were discussed, and whether details regarding reading quality was noted. Patient's self-reported race, ethnicity, and gender were identified from the electronic medical record.

Our primary analysis tested the association between a reported abnormal peripheral oxygen saturation (SpO_2) on home pulse oximetry, defined as an $\text{SpO}_2 < 90\%$ (yes/no), and being triaged to the ED or an urgent care visit (in-person care). A saturation cutoff of 90% was chosen because it is potentially clinically relevant; an international panel of experts recommended against oxygen supplementation for an oxygen saturation $\geq 90\%$.²⁰ This association was tested using a logistic regression model adjusted for patient age, self-reported race (White, Black/African American, or other), sex (male or female), primary pulmonary diagnosis (asthma, COPD, cystic fibrosis, interstitial lung disease, pulmonary arterial hypertension, or other), and clinician type (RN/NP or MD). Predicted probability of referral to in-person care in an average patient with vs without abnormal pulse oximetry results was calculated using mean values for the covariates previously described. There were no missing data in the final data set.

Given prior literature suggesting that patient characteristics and differences in triaging clinician's training and experience may affect outcomes in the triage process,^{5,9,11,21} we also

performed hypothesis-generating analyses using unadjusted logistic regressions to test for associations between reporting of home pulse oximetry data and patient age, race, gender, and clinician type.

Stata 18.0 (StataCorp) was used for all data analysis.

Results

A total of 152 operator contacts were made between May and October 2023, resulting in 118 documented triage calls fielded by physicians (MDs, $n = 77$) and RNs or NPs ($n = 41$) (Table 1). These calls were made by or on behalf of 69 unique patients. None of the calls were followed by death within 30 days. The median age of patient callers was 50 (interquartile range, 34–62). Of the calls, 85 (72%) were from White patients and 24 (20%) were from Black patients. Most calls were primarily for respiratory symptoms (ie, cough, dyspnea, increased sputum) ($n = 83$).

Reviewing the vital sign data recorded in all triage notes, 3 (3%) referenced BP, 7 (6%) referenced heart rate, and 29 (25%) referenced pulse oximetry readings. Of the 29 calls where pulse oximetry readings were mentioned, only 5 (17%) made note of the type of pulse oximeter used by the patient. In 3 cases, the pulse oximeter was medical grade; in 2, it was purchased over the counter (OTC).

Among the subset of 83 calls in which the patient's primary reason for call was respiratory, 24 (29%) commented on the presence of a home pulse oximeter, with 18 reporting specific pulse oximetry results. Of those, the lowest reported oxygen saturation was 96% in 2, 90% to 95% in 8, and $< 90\%$ in 8. The remaining 6 mentioned that oxygen saturation was evaluated without specific documentation of a numerical result. Of the notes that included pulse oximeter readings, 50% reported 1 distinct numerical reading and 40% reported 2. None of the calls described environmental or clinical factors that might affect pulse oximeter accuracy (eg, location where pulse oximetry was measured, patient position or history of recent exertion, known history of peripheral vascular disease).²² Most triage calls were managed by the triaging clinician ($n = 52$, 44%), with 33 (28%) referred for another clinician to review; 21 (18%) were referred directly to the ED or hospital and 12 (10%) for an urgent clinic visit.

In unadjusted analysis, a documented abnormal oxygen saturation ($< 90\%$) was associated with an increased likelihood of referral for in-person evaluation compared with a documented $\text{SpO}_2 \geq 90\%$ or no documented SpO_2 (OR, 7.4; 95% CI, 1.8–30.5). This association persisted with adjustment for patient age, race, sex, pulmonary diagnosis, and clinician type (OR, 6.3; 95% CI, 1.3–30.8). In the subset of patients with primarily respiratory symptoms, adjusting for age, race, sex, pulmonary diagnosis, and clinician type, patients with a documented $\text{SpO}_2 < 90\%$ had 22.3 times the odds (95% CI, 1.9–258.9) of being referred for in-person care compared with those with an $\text{SpO}_2 \geq 90\%$ or no documented SpO_2 . Translated into predicted probabilities after adjustment, in patients with respiratory symptoms, a reported $\text{SpO}_2 < 90\%$ was associated with an 84% probability (95%

CI, 0.40–0.97) of being counseled to be seen in-person as compared with a 29% probability (95% CI, 0.20–0.39) if SpO₂ was \geq 90% or not documented (Fig 1).

