Original Research

Bedside Critical Care Staff Use of Intensive Care Unit Telemedicine: Comparisons by Intensive Care Unit Complexity

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Abstract

Background: *Effects of Intensive Care Unit (ICU) telemedicine on patient and staff outcomes are mixed. Variation in utilization is potentially driving these differences.*

Introduction: *ICU telemedicine utilization is understudied, with existing research focusing on telemedicine staff. We assess ICU telemedicine utilization from the perspective of the end user—ICU staff—to better understand how telemedicine use is conceptualized and practiced at the bedside.*

Materials and Methods: *We conducted a thematic content analysis of semistructured interviews with bedside ICU staff. Staff were interviewed at seven ICUs in six Veterans Health Administration facilities, representing varying ICU complexities and points in time (2 and 12 months postimplementation of ICU telemedicine).*

Results: *Fifty-eight bedside ICU staff described instances of telemedicine use, which were categorized into three types: Urgent ICU Patient Care, Clinical Decision-Making and Support, and General ICU Patient Care. The most commonly described use was General ICU Patient Care and the least common was Urgent ICU Patient Care. ICU staff from lower complexity ICUs had fewer descriptions of use compared to staff at higher complexity ICUs. At 12 months postimplementation, staff recounted more instances of all three utilization types.*

Discussion: *It is important to understand how telemedicine is being used within ICUs to evaluate its impact. The presence of three types of use, variability in use by ICU complexity, and change in use over time suggest the need for comprehensive measures of utilization to evaluate effectiveness.*

Conclusions: *ICU telemedicine needs to develop an agreed upon typology for documenting ICU telemedicine utilization and incorporate these measures into models of its effect on clinical outcomes.*

Keywords: *telemedicine, information management, policy, technology*

Introduction

Over 5.7 million patients are admitted to intensive care units (ICUs) in the United States each year, accounting for more than $67 billion in hospital costs.[1–3] In the face of a shortage of intensivists and an aging population, management of ICU patients presents a critical problem in U.S. healthcare.[4] In response, the presence of ICU telemedicine has grown dramatically over the past decade; more than 11% of the critically ill patients admitted to private ICUs each year are supported by ICU telemedicine programs, and ICU telemedicine is projected to be more commonplace than bedside intensivist-led only programs in the near future.[5–7]

ICU telemedicine has been promoted as a means to reduce ICU mortality and length of stay (LOS) by allowing intensivists to remotely monitor patients 24 h a day in real time, alert bedside staff to physiological deterioration, and assist in implementing evidenced-based practices.[8–13] While some estimates suggest that dedicated tele-intensivist models could save between 50,000 and 100,000 lives annually, reducing ICU mortality by as much as 15–20%,[14] other research shows mixed results both in terms of patient outcomes and the optimal strategy for using ICU telemedicine technology effectively.[15–21] Recent research demonstrates that after an initial period of rapid adoption, the spread of ICU telemedicine has slowed.[22]

Reviews of telemedicine in U.S. ICUs agree that more extensive ICU telemedicine research is needed, particularly because ICU telemedicine is a complex, sociotechnological intervention.[23–26] Telemedicine utilization patterns are often

noted as a potential driver of variance in results, although relatively few studies have addressed it. Studies that have explicitly addressed utilization have done so from the perspective of ICU telemedicine staff and within the telemedicine systems' framework.[11,27,28]

The objective of this study was to characterize how end users—bedside ICU staff, including ICU physicians and nurses—use telemedicine on a routine basis. To better understand how utilization of telemedicine is defined and practiced, we conducted individual and group semistructured interviews with staff at ICUs with varying levels of complexity at two time periods (2 and 12 months postimplementation). This study is the first to our knowledge to analyze telemedicine utilization from the perspective of bedside ICU staff in the critical care setting. The study provides a foundation as we build toward the long-term goal of determining the array of factors impacting ICU telemedicine effectiveness.

