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Home Pulse Oximetry after Discharge from a Quaternary-Care Children's Hospital: Prescriber Patterns and Perspectives

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Abstract

Introduction: Pulse oximetry monitoring is prescribed to children receiving home oxygen for chronic medical conditions associated with hypoxemia. Although home pediatric pulse oximetry is supported by national organizations, there are a lack of guidelines outlining indications and prescribing parameters.

Methods: A mixed-methods analysis of pediatric home pulse oximetry orders prescribed through the institutional home health care provider at a large US children's hospital 6/2018–7/2019 were retrospectively reviewed to determine prescribed alarm parameter limits and recommended interventions. Semi-structured qualitative interviews with pediatric providers managing patients receiving home oxygen and pulse oximetry were conducted to identify opportunities to improve home pulse oximetry prescribing practices. Interviews were analyzed using a modified content analysis approach to identify recurring themes.

Results: 368 children received home pulse oximetry orders. Orders were most frequently prescribed on non-cardiac medical floors (32%). Attending physicians were the most frequent ordering providers (52%). Frequency of use was prescribed in 96% of orders, however just 70% were provided with specific instructions for interventions when alarms occurred. Provider role and clinical setting were significantly associated with the presence of a care plan. Provider interviews identified opportunities for improvement with the device, management of alarm parameter limits, and access to home monitor data.

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Discussion: This study demonstrated significant variability in home pulse oximetry prescribing practices. Provider interviews highlighted the importance of the provider-patient relationship and areas for improvement. There is an opportunity to create standardized guidelines that optimize the use of home monitoring devices for patients, families, and pulmonary providers.

Keywords

pulse oximetry; home monitoring; pediatrics; chronic lung disease; bronchopulmonary dysplasia; home oxygen therapy

Introduction

Home oxygen therapy is used to treat children with chronic hypoxemia from chronic lung disease, pulmonary vascular disease, and other etiologies. Pulse oximetry monitoring of children prescribed home oxygen therapy has multiple purposes including identification of (1) acute clinical deterioration, (2) need for clinical intervention, and (3) oxygen saturation trends to inform long-term supplemental oxygen treatment (1). Although the exact number of patients discharged home with a pulse oximeter are unknown, approximately one quarter of patients with bronchopulmonary dysplasia (BPD), which affects nearly half of extremely preterm infants who survive to 36 weeks postmenstrual age, are discharged to home on supplemental oxygen with a pulse oximeter (2, 3).

To serve its purpose, alarm parameters on home pulse oximeters are often set conservatively to prompt caregivers to recognize, intervene if necessary, and manually document all desaturations, even those that are not life-threatening. In infants and children, an alarm threshold of less than 90% is estimated to result in a median of at least 10 alarms per night (4). Frequent alarms pose a significant burden to caregivers and may cause alarm fatigue, leading to missed life-threatening alarms or premature monitor discontinuation (5, 6). The Collaborative Home Infant Monitoring Evaluation (CHIME) study investigated compliance to prescribed home pulse oximetry and found that more than 30% of families used the monitor for less than 10 hours per week (7).

Despite general support for pediatric home pulse oximetry by national organizations, guidelines for monitoring parameters and frequency of use do not exist (1, 8). The objective of the current study was to perform mixed methods analyses assessing how pediatric providers prescribe and use home pulse oximeters.

Methods

Patient Safety Learning Lab

This work was performed by the Agency for Healthcare Research and Quality (AHRQ) funded Patient Safety Learning Laboratory (PSLL) at Children’s Hospital of Philadelphia (CHOP) in the United States, which conducts longitudinal quality improvement work focused on re-engineering the systems used to monitor patients in the hospital and at home. Our qualitative work is conducted in collaboration with the University of Pennsylvania Mixed Methods Research Lab (MMRL). The MMRL works with investigators and groups

such as the PSLL to provide conceptual and technical support for community based and clinical research questions and quality work.

The hospital Committees for the Protection of Human Subjects (the IRB) determined that the PSLL's problem analysis portfolio (which included this project) was consistent with quality improvement activity and did not meet criteria for human subjects' research. The CHOP Office of Collaborative and Corporate Research executed a Business Associate Agreement between CHOP and the University of Pennsylvania governing the inter-institutional collaboration and use of data.

