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Publication Date

2021-04-01

DOI

10.1016/j.iccn.2020.102949

Peer reviewed



HHS Public Access

Author manuscript

Intensive Crit Care Nurs. Author manuscript; available in PMC 2022 April 01.

Published in final edited form as:

Intensive Crit Care Nurs. 2021 April ; 63: 102949. doi:10.1016/j.iccn.2020.102949.

Standardisation, Multi-Measure, Data Quality and Trending: A Qualitative Study on Multidisciplinary Perspectives to Improve ICU Early Mobility Monitoring

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Abstract

Objective: To explore multi-clinician perspectives on ICU early mobility, monitoring, and to assess the perceived value of technology-generated mobility metrics to provide user feedback to inform research, practice improvement, and technology development.

Methods: We performed a qualitative descriptive study. Three focus groups were conducted with critical care clinicians, including nurses (n=10), physical therapists (n=8) and physicians (n=8) at an academic medical centre that implemented an ICU early mobility programme in 2012. Qualitative thematic analysis was used to code transcripts and identify overarching themes.

Findings: Along with reaffirming the *value* of performing ICU early mobility interventions, four themes for improving mobility monitoring emerged, including the need for: 1) *standardised* indicators for documenting mobility; 2) inclusion of both *quantitative and qualitative metrics* to measure mobility; 3) a balance between *quantity and quality* of data; and 4) *trending* mobility metrics over time.

Conclusion: ICU mobility monitoring should be standardised, and data generated should be high quality, capable of supporting trend analysis, and meaningful. By improving measurement and monitoring of ICU mobility, future researchers can examine the arc of activity that patients in the ICU undergo and develop models to understand factors that influence successful implementation.

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Keywords

critical care; focus groups; early mobility; mobilization; interdisciplinary research; measurement; qualitative; fitness trackers; nurses; physicians; physical therapists

INTRODUCTION

A growing body of evidence suggests early mobility (EM) interventions in the Intensive Care Unit (ICU) can improve patient outcomes including delirium and ventilator duration (Schweickert et al., 2009), benzodiazepine administration (Needham et al., 2010), quality of life (Burtin et al., 2009, Morris et al., 2016), and functional status (Burtin, Clerckx, 2009, Morris, Berry, 2016, Schweickert, Pohlman, 2009), which has resulted in the widespread acceptance of ICU EM. Despite efforts to translate mobility protocols to practice, prevalence studies indicate that adoption of higher-level ICU mobility, such as ambulation and sitting out-of-bed is low (Berney et al., 2013, Nydahl et al., 2014). A recent survey found only 45% of ICUs in the United States reported regular practice of EM interventions (Jolley et al., 2017) and a prospective study indicated mobilisation of patients on 51% of ICU patient days might be an upper limit of feasible ICU mobilisation (Brock et al., 2018). Beyond known barriers of staffing, hemodynamic/respiratory instability and institutional culture (Barber et al., 2015, Winkelman and Peereboom, 2010), lack of agreement on optimal measurement and monitoring of ICU EM activities may also hamper translation of EM protocols to practice.

Standardised methods to quantify ICU EM are necessary to accurately evaluate the effectiveness of mobility related interventions, analogous to other physiological parameters utilised in clinical trial design and practice (Iwashyna, 2012, Parry et al., 2017). The ICU is one of the most complex, data-driven environments in healthcare and patient monitoring devices are routinely used to produce structured information for providers that quantify and record patient physiology and severity of illness. While numerous methods exist to measure and monitor patient activity in research (Parry, Huang, 2017), these measures have not been routinely integrated in practice or do not fully capture important mobility components (Fazio et al., 2020). Over 19 measures of physical function have been used as outcomes in research to evaluate activity or rehabilitation among ICU patients (Tipping et al., 2012). The most common measures are based on highest daily functional mobility and the maximum distance ambulated (Tipping et al., 2016), measures that fail to capture EM frequency or duration. Existing ICU EM measurement and monitoring practices are also limited by non-standardised implementation across electronic health record (EHR) systems.

With the rapid digitisation of healthcare and widespread consumer health tracking (Fox and Duggan, 2013), new opportunities exist for quantifying EM in clinical settings. Studies have increasingly deployed emerging health technologies, such as wearable activity monitors and motion sensors in hospitalised patients (Fazio, Doroy, 2020, Kamdar et al., 2017, Ma et al., 2017, Verceles and Hager, 2015, Yeung et al. 2019). However, these technologies vary in how they assign thresholds for activity levels and types (Chen and Bassett, 2005, Sylvia et al., 2014), which may not align with activities germane to the ICU. Despite increasing

literature on monitoring ICU EM using accelerometers (Schwab et al., 2019), there is a lack of qualitative research exploring practices around monitoring ICU EM from the multi-clinician perspective. Therefore, the purpose of this study was to gain better understanding of how practicing clinicians conceptualise and monitor ICU EM, and to assess the perceived value of technology-generated EM metrics.

