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Usability Assessment of an Electronic Medical Record-Embedded Clinical Decision Support System for Arterial Blood Gas Interpretation

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Abstract Since usability is considered a significant success factor for Clinical decision support systems (CDSSs), this study seeks to assess the usability of an electronic medical records-embedded CDSS for arterial blood gas (ABG) interpretation and ordering. The current study was conducted in the general ICU of a teaching hospital, using the System Usability Scale (SUS) and interviews with all anesthesiology residents and intensive care fellows in two rounds of CDSS usability testing. The feedback from the participants was discussed with the research team across a series of meetings, and the second version of CDSS was designed and tailored to participants' feedbacks. Subsequently, the CDSS usability score increased from 67.22±4.58 to 80.00±4.84 (P-value<0.001) through participatory, iterative design and the users' usability testing feedbacks.

Keywords. clinical decision support systems, Blood Gas Analysis, usability

1. Introduction

CDSSs are information technologies (IT) that integrates patients' clinical data and evidence-based guidelines (EBG) to generate patient-specific recommendations to healthcare providers (HCPs) at the point of decision-making [1]. One of the situations in

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which CDSS can be used to assist HCPs is interpreting ABG test in conditions that affect patient respiratory system and metabolic processes. Although ABG is amongst the high-cost and common-ordered tests in ICUs, 40.2-60% of these tests are not clinically justified [2,3]. CDSS capabilities for supporting HCPs to diagnose, predict, and provide clinical interpretation serves as an effective strategy to reduce inappropriate testing [4]. However, previous literature debated HCPs do not frequently use CDSS due to poor usability [5]. The adoption of CDSSs depends on the provision of an understandable justification of the clinical decision-making process, fully interaction to respond to physicians' questions and to provide feedback and interpretation [6]. Evidence suggested that clinicians require help for ABG tests interpretation, a challenging task due to facing physicians with six values [7]. Our developed CDSS can help clinicians in interpretation of ABG and then recommend them to decrease the frequency of ordering ABG test. In this study, we aimed to assess the usability of our CDSS.

2. Method

Given that usability has the potential to serve as a surrogate marker for IT quality, it has been suggested to be assessed through different phases of software development life cycle from prototyping to implementation [8]. An electronic medical record (EMR)-embedded CDSS was developed and run using an iterative methodology in the General ICU of Nemazee hospital, Shiraz, Iran. The CDSS provides ABG interpretation and the associated differential diagnosis (DDX) based on some in-house-developed algorithms to avoid unnecessary ABG test ordering. The CDSS was designed with seven categories of requirements, including data entry, providing recommendations/warnings, responding to recommendations/warnings, reporting, output, security/ confidentiality, and general capabilities. All anesthesiology residents with the General ICU rotation and an intensive care fellow (nine participants), who were experienced in using the EMR, were recruited to test the CDSS usability. The participants were asked to complete the SUS questionnaire and participate in an interview to collect their feedback about the system as well. The SUS contains questions with positive and negative meanings scored from 1 to 5. The user's score for positive questions is reduced by one point and for negative questions is subtracted from 5. The sum of the scores is multiplied by 2.5 to convert the original scores from 0-40 to 0-100. The feedbacks from the participants were discussed with the research team across a series of meetings and the second version of CDSS was designed and tailored to the participants' feedbacks collected through the interview. When the users' requirements were addressed, once again, the SUS questionnaire was distributed and completed by the participants to test the usability of the revised CDSS. The study was conducted based on the ethical consideration of the Ethics Review Board of the Vice-Chancellorship for Research & Technology at Kashan University of Medical Sciences [Code# IR.SUMS.NUHEPM.REC.1399.045].

3. Result

The first round of the SUS distribution showed that the SUS scores ranged from 57.5 to 72.5 with the mean of the total usability score was 67.22±4.58. The interview revealed that the participants were dissatisfied with the interface design requiring scrolling for completing different forms (Figure 1). They were also dissatisfied with the long time

required to fill the forms to receive the interpretation or the diagnosis. Moreover, the participants believed the soft-stop alerts regarding reducing ABG checking frequencies needs reconsideration and making exception based on patients' condition. For example, where the last three ABGs of a given patient had identical interpretation that shows there has been no change in the patient status and further work-out is required to manage patient's condition, the soft- stop alert could be overridden).