Using a mixed methods approach with data source triangulation, we performed a retrospective review of home pulse oximetry prescribing patterns and qualitative interviews with pediatric providers who manage home oximeters (9). CHOP is a free-standing children's hospital with 546 beds and nearly 30,000 admissions per year serving a broad patient population from local general pediatric admissions to national and international referrals for subspecialty care. Children who are prescribed home pulse oximeters are discharged from multiple units including the Neonatal-Infant Intensive Care Unit (N/IICU), Cardiac Intensive Care Unit (CICU), Cardiac Care Unit (CCU), Pediatric Intensive Care Unit (PICU), Progressive Care Unit (PCU, a step-down unit for the intensive care units for patients with tracheostomy and ventilator dependence), and general medical floors. Additionally, oximeters may be prescribed in the outpatient setting.

Retrospective Review of Home Oximeter Prescribing Patterns

CHOP Home Care provides equipment, caregiver training on equipment, injectable medications, home nursing care, and respiratory therapy services to patients throughout the CHOP Care Network. We identified all patients prescribed home oximeters through CHOP Home Care between 6/2018 and 7/2019 using the CHOP Home Care claims database. We removed duplicate orders, using the initial pulse oximeter order for patients with multiple orders. These orders were hand-written and scanned into the electronic medical record. A PSLL team member manually extracted pertinent data from the prescriptions and used a link to the EMR-to determine the patient's location on the date the order was written. Data extracted were prescribing provider role, alarm parameters (high and low heart rate and oxyhemoglobin saturations if prescribed), and interventions in the event of an alarm activation (these were written as free text in the prescriptions). Pulse oximeter prescription parameters were determined by the patient's care team members; an institutional guideline for these parameters does not exist.

We used descriptive statistics to examine pulse oximetry prescribing patterns. Univariable logistic regression models were built to evaluate the associations between presence of a prescribed intervention, provider role and patient setting at time of pulse oximetry prescription. We then used multivariable logistic regression to further evaluate the independent associations between presence of a prescribed intervention and the same factors (provider role and patient setting). Relationships between patient age at the time of prescription and saturation targets were explored with Pearson's correlation coefficients. All analyses were conducted using Stata 16.0 (Stata Corp, College Station, TX).

Qualitative Interviews about Home Oximeter Management

To further explore implications of the variability in home oximetry prescribing and opportunities for improvement, we performed semi-structured qualitative interviews with pediatric providers who manage home oxygen and pulse oximeters. The aims of these interviews were to describe clinician perception of patients' home life, understand approaches to goal setting and establishing home alarm parameters, and elicit adaptations/suggestions for improvement. Interviews were continued until thematic saturation was achieved with a minimum sample size of 10. We enrolled participants using purposive sampling and performed the interviews between 11/1/2019 and 1/30/2020.

A MMRL interviewer who did not know the participants conducted one-on-one telephone interviews with each provider. All identifiable participant information gathered for recruitment or analysis purposes was stored on secure servers using encrypted, password-protected documents only available to key study personnel. Interviews employed chart-stimulated recall to provide context about oxygen saturation (SpO2) data use in treatment decisions. The interview guide used a hybrid of the Systems Engineering Initiative for Patient Safety (SEIPS) framework and the Dual-Process Theory (DPT) framework (10, 11) (Supplemental material). Recorded interviews were transcribed by Datagain Transcription Services (Secaucus, NJ) and sent to MMRL at the University of Pennsylvania where transcripts were de-identified. Transcription analysis was conducted in NVivo 12 Plus (QSR International, Burlington, MA). A MMRL staff member reviewed initial transcripts to highlight recurring themes. Using a modified content analysis approach, initial recurring themes were used to develop a codebook within the SEIPS and DPT frameworks. The codebook organized responses into categorical nodes for analysis. Two MMRL staff members applied the codebook to all transcripts, periodically refining the themes and definitions based on inter-rater reliability tests to facilitate analysis. The staff then synthesized the coding outputs and identified key themes.

Results

Retrospective Review

We identified 368 children with pulse oximetry orders through CHOP Home Care during the 1-year evaluation period. The median patient age at time of the prescription was 11 months (Interquartile range [IQR] 3 months – 4 years). Table 1 shows the distribution of prescribing providers and units. Home oximeters were most frequently prescribed on the non-cardiac medical floor, followed by the outpatient clinic setting (32% and 21%, respectively). While attendings were the most frequent ordering providers (52%), trainees (residents and fellows) completed 46% of pulse oximeter prescriptions.

