Digital Health and Informatics Innovations for Sustainable Health Care Systems
J. Mantas et al. (Eds.)

doi:10.3233/SHTI240769

Mapping Medical Context: Workshop-Driven Clustering of Influencing Factors on Medical Decision-Making

Katharina SCHULER[a,1], Martin SEDLMAYR[a], Brita SEDLMAYR[a]
[a] *Institute for Medical Informatics and Biometry, Carl Gustav Carus Faculty of Medicine, Technical University Dresden, Dresden, Germany*
ORCiD ID: Katharina Schuler https://orcid.org/0009-0005-7054-4059

Abstract. Clinical decision support systems (CDSS) can efficiently support doctors in coping with ever-increasing amounts of data by providing evidence-based recommendations for medical decisions. To integrate the systems into the medical workflow and provide patient-specific recommendations for action in the context of personalized medicine, it is essential to tailor the systems to the context of use. This study aims to present an overview of factors influencing medical decision-making that CDSS must consider. Our approach involves the systematic identification and categorization of contextual factors relevant to medical decision-making. Through extensive literature research and a structured card-sorting workshop, we systematized 774 context factors and mapped them into a model. This model includes six primary entities: the treating physician, the patient, the patient's family, disease treatment, the physician's institution, and professional colleagues, each with their relevant context categories. The developed model could serve as a foundation for communication between developers and physicians, supporting the creation of more context-sensitive CDSS in the future. Ultimately, this could enhance the utilization of CDSS and improve patient care.

Keywords. Medical Decision-Making, Context Factors, Context Model, Clinical Decision Support Systems, Card Sorting.

1. Introduction

Clinical Decision Support Systems (CDSS) are playing an increasingly significant role in the realm of personalized healthcare. CDSS are capable of deriving evidence-based recommendations from the constantly growing data volumes, thereby efficiently assisting physicians in diagnostic and therapeutic decisions [1]. However, decision-making regarding individual patient care represents a complex and context-dependent process, significantly influenced by situational factors [2] and is inadequately considered by existing CDSS [3]. Context can be understood as any information essential for characterizing the situation of an entity, where an entity can be a person, a place or an object [4]. The inadequate adaptation of CDSS to the medical decision-making context is evident, when unwanted input prompts or the presentation of irrelevant information

[1] Corresponding Author: Katharina Schuler, Institute for Medical Informatics and Biometry, Carl Gustav Carus Faculty of Medicine, Technical University Dresden, Dresden, Germany; Katharina.schuler1@tu-dresden.de.

and warnings occur, which can severely disrupt workflow and ultimately lead to safety-critical consequences endangering patient safety [5]. To ensure appropriate knowledge modeling of CDSS and enable systems to provide patient-centered recommendation support, a structured representation of the decision context is essential. Although a multitude of relevant context factors in medical decision-making have been investigated to date, there is still a lack of a systematic compilation and categorization of these influencing factors.

Therefore, the aim of this study is to systematically categorize and classify influencing factors in medical decision-making on the basis of previously investigated factors in order to be able to describe the context of the medical decision-making process in more detail and thus realize a basis for the future design of context-sensitive clinical decision support systems.

2. Methods

In order to describe the context of medical decision-making more precisely, a scoping literature analysis was carried out in accordance with the PRISMA guidelines [6] to identify relevant contextual factors. The search was conducted in eight different databases (PubMed, CINAHL, Scopus, Embase, Web of Science, APA PsycInfo, PSYINDEX, LIVIVIO) and integrated both free-text terms and medical subject headings associated with the topics of medical-decision making and contextual factors. Only factors that are not directly biomedically related to the primary diagnosis, and can thus be understood as contextual influences on medical decision-making, were extracted. Through the Scoping Review, a total of N = 84 relevant articles were identified, from which a total of N = 774 different context factors were extracted. The context factors extracted from the literature then formed the basis for carrying out the Card-Sorting.

