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Performance Evaluation of the eICU® Acceptance Survey

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Summary of Key Points

The findings of this study further validate the reliability of the eICU® Acceptance Survey among a nation-wide sample of healthcare professionals who use eICU® service in the ICU during the post-implementation stage. This is very important because the eICU® service is a costly investment for a hospital. To receive a return on investment, patient outcomes must improve for the hospital to gain a cost savings through decreased expenditure on patient care. If the bedside healthcare professionals do not accept eICU®, therefore, do not use eICU® to its full potential, patient outcomes will not improve.

-Overall the eICU® Acceptance Survey is preforming well.
-The eICU® Acceptance Survey is a reliable evaluation instrument in post-implementation of eICU® service to examine bedside healthcare professionals' acceptance of eICU®.
-Further research is needed to determine if some items should be revised or eliminated to reduce redundancy or low contribution.

Keywords: Acceptance; Critical care; Digital health; Intensive care; Telehealth; Telemedicine; Utilization

Introduction

The quality of care delivered in the Intensive Care Unit (ICU) varies across the United States [1,2]. Research demonstrates an improved quality of care in ICUs that use intensivist-led (physician specialized in critical care medicine) staffing and standardized care protocols [1,2]. This use of intensivist-led staffing and standardized care protocols reduces variations in critical care delivery [1,2]. However, there is currently an intensivist physician shortage, so recommendations are to supplement this gap with Telemedicine intensivist-led ICU (eICU®) when on-site intensivist-led care is unavailable [1]. Reasons for the current intensivist shortage include reduced fellowship programs in intensive care, current board certified intensivists choosing not to work in the ICU, and lack of trained physician available to fill these rolls [1].

Telemedicine is the exchange of medical information between multiple sites via electronic communications [3]. TeleICU (use of telemedicine for ICU care) or eICU® (a branded Phillips product) is a multidisciplinary model of telemedicine focused on the care of the ICU patient [4].The most recent published guidelines continue to recommend intensivist-led multidisciplinary teams to care for ICU patients [5]. Further recommendations include standardizing critical care processes to improve quality outcomes, and institutional support for eICU® programs [5].

Additional reasons that many hospitals cannot provide intensivist-led ICU care model are geographical location (rural areas) and lack of financial resources to provide an on-site intensivist [5]. The use of eICU® services demonstrates improved quality patient outcomes such as: decreased mortality (6.5% before eICU® to 4.9% after implementation p<0.01; 13.6% [95%] Confidence Interval [CI], 11.9%-15.4%] before eICU® versus 11.8% [95% CI, 10.9%-12.8%] after implementation) and decreased length of stay (up to 3.6 days shorter [hazard ratio 1.44, 95% CI, 1.33-1.5]) [7-9]. However, when eICU® is implemented not all healthcare professionals uniformly use this valuable service [10,11]. When 80% of physicians did not fully use eICU® services, instead opting for emergency service only, patient outcomes were not improved [12].

Lack of acceptance of eICU can lead to low eICU® use rates [13,14]. In these studies, no improvement in patient outcomes of quality of care were observed. Both studies cite at least two thirds of bedside physicians did not allow eICU® to fully assist with patient care opting for emergency care or very low levels of care only [13,14]. Additionally [15] Therefore, it is important to assess healthcare professional acceptance of eICU® both before and after implementation of eICU® because the level of acceptance from the healthcare professional will contribute to the success or failure of the eICU® service's ability to improve quality of care. However, there are few tools currently available to evaluate healthcare professionals' acceptance of eICU®. Thus, it is important to test and provide reliable instruments assessing healthcare professionals' acceptance of eICU®. In addition, it is also critical to understand what variables impact nurses' acceptance of eICU®. The eICU® Acceptance Survey instrument includes four key constructs identified to assess healthcare professionals' acceptance of eICU® [16,17]. The four constructs of acceptance measured in this survey are: perceived usefulness, perceived ease of use, healthcare professionals' attitudes towards eICU®, and intention to use eICU® [16,17]. Each subscale has been adapted from previously created scales measuring the constructs identified in the Technology Acceptance Model [16-19]. The four constructs measured are derived from the Telemedicine Technology Acceptance Model which was adapted from the Technology Acceptance Model developed in the 1980's to predict the use of computer technology [16-19].