Materials and Methods

SETTING AND INTERVENTION

ICU staff interviews were conducted at seven ICUs in six Veterans Affairs (VA) medical centers. Study sites included 64 beds and represented both urban and rural communities: 3 tertiary academic medical centers in medium to large urban settings, 1 small urban medical center, and 2 rural hospitals (detailed characteristics of these ICUs have been previously published[29]). The tertiary academic medical centers housed four Level 1 or Level 2 ICUs and the other hospitals had Level 3 or Level 4 ICUs. Level 1 and Level 2 ICUs have a higher number of intensivists, surgical and/or medical resident and subspecialty fellowship programs, dedicated ancillary services, and a higher number of ICU beds compared to the Level 3 and Level 4 ICUs.[30]

The ICUs are supported by a centralized ICU telemedicine "hub" staffed by an intensivist and two board-certified critical care nurses 21 and 24 h a day, respectively. Patient information is remotely accessed through electronic medical records, physiological bedside monitors, archived digital imaging, and ICU clinical information systems. Twenty-four-hour, real-time audio/video technology connects ICUs to the support center, and can be activated by bedside or support center staff.

DATA COLLECTION

Semistructured interviews were conducted to understand how ICU telemedicine was utilized by ICU bedside staff. The interview guide was developed to assess staff perceptions of and experiences with ICU telemedicine; the semistructured format allowed for unscripted follow-up questions and more flexibility in question wording and order, compared to a structured interview protocol.[29] In five of the seven ICUs, we conducted in-person group and individual interviews with a convenience sample of bedside staff (ICU nurses, medical and surgical physicians, fellows, residents, and respiratory therapists); clinician-administrators at two additional ICUs were interviewed by telephone. We also collected participant characteristics, including age, years at the VA, role, and day/night shift work. Interviews were conducted between July 2011 and March 2013, at 2 and 12 months postimplementation. This study was approved by the Institutional Review Board and Research and Development Committee at the Iowa City VA Health Care System. Informed consent was obtained from all participants.

ANALYSIS

Sixty group or individual interviews, representing 81 participants, were transcribed verbatim, audited for accuracy, and coded using qualitative data management software (MAXQDA). Interview transcripts were first inductively coded by the research team (H.S.R., J.M., C.C.G.) for thematic content broadly addressing staff perceptions, expectations, and attitudes related to ICU telemedicine, described in detail elsewhere.[29]

The research team then identified salient areas in the transcripts describing the use of ICU telemedicine. Bedside staff's hypothetical descriptions of how telemedicine could potentially be used in the ICU were not coded as utilization. Descriptions of telemedicine use were extracted from the transcripts and subsequently subcoded. The subcoding was tested by two qualitative research team members (J.T.T., J.B.) with 92% intercoder agreement ($\kappa = 0.860$, standard error [SE] = 0.097).

We used descriptive statistics to understand the distribution of telemedicine use by ICU complexity type. Categorization of ICUs in the private sector[31] has been adapted to critical care in VHA,[30] with Almenoff et al. identifying two levels of complex services (Level 1 and Level 2), moderate (Level 3), and basic (Level 4) services. To compare complexity, we grouped VHA Level 1 and Level 2 ICUs as ICUs providing complex services, and VHA Level 3 and Level 4 ICUs as ICUs providing moderate-to-basic services.

t-Tests and chi-squared tests were used to test statistically significant differences for continuous (i.e., age, year at VA) and categorical (i.e., role, shift) participant characteristics, respectively.

Results

There were no statistically significant differences in participants' age (~40 years) or VA service (~7 years) by ICU complexity. A greater proportion of participants from complex ICUs were nurses (82%) compared to moderate/basic-level ICUs (50%) and a greater proportion worked the day shift (53% complex ICU vs. 31% moderate/basic ICU, $p = 0.007$) (*Table 1*).