A card sorting workshop [7] was then held to enable a suitable context categorization to be made on the basis of the identified context factors. For this purpose, the literature-based factors were written on cards so that each factor corresponded to a card used in the workshop. A total of n = 4 participants took part in the workshop, consisting of n = 3 experts from the field of human-computer interaction and n = 1 student assistant from the field of computer science. The card sorting was conducted over three consecutive days in November 2023, with each session taking place within a 4h time frame. For the categorization of the context factors, the generally valid context definition of [8] was used. According to [8] the context of each entity is composed of the descriptive properties and attributes (individuality context), the descriptive time information (time context), information about relationships and semantic dependencies (relational context), the activities involved (activity context) and the location (location context). The definition of an entity was determined as the first categorization. The basic context categories according to [8] formed the subsequent categorization level, which served as a pre-categorization in the sense of a closed card sort (Fig. 1). The task of the workshop participants in this step was to assign the factor card to the corresponding context category (Fig. 1, step 1). The second step consisted of an open card sort, where the workshop participants were asked to group similar cards within a category by consensus (Fig. 1, step 2). Once a grouping of factors was achieved, the final step was to find a name for the formed category through consensus building among the participants (Fig. 1, step 3).

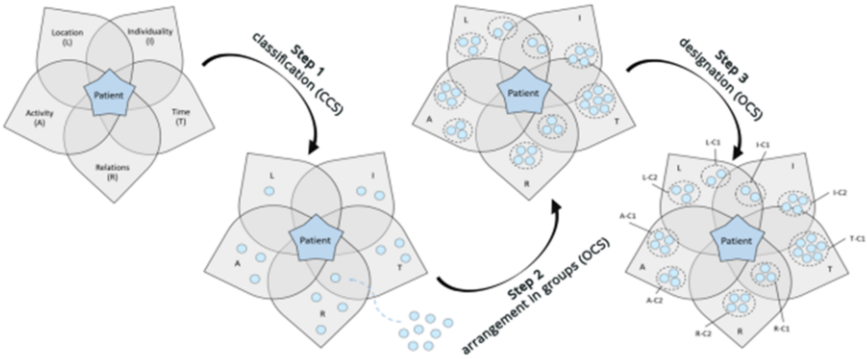

Figure 1. Procedure of the card sorting workshop. CCS = closed card sort; OCS = open card sort.

3. Results

Through the Card-Sorting process, a total of n = 6 entities were identified as relevant in the context of clinical decision-making. These entities include the treating physician, the patient, the patient's family, the disease treatment, the institution where the physician works, and the physician's colleagues. Of the context factors (n = 774) identified through literature analysis, 42% (n = 323) were assigned to the entity 'Physician', 29% (n = 227) related to the 'Patient', 5% (n = 36) to the 'Patient's Family', 5% (n = 39) to 'Peers', 12% (n = 96) to the 'Institution', and 7% (n = 53) to 'Disease Treatment'. In total, the assigned context factors resulted in n = 91 context categories, of which 22% (n = 20) were assigned to the entity 'Physician', 33% (n = 30) to the 'Patient', 13% (n = 12) to the 'Patient's Family', 13% (n = 12) to 'Peers', 8% (n = 7) to the 'Institution', and 11% (n = 10) to 'Disease Treatment'

Based on the identified entities and context categories, a context model was subsequently created (Figure 2). Each entity and its underlying context categories (Individuality, Activity, Time, Relationships, Location) are color-differentiated from each other. As in the Card-Sorting process, the respective entity was established as the first level (octagons) in the model. The second level (rectangles) was assigned the fundamental context categories. On the third level of the model (ellipses), the identified context categories are organized accordingly. Direct connections between entities are represented in the model as dashed arrows. In addition to depicting the identified context categories, the context model also represents the existing relationships between entities. These relational connections are symbolized in the model by dashed arrows. As illustrated in Figure 2, there is an interactive relationship between the entities ‘Physician’, ‘Patient’, ‘Patient's Family’, and ‘Disease Treatment’, whereas the entities ‘Physician’ and ‘Institution’ have a location-based relationship.