Prescriptions included low alarm SpO_2 settings for 99% of patients. The median low alarm SpO_2 limit was 90% (IQR 88%–92%). Five prescriptions had no low alarm limit and two prescriptions had a range of saturations prescribed as the low alarm setting. Prescriptions included high alarm SpO_2 settings for 36% of patients, and the median high alarm SpO_2 setting was 100% (IQR 92%–100%). Prescriptions included heart rate parameters for 92% of patients. When prescribed, both low and high SpO2 alarm settings correlated significantly

with patient age at the time of the order (correlation coefficients 0.28 ($p<0.001$) and 0.27 ($p=0.001$), respectively). The median low heart rate alarm was 80 beats per minute (bpm) (IQR 60–90) and high heart rate alarm was 180 bpm (IQR 160–190). Both low and high heart rate alarm settings decreased significantly with increasing patient age at the time of the order (correlation coefficients −0.52 ($p<0.001$) and −0.49 ($p<0.001$), respectively).

Spot checks (intermittent checks) were the most frequently prescribed mode of home pulse oximeter monitoring (Table 2). The majority of children prescribed monitors in the clinic, medical floor, or cardiac units were prescribed spot checks, while neonatal and pediatric intensive care unit patients were more frequently prescribed continuous monitoring. While infrequent, 4% of patients were not provided written instructions for frequency of oximeter use. In bivariate analyses, prescribed frequency of use was associated with the clinical setting in which the order was placed ($p < 0.001$) but not with the role of the prescriber ($p= 0.15$). None of the orders included specific instructions for how the oximeter should be programmed, such as alarm delays or averaging times.

Seventy percent of the orders (n=257/368) included instructions for how a parent or caregiver should respond to a pulse oximeter alarm. Interventions most commonly prescribed were to call a physician (n=207), start or increase oxygen flow (n=41), or mechanical interventions such as suctioning or repositioning mask (n=60). In bivariate analysis, the role of prescriber and clinical setting in which order was placed were significantly associated with the presence of an intervention plan for oximeter alarms ($p=0.005$ and $p<0.001$, respectively). Residents were less likely to write a plan than attendings (60% vs. 74%); fellows were most likely to write a plan (85%). Orders from the cardiac ICU/cardiac floor and pediatric ICU were significantly more likely to have an intervention plan than orders written on the general pediatrics floor (93%, 89% and 55%, respectively). When all locations and provider types were included in multivariable logistic regression analysis, discharge from cardiac units or PICU/PCU remained associated with higher odds of intervention instructions and resident in prescriber role remained associated with lower odds of intervention instructions (Table 3).

Provider Interviews

Eleven providers participated in semi-structured qualitative interviews to explore perspectives on management of home oximetry. Providers included 7 physicians, 1 advanced nurse practitioner, 2 nurses, and 1 respiratory therapist, all of whom routinely prescribe or manage home pulse oximeters. Specific roles include follow-up with patients and parents during home monitoring, ongoing disease assessment, and weaning both respiratory support and monitoring. The average interview duration was 38 (range 28–57) minutes.

Providers described three clinical scenarios that led them to prescribe home monitoring: patients with respiratory failure requiring ventilators, patients discharged on supplemental oxygen, and patients with sleep-related breathing disorders. Three main topics were explored during the interviews: clinician perception of patients' home life, approaches to goal setting and establishing home alarm parameters, and adaptations/suggestions for improvement. These topics are described in detail below, and representative quotations are presented in Table 4.

Perception of patients' home life

One of the most prevalent themes was the critical nature of the provider-parent relationship. Establishing a strong line of communication between clinicians and caregivers factored strongly into providers' perceptions of successful home monitoring. The provider's subjective assessment of a family's ability to report monitor data and adverse events was a key component of a clinician's decision to prescribe home monitoring versus considering alternatives. Parental education about home monitoring and extensive conversations about alternatives to home monitoring provided the basis for these assessments (Table 4; Quotations A & B). Other significant considerations included logistics of home monitoring, such as access to electrical outlets, the layout of the child's room, and the physical space required for the devices.

Current approaches

Goal setting:

Provider perspectives on the purpose and goal of home monitoring varied. Some providers framed goals in terms of disease improvement over time and weaning from respiratory support. Other providers reported the primary goal was ensuring patient safety in the home environment and being able to assess patients at risk of adverse events from a distance. For both goals, providers felt they were meeting the goals moderately well and used varying metrics for measuring success, such as the frequency of patients experiencing medical emergencies at home. Providers recognized room for improvement in achieving goals, particularly around accurate data collection (Table 4; Quotations C & D).