Objective

The purpose of this study was to examine the reliability of the eICU® Acceptance Survey instrument.

Methods

This was a cross-sectional, correlational study that examined how the eICU® Acceptance Survey instrument was performing in a nation-wide sample of healthcare professionals. The setting was nation-wide hospital ICUs that currently use eICU®. The survey was distributed per electronic communication with a link to the Survey Monkey website that collected the responses. The sample included physicians, advanced practice registered nurses and registered nurses who work in the ICU at hospitals with eICU® in the United States. The sample size was calculated using G*Power [20] statistical power analysis software. A total sample of 82 participants were needed to meet the objective for correlation two-tailed t-test with medium effect size of 0.3 [21], α error probability of 0.05, and power of 0.8. Inclusion criteria were 1) persons 18 years old or older and 2) current physician, advanced practice registered nurse, or registered nurse working at the bedside in ICU with eICU®. Exclusion criteria were 1) not directly involved in the bedside care and 2) current or previous employment as an eICU® teleprofessional (employed by an eICU® to care for ICU patients remotely). A total of 178 surveys were collected on Survey Monkey with 127 completed surveys. Fifty-one incomplete surveys were deleted per study protocol and one respondent was excluded due to erroneous data entry in the demographics section leaving 126 for the total analyzed sample. The survey was open to collect responses for four months.

Instrument

The eICU® acceptance survey created by Kowitlawakul and published in 2011 [16,17,22]. The 40-item survey was created to evaluate four key constructs identified by Kowitlawakul to predict nurses' acceptance and use of the eICU® (Table 1) [16,17,22]. The scoring for all items in the survey is on a 5-point Likert-type scale ranging from strongly disagree to strongly agree [22]. Each of the four subscales has been adapted from previously created scales measuring the constructs identified in the Technology Acceptance Model by Davis [16,19,22]. In addition to the four subscales the eICU® Acceptance Survey collects data related to knowledge of eICU®, awareness of eICU®, and demographics.

Subscale	# of Items
Perceived Usefulness	7
Perceived Ease of Use	6
Healthcare Professionals' Attitudes Toward eICU®	21
Intention to Use	6
Additional Information Collected	
eICU® Knowledge	5
eICU® Awareness	5
Demographics	17

Table 1: Modified eICU® Acceptance Survey (40-Items).

The eICU® acceptance survey was modified with permission from Dr. Kowitlawakul to include physicians and advanced practice registered nurses in the sample for this study. The language in the survey that referred to nurse or nurses has changed to healthcare professional on the Attitudes Towards eICU® subscale. Additionally, this survey was previously given prior to eICU® implementation. The sample for this study is post-implementation of eICU®. Therefore, the future tense has changed to present tense on the perceived usefulness scale and perceived ease of use subscales. The structure of the questions remains the same with the language changes. No other modifications have been made to the scales in the eICU® Acceptance Survey.

Validity

The subscales of Perceived Usefulness and Perceived Ease of Use of this survey were adapted from, reported favorable convergent, discriminant, and factorial validity with factor analysis values for each scale item ranging from 0.63-0.98 [18]. A psychometric evaluation of the Attitudes Towards eICU® has been published since the creation of the eICU® Acceptance Survey [16]. This analysis of the Attitudes Towards eICU® subscale found the 21 items accounted for 67.3% of the variance [16]. The factor loadings for each of the 21 items on the Attitudes Towards eICU® ranged from 0.52-0.84 [16]. The Intention to Use eICU® subscale was adapted from a previous intention to use scale created to measure physician intent to use Telemedicine in 1990's [22.23]. Construct validity was measured using correlation analysis and factor analysis [23]. The correlation values ranged from 0.36-0.63 (only one value is less than 0.45) and the factor loading ranged from 0.65-.075 [23].

