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The negative impact of interface design, customizability, inefficiency, malfunctions, and information retrieval on user experience: A national usability survey of ICU clinical information systems in Finland

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ABSTRACT

Introduction: Clinical information systems (CISs) used in intensive care units (ICU) integrate large amounts of patient data every minute, and from multiple systems and devices. Intensive care requires efficient use of information technology to acquire, synchronize, integrate, and analyze data in order to make quick decisions and implement interventions in a timely manner.
Objectives: To identify factors affecting poor user experience (UX) of CISs used in ICUs in Finland.
Methods: Data from national Electronic Health Record (EHR) and user experience survey was undertaken in 2017. Those, who used the ICU CIS on a daily or weekly basis were asked supplementary questions and, therefore, comprise a subset of the responses reported in this article.
Results: On a 4–10 scale (i.e., "*Fail*" to "*Excellent*"), the mean 'grade' for the principally used ICU CIS was 6.9 (SD 1.3) points. Of the respondents, 119 (57%) were categorized as having good UX. The factors identified as affecting poor UX of the ICU CISs related to poor interface design (OR 7.8; 95% CIs 12.5–24.1; $p = 0.001$), insufficient customizability (OR 7.2; 95% CIs 1.7–30.6; $p = 0.008$), the inefficiency of performing routine tasks (OR 4.3; 95% CIs 1.0–18.2; $p = 0.044$), malfunctions (OR 3.5; 95% CIs 1.2–9.6; $p = 0.019$), and difficulties in information retrieval (OR 3.0; 95% CIs 1.0–8.8; $p = 0.044$). The most commonly reported usability problems with the main EHR system and ICU CISs were also identified.
Conclusions: Overall satisfaction with the principally used ICU CIS was moderate. However, the overall grades varied significantly. Poor interface design, insufficient customizability, inefficiency, malfunctions, and difficulties in information retrieval all affect poor UX.

1. Introduction

Computers have been used in intensive care units (ICUs) since the 1960s [1–2]. Moreover, since 2010, Electronic Health Records (EHR) coverage in Finnish hospitals has been 100% and, since 2014, ICU clinical information system (CIS) coverage has been 100% [3–4]. ICU CISs may be included in a hospital-wide information system suite or they can stand alone, integrating a large amount of patient data every minute, and from multiple systems (e.g., laboratory, pathology, and radiology systems) and clinical equipment (e.g., patient monitors, ventilators, infusion pumps). Intensive care requires efficient use of information technology to acquire, synchronize, integrate, and analyze disparate data (e.g., vitals, laboratory data, radiology images) in order to make quick clinical decisions and implement interventions in a timely manner [5].

Despite many years of development, as well as the proliferation of smart mobile services and modern operating systems, users continue to report their dissatisfaction with and usability problems related to data entry, poor system support for workflow, and visual representations associated with ICU CISs [6]. Moreover, poor usability has been associated with user fatigue, increased error rates, and dissatisfaction [7–10]. The most important barriers to the adoption of EHR have been

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related to users' attitudinal-behavioral limitations and organizational changes [11]. For instance, younger, computer-literate male physicians, based in large/multi-group practices, have been more receptive to EHRs than their older and less-skilled female colleagues, based in solo practices [12]. A lack of expertise, time, and knowledge of how to manage the implementation process have also hindered the adoption process [12].

Rather than gathering long-term data on experiences of fully-adopted systems after longer periods of use, previous studies of end users' experiences (UX) have been conducted during the development or deployment process [13–14]. In Finland, a national EHR usage and UX survey has been repeated regularly since 2010 [15–21], 2014 [13,22], and 2017 [6,23–25]. However, and despite usability being a contextual property, the evaluation of which should always be context-specific, the national EHR usage and UX survey has not been conducted among intensivists [13,20,24,26–27]. In addition, new functionalities are implemented continuously in EHR (i.e., ICU CISs) requiring continuous updating for EHR-related competencies [28,29], whereas inconsistent intensivist–EHR interaction, insufficient user-centered interface design, and suboptimal usability have been associated with EHR-related fatigue, resulting in lowered EHR efficiency and patient care [29,30]. Consequently, we aimed to identify factors affecting poor UX in ICU CISs throughout Finland in order to optimize, redesign, and develop more user-centred ICU CISs from the perspective(s) of the end users themselves.

