Remote patient monitoring in the management of chronic obstructive pulmonary disease

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ABSTRACT

Remote patient monitoring allows monitoring high-risk patients through implementation of an expanding number of technologies in coordination with a healthcare team to augment care, with the potential to provide early detection of exacerbation, prompt access to therapy and clinical services, and ultimately improved patient outcomes and decreased healthcare utilization.

In this review, we describe the application of remote patient monitoring in chronic obstructive pulmonary disease including the potential benefits and possible barriers to implementation both for the individual and the healthcare system.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is prevalent and detrimental to quality of life (QoL) and survival, though tools to monitor and prevent disease progression are limited and often ineffective.[1 2] For many patients with COPD, their course is marked by acute exacerbations (AECOPD), defined as a paroxysmal increase in symptoms requiring escalation of therapy. These acute events have lasting effects (accelerated loss of lung function, decreased QoL, and higher rates of subsequent exacerbations), making prevention a top goal of care.[3] Similar chronic diseases like heart failure and cancer have been improved through targeted interventions in terms of healthcare delivery, mortality, hospitalization, and readmission rates; unfortunately, COPD outcomes have not had the same benefit.[4 5] Remote patient monitoring (RPM) offers an expanding number of technologies and approaches to monitor high-risk patients, offering the ability to identify and treat COPD exacerbations early.

Frequent exacerbations come at a cost to both the individual and healthcare system: while individuals with frequent exacerbations have greater mortality,[6 7] poorer QoL[8] and substantial economic burden, COPD also presents high societal healthcare expenditures and resource utilization.[9] Hospital care drives most of the cost in COPD,[10] and while the direct cost increases with increasing severity of disease, hospitalization remains the most important cost variable across stages.[11] In addition, COPD is related to high rates of readmission, as described in an evaluation of fee-for-service Medicare beneficiaries admitted for COPD which found 19.6% of these patients were readmitted within 30 days.[12] Cost also comes in the form of decreased productivity and increased absenteeism at work because of frequent exacerbations.[13 14] This will likely only worsen as disease prevalence is projected to continue to increase (in addition to the aging population).[1]

RPM is a technology solution that measures patient-generated data outside traditional healthcare systems to augment care. When applied to COPD, RPM offers many potential benefits: early detection of exacerbation, prompt access to therapy and clinical services, a possible decrease in emergency services and hospitalizations, and ideally decreased healthcare costs.[15] There is a rapidly increasing number of patient-generated data devices, metrics, and clinical-supporting platforms.

In this review, we describe how RPM has been applied to COPD—including devices and platforms—and the likely benefits and potential barriers to implementation both in individuals and healthcare systems (figure 1).

PATIENT MONITORING

Physiological monitoring

Subjective shortness of breath often occurs days before a formal diagnosis—or even patient recognition—of a COPD exacerbation.[16] Assessment of physiological derangements early could lead to earlier diagnosis and initiation of therapy that may mitigate poor outcomes. As is the case with inpatient physiological monitoring, traditional variables—oxygen saturation, heart rate, blood pressure—offer only a limited assessment of the status of patients with COPD. Furthermore, it is challenging to differentiate early patient decline from the normal increase in symptoms that might occur during a typical day (eg, with exertion). While physiological parameters have not been reliably found to predict acute exacerbations (either due to changes not being detectable early in exacerbation, natural variance of the data throughout the day, or true lack of clinical significance), numerous devices and platforms use physiological variables such as heart rate, oxygen saturation, respiratory rate, and spirometry (table 1).[17]