Establishing home alarm parameters:

Most providers reported relying on a patient's age and condition when establishing home alarm parameters. Providers also cited their perception of the home life and the family's willingness and ability to participate in home monitoring, including access to home night nurses and social support, as additional important factors in determining home alarm parameters. Providers described how alarm fatigue could cause parents to over or under monitor their child's condition, thus impacting the accuracy and comprehensiveness of the parental reports.

Some providers reported setting less strict alarm parameters in the home setting as compared to the hospital if the patient's condition allowed. Other providers preferred to err on the side of caution by setting stricter alarm parameters to ensure parents were alerted to their child's condition (Table 4; Quotations E & F). Providers reported waiting for parents to contact them with concerns regarding alarm frequency before adjusting the parameters to be less strict (Table 4; Quotations G & H).

Adaptations and suggestions for improvement

Monitoring devices and reducing false alarms:

Many suggestions for improvement were related to significant differences between inpatient monitoring equipment and technologies available for home monitoring. Providers felt

standardization of home devices was a critical need. Participants stated the multitude of brands and home monitoring devices leads to different parameters, settings, layouts, and ways of resolving alarms. This necessitates a complex network of provider and parent knowledge which may contribute to different levels of home monitoring satisfaction (Table 4: Quotations I &J).

Some providers suggested that device standardization or family access to more pulse oximeter probes may lead to a reduction in false alarms (Table 4; Quotations K & L). Another suggestion was to standardize alarm parameters based on patients' age and condition that could be changed on an ongoing basis, thus eliminating providers' reliance on parent reports regarding alarm fatigue. Other providers questioned the initial treatment pathways that assess patients' need for continuous home monitoring (Table 4; Quotation M).

Data collection:

Automating the process of obtaining home monitor data to directly download into the patients' electronic health record was the most common suggestion to improve home monitor data collection. The type and level of detail providers wanted from this data varied from real-time data to up to one year of historical data. Some providers expressed interest in information about each alarm instance to inform treatment plans (Table 4; Quotations N & O). Other providers were concerned about practical utility of greater amounts of information, including how well data from monitors captures a patient's condition and the staffing required to fully review monitor data (Table 4; Quotation P).

Discussion

This mixed methods evaluation demonstrated variability in prescribing practices for pediatric home pulse oximetry and opportunities for areas of improvement. Over one year, 368 children were prescribed a home pulse oximeter through CHOP Home Care; among these, 4% were not prescribed a frequency of use and 30% were not provided care instructions after alarm activation. Provider role and clinical setting were both significantly associated with the presence of a care plan. Provider interviews highlighted the importance of strong communication between the caregiver and the medical team and opportunities for improvement with the device, management of alarm parameters, and access to home monitor data.

Home pulse oximetry can be used to notify caregivers about adverse patient events including interruptions in respiratory support delivery that may result in clinical deterioration or the need for clinical intervention (4, 12, 13). However, this evaluation identified that only 70% of prescriptions included a written plan of care for the caregiver who is responsible for responding to alarms. There have not been previous studies assessing the frequency or content of plans of care for patients discharged on home oxygen therapy with a pulse oximeter or the parental experience of managing such equipment. The American Thoracic Society (ATS) stated that caregivers of children discharged on home oxygen therapy should have appropriate education on the management of the equipment and the skills necessary to respond to abnormal oxyhemoglobin saturations (1); however, further details regarding these skills were not stated. The lack of a care plan for 30% of patients and

the association between presence of a care plan and both provider role and clinical setting demonstrate a critical area for improvement and standardization. Focused provider education and improved understanding and standardization of home pulse oximeter goals may improve and ameliorate variation in provider prescribing practices. Standardized order sets offer an immediate solution to ensure a care plan is defined prior to discharge.