2. Materials and methods

The present study is a sub-study of a national EHR usage and UX survey undertaken in 2017 [13]. The data was collected via e-mail and the QuestBack web-based survey in spring 2017. Individual links to the survey were sent to all working-age physicians (N = 19,627) who had provided their email addresses (n = 18,326) to the Finnish Medical Association (FMA). Those who used the ICU CIS on a daily or weekly basis were also asked supplementary questions and, therefore, comprise a subset of the responses reported in this article (n = 210). The responses were anonymized after the respondents had used the link sent by the FMA; i.e., the researchers were not able to identify individual respondents.

Results from the main study have been reported in Kaipio et al. [13]. The original questionnaire included 18 background questions (including a questions about the respondent's principally used EHR system) and 38 core statements with a five-point Likert-scale (from *"Fully agree"* to *"Fully disagree"*) [13]. In addition, the respondents were asked to give an overall rating for the main EHR system by answering a summative multiple-choice question. For this study, 15 background questions and 30 usability statements were selected. In addition, the respondents were asked to give an overall rating for the principally used ICU CIS by answering a summative multiple-choice question ("*Which school exam grade would you give the ICU clinical information system you principally use?*") on a numerical scale of 4–10 (i.e., "*Fail*" to "*Excellent*").

Categorical variables were presented using frequencies and percentages and were further tested by using Fisher's Exact Test and Pearson Chi-Square, as appropriate. Continuous variables were presented as mean and standard deviations (SDs). When comparing the five-point Likert-scale answers, "*Fully agree*" and "*Somewhat agree*" were combined as "*Agree*". Correspondingly, the answers "*Fully disagree*" and "*Somewhat disagree*" were combined as "*Disagree*". In addition, a numerical scale of 4–6 was defined as "*poor user experience*". Conversely, a numerical scale of 7–10 was defined as "*good user experience*". The data was categorized according to the overall rating of the ICU CIS as either *poor* or *good* UX.

A logistic regression analysis was used to study which usability statements predicted poor UX among the respondents. All the usability statements with univariate significance level of < 0.1 were included in the model. The variables with a multivariate significance level of < 0.05 were kept in the model, as well as those with a significant impact on the log-likelihood function using the backward method. Variables that were significantly imbalanced (e.g., overall grades given to the different ICU CIS programs, i.e., the brand/developer of the software package) or that hold no predictive power (e.g., close-ended HIS questions) were excluded.

Statistical analyses were performed using SPSS 21.0 for Windows (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.). This article followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement [31].

3. Results

The questionnaire was returned by 210 intensivists, and their responses were analyzed. Of these, 119 (57%) respondents were categorized as good UX responders, according to their overall rating for the principally used ICU CIS.

3.1. Demographics

The majority of respondents were females (62.5%) with a mean age of 46.4 (SD 10.0) years and acting as a specialist (82.9%) in a university hospital (68.4%) within the public sector (89.0%) in the Helsinki capital region (41.4%). Overall, females' UX was lower than males (Table 1). In the subgroup analyses however, baseline characteristics such as age and system usage (e.g., daily versus weekly, number of software interfaces) on UX did not differ between males and females. Thirty-one percent of respondents used three different EHR systems on a daily basis, mainly in operating rooms (33.3%) and ICU (28.6%). The majority of the respondents used a similar ICU CIS program (n = 118).

3.2. Usability problems in the principal EHR systems

The most frequent usability problems in the principal EHR system were related to double-documentation (statement 30A), systems slowness and unexpected interruptions in use (statement 30C), interoperability (statement 30Q), and safety (Table 2); 35.7% of respondents felt that systems do not help prevent errors (statement 30F). The principal EHR systems were, however, well-integrated in the National Health Information Services (statement 30H) and National ePrescription services (statement 30L).