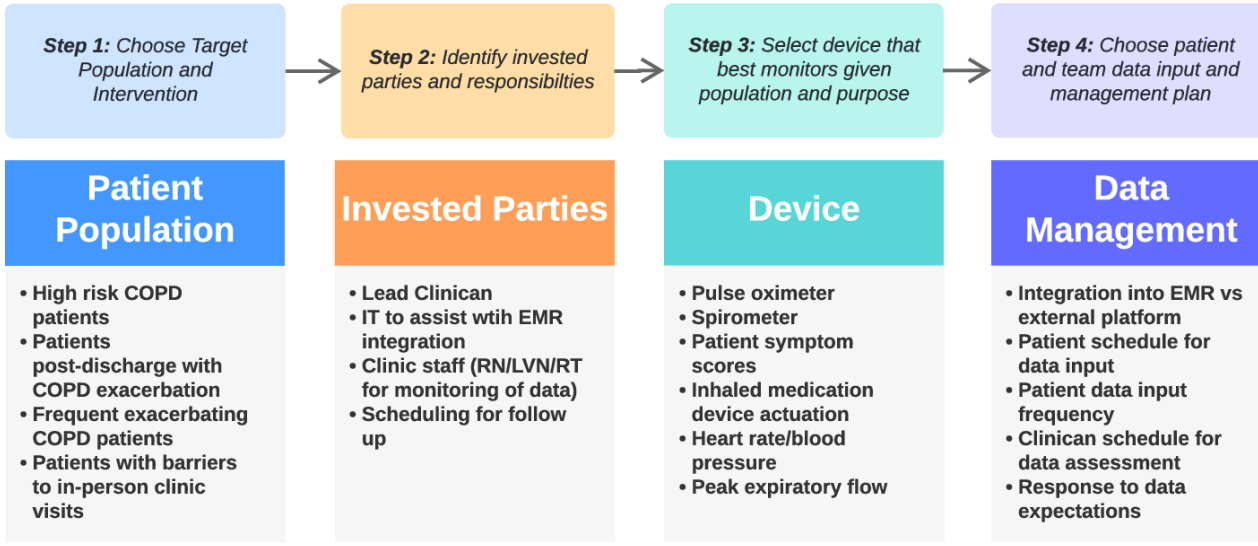

Figure 1 Aspects of various remote patient monitoring approaches. COPD, chronic obstructive pulmonary disease; EMR, electronic medical record; RPM, remote patient monitoring.

Pulse oximetry

The standard pulse oximeter is a low-cost, non-invasive device that provides heart rate and oxygen saturation via plethysmography. These devices are easily obtained and user-friendly with minimal training or technical literacy required. Data are collected in intervals (daily to multiple times; specific time vs patient preference)[18] or continuously.[19 20] Newer devices such as smartphone photoplethysmography and wearable wrist monitors minimize the burden of the patient and need to input data, but the benefit of continuous data over interval, patient-derived measurement is not clear.[19 21 22] COPD is a heterogeneous disease; therefore, there is no consensus on the thresholds that prompt intervention: fixed (most commonly oxygen saturation (SpO_2) <90%) and personalized (eg, percent change from baseline) thresholds have been used.[19 23–25]

The largest shortcomings for use in RPM are erroneous data (typically from poor perfusion) and identifying thresholds that demonstrate decline. COPD is predominantly a disease of impaired ventilation; hence oxygenation can be a secondary effect. Patients can experience AECOPD without hypoxemia. Conversely, hypoxemia can develop from other, related diseases (eg, heart failure, pneumonia). This lack of accuracy makes pulse oximetry alone a limited surrogate for AECOPD, though there is utility in pulse oximetry due to its low cost, availability, and ease of use.

Respiratory rate

While tachypnea is a sign of respiratory compromise, many patients with COPD have little reserve prompting tachypnea with minimal exertion or even at rest. Respiratory rate

Table 1 Overview of device types in remote patient monitoring

	Device	Data collected	Positives	Limitations
Physiological measurements	Pulse oximeter	Heart rate SpO_2	Low cost Widely available Non-invasive	False alarms Variable methodology Separate device
	In-line monitor/non-invasive ventilation	Respiratory rate End-tidal CO_2	Does not require active participation	Only applicable for those on home oxygen
Lung function variables	Handheld spirometry	FEV_1 FVC (or FEV_6)		Time-consuming Accurate data collection requires more training Weakly associated with acute change in symptoms
	Peak expiratory flow meters	Peak expiratory flow rate	Cheaper, simpler than spirometry	Less widely used than spirometry Change does not precede exacerbation
Symptoms	Symptom diary or questionnaire	Respiratory symptoms Activity level	High compliance	Representative of a discrete time point Symptoms influenced by external factors
Device actuation	Self-reported or measured medication use	Monitor adherence to inhaled therapy	Correlates with symptom burden Can be used for maintenance and rescue inhalers Does not require active participation Objective surrogate for respiratory symptoms	Recall bias if reported