METHODS

Design

This qualitative descriptive study explored clinician perspectives on ICU EM, monitoring EM, and technology-generated mobility metrics to inform research, practice, and technology development. The study was conducted at a Northern California academic medical centre in 2018. Our ICU EM programme, which began in 2012, involves daily assessment for clinical appropriateness, EM interventions performed by nurses and PTs, and monitoring of progress by the multi-disciplinary team (AACN, 2013, Doroy, 2014). Focus groups explored individual and shared perspectives among three ICU clinician disciplines involved in ICU EM (Kitzinger, 1995, Morgan, 1998). Disciplines were kept separate in an effort to reduce biasing responses and allow for open dialogue around potential challenges.

Participants

ICU clinicians were recruited to participate through convenience sampling through email, with a goal of enrolling 4–12 participants per group (Liamputtong, 2009). Inclusion criteria included at least 1-year experience practicing in an ICU as a nurse, PT, PT assistant (PTA), or critical care physician. Clinicians in supervisory roles were excluded.

Ethical Considerations

The University's Institutional Review Board approved the study (#1170136). Each participant gave verbal consent prior to data collection.

Data Collection

Participants completed a questionnaire including demographic information, years of ICU experience, attitudes toward EM (Koo et al., 2016), and general perceptions toward technology (Rosen et al., 2013). To assess attitude toward EM practice, we used a single item from a Canadian survey assessing the clinician's view of ICU EM using a 7-point Likert scale ranging from "crucial, should be the top priority in care of ICU patients" to "of no importance to the care of ICU patients" (Koo, Choong, 2016). We assessed attitudes toward technology using two subscales, from the Media and Technology Usage and Attitudes Scale (Rosen, Whaling, 2013). The nine items assess whether an individual has generally positive or negative attitudes toward technology with scores ranging from 1–5. Higher scores in the positive attitude subscale indicate a more positive attitude towards technology, and higher scores in the negative attitude subscale indicate a more negative attitude towards technology.

In total, we conducted three focus groups. The primary author, a nurse researcher with doctoral training in qualitative research methods and prior experience conducting focus

groups facilitated 1-hour sessions and performed data analyses (SF). A semi-structured interview guide developed by the research team (SF, HY, NA, JA, AD), was used to facilitate participant conversations through pre-assigned topics (Table 1), but also allowed for opportunities to raise ideas not previously considered. Sessions were digitally recorded and transcribed for analysis.

Data Analysis

Questionnaire data were summarised with either means and standard deviations (SD), medians and interquartile ranges (IQR), or proportions using Microsoft Excel. An iterative thematic analysis approach was used to analyse focus group transcripts within the research team. Analysis began by reading transcripts for general understanding and context (Crabtree and Miller, 1999). Once familiarity with the transcripts was achieved, a process of inductive and deductive coding was performed to identify concepts and themes (Charmaz and Belgrave, 2007). Coding involved re-reading transcriptions, conducting line-by-line review, and assigning a ‘tag’ to data concepts (Fereday and Muir-Cochrane, 2004). Memo-writing occurred throughout the coding process to explore connections between codes and elaborate on preliminary ideas, impressions and additional areas of inquiry (Charmaz and Belgrave, 2007). After initial coding and memo-writing by the primary author was completed, members of the research team met to discuss codes, make comparisons, and begin to form linkages between codes. Additional rounds of coding and research team discussions focused on participant perspectives around EM data obtained from technologies and relationships between the clinical disciplines (Strauss and Corbin, 1990). Member checks were also performed by meeting with additional clinicians from each discipline (n=3), to confirm themes identified and resolve any discrepancies (Cope, 2014, Joffe, 2012, Lincoln and Guba, 1986). This iterative approach of coding, memo-writing, discussing concepts with the research team, and clinician member checks allowed us to identify patterns among concepts and group them into broader themes (Braun and Clarke, 2006, Glaser and Strauss, 1967).

FINDINGS

Participants

A total of 26 ICU clinicians participated in the study, including 10 nurses, eight PT/PTAs, and 8 physicians (Table 2). Less than half of the participants were male (42%) and half were younger than 41 years (50%). Median years practicing in an ICU was 5.5 (IQR 3.0–14.8).