3.3. Usability problems in the main ICU CISs

On a scale of 4–10 (i.e., "*Fail*" to "*Excellent*"), the mean grade for the principally used ICU CIS was 6.9 (SD 1.3) (Q51). The most frequent usability problems in the ICU CIS (Table 3) were related to decision support (statements 48.5 and 44.6), interoperability (statements 44.1–44.3, 44.5, 44.7), and customization (statement 44.4), while 28.5% of the respondents felt that system malfunctions had or had almost caused a patient serious harm (statement 48.6). In addition, only 37.6% of respondents felt that performing routine tasks is straightforward (statement 48.2).

3.4. Factors affecting poor user experience of the ICU CISs

Identified factors affecting poor UX of the ICU CISs were related to poor user interface (UI) design (statement 48.1; OR 7.8; 95% CIs 12.5–24.1; $p = 0.001$), insufficient customizability (statement 44.4; OR 7.2; 95% CIs 1.7–30.6; $p = 0.008$), the inefficiency of performing routine tasks (statement 48.2; OR 4.3; 95% CIs 1.0–18.2; $p = 0.044$), malfunction (statement 48.6; OR 3.5; 95% CIs 1.2–9.6; $p = 0.019$), and difficulties in information retrieval (statement 44.7; OR 3.0; 95% CIs 1.0–8.8; $p = 0.044$) (Table 4). System crashes (technical reliability) did not, however, affect poor UX (Q46, data not shown).

Table 1
Baseline characteristics between respondents with a poor and good user experience.

	Poor user experience (grade 4–6), $n = 66$	Good user experience (grade 7–10), $n = 119$	*P*-value*
Age group			>0.9
<35 years, No. (%)	8 (12.3)	14 (11.9)	
35–44 years, No. (%)	21 (32.3)	43 (36.4)	
45–54 years , No. (%)	19 (29.2)	32 (27.1)	
>55 years, No. (%)	17 (26.2)	29 (24.6)	
Gender			0.004*
Female, No. (%)	50 (76.9)	65 (54.6)	
Male, No. (%)	15 (23.1)	54 (45.4)	
Specialization			0.687
Not specialized, No. (%)	12 (18.2)	19 (16.0)	
Specialized, No. (%)	54 (81.8)	100 (84.0)	
Specialty			0.027*
Anesthesiology, No. (%)	30 (45.5)	68 (57.1)	
Internal Medicine, No. (%)	16 (24.2)	12 (10.1)	
Pediatrics, No. (%)	8 (12.1)	24 (20.2)	
Other, No. (%)	12 (18.2)	15 (12.6)	
Setting			0.018*
ICU, No. (%)	18 (27.3)	41 (34.5)	
Operating room, No. (%)	18 (27.3)	48 (40.3)	
Other, No. (%)	30 (45.5)	30 (25.2)	
Work tenure (experience)			0.735
0–9 years, No. (%)	12 (19.0)	21 (17.6)	
10–19 years, No. (%)	18 (28.6)	43 (36.1)	
20–29 years, No. (%)	19 (30.2)	29 (24.4)	
≥30 years, No. (%)	14 (22.2)	26 (21.8)	
Healthcare sector			>0.9
Hospital, No. (%)	66 (100.0)	117 (99.2)	
Healthcare center, No. (%)	0 (0.0)	1 (0.8)	
Other, No. (%)	0 (0.0)	0 (0.0)	
Hospital district			<0.001*
District 1, No. (%)	44 (69.8)	41 (35.3)	
District 2, No. (%)	5 (7.9)	11 (9.5)	
District 3, No. (%)	5 (7.9)	23 (19.8)	
District 4, No. (%)	3 (4.8)	16 (13.8)	
District 5, No. (%)	6 (9.5)	25 (21.6)	
ICU Clinical Information System			<0.001*
Brand 1, No. (%)	29 (43.9)	89 (74.8)	
Brand 2, No. (%)	29 (43.9)	20 (16.8)	
Other, No. (%)	8 (12.1)	10 (8.4)	
ICU Clinical Information System usage			0.168
Daily	25 (37.9)	58 (48.7)	
Weekly	41 (62.1)	61 (51.3)	
Number of software interfaces, mean (SD)	3.8 (1.1)	3.3 (1.2)	0.012