FEV_1, forced expiratory volume in 1 s; FEV_6, forced expiratory volume in 6 s; FVC, forced vital capacity ; SpO_2, oxygen saturation.

has been measured with clever approaches. Devices have been built to measure respiratory rate in-line with home oxygen supplementation devices[26 27] or non-invasive ventilation.[28 29] Impedance plethysmography and inductance plethysmography sensors have been used for the measurement of continuous respiratory rate.[30] Leveraging the increased popularity of wearable sensors and phones, ECG and pulse oximetry signals can be used to estimate respiratory rate as well.[31] AECOPD could be predicted with the proportion of patient-initiated breaths and increased respiratory rate (defined as an increase above baseline beyond SD).[28 29]

Lung function variables

While spirometry is key in the diagnosis of COPD as well as subsequent assessment of severity and progression, there are limited data to support its role in the diagnosis and monitoring of acute exacerbations.[32] Portable, handheld spirometers are available and have also been evaluated as a tool for RPM. A limitation to handheld spirometers is their dependence on the patient to obtain reliable data in the absence of a medical professional.

Peak expiratory flow rate (PEFR) meters have been implemented in RPM and offer a simple, cheap option in the remote evaluation of pulmonary mechanics. The limited studies in which PEFR has been evaluated suggest that while it can detect acute exacerbations, it is often outperformed by other physiological variables (such as SpO_2) and only a slight decrease in lung function measured precedes exacerbation.[33 34] While variation in PEFR may be seen before and during exacerbation, significant change may not be present until a few days into the exacerbation which limits its predictive ability.[18] Overall, in patients with COPD, peak expiratory flow is likely not reliable given its increased variability and possibility of pressure-dependent airway collapse in this population.[35] Similar to spirometry, changes in PEFR are discordant with changes in symptoms or other measures of exacerbation.[23] While PEFR has been studied only in a few trials, the trend of this data suggests it has low utility in RPM.

Two more commonly obtained spirometry parameters which have been studied with RPM include forced expiratory volume in 1 s (FEV_1)—the total volume of air that one can exhale in the first second of maximal effort—and forced vital capacity (FVC)—the total volume of air one is able to exhale for the duration of the test. Early devices and approaches found no discernable changes in FEV1, FVC or peak flow preceding exacerbations, and these variables were not concordant with changes in symptoms.[16] Newer studies support the predictive capacity of spirometry in isolation,[23] and while implementation of home personal spirometry appears feasible,[36] limitations of its use in detection of acute processes have become more apparent. FEV_1 has only a weak association with respiratory symptoms and has often been cited as the most frequently missed data point collected by patients.[37]

However, in combination with other physiological variables[24] or symptom reporting,[25] spirometry has been shown to augment detection of AECOPD. An example of this came in the form of the COPDPredict platform, a device with which a patient can collect a daily symptom survey and spirometry via Bluetooth.[25] In this study, data logged was then processed using an algorithm constructed from percentage thresholds for disease state changes. Their subsequent algorithm had high sensitivity (97.9%) and specificity (84.0%) and negative predictive value (99.8%), the combination of which suggests it may be a useful clinical tool.[25]

Retrospective studies have shown the ability to detect early physiological derangement prior to exacerbation, but there remains a paucity of prospective, randomized, unbiased studies to demonstrate benefit and the correct approach to physiological monitoring.

Symptom assessment

An increase in respiratory symptoms dictates the diagnosis of acute exacerbation of COPD. Implementing a standardized, remote symptom diary or questionnaire offers the possibility to detect early *trends* in symptoms that indicate AECOPD, allowing the chance for timely intervention. Devices have measured standard, validated metrics for dyspnea and COPD clinical status (eg, COPD Assessment Test or St. George's Respiratory Questionnaire), or their own questions.[25 38–40] Given the high rates of generalized anxiety and depression, devices have been developed to monitor mood specifically in this population.[41]

The limited existing data implementing isolated symptom recording suggest that may be a useful adjunct when combined with other metrics for early detection of exacerbation.[38] In fact, symptom assessment is commonly implemented into RPM platforms which collect a variety of data points.[42]

Patients are highly compliant with symptom assessment and recording (as high as 98% in Patel *et al*'s 2021 study), though it does come with a few inherent limitations.[25] The patient is being asked to log symptoms at a discrete point in time, while symptoms often vary throughout the day. The input is ultimately subjective and may be influenced by other external factors. Symptom recording is a promising way to increase detection of acute COPD exacerbations through contextualizing physiological data.

