MEDINFO 2023 — The Future Is Accessible
J. Bichel-Findlay et al. (Eds.)

doi:10.3233/SHTI231070

Say Goodbye to the 'Paper on Screen', Rethinking Presentation of and Interaction with Medical Information

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Abstract. Traditionally, Electronic Medical Records (EMR) have been designed to mimic paper records. Organizing and presenting medical information along the lines that evolved for non-digital records over the decades, reduced change management for medical users, but failed to make use of the potential of organizing digital data. We proposed a method to create clinical dashboards to increase the usability of information in the medical records. Official clinical guidelines were studied by a working group, including dashboard target users. Necessary clinical concepts contained in the medical records were identified according to the clinical context and finally, dedicated technical tools with standard terminologies were used to represent categories of information. We used this method to generate and implement a dashboard for sepsis. The dashboard was found to be appropriate and easy to use by the target users.

Keywords. Clinical dashboard, data display, medical record, problem-oriented

1. Introduction

Medical records are primarily used to record information about patients, so healthcare professionals (HCPs) can assure continuity of care, review the course of treatment, and transfer information to other practitioners [1]. Introducing computer technology for the development of the Electronic Medical Records (EMR) allowed paper records to become digital and available almost everywhere. However, nearly all EMRs retained the structure of non-digital records, which had evolved over decades for the documentation of a patient's medical history and care. Unsurprisingly, this record structure is significantly owing to the constraints of paper. For example, to avoid laborious repeated handwriting, the paper records are structured by source of data (lab, medication, vital signs, etc.). Electronic records have adopted this structure despite the lack of similar constraint.

Such an approach, while unavoidable on paper, impedes understanding of the current situation of the patient. To attain a complete clinical picture, information from a multitude of sources needs to be considered, however, only a subset of all information is relevant in many situations (e.g., assessing oxygenation from a full blood gas analysis

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result report). Therefore, replicating the paper mandated organization of information in EMRs unnecessarily inhibits the potential brought by digital media.

Healthcare practitioners need to consider the complete clinical context, defined by a combination of multiple aspects including disease, symptoms, comorbidities, stage of the problem or demographic patient data, when reviewing a patient and adapting treatment [2]. In digital systems, organizing information appropriately for a given clinical context should not require additional effort by the end user.

Although the frozen structure of paper based medical records, with fixed sections, assures the integrity of medical information within specific categories, the information presentation remains the same regardless of the clinical context. In contrast, a dashboard designed according to the clinical context breaks the traditional frame of the presentation of medical records and facilitates access to the relevant clinical information in a fraction of a second and at the point of care [3]. Studies have shown that providing clinicians with immediate access to information via clinical dashboards, can improve adherence to quality guidelines and may help improve patient outcomes [4].

The aim of this study is, to develop and evaluate a method to create clinical dashboards. While the methodological framework we describe here is applicable to any clinical context, we present our results for the example of the clinical dashboard for sepsis.

2. Methods

We created a working group including relevant profiles, such as HCPs, experts in information technology (IT) and clinical informaticians. Subsequently, the group defined four phases, illustrated in figure 1, to create a clinical dashboard.

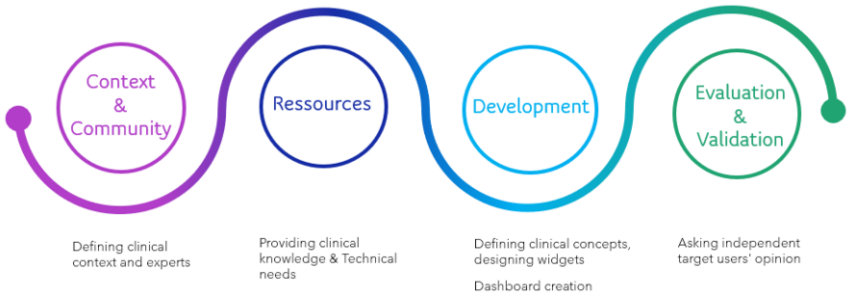

Figure 1. Four phases of creating a clinical dashboard: 1) Clinical context and community 2) Necessary resources 3) Development 4) Evaluation & validation.

In the first phase, the clinical context and relevant clinical experts along with the target users of a clinical dashboard, were defined. Involvement of clinical experts in the development process are a necessary pre-requisite for acceptance and successful integration in the end users' daily clinical practice.

Resource requirements included both a dedicated platform for creating the structure of the dashboards containing standard, and interoperable clinical concepts [2], and a tool for developing the visual aspects of the dashboard (the location and size of the clinical concepts, the color, graph shapes, etc.). Another requisite was the clinical knowledge, including official guidelines in the relevant clinical field, necessary to know what needs

to be displayed or reviewed during assessment of the relevant clinical context and therefore, for the elaboration of a clinical dashboard.

Once the clinical context had been defined and the community members were recruited, meetings with all stakeholders including target users and relevant clinical specialists were organized to discuss which clinical concepts should be displayed in the concerned dashboard and how they should be visualized (e.g., with or without trend, combined with other data, graphical or numeric). The presence of the target users in the community assisted to answer a fundamental practical question: how the developed dashboard could boost effectiveness and facilitate the end users' already existing activities and processes. In meetings, the SMART (Specific, Measurable, Achievable, Relevant, Time-bound) goal planning method was adopted [5]. The SMART-based requirements were documented during the meetings for subsequent validation by the working group, before embarking on development via dedicated tools assuring interoperability.

The evaluation was performed by users familiar with the clinical context covered by the dashboard, who were not involved in the dashboard design. After presentation and walkthrough, the evaluators scored the dashboard via a questionnaire, based on System Usability Scale [6,7] and using a 5-point Likert scale, from 1 (strongly disagree) to 5 (strongly agree). The standard SUS questions were adapted to our use case. Another four questions were added to elicit general feedback on usefulness, impact on quality of care and patient safety, and design.