4. Discussion

4.1. Main contribution

To the best of our knowledge, this is the first study identifying factors affecting poor UX in ICU CISs on a national level. Our study also identified the most commonly reported usability problems in the main EHR system and ICU CIS. The results showed notable differences in the overall grades given to the different ICU CIS brands.

4.2. Usability problems in the main EHR and ICU CISs

In this study, females' UX was lower than males. Contrary to previous literature [12], however, younger male physicians were as satisfied with EHRs than their older female colleagues. In addition, the responses were evenly distributed between men and women. Minor differences, however, were detected related to double-documentation (statement 30A) and system malfunction (statement 48.6). In the literature, female physicians have shown to be faster than male physicians but required more mouse clicks than males [31]. In addition, longer work experience (>6 years) has been associated with higher competency among nurses [29].

The most commonly reported usability problems in the principal EHR systems were related to double-documentation, system slowness and unexpected interruptions in use, interoperability, and safety. In the literature, users' acceptance of and attitudes toward EHR systems have been closely related to system usability (e.g., ease of use, ease of access, ease of log-in, functionality, technical reliability, context coverage), workflow integration, interoperability, and helpfulness (e.g., efficiency, safety, data security) [11–12,14], whereas poor UI design, system slowdown, system complexity, and time-consuming navigation have been considered the most common factors in influencing clinicians' negative attitudes towards clinical IT systems [12].

In line with previous literature, our results show significant differences between both ICU CIS brands and hospital districts [13,19]. It should be noted, however, that different brands contain different features that constitute the UX, and, therefore, these features are more important than the program itself. In the literature, user experiences have varied between the professional groups using the same program of EHR system in public hospitals, particularly with regard to technical quality and ease of use [6], which demonstrates the differing needs and expectations associated with specific roles and responsibilities [27].

Generally speaking, the findings on the capacity of ICU CISs to support collaboration only indicated negative observations: less than 10% of the respondents agreed that ICU CISs facilitate inter-specialist and remote consultation, despite the increased needs for telemedicine in intensive care [13,33]. In the previous literature, nurses have praised the capacity of EHR systems to support collaboration and information exchange between professional groups more than physicians [6].

4.3. Factors affecting poor user experience of ICU CISs

In line with previous literature [12], poor UI design was found to be the most common factor affecting poor UX. In this study, half of respondents felt that the fields and functions were not arranged logically in the main ICU CIS (statement 48.1). In general, click-heavy, data-busy, and cumbersome multi-page navigation have been associated with poor usability in EHR-UI [31]. In addition, inappropriately designed EHR have had a roughly six-fold greater number of clicks compared to systems that aggregate relevant information into a single screen increasing the cognitive load, the possibility of making errors [32], and inefficiency [31–32].

The inefficiency of performing routine tasks was also found to be associated with poor UX, which is in line with Khairat et al. [34], who found that system speed and reliability, memorizing menu and button names and commands, and the inefficiency of performing routine tasks were the main factors causing high EHR frustration. In this study, most respondents felt that performing routine tasks was not straightforward in the main ICU CIS (statement 48.2) whereas one third of them felt the main EHR system illogical (statement 30D). In the literature, poor usability and insufficient workflow integration of software have prolonged the perforce of simple tasks. In fact, insufficiently designed EHR have had a roughly six-fold greater number of screen transitions to navigate to the required patient information compared to systems that aggregate relevant information into a single screen [Senathirajah et al., 2017]. Consequently, the need to optimize, redesign, and develop digital workflows in EHR design instead of conventional clinical workflow-based design have been highlighted, for instance by Coleman et al. [30].