Medication device actuation

Reliable adherence to inhaled medications reduces acute exacerbations and is associated with a reduction in COPD-related death and hospital admission.[43] Adherence in practice is far less than in clinical trials, with many studies showing that less than one-third of patients achieve the recommended adherence to inhaled medications.[44–46] Frequency of as-needed medications can also be used as a surrogate for respiratory symptoms in COPD, which traditionally is self-reported by patients, introducing recall bias. This is supported by an association between increased short-acting beta-agonist use and patient-reported exacerbations.[47]

RPM offers a real-world assessment of patient adherence to prescribed medications that can inform care (eg, education on proper indications and frequency for use, avoiding escalating to other expensive inhalers when adherence is low). Devices like SmartTurbo and Propeller offer direct monitoring of inhaler use, negating the need for patients to input data on their own. These devices have been shown to accurately record inhaler use.[48 49] In addition, these

monitors have feasibly been integrated into a digital RPM platform with fair patient engagement.[50]

There remains a paucity of randomized controlled trials evaluating the benefit of implementing such devices in COPD. Implementation of the Propeller digital inhaler monitoring device increased adherence (particularly with the addition of audiovisual reminders integrated into the device), decreased rescue inhaler usage and resulted in a trend towards reduction in COPD-related hospitalizations.[51 52] Improved adherence may be attributed to integration of audiovisual reminders, the use of which created a significant reduction in healthcare utilization, as well as study team feedback based on generated platform alerts.[51]

Remote monitoring of device actuation is a promising solution to the need for an objective surrogate for respiratory symptoms while requiring minimal patient effort and data input.

IMPACT OF RPM

The adoption of telehealth and RPM has continued to gain popularity in the management of chronic conditions. Large impacts have been shown in the management of diabetes and heart failure, but the heterogeneity and lack of objective signs of disease exacerbation make COPD especially challenging for RPM. There are numerous outcomes to consider from both an individual and health systems perspective when evaluating the success of implementing RPM.

A Cochrane review was published in 2021 reviewing 29 studies which included 5654 subjects. The authors noted significant heterogeneity and potential for bias among approaches, with all but five studies using asynchronous provider data review and none comparing to usual care. While RPM was found to be no better than usual care for most health outcomes (with the notable exception of a reduction in hospital admissions), there is a paucity of evidence at this nascent juncture. Furthermore, as technologies improve and more platforms offer synchronous, integrated processes, it is likely the benefit of RPM may become more clear.[5]

Healthcare cost

COPD is associated with a substantial economic burden, largely driven by direct costs related to hospitalization for acute exacerbation of disease.[53] In the USA in 2010, the direct costs of COPD were estimated to be 32 billion dollars,[11] with annual costs increasing according to exacerbation frequency.[54] Severe exacerbations resulting in admissions requiring intubation and/or ICU stay come at the highest economic cost with a mean cost per complex admission of US$44,909 in one study.[53]

Both direct and indirect costs are greatest in the "frequent exacerbator" phenotype, and, consequently, this is often the target population in RPM.[13] While there are compelling arguments for adoption of RPM to reduce COPD-related costs, the data directly measuring cost savings are limited.

Using the outcome of reduction in healthcare utilization, implementation of a multifaceted RPM platform (including education, telecommunication with study coordinators, and pulse oximetry) has the potential to reduce cost by US$4359 per patient over 1 year.[40] This cost savings has been directly measured in previous studies. An US$2931 savings per patient per year was found with daily RPM using physiological and symptom measurement,[55] while another study found a more conservative savings of US$355 per person over 6 months.[56]

Despite the minimal existing evidence for the economic viability of RPM, it appears to have potential cost-saving benefits,[57] which would likely be more pronounced if the price of technology can be reduced and the accuracy of alerts can be improved.