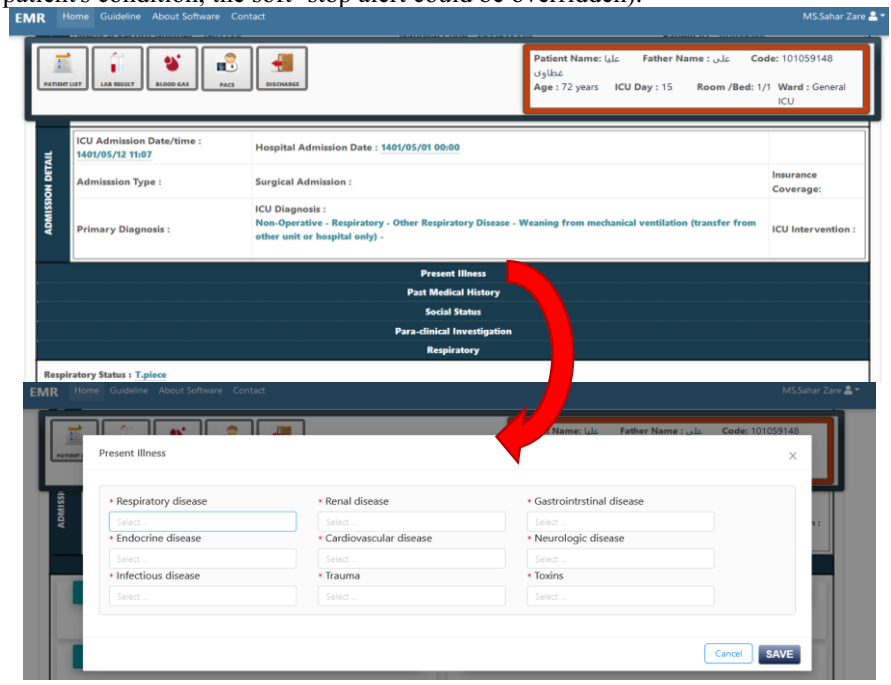

Figure 1. A screenshot of the primary CDSS for interpreting ABGs

The research team decided to separate the interpretation and the diagnosis and provide some default answers to save time. Moreover, the users were required to fill the forms only when they required the system to provide them with the "DDX". Two buttons (INTERPRET and DDX) are in front of each ABG requested for a given patient. "Interpret" provides the users with the oxygenation status of the patient (e.g., Moderate hypoxemia) and the acid-base disorder associated with the ABG values (e.g., High anion gap metabolic acidosis with Acute respiratory acidosis) without requiring the user to fill something. DDX provides the users with the differential diagnosis which can produce the associated blood gas disorder. Alerts about reducing ABG checking frequency were presented on the ordering page when physicians were going to place a new order and could be overridden in particular patient's conditions. After CDSS revision (Figure 2), the total usability scores of the participants ranged from 72.5 to 87.5 and the mean of total usability score increased to 80.00±4.84 (P-value<0.001).

4. Discussion

After two rounds of usability testing and improvement through engaging the end-users, the CDSS sounds usable according to the participants, that aligns with Thum et al. study

[9]. Developing CDSSs through human-centered and participatory design is challenging mainly due to the research and design object complexity [10]. In addition, receiving the actual users' feedback is difficult since they are too busy [10] especially in ICUs. On the other hand, usability of the CDSSs is not only about considering "ease of use" and "visualizations" but about presenting suitable alerts during physicians' decision-making. Thus, considering a balance between system flexibility and alerts is vital in designing a CDSS for preventing "alert fatigue" [4]. This study exemplifies the importance of human-centered participatory design and iterative usability testing when designing CDSS for assisting physicians with decision-making and improving healthcare quality.

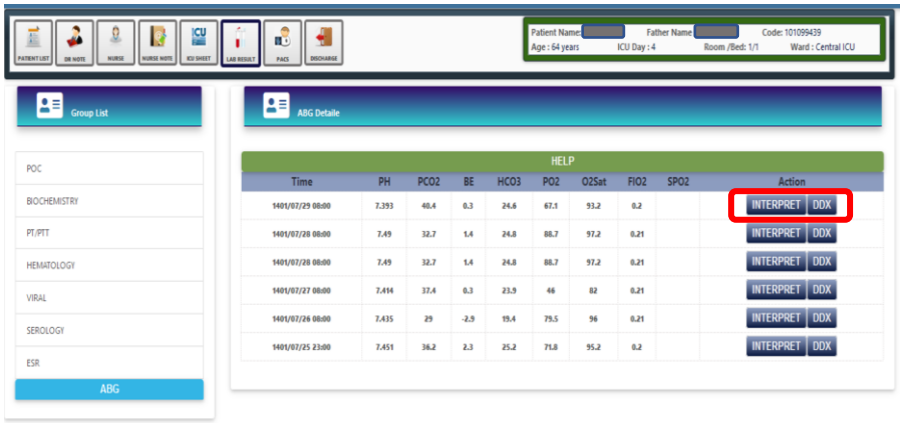

Figure 2. A screenshot of the second version CDSS based on participants' feedback

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