The principally used ICU CIS were found to be insufficiently customizable (statement 44.4). In fact, user experiences varied between the

Table 2
The most commonly reported usability problems in the main EHR systems.

Item no	Statement	Total agree,No. (%)	True, No. (%)		False, No. (%)		*P*-value*
			Poor user experience (grade 4 – 6)	Good user experience (grade 7 – 10)	Poor user experience (grade 4 – 6)	Good user experience (grade 7 – 10)	
Q30A	The same thing needs to be entered in many places	127 (60.5)	45 (68.2)	67 (56.3)	21 (31.8)	52 (43.7)	0.12
Q30B	The user interface view is the same regardless of the system user's tasks or needs	31 (14.8)	9 (13.6)	20 (16.8)	57 (86.4)	99 (83.2)	0.675
Q30C	Slowness of the systems and unexpected interruptions in use	118 (56.2)	34 (51.5)	69 (58.0)	32 (48.5)	50 (42.0)	0.441
Q30D	Illogicality (paths need to be learned by heart)	72 (34.3)	25 (37.9)	33 (27.7)	41 (62.1)	86 (72.3)	0.186
Q30E	Poor support for electronic decision support (notes, reminders, and links to clinical guidelines)	30 (14.3)	7 (10.6)	21 (17.6)	59 (89.4)	98 (82.4)	0.284
Q30F	The systems do not help prevent errors	75 (35.7)	23 (34.8)	45 (37.8)	43 (65.2)	74 (62.2)	0.751
Q30G	Poor usability of the regional health information exchange systems (information system used to find information about a patient having been treated in another organization)	92 (43.8)	33 (55.0)	49 (41.2)	33 (50.0)	70 (58.8)	0.281
Q30H	Awkwardness of seeking information in the National Health Information Services (Kanta)	71 (33.8)	22 (33.3)	42 (35.3)	44 (66.7)	77 (64.7)	0.872
Q30I	Acknowledging and reacting to the information that has arrived in the result mail / checklist is laborious	27 (12.9)	13 (19.7)	9 (7.6)	53 (80.3)	110 (92.4)	0.018*
Q30J	Absence or poor quality of summary view (e.g., temperature or daily treatment charts)	61 (29.0)	18 (27.3)	39 (32.8)	48 (72.7)	80 (67.2)	0.507
Q30K	Structured entering of nursing documentation makes it difficult to get an overall picture of the patient	61 (29.0)	14 (21.2)	35 (29.4)	52 (78.8)	84 (70.6)	0.297
Q30L	Poor usability of the National electronic prescription (ePrescription) service implementation	33 (17.1)	12 (18.2)	19 (16.0)	54 (81.8)	100 (84.0)	0.687
Q30M	Electronic communication with the patient is lacking or cumbersome	36 (15.7)	11 (16.7)	16 (13.4)	55 (83.3)	103 (86.6)	0.664
Q30N	Forms are not smart and self-supplementing (e.g., referral forms, certificates)	39 (18.6)	14 (21.2)	18 (15.1)	52 (78.8)	101 (84.9)	0.315
Q30O	No single sign-in / no desktop integration	36 (17.1)	12 (18.2)	20 (16.8)	54 (81.8)	99 (83.2)	0.841
Q30P	Constantly changing passwords	34 (16.2)	14 (21.2)	18 (15.1)	52 (78.8)	101 (84.9)	0.315

*P-value < 0.05 was considered statistically significant.

professional groups significantly; the needs and expectations for customization were greatest among specialists compared to their non-specialized colleagues or managers. In general, specialized information systems with defined functionalities have indeed received more favorable assessments than CISs, due to the improved customization of specialized information systems for specific working environments [13,19]. According to Sinsky et al. [35], the balance between standardization and customization must be struck in order to improve both satisfaction and quality of care. In addition, an individual customization on the "summary page" of the chart, better facilitation of common navigation transitions and eliminating unnecessary tabs/screens from the default view are recommended [30].