Healthcare utilization and patient outcomes

Healthcare utilization is a common outcome measure in the evaluation of RPM, and beyond the burden of healthcare utilization, exacerbations and consequent hospitalizations are also rated as the most important outcomes by patients with COPD.[58]

Several early studies of RPM with positive outcomes (including a decrease in respiratory symptoms, improved QoL measures, and reduced healthcare utilization) led to increased support and popularity of telehealth.[56 59–61] More recently, however, two well-designed clinical trials had startlingly negative results. Both involved interventions including COPD-related education, an individualized home-based action plan, and scheduled telecommunication. One was stopped early due to increased mortality[62] and the other found a significant increase in COPD-related hospitalizations and emergency department (ED) presentations.[63] The cause of these unanticipated findings is unclear, though multiple hypotheses have been posed. Self-management programs may cause patients to delay seeking care, and increased touch points with the medical system may produce greater anxiety leading to unnecessary clinical care or reduced clinician threshold for referring them to seek care.[64]

The data available remain heterogeneous. Early studies of RPM interventions showed a reduced risk of ED visits and hospitalization.[33 55 65] Subsequent studies have failed to demonstrate a significant improvement in healthcare utilization.[66–68] The range of effectiveness in these studies is likely related to the wide range of protocols (both in monitoring parameters and support provided), limited study sizes, different target groups, making results difficult to interpret.

The short duration of most available studies had led to limited data evaluating the effect of RPM on mortality. None have found a significant difference in mortality although these were all evaluated with a time frame of 6–12 months.[40 60 69]

Patient satisfaction and health-related quality of life

COPD is both a physically and psychologically disabling disease; the incidence of depression and/or anxiety is not only higher in comparison to other advanced, chronic diseases but it also corresponds with progression in physical disability.[70–72] Despite the high prevalence of depression and anxiety in patients with COPD, a discordantly low percentage of this population receives treatment for their mood disorder (31% of those who had a formal diagnosis of depression and/or anxiety in one study).[73] Comorbid depressive symptoms in patients with COPD are associated with increased symptom burden and mortality and

decreased functional status.[74] There is a startling 1.9-fold increase in the rate of suicide in persons with COPD.[75]

Improvement of both physiological and depression symptoms has been seen in patients with congestive heart failure both through cardiac rehabilitation and learned self-management skills.[76 77] There is promise that similar approaches in COPD are both feasible and impactful, as depression and anxiety occur disproportionately.[41] Given the burden of mood disorders in this population, particularly prevalent in the severe and frequent exacerbator phenotype, evaluation of RPM beyond physical health outcomes must be considered. Two such outcomes include QoL measures and patient satisfaction.

No mode of RPM has unequivocally produced a significant improvement in reported QoL, and some studies have failed to show any discernable benefit.[78] However, the majority of data support that implementation of RPM can improve QoL measures; in particular, the few studies implementing active interventions have demonstrated the largest improvement in QoL.[40 79 80] Implementation of daily education with RPM using both symptom reporting and objective measures of exacerbation can significantly improve reported QoL and exercise capacity; however, this is limited by the ability to adhere to the significant time requirement.[40] RPM programs involving access to a nurse or other healthcare professional providing real-time, interpersonal support appear to be more consistently associated with increased QoL measures.[81] The level of engagement required to optimize both QoL outcomes as well as adherence remains undefined.

Acceptability of RPM technology (ie, patient buy-in) is an important component in adherence and perceived benefit. Patients generally respond positively to user-friendly electronic monitoring platforms.[32 55 81] Multiple small studies which did not find a significant effect on healthcare utilization or QoL with RPM reported high patient-user satisfaction with the program and good compliance[82–84] (interestingly these studies all implemented handheld spirometry).

This benefit is likely due to a combination of increased awareness and knowledge of their disease state, increased touch with the medical care team, and more rapid clinical assessment and treatment.[85]

INFRASTRUCTURE OF SUPPORT SYSTEMS

We have long known that patients generally prefer being treated at home; however, this is in the context of access to additional provider support.[86] As telehealth continues to gain popularity, patients with chronic conditions appear to support the integration of home monitoring.[87] While new devices and monitoring systems for physiological and behavioral parameters become available, challenges with data upload, interpretation, and response remain.

How remote monitoring platforms have been integrated into the clinical workflow in studies varies greatly and remains distinct from much of current clinical practice. Most available RPM systems have implemented a separate platform for data entry and upload which does not allow direct interaction with health system electronic health records (EHRs). Many of these asynchronous platforms do offer patient-specific thresholds or algorithms to generate alerts that may provide a more succinct overview of patient status. Regardless, how patient-generated data are managed and triaged remains heterogeneous in clinical studies, spanning from a personalized self-management plan to the involvement of clinical nurses and clinicians.