Reliability

Reliability for the eICU® Acceptance Survey has been reported in terms of internal consistency using Cronbach's alpha. Each of the constructs as well as the overall internal reliability was measured pre-implementation of eICU® service. The coefficient alpha for Perceived Usefulness subscale was reported as 0.96, Perceived Ease of Use subscale-0.94, Attitudes Towards eICU® subscale-0.91, and Intention to Use subscale-0.95 [22]. The overall coefficient alpha was reported as 0.96 [22]. In the original subscales, Perceived Usefulness and Perceived Ease of Use, Davis [18] reported Cronbach's alpha as 0.98 for Perceived Usefulness and 0.94 for Perceived Ease of Use. The psychometric evaluation of the Attitudes Towards eICU® subscale, Cronbach's alpha was reported as 0.91 overall [16]. The original scale for Intent to Use reported a Cronbach's alpha of 0.86 [23].

Approval, Recruitment, and Data Analysis

This study was approved by the Institutional Review Board. The eICU® Acceptance Survey instrument was uploaded into Survey Monkey an online survey collector website.

Recruitment emails were sent to hospital administrators or executive administrators at hospitals in the United States that use eICU® with a request to forward on to ICU nursing and medical staff. The email explained the purpose of the study, stated participation was voluntary, and confidentiality would be strictly maintained for all participants. The email stated that the participant consented to participate in this study by clicking the Survey Monkey weblink to take the survey, and that participants could withdraw from the study by not completing the survey.

The weblink directed the participants to the Survey Monkey website used to collect survey responses which did not record names, email address, IP address, or other personally identifiable data. Recruitment also occurred at a national conference where critical care healthcare professionals who work in the ICU with eICU® service attended. Permission was granted from the conference sponsoring organization prior to attending and recruiting at the conference. The researcher recruited at a table with flyers and a laptop for any qualifying healthcare professional to take the survey onsite at the conference. The national organization who sponsored the conference also advertised the study on their website for their healthcare professional members to participate. This study was also advertised on social media in closed healthcare professional groups.

Data were analyzed using Statistical Package for the Social Sciences (SPSS) 24 software. Demographic information was analyzed using descriptive statistics: means, frequencies, and percentages. Item, subscale, and instrument performance were evaluated by: item means with standard deviations, inter-item correlation, item-total correlation, and Cronbach's α were calculated. Acceptable coefficient for inter-item correlations are greater than 0.30 and less than 0.70 [24]. Inter-item correlation coefficients less than 0.30 do not contribute to the scale while coefficients of greater than 0.70 indicate redundancy. Acceptable coefficients for item-total correlations are greater than 0.30, which indication a contribution to the scale [24]. An acceptable Cronbach's α is 0.70 for research instruments and 0.90 for clinical instruments [25].

Results

The participants in this study were mostly female, registered nurses, and held an undergraduate nursing degree (Table 2). (Table 3) displays item content, individual item means, standard deviations, corrected item-total correlations per subscale and per whole instrument, and Cronbach's α by subscale. Overall the 40-item means ranged from 2.91-4.25 (each item is scored from one to five on a Likert-type scale). The means for each item is mid- range without approaching a low mean of one or high mean of five, which indicates there is not a far left or right skew for each item. Item variation (standard deviation) ranged from 0.57-1.68, which indicates each item response is varied with no one item receiving the same score from much of the sample. Corrected item-total correlation per subscale and per whole instrument was adequately correlated greater than 0.30 for each item on the eICU® Acceptance Survey. Inter- item correlations ranged from 0.03-0.92. Some of the items on the survey are redundant (inter- item correlations >0.70) while others do not contribute to the subscale measure (inter-item correlations of <0.30). Cronbach's α per subscale ranged from 0.90-0.97 and is 0.97 for the whole instrument which is acceptable for both a research instrument as well as a clinical instrument.