In exploratory analyses, we found a small association between patient age and home pulse oximetry data being referenced (OR, 1.03; 95% CI, 1.01–1.07). There was a trend toward increased reporting of home pulse oximetry data when the triaging provider was an MD vs RN/NP (OR, 2.48; 95% CI, 0.92–6.71) and a trend toward increased reporting of home pulse oximetry data among female patients compared with male patients (OR, 3.38; 95% CI, 0.94–12.19), but these associations were not statistically significant. There was no association between self-reported race and home pulse oximetry data being referenced (OR, 1.01; 95% CI, 1.00–1.03).

Discussion

In this study, we found that 25% of phone triage notes written by pulmonary clinicians at a tertiary care center mentioned home pulse oximetry data. In contrast, only 3% included home BP readings and 6% included home heart rate readings, suggesting a prioritization of home oxygenation data in this population. We found that few clinicians documented details about the type of home pulse oximeter being used, documented multiple readings over time, or commented on factors that might influence home pulse oximeter accuracy. We also found that patients who had a documented abnormal oxygen saturation (SpO₂ < 90%), particularly those reporting respiratory symptoms, were significantly more likely to be referred to an ED or urgent clinic visit. Of note, not all patients with a saturation < 90% were triaged to in-person care, and pulse oximetry data were sometimes documented in the absence of overt respiratory symptoms, suggesting that clinicians were using reported oxygen saturation data within the context of other clinical information.

This study demonstrates that home pulse oximeters, approved for medical use or not, are being used by health care providers tasked with telephone triage of patients. Given the ease of communicating home pulse oximetry data and studies showing high levels of patient satisfaction and engagement with home pulse oximeters,^{17,23,24} this illustrates the potential practical utility of high-quality home pulse oximetry. However, the downstream implications of these findings require further study.

Relationship to Previous Studies

A primary purpose of home pulse oximetry is to identify situations in which patients should be evaluated in a hospital or urgent care setting, a fact which theoretically supports its usefulness in telephone triage decision-making.²⁵ However, pulse oximeters can be inaccurate and carry the risk of occult hypoxemia (arterial oxygen saturation < 88% with concurrent noninvasive oxygen saturation measurement \geq 92%).²⁶ Multiple studies have shown peripheral pulse oximetry can particularly overestimate arterial oxygen saturation in darkly pigmented individuals including Black or Hispanic patients.^{26–29} This has been shown to lead to a delay in recognition of eligibility for therapies or need for care among inpatients, with clinically relevant consequences.^{30,31} Given our findings that home pulse oximeters are likely being used by triaging providers to determine whether or not a patient

ought to be referred for in-person evaluation, an important next step will be to evaluate whether patients at risk for occult hypoxemia are experiencing undertriage.

Our study also found that clinicians are infrequently assessing patients' familiarity with assessing accuracy of pulse oximeter readings or the type of pulse oximeter being used, highlighting a potential area for intervention to improve the value and reliability of home pulse oximetry data when incorporated into routine telephone triage. Prior work has suggested that the use of home pulse oximetry may improve prediction of acute exacerbations in individuals with COPD and aid in triage of patients with acute respiratory illness (eg, COVID-19) in the context of structured remote monitoring programs in which trained patients use medical-grade pulse oximeters.^{13,32}