Interaction with providers

The interpersonal relationship between patient and clinician is a driving force in patient participation in the RPM program.[88] The amount of engagement between patients and clinicians—and type of clinician—in RPM is both variable and often not well-described.

There is notable heterogeneity not only in the devices and technologies studied but also in how this information is transmitted to the intended target. Independent of the clinician, accountable processes need to be implemented to allow expedient response to potentially dangerous findings. Ideally, these processes are aligned with standard practices.

Patient and healthcare system communication may occur through study coordinators,[40] registered nurses,[55 60 82 83 89] respiratory therapists,[39 52 80] or physicians. While there has been no direct comparison in outcomes from RPM platforms based on who both triages the data and delivers education, given the importance of healthcare interaction and education in these programs, it can be surmised that the training and experience of the healthcare professional involved would have a significant effect on how the program functions.

Data management

Patient-generated data can be continuously measured and automatically sent from the monitoring platform (ie, heart rate from a wearable device) or collected and submitted by the patient at a discrete time point. Many RPM platforms go beyond offering raw data and use thresholds or algorithms to create an alert system or categorize patient severity. Thresholds can be either fixed, such as the generation of an alert for any patient with SpO_2 <88% over a predetermined amount of time, or patient-specific. When evaluated using multilevel logistic regression, a large proportion of the variance in physiological parameters is due to differences between individuals.[37] Setting individual alarm limits, if possible, to accommodate for intraperson and interperson variability can be implemented to improve prediction tools. Previous studies have used a set time frame to obtain a baseline for patients prior to initiation of intervention.[18 24 36 90] There are no data currently available to compare different methods of personalizing alarm limits. To circumvent this variability between patients, an algorithm to create a dynamic threshold may improve the accuracy of detection and reduce false alarm rates.[91] This baseline could then be integrated into the algorithm decision tree to determine when to send alerts about a patient condition.

BARRIERS TO IMPLEMENTATION OF AN RPM PROGRAM

The potential barriers to be considered when implementing an RPM program can be divided into three categories: integration and oversite, patient, and reimbursement. Assessing and addressing barriers prior to go-live will allow for a more successful rollout (table 2).

Table 2 Barriers and considerations in starting a remote patient monitoring system

Factor	Description	Considerations
Patient	The phase of disease and environment of focus	► What physical considerations may interfere with adherence? ► Is the patient residing in the same state? ► Is the time needed for data collection prohibitory for long-term use? ► What health and technology literacy is needed for use of the device? ► Does the patient need other resources (smart phone, WiFi, etc.)?
Device	Device given to patient to collect and upload data	► Will the devices be reusable or will one be needed for each patient? ► Is the device wearable? Does device require patient to input data? Continuous or intermittent data collection? ► Is the data integrated directly into electronic health records or an external platform? Manual or automatic upload?
Implementation	Team and infrastructure necessary for onboarding and implementation in clinical practice	► What information technology support is needed for patient onboarding and troubleshooting? ► What medical staff and training are needed for patient onboarding? ► Who is responsible for patient collected data and in what time frame? What are the indications for intervention? What is the patient expectation for response? ► What is the reimbursement strategy?

Integration and oversite

Building an RPM program within a healthcare system requires time and coordination between the information technology (IT) team and a group of engaged clinicians who will be monitoring the cohort of patients. This step must include the right team with the experience to build reporting systems and integrate the RPM device into either the already existing EHR (which allows integration with other clinical data and is more often accessed) or implement a third-party reporting system (with the benefit of the company managing data and technological issues that may arise). Clinicians will need to identify the appropriate metrics to measure, the thresholds for alarms, and the process to reliably interpret data regularly.

Clear messaging and instructions for patients need to be created and provided prior to implementation. Patients need explicit training on both the technological onboarding and the clinical measurement and expectations of care (eg, how to handle after-business hours data). In addition, patients' expectations need to be explicitly conveyed so that emergency situations are not inappropriately expected to be addressed through RPM data input. Terms for required consent to participate in an RPM program may vary with private insurance companies; Medicare requires an established patient-physician relationship, consent to receive remote physiological monitoring services, and documentation of evaluation and management services.[92] Assurances and standards of privacy are imperative to protect the privacy of our patients and their data with the same guarantees of other data collected in the course of their care.