In this cohort, 24% of patients were prescribed continuous pulse oximetry monitoring, and the frequency of monitoring varied significantly by clinical setting in which the home monitor was prescribed. While this may be due to variation in disease processes by unit, this may also represent unnecessary practice variation and should be further explored to improve home monitoring. Furthermore, 50% of prescriptions had a low SpO_2 alarm limit of 90% or greater. A prior study has shown that an alarm threshold of less than 90% resulted in a median of at least 10 alarms per night. This high alarm rate can cause alarm fatigue resulting in potentially life-threatening outcomes if an alarm is ignored or monitoring is discontinued (4, 5). Such a high alarm rate also puts significant burden on a population of caregivers already known to suffer from high rates of depression and anxiety (14). Understanding and defining the goal of home pulse oximetry monitoring may yield opportunities to change current prescribing practices that could impact alarm fatigue frequency and improve patient and caregiver quality of life (15–19).

Pulse oximetry is also used to guide clinical decisions about outpatient management of supplemental oxygen, particularly for patients with chronic lung disease of prematurity, though there is significant variability in practice patterns for how premature infants are weaned from supplemental oxygen (12, 13, 20, 21). In one study of patients with bronchopulmonary dysplasia, recorded home oximeter data reduced the duration of use for home oxygen compared to monthly clinic visits (20).

In a newer application of this technology, remote monitoring of vital signs using wearable technology increased in frequency during the COVID-19 pandemic among adults who might need admission and those recently discharged from the hospital (22). Although not used in pediatrics during the pandemic, challenges raised with these systems include motion artifact, power consumption, real-time processing needs, and privacy and data sharing concerns (23). Similar challenges were highlighted during our provider interviews. Our interview participants expressed interest in automating the process of obtaining home monitor data to aid in patient management, but also reported variability in the level of detail they desired and concern regarding the potential challenges in data interpretation and personnel effort required to review large volumes of oximetry data. Further understanding of the quantity and type of data that would best facilitate decision making across multiple clinical scenarios as well as work flows to manage such data will be critical to optimizing integration of recorded home pulse oximetry into routine outpatient care.

Given the frequency of home pulse oximeter use, the lack of published guidelines for home pulse oximetry monitoring for children is a critical gap. Statements from the ATS on the care of children with chronic lung disease strongly endorse the importance of in-home pulse oximetry for infants on supplemental oxygen (1)(6); yet, the ATS recognizes the limitations of the literature on in-home pulse oximetry and does not offer guidelines

for how to monitor or how to appropriately prescribe monitors. We hypothesize that the inconsistent prescribing practices identified in the current evaluation result from the lack of evidence-based guidelines to support clinical decisions about pediatric home pulse oximetry. The lack of action plans for responding to oximeter alarms is an additional weakness in the system of home oxygen monitoring. Provider interviews highlight variability in prescribing practices of alarm parameters, goals of home monitoring, and prescribed action plans. The provider interviews further reinforce and describe several challenges with the current system including a lack of standardization for monitoring parameters, communication and efficient dissemination of home pulse oximetry data, and a lack of standardization of home care equipment.

We acknowledge several limitations of the current evaluation. The quantitative analyses utilize retrospective data from a home care company embedded within a single institution, which may limit generalizability. The pulse oximeter orders did not include specific diagnoses or indications for home pulse oximetry, which might have provided additional insights into decisions about alarm parameter prescriptions. Data regarding the specific pulse oximeter provided were not available; however, CHOP Homecare specializes in providing pediatric appropriate medical supplies and education. Lastly, sample sizes resulted in wide confidence intervals for some results.

In balance, our institution serves a large patient population with diverse disease processes such that one year of records provided sufficient data to answer our primary questions. Our rigorous mixed methods approach allowed us to elicit perspectives of the providers who manage patients on home oximeters on a regular basis. These same providers would utilize a re-engineered system for home oximeter monitoring. Future work to improve our systems will be directly informed by these detailed interview data including the creation of a standard curriculum to train caregivers on how to navigate pulse oximeter alarms at home.

In conclusion, this quality improvement evaluation demonstrated significant variability in home pulse oximetry prescribing practices and opportunities for immediate improvements in care. Provider interviews highlight challenges and areas for improvement for home pulse oximetry monitoring of children. Further work is needed to create standardized guidelines that optimize the use of home monitoring equipment.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1:

Prescribing Provider Role by Setting

	Provider Type n (%)					
	All Providers	**Attending**	**Fellow**	**Resident**	**Advanced Practitioner**	**Unknown**
All Settings n (%)	368 (100)	190 (52)	39 (11)	130 (35)	5 (1)	4 (1)
Individual Settings n (%)						
Medical Floor	119 (32)	23 (19)	4 (3)	91 (76)	0	1 (1)
Outpatient clinic	77 (21)	68 (88)	5 (6)	2 (3)	1 (1)	1 (1)
CICU & CCU	69 (19)	17 (25)	24 (35)	27 (39)	1 (1)	0
PICU & PCU	45 (12)	33 (73)	6 (13)	6 (13)	0	0
N/IICU	27 (7)	24 (89)	0	3 (11)	0	0
Other*	31 (8)	25 (82)	0	1 (3)	3 (10)	2 (6)

CICU: cardiac intensive care unit; CCU: cardiac care unit; PICU: pediatric intensive care unit; PCU: progressive care unit; N/IICU: Neonatal-Infant Intensive Care Unit

*Other category includes other institutions, other home care companies, and the emergency department.

Table 2:

Prescribed Frequency of Pulse Oximeter Use by Setting

	Frequency n(%)					
	Intermittent (spot check)	**Continuous**	**Overnight only**	**Overnight & napping**	**Other****	**None Indicated**
All Settings n(%)	189 (51)	89 (24)	17 (5)	25 (7)	35 (10)	13 (4)
Individual Settings n(%)						
Medical Floor	56 (47)	23 (19)	8 (7)	13 (11)	13 (11)	6 (5)
Outpatient clinic	44 (57)	4 (5)	6 (8)	8 (10)	11 (14)	4 (5)
CICU & CCU	59 (86)	6 (9)	1 (1)	0	3 (4)	0
PICU & PCU	8 (18)	32 (71)	1 (2)	1 (2)	3 (7)	0
N/IICU	5 (19)	17 (63)	0	2 (7)	2 (7)	1 (4)
Other*	17 (55)	7 (23)	1 (3)	1 (3)	3 (10)	2 (6)

CICU: cardiac intensive care unit; CCU: cardiac care unit; PICU: pediatric intensive care unit; PCU: progressive care unit; N/IICU: Neonatal-Infant Intensive Care Unit

* Other category includes other institutions, other home care companies, and the emergency department.

** Examples of other prescribed frequencies include “when unattended,” “continuous when ill,” “prn for increase work of breathing,” and “continuous while feeding.”

Table 3:

Multivariable Analysis of Prescribed Interventions in Response to Oximeter Alarms

	Number of prescriptions	Odds Ratio (95% Confidence Interval)	p-value
Setting			
Medical floor	118	reference	reference
Outpatient clinic	77	0.89 (0.40, 2.01)	0.78
CICU & CCU	69	9.59 (3.41, 27.00)	<0.001
PICU & PCU	45	4.34 (1.47, 12.83)	0.01
N/IICU	27	0.99 (0.36, 2.74)	0.99
Other *	29	0.90 (0.32, 2.53)	0.84
Prescriber role			
Attending	191	reference	reference
Fellow	39	0.69 (0.23, 2.04)	0.50
Nurse practitioner or physician assistant	5	0.21 (0.03, 1.65)	0.14
Resident	130	0.45 (0.22, 0.95)	0.04

CICU: cardiac intensive care unit; CCU: cardiac care unit; PICU: pediatric intensive care unit; PCU: progressive care unit; N/IICU: Neonatal-Infant Intensive Care Unit

* Other category includes other institutions, other home care companies, and the emergency department.

Table 4:

Representative quotations from clinician interviews

Perception of patients' home life	
A.	"There's some families that just don't have the resources to care for a complex child. In a lot of cases, they're not just going home on supplemental oxygen, they're also going home with things like G-tube feeds and a whole list of medications. And so if the family decides that they don't want to put this child in a long-term care facility, or an acute care facility for that matter, then we may decide that it's best to just keep the child in the hospital and continue to wean. And then there's other families who are – would rather just take the child home and care for them at home rather than keep them in the hospital."
B.	"[It's important to] really understand that family dynamic, which is a little bit more difficult to ascertain. So, having to spend time with the family and talk about the pros and the cons and getting a concept of whether or not they understand what I'm trying to get out of it versus what they may be trying to get out of it."
Current approaches	
Goal setting	
C.	"The goals are to be able to assess the patient in the home to see if they are at risk of having an adverse event or are in the process of having an adverse event."
D.	"I think the big thing with home monitoring from our standpoint is that our main goal, if we can, is to get children off respiratory support. So, specifically with our kids that are on our chronic lung disease or our bronchopulmonary dysplasia patients is, as they grow, we want to be able wean them off of oxygen."
Establishing home alarm parameters	
E.	"You have to weigh the risks and benefits. There's a lot of studies to say that monitoring for an irregular child – more specifically for neonates – is you're gonna run into problems with alarm fatigue, it's gonna over-alarm. In general, it's thought to not be a good process. So, deciding on which patients actually need that and more specifically which families need that as well. It's a balance between do I think this patient has serious enough pathology that this is important that they need to be monitored at home? And the alarm fatigue is less of a factor than what I need to monitor specifically? And then, is the family capable of understanding that sometimes this is gonna alarm? Do they potentially need home nursing so that somebody can actually physically watch [the child]?"
F.	"Especially kids that require higher saturations be maintained at all times, like pulmonary hypertension, we don't let them dip as low as somebody that just came in with bronchiolitis for instance. Occasionally, they'll have high 80s. We may set the lower limit a little bit lower on those kids to help avoid issues with the family if we feel that they're only briefly going down, hitting a lower sat, and coming back up pretty quickly. If it's somebody that needs more intensive monitoring, like someone with pulmonary hypertension, then we would be stricter with the lower limit that we set."
G.	"I mean, not everyone has great nursing as I mentioned before. So if you have a family that doesn't have a lot of night shift nursing, we may set those alarms a little tighter because we want to make sure that the parents who we know are not necessarily – they might be sleeping in the room, but they're not sitting there awake like we ask them to be. That the alarms are gonna ring earlier, so they have a little bit more time to respond to whatever the issue may be."
H.	"Once [the patient] goes home, it really depends on what the family's telling us, on how often they're alarming, how frequently, is it keeping them up all night. We'll try to troubleshoot why it's happening. And then we may adjust from there."
Adaptations and suggestions for improvement	
Monitoring devices and reducing false alarms	
I.	"I mean, I think the alarms on some of these new vents are excessive to a certain degree. And I think there's a lot of things that are put in – alarms – as I'm finding out with patients that are going home on these new vents – alarms that are put in place by – truly I'm not sure who makes the parameters for some of these alarms that are new, that we had very little understanding of what they were and how they measure them. I think the DME company must make recommendations and this is what we prescribe and there are QI folks in our group who are looking more into it. But I just question sometimes whether or not – how much utility we get from them, as families are continuing to call in about them alarming."
J.	"… Many times people are working with equipment that in the hospital you would never use. And they're trying to make it work. So I think that it becomes a challenge in terms of trying to figure out what the right thing to do and what the next step really should be. So having more consistency in the type of machines that home companies are using, and having more access to the equipment that's needed."
K.	"We can't get more than eight pulse ox probes a month. I mean, there are kids in the hospital who go through eight pulse ox probes in two days. So having a better supply, or a machine that has a more realistic probe would be number one."
L.	"When it comes to excessive alarming, I think families often call in when they have concerns about that and we do address it. When it comes to ventilator alarms, I think it's something that's become more complicated over the years. We have new vents with new alarms and they alarm for different things that we are learning more about and trying to troubleshoot some of those things."

M.	"I think we need to be more proactive about what settings we're sending these kids home on. And also, at times, questioning the need for continuous monitoring. Like a kid that's on an eighth of a liter nasal cannula continuously that's been growing and developing well, do they need to be on a pulse ox 24/7? Or can it just be while they're asleep and eating?"
Data collection	
N.	"I think the biggest thing for us [is] just having some sort of – like for our patients that are on CPAP or BiPAP, you could get basically a download of the past 30 days. Actually, probably even more than that, probably about a year of just how many times it was used. When the machine was even turned on, what the pressures were, all of this stuff. So, just to have objective data rather than rely on some manual writing of someone, writing it down."
O.	"I think gathering more specific data would maybe be one thing that's beneficial. So, having the parameters around not only what time of day. Maybe if it gave me a snapshot of what the pleth on the waveform looked like."
P.	"[Data downloaded from the monitor] doesn't necessarily tell you what the patient looks like or if the mask is in the right place, and all of that other information. So I don't know how you could invent that. 'Cause if you have too much data pouring in at once, there's no way that you can be responsible for looking at everything. Which is why we don't get people dumping their every night sleeps monitoring it into our system, because we would never have the personnel to review all of that. So I think it's really just education with the caregivers to be able to have them know when their supposed to call us. And making sure you have people available that can take their calls and get back to them on the same day."