In this study, half of the respondents felt that it was easy to retrieve the necessary information from the ICU CIS (statement 44.7), even though the ICU CISs do not automatically retrieve external data (statement 44.5). At the same time, one third of the respondents felt that summary views in the main EHR system were lacking or were of poor quality (statement 30 J). In the literature, key information has been found to be spread out across multiple screens [30]. Display fragmentation warrants immediate corrective action [32]. It has been shown, for instance, that a sleek one-page design instead of cumbersome multi-page navigation method reduce the "click burden", whereas visualization dashboards appear to be more highly prioritized in intensivist–EHR interaction [30].

One third of respondents felt that ICU CIS malfunctions have caused or have been close to causing a serious adverse event for a patient. System crashes (technical reliability) did not, however, affect poor UX. In a recent meta-analysis, electronic interventions have not been shown to have a substantial effect on mortality, length of stay, or cost in ICUs [36]. This lack of impact may, however, be attributable to the unsuccessful implementation or heterogeneity of the current evidence.

4.4. Limitations

This study has limitations due to its design (e.g., response and selection bias), methods (e.g., online survey), and generalizability. Firstly, an overall rating for the principally used ICU CIS was measured on a numerical scale of 4–10 (i.e., "*Fail*" to "*Excellent*"), which may also cause response bias. In addition, the Likert-type scale may limit the range of participant responses [37]. These measurements have, however, been uniform in several publications, showing the direction of the overall satisfaction [6,13,15–22,24–25]. In addition, our subset of respondents displayed similar demographic features as the original sample [23]. Secondly, although in line with Colleti et al. [38], the sample size was small. In general, online response rates tend to be 10–20% lower than those in traditional mail surveys [37]. In addition, the majority of respondents were from the Finnish capital region, where the new EHR system was being deployed.

4.5. Future research

This study is a part of larger research project, which has become a part of eHealth strategy implementation in Finland [39]. Currently the subprojects are surveying UX among physicians and nursing staff. In future, a corresponding questionnaire about the UX of their CISs will be send to social workers, in order to cover different professional groups, too. However, more research is needed to investigate the root causes of EHR-associated fatigue to support user-centered design in ICU CISs. In addition, more UI/UX research is needed to include key clinical content in an economical manner to provide navigational efficiency and flexibility. Consequently, regular monitoring and evaluation is critical to ensure that the planning, design, and development of softwares focuses on end user's needs and expectations.

Going forward, usability and human factor approaches need to be

Table 3
The most commonly reported usability problems in the main ICU Clinical Information Systems.

Item no	Statement	Total agree, No. (%)	Agree, No. (%)*		*P*-value¤
			Poor user experience (grade 4 – 6), $n = 66$	Good user experience (grade 7 – 10), $n = 119$	
Q44.1	Using parallel information systems in my unit is smooth	42 (20.3)	4 (6.1)	37 (31.6)	<0.001¤
Q44.2	The ICU's Clinical Information System facilitates remote consultation between hospitals	15 (7.6)	1 (1.5)	14 (12.1)	0.011¤
Q44.3	The ICU's Clinical Information System facilitates consultations between different medical specialists within the hospital	16 (8.0)	3 (4.5)	12 (10.3)	0.262
Q44.4	The ICU's Clinical Information System is sufficiently customizable to meet the needs of my unit	70 (35.5)	5 (7.6)	65 (55.6)	<0.001¤
Q44.5	The ICU's Clinical Information System automatically retrieves the patient information I need from other systems or devices	31 (15.7)	3 (4.6)	28 (23.9)	0.001¤
Q44.6	Reminders, notes, and warnings provided by the ICU's Clinical Information System are helpful and appropriate	40 (20.9)	2 (3.1)	37 (32.7)	<0.001¤
Q44.7	The ICU's Clinical Information System makes it easy to retrieve the necessary information about the patient	101 (51.3)	11 (16.9)	84 (72.4)	<0.001¤
Q48.1	In views (windows), fields and functions are arranged logically	97 (50.0)	7 (10.6)	90 (78.3)	<0.001¤
Q48.2	Performing routine tasks is straightforward (succeeds without additional choices)	73 (37.6)	3 (4.7)	69 (59.5)	<0.001¤
Q48.3	It is easy to correct mistakes made (e.g., error logging, ending up in the wrong view, changing selections, etc.)	55 (28.6)	6 (9.2)	49 (42.6)	<0.001¤
Q48.4	Using the system does not require long and thorough familiarization	47 (24.5)	7 (10.8)	40 (34.8)	<0.001¤
Q48.5	The system automatically brings up patient / diagnosis-specific care instructions and protocols.	25 (13.1)	1 (1.6)	23 (20.2)	<0.001¤
Q48.6	A system malfunction has caused or has been close to causing a serious adverse event for a patient.	55 (28.5)	32 (49.2)	21 (18.3)	<0.001¤