As patients are not physically in clinic, there is the potential visits can be performed outside of a state (and the provider's license). The Federation of State Medical Boards created the Interstate Medical Licensure Compact which supports portability of licensure for telemedicine, but the effects of this are not clear on an individual patient basis.[93]

When choosing a device, one must decide if the device will be one-time use or if the device will need to be collected after completion of the program. Other barriers include the weight and location of the sensor, the need for charging, access to WiFi or hardwired internet.

EHR integration is still a challenge for many devices. Many offer external platforms, but these pose limited ability to integrate into existing healthcare teams. Direct integration into EHRs is possible, but typically requiring an application-specific build through IT. This requires close attention to protect the confidentiality and privacy of patients.[94]

Devices can be returned or reused at the discretion of each individual program. Factors that influence this decision include the cost of the device, reusability in the design of the device (eg, home spirometers without reusable pieces), advantage to patient of keeping long term (eg, pulse oximeter they could benefit from keeping), and time frame of RPM intervention.

As external devices are increasingly used in healthcare and incorporated in electronic health systems, assurances and standards on privacy are imperative to protect the privacy of our patients and their data. Data generated should exclusively be accessed and owned by healthcare systems and patients with the same protections and guarantees of other data collected in the course of care.

Patient barriers

There are key demographic differences in a patient with COPD compared with other disease groups. Beyond the major risk factor of smoking, socioeconomic differences have been described in the COPD population. Prevalence of COPD decreases with increasing income levels, the highest prevalence being in those with family income below the federal poverty line.[95] Closely tied with socioeconomic status, level of education has been found to be a major predictor of mortality in patients with COPD with higher level of education being associated with lower mortality.[96] Lifestyle factors associated with lower socioeconomic status must be understood to properly target this population. Cost of commercially available devices in RPM varies greatly and many devices may be cost-prohibitive or lead to significant patient financial burden if not discounted through sponsored health plans.[97]

Several patient barriers exist within telehealth and RPM, including technological and health literacy, access to necessary adjunct technology (ie, owning a smartphone) and physical barriers, such as poor vision, dexterity, and time limitations. Understanding the patient population focus of your RPM program and individual barriers can make for better planning. Patients may require physical support

when setting up and performing RPM. Providing adequate resources for patients and families, in the language they understand and at their comprehension level is key.

Health inequities in our country have been brought to light during this digital era. Addressing the digital divide that exists must include confronting internet access, digital literacy, and linguistically appropriate information.[98] Internet connectivity depends on geographic availability and a patient's embracing of internet services.[98]

Reimbursement

Billing and reimbursement should be addressed during the integration phase; however, understanding billing aspects is a challenge. In 2019, the Centers for Medicare and Medicaid Services (CMS) established new billing codes for RPM.[99] These codes incentivize RPM set-up and allow monthly billing per patient in 20-min increments. With the COVID-19 pandemic, further efforts were made to incentivize telehealth visits[100]: co-pays were allowed to be waived by providers, consent for RPM services needed yearly, and more monthly billable time.[99] Still, when it comes to RPM, billing is very different than face-to-face visits and traditional telehealth visits. The recent expansion of billable services allowed for non-physician providers to receive reimbursement for RPM services, which offers benefits for health systems and programs but must be completely understood to be successful.[101]

RPM programs that are starting their initiation should consider starting slowly with substantial communication before a full go-live. Starting with a small, engaged cohort of patients will allow time to identify barriers and needed workflow improvements. Weekly team meetings with the clinicians, IT, and billing team will address issues and fixes in a timely manner. Once there are fewer problems that arise and the RPM process appears to be running efficiently, rolling out to a larger cohort will assure less confusion and better time used to monitor the patients.

CONCLUSION

RPM in COPD uses technology to bridge the gap between the clinic and a patient's home. While prior studies have demonstrated minimal benefit on patient and healthcare system-oriented outcomes, myriad RPM technologies and approaches are being developed offering nuanced tools for this heterogeneous and elusive disease to manage.

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