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Table 1. Participant Characteristics by Intensive Care Unit Complexity

CHARACTERISTICS	TOTAL $N=81$	ICU COMPLEXITY: MODERATE/BASIC ICU $N=16$	ICU COMPLEXITY: COMPLEX $N=65$	p
Age, mean ± SD	40.6 ± 11.6	42.4 ± 11.2	40.2 ± 11.8	0.49
Years at VA, mean ± SD	8.1 ± 9.2	7.3 ± 5.7	8.3 ± 10.0	0.60
Occupation, *n* (%)				0.02
Nurse[a]	61 (75.3)	8 (50.0)	53 (81.5)	
Physician[b]	10 (12.3)	3 (18.8)	7 (10.8)	
Respiratory therapist	4 (4.9)	2 (12.5)	2 (3.1)	
Other[c]	6 (7.4)	3 (18.8)	3 (4.6)	
Shift, *n* (%)				0.007
Day	40 (49.4)	5 (31.3)	35 (53.1)	
Night	30 (37.0)	5 (31.3)	25 (39.2)	
Other	11 (13.6)	6 (37.5)	5 (7.7)	

[a]Nurse designation includes both registered nurses (RNs) and critical care registered nurses (CCRNs).

[b]Physician designation includes attending physicians, residents, and fellows.

[c]Other designations include ICU administrators, pharmacists, and healthcare technicians.

ICU, intensive care unit; SD, standard deviation.

Table 2. Definitions of Telemedicine Utilization Categories

ICU UTILIZATION CATEGORY	DEFINITION
Urgent ICU Patient Care	Situations of rapid physiological deterioration of a patient (e.g., intubation, code blue, respiratory distress) or emergencies requiring immediate ICU telemedicine support.
ICU Clinical Decision-Making and Support	Active input and support from the ICU telemedicine clinician with tasks such as reviewing laboratory results, issuing new orders, intubation and ventilator consultation, catheter insertion, protocols, and more broadly, discussions of protocols or clinical best practices in association with the treatment plan of a specific individual.
General ICU Patient Care	Requests for assistance with charting and other forms of documentation, including admissions and transfers, ICU telemedicine participation in interdisciplinary rounds, general technical support (e.g., help with being locked out of clinical support software and other software issues), and patient monitoring.

Seventy-two percent ($n=58$) of bedside staff described how and why telemedicine had been used in the ICU. A total of 225 descriptions of telemedicine use by ICU clinicians were identified in the interview transcripts. We subdivided descriptions into three distinct categories based on their shared thematic content: Urgent ICU Patient Care, ICU Clinical Decision-Making and Support, and General ICU Patient Care (*Table 2*). Categories were developed both inductively and deductively; content elements were grouped together into distinct themes through inductive review of the transcripts, while our knowledge of the literature and critical care processes informed how categories were defined after the thematic content analysis was complete. One hundred sixty-two descriptions of utilization were from complex ICUs and 63 descriptions from moderate/basic ICUs (*Table 3*).

QUALITATIVE DESCRIPTION OF UTILIZATION CATEGORIES

Urgent ICU patient care. High-intensity situations, including codes, represent instances of Urgent ICU Patient Care. Descriptions of telemedicine support in this category always included language about its positive value at the bedside. For example, a nurse provided detail about the benefit of telemedicine support: "I had them online in the room when there was a crisis, and it went well. They recorded for us while we did different procedures and then faxed us the information for me to chart it—the times we were intubating the guy, times of medication administration, what his rhythm was, what his blood pressure was." (Registered Nurse [RN], moderate/basic ICU, 2 months postimplementation).

ICU telemedicine was also seen as valuable in instances when physicians were absent from the ICU, particularly when residents and physicians must cover multiple areas of a hospital or when there is only one medical officer on duty during the night shift. As one nurse stated, "There was a patient whose nurse had been trying to get a hold of a doctor for an extremely high respiratory rate. She tried to page and page and page all these surgery doctors, so instead, [the nurse] hit the Tele-ICU, 'Hey! He's breathing fifty. Can we intubate him?' 'I think that's a good idea.' [The support center intensivist] gave the go. And then it happened." (RN, complex ICU, 12 months postimplementation).