Demographics (N=126)	%(n)	Mean (SD), range
Gender		
Female	90 (113)	-
Male	10 (13)	-
Age	-	43 (13), 22-71
Shift		
Day	60 (75)	-
Night	37 (47)	-
Other	3 (4)	-
Title		
Medical Doctor	2 (2)	-
Advanced Practice Registered Nurse	2 (2)	-
Registered Nurse	96 (122)	-
Education		
Medical Doctor	1 (1)	
Doctor of Philosophy	1 (1)	
Master of Science in Nursing	14 (18)	
Bachelor of Science in Nursing	63 (79)	
Associate Degree in Nursing	18 (23)	
Diploma of Nursing	3 (4)	
Years' Experience working as Healthcare Professional	-	18 (12), 1-43
Years' Experience Working in Hospital	-	10 (10), 0-40
Years' Experience Working in Intensive Care Unit	-	12 (11), 0-40
Type of Intensive Care Unit		
Surgical/Trauma	14 (17)	-
Coronary Care	10 (12)	-
Cardiovascular Care	21 (27)	-
Medical/Surgical	38 (48)	-
More than one Intensive Care Unit with eICU®	17 (22)	-
Location		
Rural (city/town population < 50,000 people)	49 (62)	-
Urban (city/town population > 50,000 people)	51 (64)	-
Abbreviation: eICU, electronic intensive care unit		

Table 2: Participant Characteristics.

Item Content/ Subscale	Item Mean	Standard Deviation	Corrected Item-Total Correlation Per Subscale	Corrected Item-Total Correlation Whole Instrument
Perceived Usefulness (α=0.97)				
1. Using an eICU® technology enables me to accomplish tasks more quickly.	3.08	1.27	0.84	0.72
2. Using an eICU® technology improves my job performance.	3.22	1.26	0.92	0.85
3. Using an eICU® technology in my job increases my productivity.	3.02	1.23	0.89	0.76
4. Using an eICU® technology enhances my effectiveness on the job.	3.23	1.3	0.9	0.84
5. Using an eICU® technology makes it easier to do my job.	3.21	1.25	0.89	0.79
6. I find an eICU® technology useful in my job.	3.43	1.29	0.85	0.82
7. Using eICU® technology improves communication on my job.	3.08	1.26	0.86	0.75
Perceived Ease of Use (α=0.90)				
1. Learning to operate an eICU® technology is easy for me.	4.12	0.8	0.64	0.38
2. I find it easy to get an eICU® technology to do what I want it to do.	3.69	0.98	0.77	0.6
3. My interaction with eICU® technology is clear and understandable.	3.79	1	0.77	0.57
4. I find eICU® technology to be flexible to interact with.	3.79	0.99	0.72	0.71
5. It is easy for me to become skillful at using eICU® technology.	3.98	0.79	0.72	0.58
6. I find eICU® technology easy to use.	4.06	0.75	0.8	0.6
Healthcare Professionals' Attitudes Toward eICU (α=0.95)				
1. The use of an eICU® technology improves patient care by giving the healthcare professional more time with the patients	2.91	1.21	0.62	0.72
2. An eICU® technology can be adapted to assist healthcare professionals in many aspects of patient care.	3.79	0.98	0.63	0.71
3. An eICU® data system offers healthcare professionals a remarkable opportunity to improve patient care.	3.65	1.12	0.74	0.79
4. An eICU® technology represents a violation of patient privacy	3.71	1.17	0.65	0.6
5. An eICU® technology causes healthcare professionals to give less time to quality patient care.	3.51	1.28	0.75	0.71
6. An eICU® technology increases costs by increasing the healthcare professional's workload.	3.57	1.12	0.67	0.63
7. It takes as much effort to maintain patient records in an eICU® technology as it does by hand.	3.21	1.11	0.56	0.5
8. An eICU® technology creates more problems than they solve in healthcare professional practice.	3.46	1.22	0.81	0.78
9. The use of an eICU® technology dehumanizes healthcare professional care.	3.53	1.29	0.81	0.76
10. Part of the increase in costs of health care is because of an eICU® technology.	3.29	1.11	0.63	0.6
11. Confidentiality will not be sacrificed by an eICU® technology.	3.58	1.08	0.48	0.49
12. I would be comfortable using an eICU® technology	3.86	1	0.79	0.84
13. Working with an eICU® technology would make me very nervous.	3.94	0.97	0.66	0.63
14. I feel threatened when others talk about an eICU®.	4.25	0.85	0.61	0.57
15. An eICU® technology does not scare me at all.	4.02	0.93	0.53	0.53
16. I feel hostile toward an eICU®.	4.03	1.12	0.69	0.67
17. An eICU® technology makes me feel uneasy and confused.	4.1	0.99	0.73	0.68
18. I have a lot of self-confidence when it comes to working with an eICU® technology.	3.71	0.9	0.48	0.54
19. Confidentiality is nearly impossible if patient records are in an eICU® technology	3.88	1.06	0.8	0.77
20. Healthcare professional data does not lead itself to an eICU® technology.	3.45	0.84	0.38	0.32