Concepts & Themes

Five themes emerged, aligned with three main concepts: a) perspectives towards ICU EM; b) current measurement and monitoring practices; and c) adoption of future technologies for monitoring ICU EM. We describe and discuss the five themes according to each concept (Table 3), along with the overlap and variability between clinician perspectives (Figure 1).

Perspectives Toward ICU Early Mobility—In the questionnaire, 80.8% (n=22) of clinicians reported that EM was either “crucial” or “very important” to their ICU practice, while 15.4% (n=4) reported mobility was only “important” or “somewhat important” (Table

2). The primary reason clinicians perceived mobility as important was the *value* mobility offered to patients, their families, and staff.

Theme 1: Value: The main theme that emerged was the *value* that EM provided to the ICU patient, family, and staff. From the physician perspective, benefits to the patient's respiratory status was the primary motivation for implementing ICU mobility interventions.

I see a lot of atelectasis in the ICU if the patient is lying on their back all day...if you can get the patient up and moving, they take bigger breaths and it's sometimes the best pulmonary hygiene.

[Physician-FG2]

In addition to respiratory status improvement, clinicians also reported prevention of physical deconditioning, delirium, venous thromboembolism, and lightening sedation as patient benefits of EM. A nurse described the mental status value of EM and introduced a broader sense of provider satisfaction resulting from EM-related care.

I've had many experiences where patients are having a hard time and delirious and can't sleep. Then, physical therapy will have a session in the morning, then the patient will take a nap, and then I've gotten them up in the afternoon in a chair for a couple hours. When I come back the next day, I'll hear that the patient slept so well last night. And that's fabulous, because then that improves mental status, the patient sleeps and it's wonderful all the way around.

[Nurse-FG1]

By witnessing the beneficial effects of mobility on sleep from one day to the next, the nurse also felt a sense of satisfaction and reaffirmed that the interventions she implemented were valuable. Another nurse further described the impact on well-being for the patient and staff members.

It seems also to help the overall well-being of your patients who realise that they're not just sitting in bed all the time or lying in bed being turned. They are doing something physical so it's further motivating for them. And I think that's gratification for us, too, because you're doing something, and you see that it's working...we do so many things that we don't actually get to see the results.

[Nurse-FG1]

In addition to staff members perceiving the value in performing ICU mobility interventions, clinicians also described how families associate mobility with recovery. As stated by a nurse, "*you see families really happy to see the patient moving*". While clinicians expressed the value ICU mobility provided to patients, staff and families, they also described opportunities to improve how they currently document and monitor the mobility interventions implemented.

Current Measurement and Monitoring Practices—The two themes that arose regarding measurement and monitoring of ICU EM among the nurses, physicians, and PT/PTAs were the need for *standardisation* of EM documentation, and utilization of *multiple metrics for evaluation*, including both quantitative and qualitative metrics.

Theme 2: Standardisation: The first theme that emerged was standardisation of mobility documentation and metrics. Clinicians from all disciplines voiced that EHR mobility related information was “hidden”, located in different places, and hard to meaningfully extract. A physician described the large amount of EH data and the difficulty of finding information related to EM.

There are so many different places to find information. There are all the different snapshots and flowsheets. If you don't type in the exact name of the flowsheet, you can't find it. And so, you're looking through all these notes, and you've got a bunch of [patients] to look through, it's tough. Maybe the information is there somewhere, but I don't feel like it's readily available where you can look in the chart and understand, “Oh, they did this activity today.”

[Physician-FG2]

Clinicians described how mobility-related information, such as functional status and EM performed might be located in a number of different locations and text formats in the EHR, including structured data entries across multiple flowsheets, structured and unstructured entries in progress notes, and unstructured entries in nursing communication dashboards. Nurses further described how mobility-related activities were “buried” in the EHR, suggesting the need for a standardised and easily identifiable location for communicating EM interventions.

If it would be something that was more of a consistent, commonplace priority and that was up front, we would see it more, and it would be more of a topic of conversation and in the schedule as opposed to the way it is now, which is just buried in a few places.

[Nurse-FG1]

In addition to mobility-related information being difficult to locate, clinicians acknowledged EM interventions are not always be consistently documented. Instead, clinicians reported they often relied on each other's verbal accounts rather than attempt to search the EHR, which they described as often unreliable for ascertaining EM progress. Verbal accounts often occurred during shift changes or informal conversations, as a PT explained.

I can't tell you how often I come in and I ask the nurse if this patient's gotten up, and they say, “the patient walked three laps last night,” but there's nothing in the chart. How was I supposed to know other than I got lucky and the nurse giving the report gave it to you, who gave it to the next guy?