ICU clinical decision-making and support. ICU clinicians frequently asked telemedicine support specialists with assistance in reviewing laboratory results, issuing new orders, intubation and ventilator consultation, catheter insertion, and providing information about external protocols. As one physician stated, "I had one individual in septic shock with strep bacteremia

Table 3. Bedside Staff's Telemedicine Utilization Descriptions by Intensive Care Unit Complexity and Time Period

UTILIZATION TYPES	TOTAL DESCRIPTION[a] (STAFF)[b]	ICU COMPLEXITY			
		MODERATE/BASIC ICU		COMPLEX ICU	
		2-MONTH DESCRIPTION (STAFF)	12-MONTH DESCRIPTION (STAFF)	2-MONTH DESCRIPTION (STAFF)	12-MONTH DESCRIPTION (STAFF)
Urgent ICU Patient Care	35 (25)	1 (1)	2 (1)	13 (10)	19 (13)
ICU Clinical Decision-Making	94 (47)	12 (4)	20 (5)	27 (18)	35 (19)
General ICU Patient Care	96 (41)	15 (5)	13 (7)	20 (14)	48 (23)
Total	225 (58)	28 (12)	35 (11)	60 (28)	102 (27)

[a]Description of telemedicine utilization.

[b]Number of staff providing these descriptions of telemedicine utilization.

and questionable fasciitis in his leg [that] was a worry. That was I guess a useful interaction with the doc at the hub, who happened to be one of the surgical intensivists that day, and…ultimately we ended up shipping that individual out to a local more tertiary center." (MD, moderate/basic ICU, 2 months postimplementation). Another physician described it in a general way: "What I have tended to call them about mostly are kind of specific management questions in more complicated patients. Specific treatment interventions or diagnostic issues." (MD, moderate/basic ICU, 2 months postimplementation). Similarly, nurses reported to telemedicine to improve protocols in their own ICUs. As one nurse stated, "Some of the nursing staff have called just to see what protocols [the support center] has that are different than ours that might work." (RN, moderate/basic ICU, 12 months postimplementation).

The ICU telemedicine program also provided ICUs in small, rural facilities with extra support. As a respiratory therapist stated, "We do not have intensivists here and currently we do not have a pulmonologist. We have a long-term ventilated patient that we are trying to wean, and so we have been in contact with the Tele-ICU intensivists, their pulmonary doctor, and so that has been VERY helpful to have that available to us." (RT, moderate/basic ICU, 12 months postimplementation). ICU telemedicine intensivists were also consulted about transfers. As an ICU nurse reported, "If a patient was getting to the point when we felt we had to transfer, or if it was just something our hospitalist wanted a further look at by an intensivist, they would contact [the support center]." (RN, moderate/basic ICU, 12 months postimplementation).

General ICU patient care. Across a diverse range of ICUs, the use of telemedicine was described as a general way to make ICUs run more safely and efficiently. The type of assistance that was cited most often was observation of patients while bedside nurses are occupied with other tasks, broadly referred to in the interviews as "a second set of eyes" or a "second pair of hands." "On a busy night, I like that I can call [the support center] and say, 'Can you just keep an eye on everybody and round through just to make sure everybody is okay?' And I did see that one night [the support center] caught my patient about to self-extubate." (RN, complex ICU, 12 months postimplementation). As this nurse describes, ICU telemedicine can combine routine observation of the general clinical environment (rounding through all the rooms) simultaneously with patient monitoring (patient self-extubation).

ICU telemedicine nurses also provided charting assistance for bedside nurses. "I had one guy that was on multiple drips. He emergently had come in on the night shift, and I just called [the support center] and said, 'I'm going to do a head to toe. As I'm going through this, will you chart what I'm telling you?' And so by the time I got done with doing my head to toe and everything that I needed, all my charting was done, and it was wonderful." (RN, complex ICU, 12 months postimplementation). Other daily patient care activities were discussed by nurses at some ICUs, including daily interdisciplinary rounds, night hand-offs or check-ins with ICU telemedicine intensivists, and technical support for the new ICU computer information system. Additional examples of instances of ICU telemedicine utilization are provided in *Table 4*.