3. Results

We applied the proposed framework to develop a clinical dashboard for sepsis in the following steps:

Phase 1: The clinical context was defined as patients with sepsis and suspected sepsis who are admitted to, or being treated in the intensive care unit (ICU). Target users involved in the relevant community group included five intensivists, four internists and four infectious diseases specialists, all experienced in managing patients with sepsis.

Phase 2: Official sepsis guidelines, released by Deutsche Sepsis Gesellschaft e.V. and provided by the Association of the Scientific Medical Societies in Germany (AWMF) [8], were studied by the working group to select the relevant clinical concepts which should be displayed on the dashboard. Standard clinical concepts mapped to official terminologies were then identified in the Clinical Knowledge Platform (CKP)[2].

Phase 3: Widgets were designed to reflect the requirements identified in phase 2 on the dashboard (Table 1). A screen shot of the dashboard is given in figure 2.

Table 1. Sepsis dashboard requirement components. The relevant clinical concepts to be displayed are categorized by various widgets.

Widget	Description of items
Main diagnosis	Main diagnosis with the point in time when this diagnosis was determined/changed
SOFA	Sequential Organ Failure Assessment Score and trend from admission to current. Highlighted if ≥2
MAP, Lactate, Weight	Mean arterial pressure (MAP); Lactate Level; Actual body weight
Infection	Body temperature and 48 h trend; infection-relevant lab values; Highlighting of Values out of range. Important events (surgical intervention, specimen sampling). Microbiology status and results. Related medication

Cardiovascular	MAP, Heart rate and respective trends. Most recent Cardiac Output (CO) and -index (CI. Flip-card-behavior to show more details on cardiac parameters
Respiratory	SpO_2, Respiratory rate, $ScvO_2$ and respective 24h trends. O_2-administration
Fluid balance	Fluid balance, arterial pH and 24h trend
Metabolism	Blood glucose and 24h trend, indicator if insulin administered.
Neurology	Glasgow coma scale and trend from admission to current.
Coagulation	INR, Thrombocytes, D-Dimer
Renal	Creatinine, GFT and Urea parameters
Gastrology	ALT, AST, Bilirubin
Tasks	Relevant one-off and recurring care activities and respective status
Specific medication	Includes drug therapy with vasoactive, anti-infective, coagulation modulation, homeostasis, and metabolic correction (e.g., insulin) intention
Recommendations	Clinical decision support recommendations

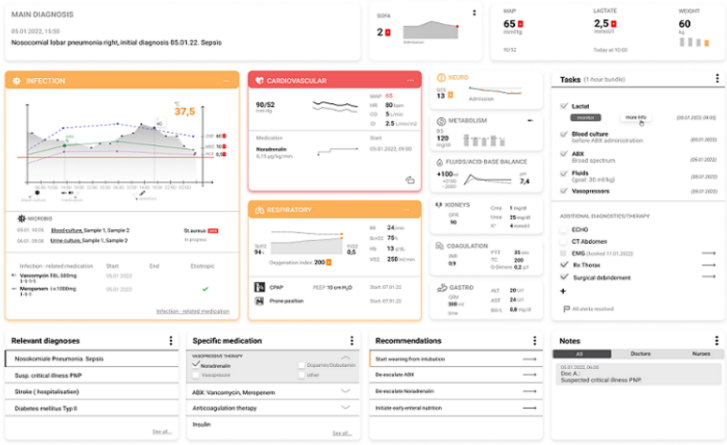

Figure 2. Sepsis dashboard front end view.

Phase 4: 18 physicians from various health care institutions in Australia, Germany, Switzerland, UK, and Italy independently evaluated the sepsis dashboard user experience (clinical UX). Table 2 shows the results of the evaluation.

Table 2. Dashboard evaluation results (SUS Score).

Question	Mean	Standard deviation
I think that I would like to use this dashboard frequently	4.12	0.47
I found the dashboard unnecessarily complex	1.94	0.73
I thought the dashboard was easy to use	3.81	0.81
I think that I would need the support of a technical person to be able to use this dashboard	1.88	1.23
I found the various widgets in this dashboard were well integrated	4.00	0.49
I thought there was too much inconsistency in this dashboard	1.82	0.51
I would imagine that my colleagues would learn to use this dashboard very quickly	3.88	0.83
I found the dashboard very cumbersome to use	2.00	0.84
I would feel very confident using the dashboard	4.00	0.49
I would need to learn a lot of things before I could get going with this dashboard	1.81	0.81

The average SUS score for the dashboard was 75.9, which means that the clinical UX received very positive feedback from the target users. Almost all gave a high appreciation of usefulness and design and expected positive impact on quality of care and patient safety.

4. Discussion

Effective medical record consultation relies on clear, easily accessible information. Our study introduces a model for clinical dashboards, using a sepsis dashboard as an example. Built on a structured knowledge base like CKP [2], it offers customization and semantic interoperability, providing a quick overview of a patient's clinical status. Positive feedback on the dashboard's clinical UX underscores the importance of involving healthcare professionals in design. The involvement of concerned HCPs in the conception or development of the digital applications has been shown to enhance the usability of software [9].

The SUS method that we used for evaluation, has been used in other studies to evaluate various systems including clinical dashboards [10].

5. Conclusions

In conclusion, our study advances medical record usability with a model for clinical dashboards. It enhances information clarity and accessibility, potentially improving healthcare decision-making. User involvement is crucial in design. A quantitative evaluation of the impact of the dashboards in terms of behavior of target users and patient outcome would be of considerable interest. Further evaluation of clinical dashboards is required to confirm the generic nature of the method.

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