[PT-FG3]

In addition to verbal communications occurring between clinicians to gain knowledge around EM performed on previous shifts or days, clinicians described how verbal reports may also come from family members.

When I ask about mobility at the start of my shift, the nurse leaving might say, “I think the patient got up yesterday, I think they dangled.” Or, often the family will tell us that yesterday the patient walked. If you have a family that's active and participating, then they're good historians for mobility.

[Nurse-FG1]

Clinicians also emphasised the importance of standardised metrics to evaluate and monitor EM across disciplines. Clinicians agreed that having consensus on a standard set of EM metrics meaningful to each discipline was important in order to improve EM monitoring and communication, assess patient progress, and contextualise outcomes of interventions.

Theme 3: Multiple Metrics: The next theme that arose regarding monitoring practices was the importance of including multiple indicators, a combination of quantitative and qualitative metrics to monitor ICU EM. Across groups, a core set of mobility metrics surfaced that ICU nurses, physicians, and PTs were all interested in monitoring (Figure 1). After EM interventions, clinicians expressed the importance of evaluating and recording the (1) type of activity performed, (2) activity duration, (3) frequency counts, and (4) distance travelled (in feet or steps), if ambulation occurred. Although these four similar metrics for quantifying EM emerged, additional discipline-specific mobility indicators and strategies of communicating data surfaced (Figure 1).

Physician-Specific Metrics.: When discussing potential metrics to quantify and describe ICU EM, the physicians were largely interested in summary data describing EM performed over the course of a single day. In the following quote, a physician identified how a simple summary of mobility performed could be integrated to their documentation workflow through daily event reporting.

The other thing I would like to see is that mobility becomes part of a patient's 24-hour event report. The last 24-hours, they got their central line. They got a [CT scan], and they remain paralysed and sedated, and so on. We got minimum mobility. They got out-of-bed or something like that. It would be a nice thing to put a sentence in for their 24-hour events of what did they do?

[Physician-FG2]

While physicians were interested in a concise indicator to identify whether daily EM interventions occurred, other clinician groups described process metrics in preparing, implementing, and evaluating individual EM interventions.

Nursing-Specific Metrics.: ICU nurses described the need to monitor and communicate the *work* involved in providing higher level mobility interventions, such as getting out-of-bed or ambulation. A nurse described, *“that is the hardest part, it's really physically demanding to get our patients up because they are connected to oxygen, IV poles, and the patient is doing only a little amount of the work themselves.”*

To track the effort involved in ICU patient mobilisation, nurses supported identification of process metrics, such as equipment needed to facilitate EM, time required to prepare for an EM session, providing pain management pre-medications, and persons vital to mobilize (e.g. nurse, PT, respiratory therapist, lift-team member). They described that those pieces of information were important for monitoring and ensuring that EM took place. Below, a nurse describes a potential strategy for documenting these process-related metrics.

What I imagine is a checklist before somebody goes to the [operating room], or something like that. This is the time, these are the tools, this is how many people, this is how long it took to prepare the patient, this is what medication we gave. And then I think very, very important is, how did it go? What was the result? Did the patient get tired? Were there any challenges to watch out for so that next time you'll know how to better prepare beforehand?

[Nurse-FG1]

PT/PTA-Specific Metrics. The PT group described how many aspects of their ICU mobility assessments were also qualitative in nature, such as the level of assistance and cuing required during interventions. A PTA expressed this need for multiple types of metrics. “A patient that’s in the ICU can require maximum assistance for several days or weeks, so it is about both the quantity and quality of the assistance we provide”. In addition to the assistance required during EM, a PT explained the movement quality assessments they perform.

We are tracking a specific amount of function that a patient has and the quality of that function. We can theoretically walk a patient a 100-feet, but what does that look like in terms of their abilities out in the real world when they leave the hospital? “Are they safe to walk that 100-feet? What is the quality of their gait?”

[PT-FG3]

This theme of multiple metrics for measuring and monitoring mobility reflects the need for both quantitative and qualitative indicators that describe the preparation required to mobilize ICU patients, the quantity of EM, and the result of EM sessions performed.

Adoption of Emerging Technologies in ICU Early Mobility Monitoring—

Participants reported generally favourable views towards technology, agreeing that various forms of technology were important in their daily lives, with all groups reporting similar perceptions towards technology (Table 3). Two themes of *data quality* and *trending* emerged regarding adoption of emerging technologies to monitor EM, such as video monitoring, wearable activity monitors, automatic data entry from medical devices, and clinical decision support tools.