TRENDS IN UTILIZATION TYPES

Comparing utilization types, ICU Clinical Decision-Making and General ICU Patient Care utilizations were described nearly as frequently ($n = 94$ and 96, respectively). Descriptions of Urgent ICU Patient Care utilization comprised approximately one-third of the total ($n = 35$). A general trend toward increasing

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Table 4. Examples of Routine Intensive Care Unit Telemedicine Utilization

ICU UTILIZATION CATEGORY	INTERVIEW SEGMENT
Urgent ICU Patient Care	"I happened to walk in and a patient had rolled into [the ICU] earlier who was having some apneic spells, and some chest pain. The [ICU nurses] had already contacted the Tele-ICU person with that, and started him on BiPAP [Bilevel Positive Airway Pressure]." (MD, complex ICU, 12 months postimplementation)
	"I can remember one incident when a resident was in a room and a patient was spiraling down. The Tele-ICU nurse and doc were online to help out the resident as needed, and they kept the patient from coding." (RN, moderate/basic ICU, 2 months postimplementation)
	"If it is a code blue, [ICU bedside staff] do dial in, and the main reason they do that is that they've got somebody readily available to document the code and do the code blue sheets." (RN, moderate/basic ICU, 12 months postimplementation)
	"I had a patient transfer down from the floor and he quit breathing and went apneic for twenty to thirty seconds. There weren't any residents around. None whatsoever. So I just hit the Tele-ICU." (RN, complex ICU, 12 months postimplementation)
ICU Clinical Decision-Making and Support	"[ICU residents] call for patients, 'Should we start these IV fluids or not? The pressure started with a vasopressor. Should I add the next one?' Those kinds of resident questions." (MD, complex ICU, 12 months postimplementation)
	"We hit it during rounds and they listen to what the attending and residents figure out, and usually the attending will ask them if they have any suggestions or any input or whatever." (RN, complex ICU, 2 months postimplementation)
	"Tele-ICU has been beneficial in that if we can't get a hold of the in-house doctor, the Tele-ICU doctor is there and responds quickly. So it really streamlines patient care. We don't have to wait for the call back from the in-house doctor. We'll just go to the Tele-ICU doctor and get a plan of care from them." (RN, complex ICU, 2 months postimplementation)
	"We get a lot of locum tenens here, so if they are uncomfortable with an answer that the provider gives, our nurses feel pretty comfortable in calling the Tele-ICU doc and saying, 'Hey, can you look at the lab work or look at the orders and see what you think?'" (RN, moderate/basic ICU, 12 months postimplementation)
General ICU Patient Care	"[Tele-ICU physicians] do a checkout both morning and night, so if they round in the morning, they'll pull the physician or the nursing staff in and ask about anything that they've seen overnight with the patient. And then as they check out in the evening, they'll let them know, 'These are the things I want you to watch for.'" (MD, complex ICU, 12 months postimplementation)
	"We have called and asked them to help us build our flow sheets in the ICIP [IntelliVue Clinical Information Portfolio] system, so that when we do get a chance to go in and document, it's already built for us. We don't have to take the extra time to plug all that stuff in." (RN, complex ICU, 12 months postimplementation)
	"If [the ICU nurses] are busy with a patient, turning a patient, or cleaning up a patient, they'll buzz in and say, 'Can you camera in on bed number two? I'm going to be in bed number three for a while." (RN, complex ICU, 2 months postimplementation)

telemedicine utilization descriptions of all types, at both complex and moderate/basic ICUs, was observed (*Fig. 1*). ICU telemedicine was used for General ICU Patient Care most frequently and had the greatest increase over time, particularly at hospitals with moderate/basic ICU services (42% at 2 months to 64% at 12 months). Staff from moderate/basic ICUs described contacting the support center for the purposes of ICU Clinical Decision-Making less often than complex ICUs. Complex ICUs reported using the telemedicine support center for Urgent ICU Patient Care more frequently than did moderate/basic ICUs, irrespective of time point.