Implications

We found that documented abnormal home pulse oximetry readings were associated with a recommendation that a patient be evaluated in person. Given this finding, it is essential that patients and providers understand the limitations of home pulse oximeters. Although rarely recognized in clinician notes, not all pulse oximeters are regulated equivalently. Medical-grade pulse oximeters are subject to US Food and Drug Administration (FDA) review, but access to these devices has until recently been limited to prescription. Furthermore, current FDA approval practices under the so-called 510k pathway require medical-grade pulse oximeters be tested on only 10 individuals, of which at least 2 (or 15% of the pool, whichever is larger) are darkly pigmented.^{33,34} In contrast, OTC pulse oximeters are categorized as general wellness or sporting/aviation products by the FDA and until February 2024, when the first and thus far only FDA-approved OTC pulse oximeter was announced, none had been subject to formal review.^{35,36} Access to the recently approved OTC option may be limited by its cost, which is approximately 10 times that of other available OTC pulse oximeters. Discussion at the 2024 Anesthesiology and Respiratory Therapy Devices Panel of the Medical Devices Advisory Committee raised the point that while clear labeling of which products are approved for medical use is essential, off-label or physician-directed use of nonmedical devices occurs in practice; as of April 2024, no policy changes have been enacted from these discussions.³⁷

To ensure appropriate and equitable use of home pulse oximetry data, acknowledging that patients are using nonmedical OTC pulse oximeters to monitor their health, it may be of value that triaging clinicians are consistent in their approach to data acquisition and assessment of data quality, and are able to assess and document the role these data are playing in their decision-making. We found that even in triage notes where pulse oximetry use was referenced, 25% of the time there was no documentation of specific numerical readings, limiting the value of the triage note in retrospective assessment of the role pulse oximetry data played in clinical decision-making. Some guidance has been published regarding best practices for pulse oximetry use. These include recommendations related to method of data collection (ie, patient positioning; digit selection; frequency of assessment; timing of assessment relative to exertion; use of hot-pads, as occurs in laboratory testing whence pulse oximeter approval and validation data come), resources available to patients for training on the use of pulse oximetry, and suggestions regarding predetermination of

thresholds at which to escalate care.^{13,22,38} There is currently no evidence that clinicians are being routinely educated on these best practices, but this study suggests there may be benefit from doing so. More generally, in the nursing literature, there are descriptions of frameworks and mnemonics used for teaching telephone triage skills, but this training has not necessarily extended to trainee MDs who are increasingly being asked to staff telephone triage systems.²¹

Making decisions as a triaging clinician requires data acquisition, assessment of data quality, and formulation of judgments about the future consequences of the data acquired; these types of decisions have been shown to be influenced by a variety of patient and triaging clinician characteristics.^{7–12} Further work is needed to better understand which patients are most likely to be using and reporting home pulse oximetry data. Additionally, both nurses and physicians are critical members of triage teams across the health care system, and understanding practice variation between clinicians may shed light on how tools (eg, home pulse oximeters) can best be leveraged to standardize triage decisions.

Finally, there is currently no standard guidance regarding what SpO₂ cutoff represents a clinical need for a patient to be seen in person; in this study, we selected a cutoff of 90% based on prior clinical practice guidelines suggesting that this is an appropriate cutoff at which to initiate supplemental oxygen and based on the fact that an oxygen saturation of 90% typically approximates a partial pressure of oxygen of 60 mm Hg, signifying that the patient may be at an inflection point of the oxygen dissociation curve.^{13,20} Whether this is an appropriate cutoff for patients with pulmonary diseases characterized by chronic hypoxemia is not established.

Limitations

Given the retrospective nature of this study, a major limitation is that we were only able to assess clinical decision-making to the extent that it was documented in the electronic medical record. This was a single-center observational cohort at an academic tertiary care center including a limited pool of triaging clinicians who may have specific practice patterns and may have different levels of familiarity with recent literature regarding accuracy of home pulse oximeters. Additionally, most patients with pulmonary disease are not managed by specialty pulmonary clinicians, but rather primary care physicians who may have different practice patterns. Our sample size was small, limiting our ability to assess for differences in triage decisions for patients of different self-reported race, and further work is needed to better evaluate the concern that patients at risk for occult hypoxemia may experience a delay in the recommendation that they seek a higher level of care if triaging clinicians rely too heavily on the accuracy of home pulse oximetry data for reassurance. Finally, data on baseline home oxygen saturation were not collected; therefore, we did not adjust for this factor.