Theme 4: Data Quality: Clinicians were overall accepting of new tools and technologies for ICU EM assessment and tracking but had concerns regarding the volume, accuracy, and granularity of data that they would have to process and validate, compared to the added value it might bring to their practice. Clinicians were also interested in mobility monitoring issues, such as, accuracy of information generated from medical devices and how that information would be recorded in the EHR. A clinician familiar with activity monitoring devices expressed worry over the potential to generate inaccurate data.

“There is that level of accuracy. I can sit here with my watch that counts my steps and wave my arm a couple of times and it could register as steps, versus actually taking steps.”

[PT-FG3]

In addition to the need for accurate data, clinicians viewed tailoring information generated from devices to the differing levels of mobility seen in the ICU as important. Clinicians pointed out that while some ICU patients are bedridden for weeks, others may have shorter ICU stays and function independently. Therefore, matching the type and amount of activity data generated to the patient's level of function was also important, as described below.

"I'd get really irritated with a lot of activity data...if the patient is independent, I'm less concerned about seeing as much activity data."

[Nurse-FG1]

Instead of high-frequency activity data, clinicians wanted the ability to summarise EM types and control data transfer into the EHR to avoid data overload. A physician described that data granularity should be adapted to the patient's level of physical functioning.

I do worry if we get too granular, I'll just glaze over a lot of the data, because if you talk about every single range of motion activity, and whether it's passive or active. I only care about the top milestone that they achieved for that day and then the degree of that. I think I would bypass that extraneous stuff...if it's in your face and it's this massive output, then I find that unlikely to be helpful.

[Physician-FG2]

In addition to EM data generated through sensors, considerations related to data quality and quantity were important when discussing video monitoring. A PT described this balance between quantity versus quality of data and the value it might provide.

"I think having video available to justify the qualitative data is helpful. I don't know if it's necessarily a need for me to sit down every single day and look at video with the patient, especially if I'm following that patient on a consistent basis. But often for a 30 second video clip to see what maybe what the primary therapist had done a few days before, I think that could be very beneficial. But sitting down watching hours of a patient in bed probably isn't useful."

[PT-FG3]

The balance between quantity and quality of activity data from emerging technologies is complex. Clinicians were generally open to adopting and utilizing mobility data generated through technologies but expressed consistent concerns that too much or inaccurate information may cause them to ignore the data altogether.

Theme 5: Trending Data: The final theme that emerged in the three concepts was the desire to utilize technologies to assist with *trending* mobility data over time and in relation to other clinical information. The physicians described the importance of "*trend-able*" activity data to help drive patient assessment and decision making.

Some kind of movement score would be helpful, not so much comparing one patient to another patient, but comparing that patient to themselves the day earlier. If the patient has the same exact score five days in a row, that patient is in trouble. There will be other reasons that you'll know that. It's not just going to be from the mobility, but I think that trend would be helpful."

[Physician-FG2]

Clinicians were interested in how data trends could be displayed using technology and offered specific suggestions of either a clinical decision support tool to alert clinicians when a patient is at risk for profound weakness due to prolonged inactivity, or an EHR dashboard to trend mobility data over time. An EHR dashboard example capable of integrating and trending mobility was described.

If I want to know if a patient has had a [Spontaneous Breathing Trial], I look at the Respiratory flowsheet. If you go to the infectious disease dashboard, you know the antibiotics, the fever curve, the white blood cell count. It would be nice to have something like that for mobility.

[Physician-FG2]

Similar to monitoring and trending other clinical events, clinicians voiced the need for a specific area of the EHR to monitor EM along with other clinical parameters related to mobility. In Table 3, a PT explained how vital signs, including oxygen saturation (SpO₂), are important to trend in tandem with mobility. Clinical parameters related to sleep, delirium, and respiratory status were also mentioned as important to monitor alongside mobility. The ability to trend mobility indicators over time, and together with other clinical parameters was expressed by clinicians as an opportunity for emerging technologies to improve measurement and monitoring of ICU EM interventions.

DISCUSSION

This study was unique in its use of qualitative research to explore ICU EM monitoring from a multi-clinician perspective, with the aim to inform research, practice improvement, and technology development. ICU clinicians have both common and distinct perspectives when it comes to the value EM provides, standardisation of EM metrics, and use of technologies to monitor ICU EM in practice. Along with affirming the *value* of performing ICU EM interventions, four themes for improving mobility monitoring emerged among the critical care nurses, physicians and PTs, including the need for: 1) *standardised* metrics of documenting EM; 2) inclusion of *quantitative and qualitative metrics* to measure mobility; 3) a balance between *quantity and quality* of data; and 4) *trending* EM indicators over time. Though the first value theme does not directly align with clinician perspectives to improve EM monitoring, it underscores how and why clinicians conceptualize improving EM monitoring as important.