Discussion

This study is the first to our knowledge to describe ICU telemedicine utilization in detail from the perspective of bedside staff.[11,24] Overall, bedside ICU staff provided hundreds of specific descriptions of ICU telemedicine utilization. The qualitative data describing routine utilization of ICU telemedicine suggest there is significant variation in how critical care staff use telemedicine support at facilities with different ICU complexities. This variability in use may have important impacts on patient outcomes, staff satisfaction, and determining the optimal role for ICU telemedicine as a tool for quality improvement.

Previous research suggested that a possible reason for decreased mortality and LOS is that ICU telemedicine functions as "an extra set of eyes."[33] Anders et al. found significant variation in telemedicine utilization over a 2-year period, identifying nine distinct types of ICU telemedicine use in nursing log data at an ICU telemedicine center supporting six ICUs.[11]

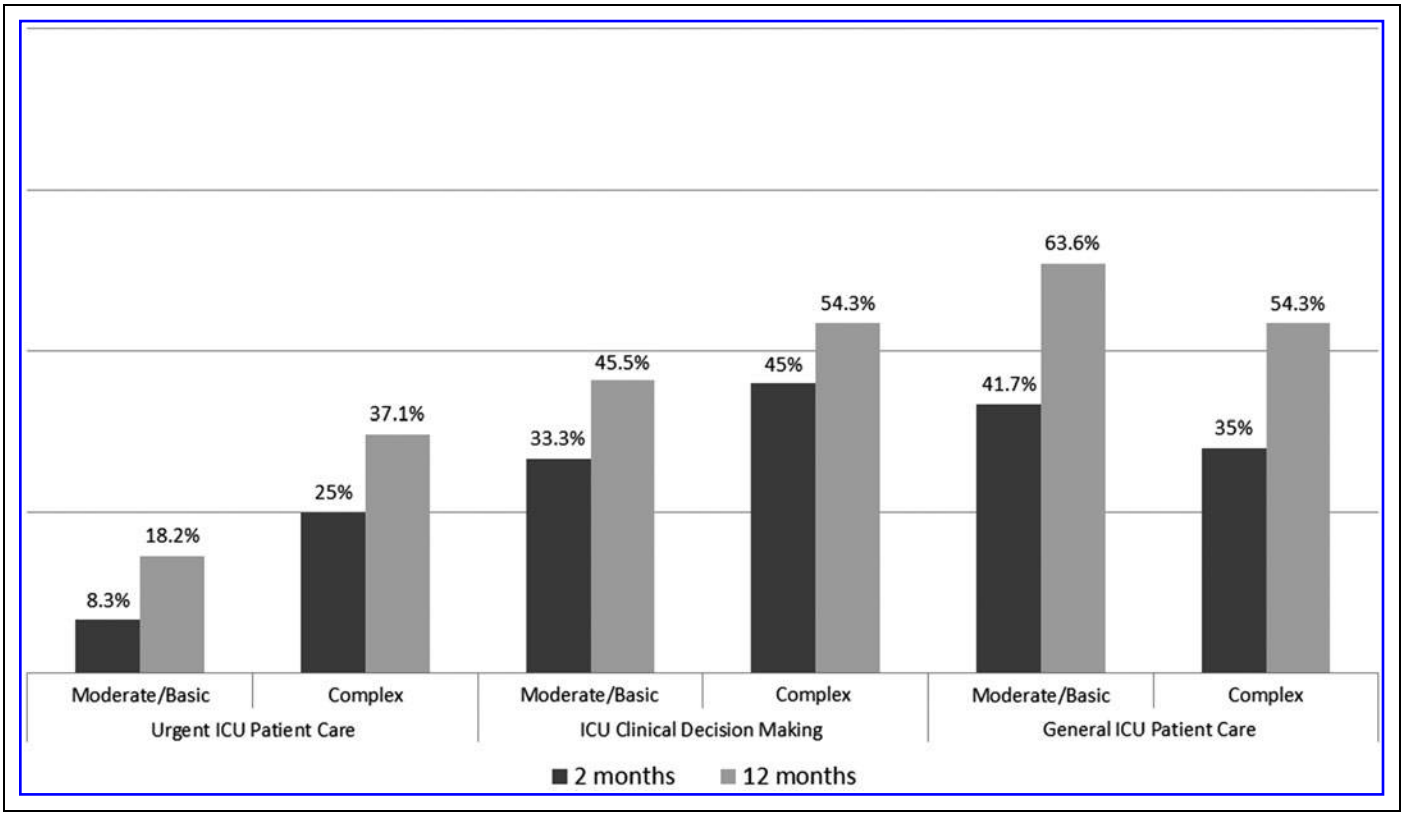

Fig. 1. Percentage of bedside staff who described telemedicine use. Percentages represent the number of staff members describing telemedicine utilization divided by the total number of staff interviewed. Total number of staff interviewed: moderate/basic ICUs at 2 months ($n=12$) and at 12 months ($n=11$); complex ICUs at 2 months ($n=40$) and at 12 months ($n=35$). ICU, intensive care unit.

Consistent with our data, Anders et al. found that in addition to a general trend toward increasing incorporation of telemedicine into clinical practice, the general use of ICU telemedicine remained the most frequent category of telemedicine use within ICUs over time. Qualitative data from bedside staff, however, additionally suggest that ICUs of differing complexities rely on telemedicine for widely varying purposes.

Our data also show that ICU complexity plays an important part in how telemedicine use is operationalized at different facilities. Much of the initial literature surrounding the implementation of telemedicine focused on its potential benefit for less complex (typically rural) ICUs with restricted access to intensivists.[32] Our study found that complex ICUs report two to three times as many descriptions of telemedicine utilization for Urgent ICU Patient Care than did moderate/basic ICUs. Even when the number of staff interviewed at each facility is accounted for, complex ICUs used ICU telemedicine support more often and for a wider range of tasks than did moderate/basic ICUs.