Interpretation

Our results demonstrate that clinicians are obtaining and using home pulse oximetry data in their assessment of patients seeking recommendations through a telephone triage line. In the absence of regulation, standardization of clinical practice, and technologic advances to

improve pulse oximetry accuracy and its equitableness, reliance on home pulse oximeters may result in undertriage related to occult hypoxemia, but this requires further study. Our study suggests a need to ensure that both patients and clinicians are appropriately trained in best practices for obtaining data from a home pulse oximeter and in the pitfalls of unregulated home pulse oximeters. Better characterization of social and cultural barriers to use of new technology (eg, home pulse oximetry) will also be important given existing risks of bias related to age, gender, and socioeconomic status in triage decisions.

Funding/Support

Research reported in this publication was supported by the National Heart, Lung, and Blood Institute of the National Institutes of Health [Award T32HL007534].

Role of sponsors:

The sponsor had no role in the design of the study, the collection and analysis of the data, or the preparation of the manuscript.

ABBREVIATIONS:

ED	emergency department
FDA	US Food and Drug Administration
MD	doctor of medicine
NP	nurse practitioner
OTC	over the counter
RN	registered nurse
SpO₂	peripheral oxygen saturation

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Take-Home Points

Study Question:

Is home pulse oximetry incorporated into routine telephone triage decision-making and is it associated with triage disposition?

Results:

When fielding calls from patients with respiratory symptoms, clinicians documented data from home pulse oximeters 29% of the time and were significantly more likely to refer a patient for in-person evaluation when reported peripheral oxygen saturation is < 90%; however, clinicians were infrequently assessing factors which influence the accuracy of home pulse oximetry.

Interpretation:

Our results show that clinicians are obtaining and using home pulse oximetry data in their assessment of patients seeking recommendations through a telephone triage line, which could result in undertriage of patients with occult hypoxemia.