Our participants predominately contextualised EM monitoring through the EHR system used to assess and document functional status and mobility interventions (Epic; Verona, WI). Research evaluating provider and clinician adoption of EHRs has identified similar themes, suggesting clinician perceptions towards emerging health technologies influence their willingness for adoption and implementation success (Chan et al., 2010, Rose et al., 2005, Strudwick et al., 2016, Williams et al., 2019). Based on their experiences, we found that clinicians wanted metrics for mobility that are standardised, quantifiable, of high quality, and clinically meaningful. However, EHR documentation historically has been dictated by administrative, billing, legal requirements, or template design, with limited consideration for

clinical decision-making or future use of data for research (Cusack et al., 2012). While clinicians spend roughly 20–35% of their time documenting (Stetson et al., 2008, Young et al., 2018), diagnostic and treatment data in the EHR is often inaccurate, missing or recorded at inconsistent time points (Berner and Moss, 2005, Chan, Fowles, 2010, Cusack, Hripesak, 2012). When clinicians perceive data recorded as inconsistent or challenging to retrieve, clinicians may use verbal information exchange over recorded data (Collins et al., 2011), which we also found. As a result, key information that could be used to evaluate EM implementation and effectiveness in clinical care and research is lost, further contributing to the limited availability of high quality EHR data.

The clinicians collectively identified three of the four dimensions of physical activity described by the World Health Organization, which recommends measuring activity by its four main components: frequency of the activity; intensity at which the activity is carried out; the activity duration or time; and type of activity (Cavill et al., 2006). While participants agreed that type, frequency, and duration metrics should be part of standardised EM assessment, they did not mention intensity as an indicator of interest. However, given the emergence of activity monitors that estimate energy expenditure, intensity is an increasingly common measure of human activity in research (Sylvia, Bernstein, 2014) that should be further explored with clinicians prior to deployment in practice.

Participants also identified unique qualitative and quantitative mobility metrics pertinent to their individual disciplines. Physicians were generally interested in identifying a summative score for EM or highest level of EM achieved, in line with tools, such as the ICU Mobility Scale, which provides a EM assessment using an 11-point ordinal scale ranging from “lying-in-bed” to “independent ambulation” (Tipping, Bailey, 2016). In addition to using a global rating, nurses were interested in measuring the physical work and coordination involved in EM implementation. Interestingly, these process metrics have been cited as barriers to implementation of EM (Barber, Everard, 2015). It appears that by including process metrics reflecting the work involved in facilitating EM, clinicians are searching for strategies to overcome and prepare for potential barriers that may interfere with intervention delivery. Distinct from the other disciplines, PTs suggested measuring daily goal achievement as another approach to monitor patient progress, which is a successful feedback strategy used in behaviour change theory and included in current commercially available technologies (Miyachi et al., 2016). For optimal EM measurement, future research may benefit from including quantitative, qualitative, and process metrics when testing efficacy and visualisation of health technology monitoring solutions.

Clinicians were overall accepting of new tools and technologies for EM monitoring but cared about issues also important to researchers, such as data validity, reliability, workflow integration, and data synthesis required to transform data into actionable information (Chan, Fowles, 2010, Payne et al., 2015). As technology adoption for quantified activity monitoring becomes more common, clinicians will be required to either manually record information generated from devices or validate data that auto-populates into the EHR by interpreting the results and determining whether the data is true signal or noise. As a result, future research will need to address clinician perceptions, workflows, and data synthesis to improve usefulness of data derived from emerging monitoring technologies into clinical practice.

This study was exploratory and had several limitations. Participants were recruited from a single academic medical centre using a specific EHR. Because the study was voluntary, sampling biases potentially included clinicians who perceive EM as important to their practice or who have more favourable attitudes toward technology. While we recruited multiple clinician types involved in ICU EM, we were limited in the available number of critical care physicians and PTs, and as a result, we may not have reached data saturation. We also made the decision to keep the focus groups discipline specific, and multi-disciplinary sessions may have led to different findings. Therefore, additional research is necessary to determine transferability of our findings to other ICU environments, EHR systems, and institutions.