*Fully agree and somewhat agree combined as agree.¤ *P*-value < 0.05 was considered statistically significant.

Table 4
Factors affecting poorer UX of the ICU Clinical Information Systems.

Item no	Statement	OR (95% CIs)	*P*-value¤
Q44.4	The ICU's Clinical Information System is sufficiently customizable to meet the needs of my unit	7.2 (1.7–30)	0.008¤
Q44.7	The ICU's Clinical Information System makes it easy to retrieve the necessary information about the patient	3.0 (1.0–8.8)	0.044¤
Q48.1	In views (windows), fields and functions are arranged logically	7.8 (12.5–24.1)	0.001¤
Q48.2	Performing routine tasks is straightforward (succeeds without additional choices)	4.3 (1.0–18.2)	0.044¤
Q48.6	A system malfunction has caused or has been close to causing a serious adverse event for a patient.	3.5 (1.2–9.6)	0.019¤

P-value < 0.05 was considered statistically significant.

integrated into the design and monitoring of EHR system development, in order to overcome the prevailing mismatch between clinical work and IT systems and to support practices that improve patient safety [26,40]. Furthermore, consensuses need to be built among the interprofessional teams to pull relevant information to EHR dashboards and to decrease information overload.

Current restrictions related to collaboration (e.g., inter-specialist and remote consultation) as well as interface design (e.g., workflow integration, customizability) also need to be accounted for. More precisely, an efficient, safe, and accessible remote consultation service delivered through state-of-the art digital technologies needs to be integrated into ICU CISs. In addition, the value of digital twin technology in inter-specialist and remote consultation, for instance, could be explored. The most appropriate features and architecture of user interface design need to be identified in different situations and contexts. Moreover, the involvement of end-users in developing ICU CISs is crucial; adoption by clinicians will be achieved when the interface design features align with their needs and expectations of such features.

In future, the usability of ICU CISs needs to be improved in order to facilitate cross-organizational electronic health information exchange, which ensures the greater continuity and timeliness of care between different service providers throughout the clinical journey [22,24]. In addition, intelligent systems, big data, edge computing, and predictive analytics (e.g., reminders, notes, and warnings) will be required, in order to support clinical workflow (e.g., assist, augment, or automate tasks) and improve situational awareness in clinical decision-making. Consequently, the quality of data (e.g., relevance, completeness,

timeliness, accuracy) must be highlighted when integrating clinical decision support systems in ICU CISs [26]. In addition, specialism-specific needs and requirements call for more user participation in ICU CIS design.

The need for ongoing training is warranted, as well. According to Carayon et al. [41], skilled users may be able to overcome usability obstacles, but this requires that they are given proper resources, education, and training; whereas lengthier training provision has been associated with clinicians' views on implementation and their ongoing use of the EHR system [12].

5. Conclusions

Overall satisfaction with the principally used ICU CIS was moderate. However, the overall grades given to ICU CISs varied significantly. Poor interface design, insufficient customizability, inefficiency, malfunctions, and difficulties in information retrieval affect poor UX.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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