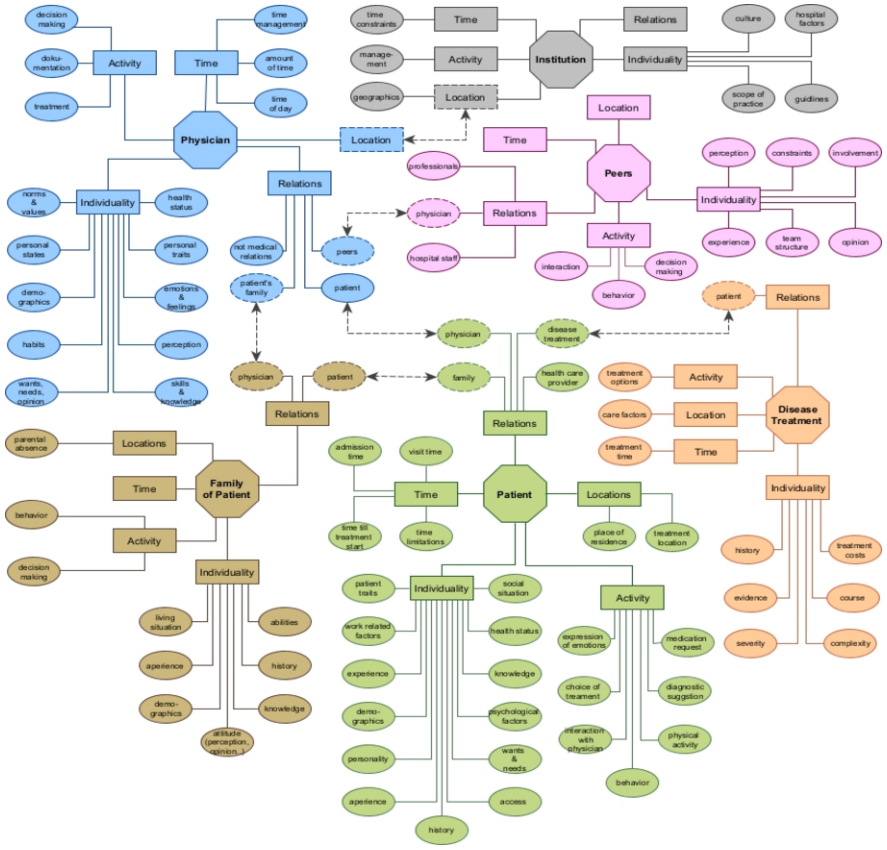

Figure 2.Schematic representation of the identified context categories in medical decision-making.

4. Discussion

This study aimed to categorize and model contextual factors from a literature review to better understand the complexity of medical decision-making. A card sorting workshop structured the key entities and their characteristics influencing the decision-making process. In contrast to previous models of medical context, which are not based on a systematic evaluation of evidence-based knowledge or are tailored for specific specialties (e.g., physiotherapy as discussed by [2]) or particular diseases (e.g., kidney cancer as per [9]) the context model developed in this work offers a comprehensive overview of contextual factors impacting medical decision-making.

This model, grounded in a universally applicable definition of context, aids developers in identifying relevant entities and their characteristics during the development of clinical decision support systems. In the development process of context-sensitive systems, comprehending the concept of context can pose a challenge [10]. Consequently, a model representation of the entities and their attributes involved in the medical decision-making process can be instrumental for developers. This approach helps identify critical factors and facilitates communication between developers and physicians. This structured representation clarifies the variables influencing medical

decisions, streamlining their integration into system design and enhancing the synergy between technical development and medical expertise. However, the study does not yet provide a method for integrating these factors into CDSS. Future research should therefore investigate how the factors presented in the context model can be adequately implemented in CDSS. Considering the context model is solely based on factors that have been previously investigated in the medical settings, it is important to acknowledge that it might not yet encapsulate the full spectrum of contextual influences. However, this model serves as a pivotal reference for future research efforts focusing so far unexamined contextual influences in medical decision-making. Additionally, it provides a structured framework for physicians to integrate influential contextual factors into their decision-making processes, facilitating the development of more accurate and patient-centric treatments.