The broad range of documented uses and the variability in types of use between ICUs of different complexities in this study suggest that comprehensive documentation of telemedicine utilization—by support center *and* bedside clinicians—may improve our understanding of its impact on clinical outcomes. Use of telemedicine for Urgent ICU Patient Care may have direct and measurable impact on patient outcomes because of its critical, time-sensitive nature. Certain categories of utilization, such as General ICU Patient Care, may have no immediate, discernable effects in terms of patient outcomes, but may be associated with improved patient and staff satisfaction and therefore also are important to report. While our use of three broad categories highlights differences based on the criticality of the situation, time sensitivity of the response, and degree of impact of different types of outcomes, it does not take the necessary next step of typology development.

Future work should focus on synthesizing perceptions of utilization from bedside and tele-ICU staff to develop a comprehensive typology, and then test the typology so that utilization could be a more responsive measure when modeling clinical outcomes. This study's limitations include data that were collected in one region of a national healthcare system; however, the ICUs represent both rural and urban settings and different levels of complexity. Routine and standardized

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documentation of these different types of telemedicine use would provide more robust quantification of use over time. We used qualitative methods to identify telemedicine utilization regardless of whether it is currently being documented, and therefore, bedside staff's accounts of telemedicine use may not be representative of these more standardized methods. Finally, the sample participants may not be representative of the population as a whole; interviews were conducted using a convenience sample, and our sample size and roles sampled by ICU type are not proportionate. That said, one of the strengths of open-ended qualitative interviewing is exploring newly emergent patterns that do not have standardized measurements but are most salient to the interviewees.

Qualitative data of bedside telemedicine utilization demonstrate that a large amount of variation exists in how beside staff use ICU telemedicine programs in ICUs of differing complexities. Without measuring its varied uses from the perspective and experience of end users, ICU telemedicine programs may continue to show mixed outcomes in regard to their effectiveness. In addition, impact can be measured in multiple ways. Some uses of ICU telemedicine for daily or routine patient care may not have a direct impact on patient outcomes but improve ICU staff and patient satisfaction. ICU telemedicine needs to develop an agreed upon typology for documenting utilization, further explore associations between use and impacts, and incorporate these measures into models of its effect on clinical outcomes.

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Disclosure Statement

No competing financial interests exist.

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