CONCLUSIONS

In order to advance the field of ICU EM in both practice and research, measurement of inpatient mobility should be standardised, of high quality, trend-able, and meaningful to be perceived as valuable. With the rapid pace of technology adoption in healthcare, additional research into clinician attitudes toward use of emerging technologies will help to create more effective systems and efficient workflows for capturing valid and reliable clinical data for operations, quality improvement, and research. By incorporating diverse clinician perspectives in the design of new EM monitoring technologies, providers will more readily adopt EM metrics in practice, and more effectively use them to evaluate success and track patient progress. Improved EM monitoring in practice will also support researchers to examine the arc of activity that ICU patients undergo and develop models to understand the factors that influence successful implementation of EM interventions. Insights gained from this study related to improving mobility monitoring will form the basis of a framework to guide more thoughtful development of novel technology-leveraged models of nursing and ICU team-based care delivery.

Acknowledgments:

We would like to thank the nurses, physical therapists, and physicians who participated in this study, as well as the members of the UC Davis Critical Care Informatics Lab, Gordon and Betty Moore Foundation, and Dr. Stuart Henderson, for his review of an early version of this manuscript.

Funding: This research was generously supported by the UC Davis Betty Irene Moore School of Nursing, UC Davis Clinical and Translational Science Center (National Center for Advancing Translational Sciences, UL1 TR000002), and National Heart, Lung, and Blood Institute (T32 HL007013). The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH.

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IMPLICATIONS FOR CLINICAL PRACTICE

- Numerous methods exist to measure and monitor patient status in critical care however, mobility interventions are difficult to evaluate due to subjective and indirect forms of measurement.
- ICU clinicians have both common and distinct perspectives when it comes to standardisation of metrics and use of new technologies to monitor ICU early mobility in practice.
- ICU early mobility monitoring is improved by 1) standardised metrics of documenting mobility; 2) inclusion of both quantitative and qualitative metrics to measure mobility; 3) a balance between quantity and quality of data; and 4) trending mobility indicators over time.

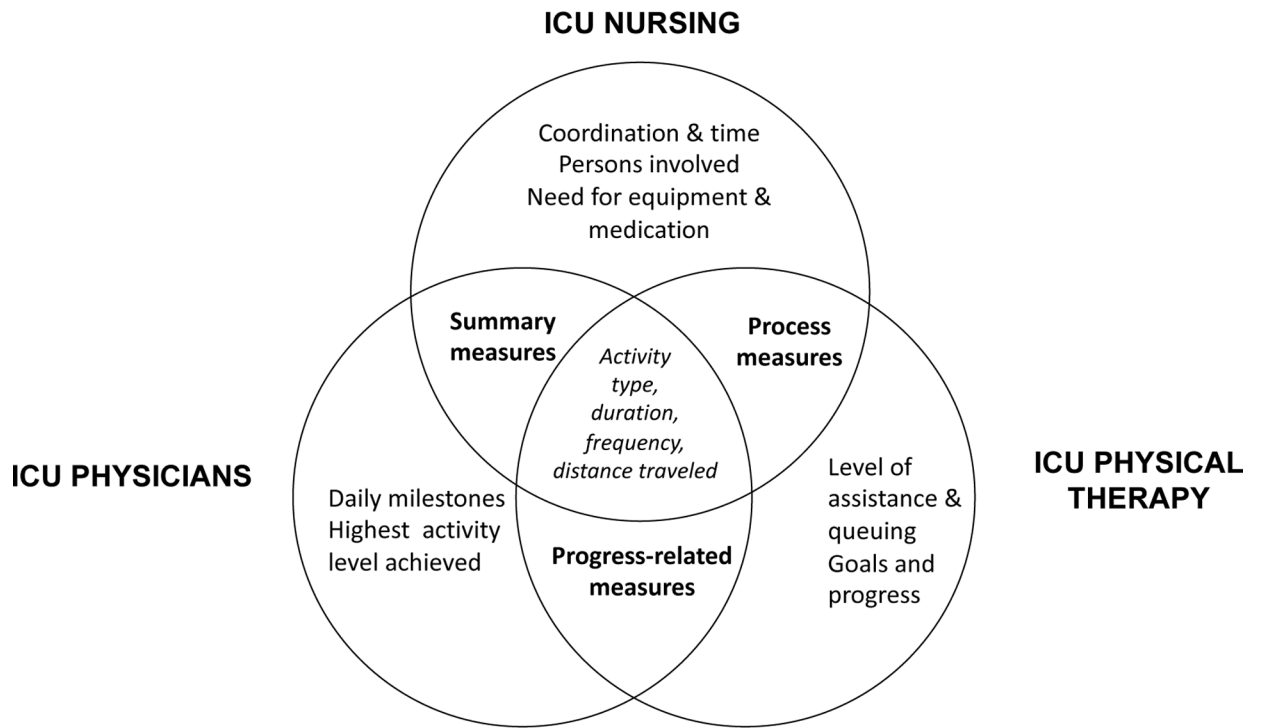


Figure 1. Common and distinct metrics, to assess and monitor ICU early mobility among ICU nurses, physicians and physical therapists

Table 1.