21. An eICU® technology would make healthcare professionals' job easier.	3.41	1.14	0.77	0.83
Intention to Use (α=0.93)				
1. I intend to use eICU® technology with my patient care and management when it is available in my department or hospital.	3.98	1	0.85	0.77
2. I intend to use eICU® technology to provide health-care services to patients as often as needed.	3.87	1	0.82	0.77
3. I intend NOT to use eICU® technology in my patient care and management routinely.	3.91	1.05	0.82	0.77
4. Whenever possible, I intend NOT to use eICU® technology in patients care and management.	3.83	1.15	0.83	0.83
5. To the extent possible, I would use eICU® technology to do different things, clinical or non-clinical.	3.6	0.91	0.58	0.53
6. To the extent possible, I would use eICU® technology in my patient care and management frequently.	3.68	1.06	0.81	0.77

Table 3: Reliability of the eICU® Acceptance Survey.

The Perceived Usefulness subscale inter-item correlations are all above 0.70 which indicates the seven items on this subscale are redundant. Each item/question on this scale is worded very similarly which could account for this finding (Table 3). The Perceived Ease of Use subscale inter-item correlations range from 0.42-0.77. Two correlations are greater than 0.70. Items three and four have a correlation coefficient of 0.75 and items five and six have a correlation coefficient of 0.77. Questions three and four both ask about interaction with eICU® while questions five and six both ask about the use of eICU® (Table 3).

The HCPATE subscale inter-item correlations range from 0.03-0.75. Item 20 on this subscale has inter-item correlation coefficient range of 0.03-0.42. Item 20 coefficients are only greater than 0.30 on six (items: 5, 6, 8, 9, 10, 19) of the possible 20 items. Each of the six items that item 20 is correlated with asked about eICU® technology. The other 20 items on this 21-item subscale are generally adequately correlated to each other.

The Intention to Use subscale inter-item correlations range from 0.41-0.85. Item five is the only item with inter-item correlations within the acceptable range (0.41-0.61) while the other five items inter-item correlation are greater than 0.70. Items one, two, three, four, and six of this subscale all ask about the intention to use eICU® with patients or patient care while item five does not mention patients or patient care. In corrected item-total correlations each of the items on the four subscales are adequate, greater than 0.30 (Table 3).

Discussion

Overall the eICU® Acceptance Survey is preforming well with mid-range means per item, adequate corrected item-total correlations, adequate item variability, and adequate Cronbach's alpha per scale as well as for the total instrument. Most individual items are preforming well and add to the reliability of the instrument. However, the inter-item correlation coefficients of 17 items were lower or higher than the acceptable range, which indicates low contribution or redundancy. Thus, further research is needed to recheck the item-total correlations to determine whether elimination or revision of those items are needed or not. To the best of our knowledge this is the second use and psychometric evaluation of this survey instrument which had a similar reliability performance in the previous study [16]. This is the first use of this instrument in the post-implementation of eICU® service.