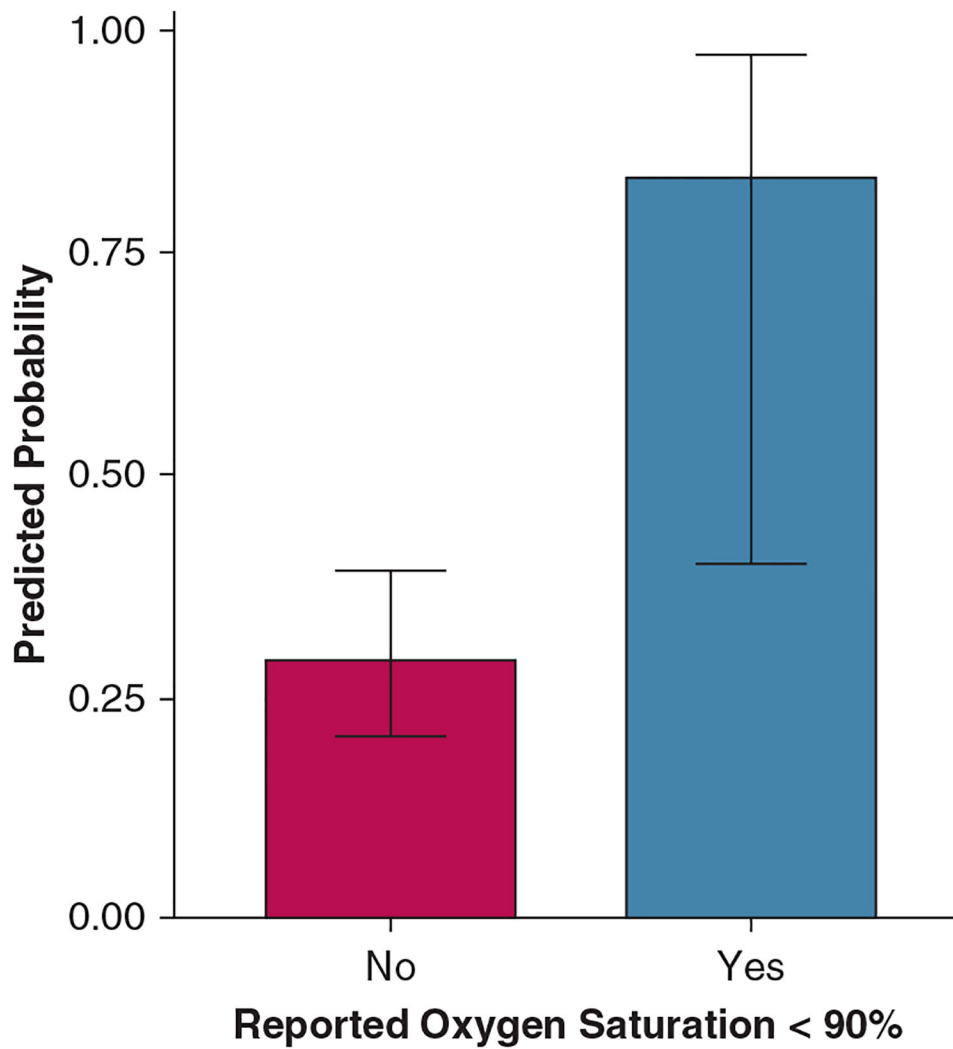


Figure 1 –.

Abnormal home pulse oximetry and probability of triage to in-person care. This plot illustrates the effect on predicted probability of triage to in-person care of a reported abnormal oxygen saturation (< 90%) on home pulse oximetry compared with no reported abnormal oxygen saturation (>= 90% or not reported). Point estimates presented with 95% CIs. The model assumes average values for patient race, sex, and triaging clinician based on our data set.

TABLE 1]**Characteristics of Study Participants**

Characteristic	Home Pulse Oximetry Data Collected	
	No (n = 89)	Yes (n = 29)
Age, y	48 [16.2]	56 [12.7]
Sex		
Male	25 (28.1)	3 (10.3)
Female	64 (71.9)	26 (89.7)
Race		
White	63 (70.8)	22 (75.9)
Black or African American	21 (23.6)	3 (10.3)
Other ^a	5 (5.6)	4 (13.8)
Ethnicity		
Not Hispanic or Latino	88 (98.9)	28 (96.6)
Unknown	1 (1.1)	1 (3.4)
Triaging provider		
RN/NP	35 (39.3)	6 (20.7)
MD	54 (60.7)	23 (79.3)
Triage disposition		
ED or hospital	14 (15.7)	7 (24.1)
Urgent visit	7 (7.9)	5 (17.2)
Provider review	30 (33.7)	3 (10.3)
Managed by triaging provider	38 (42.7)	14 (48.3)
Primary pulmonary diagnosis		
Cystic fibrosis	40 (44.9)	6 (20.7)
COPD	9 (10.1)	4 (13.8)
Asthma	10 (11.2)	3 (10.3)
Pulmonary arterial hypertension	4 (4.5)	0 (0.0)
Interstitial lung disease	9 (10.1)	10 (34.5)
Other ^b	17 (19.1)	6 (20.7)

Categorical variables described by No. (%), and continuous variables described by mean [SD]. ED = emergency department; MD = doctor of medicine; NP = nurse practitioner; RN = registered nurse.

^aIncludes Asian, American Indian or Alaska Native, Native Hawaiian or other Pacific Islander, not specified, and unknown.

^bIncludes common variable immunodeficiency, lung transplantation, metastatic malignancy affecting the lungs, non-cystic fibrosis bronchiectasis, primary lung malignancy, sarcoidosis.