Focus group interview guide and sample questions

Main Topics	Sample Questions
ICU Mobility in General	<ul style="list-style-type: none"> • How do clinicians define early mobility? • What activities are considered be part of ICU mobility? • How important is it that patients receive early mobility in the ICU?
Current Practices	<ul style="list-style-type: none"> • How do you communicate with team members about early mobility? • How do you currently monitor/track early mobility in the ICU? • Where do you find information about early mobility in the EHR? • What is your opinion of the quality of early mobility data?
Improving Measurement & Monitoring	<ul style="list-style-type: none"> • How can early mobility tracking and documentation be improved? • What types of physical activity would you want to track better? • How would you want to visualise mobility data?
New Technologies	<ul style="list-style-type: none"> • How do you feel about emerging health technologies such as video monitoring & wireless sensors (e.g. fitbits)? <ul style="list-style-type: none"> – If you were able to get data from these methods, how would you use it? – How might it inform or change the care you provide?

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Table 2.

Characteristics of focus group participants

Characteristics (n = 26)	ICU Nurses n=10	ICU Physical Therapists n= 8	Critical Care Physicians n=8
Gender, n (%)			
Female	9 (90.0)	2 (25.0)	0 (0.0)
Male	1 (10.0)	6 (75.0)	8 (100.0)
Years in Critical Care Practice, median (IQR)	13.5 (7–20)	4.0 (3–6)	3.0 (3–8)
View of ICU Early Mobility, n (%)			
Crucial, should be the top priority	2 (20.0)	4 (50.0)	1 (12.5)
Very important, should be a priority	4 (40.0)	4 (50.0)	7 (87.5)
Important, should be a priority	3 (30.0)	0 (0.0)	0 (0.0)
Somewhat important, should be considered	1 (10.0)	0 (0.0)	0 (0.0)
Not of great importance, but clinicians should bear it in mind	0 (0.0)	0 (0.0)	0 (0.0)
Of minimal importance	0 (0.0)	0 (0.0)	0 (0.0)
Of no importance	0 (0.0)	0 (0.0)	0 (0.0)
Attitudes Toward Technology^a, mean (SD)			
Positive attitudes, mean score ^b	4.0 (0.5)	4.1 (0.4)	4.0 (0.4)
Negative attitudes, mean score ^c	2.9 (1.1)	2.9 (0.6)	3.2 (1.0)

^aScale scores range from 1 to 5^bHigher scores indicate more positive attitudes toward technology^cHigher scores indicate more negative attitudes toward technology

IQR = interquartile range, SD = standard deviation

Table 3.

Overview of concepts and themes for improving ICU early mobility monitoring based on current ICU practice and potential technology adoption

Concept	Theme	Description	Exemplar Quote
Perspectives towards ICU early mobility	Value	Benefits to patient, family and staff as a result of mobility interventions	<i>"It seems also to help the overall well-being of your patients who realize that they're not just sitting in the bed all the time or lying in the bed being turned. They are doing something physical so it's further motivating for them. And I think that's gratification for us, too, because you're doing something and you see that it's working."</i> [Nurse]
Improving current measurement and monitoring practices	Standardization	Need for standardized recording and monitoring of mobility	<i>"There are so many different places to find information. There are all the different snapshots, all the different flowsheets. If you don't type in the exact name of the flowsheet you can't find it. Maybe the information is there somewhere, but I don't feel like it's readily available where you can look in the chart and understand, "Oh, they did this activity, today." [Physician]</i>
	Multiple Metrics	Inclusion of both quantitative and qualitative metrics to quantify mobility	<i>"We are tracking a specific amount of function that a patient has and the quality of that function. Because we can theoretically walk a patient a 100-feet, but what does that look like? "Are they safe to walk that 100 feet? What is the quality of their gait?" [Physical Therapist]</i>
Adoption of future technology	Data Quality	Balance between data granularity, quantity and quality of mobility data recorded	<i>"[Sensor data] might be great, but if the patient moves and [data] populates the flowsheet, pretty soon between that and your assessments you have how many rows of data in your chart?? If the patient is independent, I'm less concerned about seeing as much data."</i> [Nurse]
	Trending Data	Trending mobility measures with other clinical parameters to drive assessment and decision making	<i>"I'm really big on monitoring vital signs during activity because you can see, they were 92% [oxygen saturation] in bed, and after we walked down the hall, and they're 98%. So that's a pretty good change."</i> [Physical Therapist]