The previous use of the eICU® Acceptance Survey was in a sample of 117 registered nurses from two metropolitan hospitals, pre-implementation of eICU® service [16,22]. This study modified the eICU® Acceptance Survey, used Survey Monkey and used several recruitment methods, to include physicians, advanced practice registered nurses, and registered nurses in a nation-wide sample of 126 participants. These strategies increased eligible participants from a wide range of geographic locations. Physicians and advanced practice registered nurses at the bedside make the decision on how and when to use eICU for their patients in the ICU [26-28]. Physicians that use eICU® at the highest level have improved patient outcomes [7,26] while physicians that only use eICU® for emergencies have no improvement in patient outcomes [13]. Thus, it is imperative to assess acceptance of eICU® among physicians and advanced practice registered nurses in addition to the bedside registered nurses who are with the patient 24 hours a day seven days a week. The previous study collected responses by paper and pencil method [16,22], while the current study used Survey Monkey to collect survey responses. Changing the data collection method from paper and pencil to online increased the ability of the researcher to reach more participants throughout the United States [29]. Additionally, the previous study recruited in- person at two metropolitan hospitals while the current study recruited through emails, in-person at a national critical care conference, and on a national critical care organization website. Extension of eligible participants and geographic regions in this study led to increased generalizability of the results.

Dr. Kowitlawakul [22] used the eICU® Acceptance Survey pre-implementation of eICU®, while these authors modified the survey for post-implementation use in a nation-wide sample of physicians, advanced practice registered nurses, and registered nurses. Reliability results are similar between the two studies. The item mean for the total scale and each of the four subscales in the previous study and this study were comparable: Total scale: 3.2 vs. 3.6, Perceived Usefulness: 2.8 vs. 3.2, Perceived Ease of Use: 3.4 vs. 3.9, Nurses' (or Healthcare Professionals') Attitudes Towards eICU®: 3.3 vs. 3.7, and Intention to Use 3.2 vs. 3.8 [22]. Cronbach's α for the total scale and each of the four subscales in the previous study and in this study were also comparable and acceptable, ranging from 0.91-0.96 [22] and 0.90-0.97. The reliability of this instrument demonstrates great utility in evaluating eICU® acceptance due to the lack of reliable post implementation evaluation tools. In both studies, the eICU® Acceptance Survey performed well with acceptable reliability in both a regional and nation-wide sample as well as both pre- and post eICU® implementation, even though more research is needed to check the inter-item correlations of some items. The previous evaluation of this instrument validated it's use in the pre-implementation stage among bedside registered nursing staff to determine their acceptance of eICU® services [22]. The current study demonstrates this instrument to be reliable in a nation-wide sample of healthcare professionals post-implementation of eICU® services. This is very important because the eICU® service is a costly investment for a hospital. To receive a return on investment, patient outcomes must improve to gain a cost savings through decreased expenditure on patient care [7,30]. If the bedside healthcare professionals do not accept eICU®, therefore, do not use eICU® to its full potential, patient outcomes will not improve [12,13,26].

Limitations

The participation in this study was voluntary, which was subject to self-selection and self-reporting bias. Additionally, there are only four advanced healthcare professionals (two physicians and two advanced practice registered nurses) who participated in this study, which was not a large enough sample to represent these groups. Thus, the findings of this study may not be generalized to the population of physicians and advanced practice registered nurses who use eICU® in the ICU.

Conclusions

The findings of this study further validated the reliability of the eICU® Acceptance Survey among a nation-wide sample of healthcare professionals who used eICU® service in the ICU. This instrument is now ready to be used in both pre- and post-implementation of eICU® to measure healthcare professionals' acceptance of eICU® services in the ICU. Further research is needed to test the inter-item correlations of some items.

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