5. Conclusion

The context model developed in this study is a significant contribution towards the development of context-sensitive CDSS in personalized medicine. It provides a comprehensive framework for understanding and integrating various context factors in clinical decision-making, paving the way for more personalized, informed, and efficient patient care.

References

[1] Sutton RT, Pincock DC, Baugart DC, Sadowski DC, Fedorak RN, Kroeker KI. An overview of clinical decision support systems: benefits, risks, and strategies for success. Npj Digit. Med. 2020;17(3) 1–10, doi:10.1038/s41746-020-0221-y.

[2] Smith M, Higgs, J, Ellis, E. Factors influencing clinical decision making. In: Higgs, J, Jensen, GM, Loftus, S, Christensen, N. Clinical reasoning in the health profession. 3rd ed. Sydney: Butterworth-Heinemann; 2008. p. 89-100.

[3] Abell B, Naicker S, Rodwell D. Donovan T, Tariq A, Baysari M, Blythe R, Parson R. Identifying barriers and facilitators to successful implementation of computerized clinical decision support systems in hospitals: a NASSS framework-informed scoping review. Implement Sci. 2023 Jul;18(1):32, doi:10.1186/s13012-023-01287-y.

[4] Dey AK, Abowd GD, Salber D. A Conceptual Framework and a Toolkit for Supporting the Rapid Prototyping of Context-Aware Applications, Human–Computer Interaction. 2001;16(2-4):97-166, doi:10.1207/S15327051HCI16234_02

[5] Wake DT, Smith DM, Kazi S, Dunnenberger HM. Pharmacogenomic Clinical Decision Support: A Review, How-to Guide, and Future Vision, Clinical Pharmacology & Therapeutics. 2022 Jul;112(1): 44-57, doi: 10.1002/cpt.2387.

[6] Tricco AC, Lillie E, Zarin W, O´Brien KK, Colquhoun H. Levac D, Moher D, Peters MDJ, Horsley L, Weeks L, Hempel S, Akl EA, Chang C, McGowan J, Stewart L, Hartling L, Aldcroft A, Wilson MG, Garritty C, Lewin S, Godfrey CM, Macdonald MT, Langlois EV, Soares-Weiser K, Moriarty J, Clifford T, Tuncalp Ö, Straus SE. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. Ann Intern Med. 2018;169:467-73, doi:10.7326/M18-0850.

[7] Spencer D, Garret JJ. Card Sorting: designing usable categories. Brooklyn (NY): Rosenfeld; 2009.

[8] Zimmermann A, Lorenz A, Oppermann R. An Operational Definition of Context. In: Kokinov B, Richardson DC, Roth-Berghofer TR, Vieu L, editor. Modeling and Using Context. Berlin (DE): Springer; 2007. p. 558-71, doi:10.1007/978-3-540-74255-5_42.

[9] Beyer K, Barod R, Fox L, Van Hemelrijck M, Kinsella N. The Current Evidence for Factors that Influence Treatment Decision Making in Localized Kidney Cancer: A Mixed Methods Systematic Review. J Urol. 2021 Oct;206(4):827-39, doi:10.1097/JU.0000000000001901.

[10] Vieira V, Tedesco P, Salgado AC. Designing context-sensitive systems: An integrated approach, Expert Systems with Applications. 2011 Feb; 38(2):1119-39, doi:10.1016/j.eswa.2010.05.006.