Influencing factors of physician acceptance of AI-based clinical decision support systems (AI-CDSS) for diagnosis of rare diseases[1]

Ulrike Pietrzyk & Michael Gühne

TU Dresden, University of Technology, Faculty of Psychology

ABSTRACT

AI-CDSS can significantly enhance the decision-making performance of physicians who are not specialists in diagnosing rare diseases. Acceptance of the AI-CDSS is crucial for its effective use. In the Leuko-Expert project, the factors influencing physician acceptance of AI-CDSS were examined. This article introduces how these influencing factors were identified through a systematic review. Subsequently, semi-structured interviews were conducted to explore additional influencing factors for the use of AI-CDSS in the context of leukodystrophy. Finally, we discuss the limitations of transferring these findings to other rare disease cases and suggest directions for future research.

Keywords

Clinical decision support system (CDSS) – rare diseases – AI-supported diagnosis – physician acceptance

1 Introduction

According to the EU definition, a rare disease affects five or fewer people in 10,000. As approximately 8,000 rare diseases are identified, the World Health Organization (WHO) estimates that around 400 million people worldwide are affected by rare diseases (Kaplan et al., 2013).

AI-supported clinical decision support systems (AI-CDSS) can improve the often incorrect or delayed diagnosis of rare diseases by physicians not specialized in rare diseases. This improvement can enable or accelerate the referral of affected patients to specialized centers for rare diseases. In the following, the term „physicians“ refers only to physicians who do not specialize in rare diseases. The aim of the joint research project Leuko-Expert (https://leukoexpert.hs-mittweida.de), funded by the German Federal Ministry of Health (BMG) from 2020 to 2024, was to develop an AI-CDSS for diagnostic support of rare diseases using the Leukodystrophy case. In the context of Leuko-Expert, the term AI refers to machine learning models.

AI-CDSS can only improve the often incorrect or delayed diagnosis of rare diseases if physicians use it as intended in the diagnostic process. Physician acceptance of the AI-CDSS is an essential prerequisite for its intended use (Romero-Brufau et al., 2020), therefore factors influencing physician acceptance should be considered during software development, evaluation, and implementation.

However, since the literature lacks analyses of the factors influencing physician acceptance of AI-CDSS in rare diseases, these were investigated in the Leuko-Expert project and taken into account in developing and evaluating the AI-CDSS for Leukodystrophy. The influencing factors identified for the intended use of AI-CDSS in the Leuko-Expert project, which focused on leukodystrophy, can also be applied to other rare disease cases (Gühne & Pietrzyk, 2023; Pietrzyk & Gühne, 2022). If the developed AI-CDSS is to be expanded to include other rare diseases or if many rare diseases are to be integrated into another AI-CDSS, the factors influencing acceptance should again be considered during software development, evaluation, and implementation. This article analyzes how the factors influencing physician acceptance of AI-CDSS, identified in the Leuko-Expert project using Leukodystrophy as an example, can be transferred to other rare diseases.

Section 2 and 3 illustrates the methodological approach used in the Leuko-Expert project to investigate the factors influencing acceptance. Section 4 discuss-

[1] This paper is dedicated to Prof. Dr. rer. nat. habil. Dr. phil.h.c. Winfried Hacker.

2024 – *innsbruck* university press, Innsbruck
Journal Psychologie des Alltagshandelns / *Psychology of Everyday Activity*, Vol. 17 / No. 2, ISSN 1998-9970
DOI 10.15203/1998-9970-17-2-04

es, how far the identified influencing factors can be transferred to other rare diseases and outlines further necessary steps.

2 Examination of influencing factors in Leuko-Expert

2.1 Framework model

Since studies on factors influencing the physician acceptance of AI-CDSS for the diagnosis of rare diseases are lacking in the literature and since technology acceptance models (TAM1, TAM2, TAM3, UTAUT) have limited applicability in the healthcare sector (Ward, 2013), we adapted Bürg & Mandl (2005) framework model for investigating factors influencing attitude acceptance to focus the analysis and strucure the results (Müller-Böling & Müller, 1986).

The framework model distinguished influencing factors into three levels: (A) the product level, (B) the personal level, and (C) the institutional environment level. Based on ISO standard 9241-11 (2018), influencing factors at the level of the product can be divided into (A1) factors that affect the effectiveness of solving a task, (A2) factors that affect the efficiency of task processing, and (A3) factors that affect user satisfaction. According to Müller-Böling & Müller (1986), influencing factors at the level of the person can be divided into (B1) affective and (B2) cognitive factors. Regarding influencing factors at the level of the institutional environment in the medical context, the factors are divided into (C1) practice organization, (C2) practice staff, and (C3) practice environment.

2.2 Research question

The research question concerning which factors influence the acceptance of AI-CDSS by neurologists who do not specialize in rare diseases (Leukodystrophy is a neurological disease) is part of the question of which factors influence physician acceptance of CDSS. Since central challenges to acceptance arise in both cases, findings from the literature on CDSS acceptance by physicians were taken into account when searching for influence factors. Key challenges for the issue are: (a) fear of physician substitution, as CDSS for diagnosis intersects with the core medical activity, or (b) the high degree of physician autonomy, which allows physicians to decide whether to use the software.

However, very few studies adress (a) specifics of AI-CDSS (e.g., expectations or fears related to AI) or (b) specifics of the CDSS for rare diseases by neurologists or physicians in general (e.g., the challenge of integrating a CDSS for uncommon disease into routine diagnostic processes. Following this, it was necessary to explore these issues issues exploratively to address the question of the influencing factors in the Leuko-Expert project.

3 Methods and results

The data were collected and analyzed using a concurrent triangulation mixed methods design (Creswell et al., 2003). A systematic review was conductedd to examine factors influencing physician acceptance of CDSS. In addition, qualitative interviews were carried out to explore the two key issues identified in the literature.

3.1 Systematic review

The search string for identifying relevant studies on factors influencing physician acceptance of CDSS included English terms and synonyms related to CDSS, physicians (linked to NEAR50), and acceptance (linked to AND). Variations in terms were taken into account using wildcards. The search string was applied to titles, abstracts, and keywords in general databases in psychology, computer science and medicine (ACM Full-Text Collection, ACM Guide To Computing Literature, Business Source Complete, PsycArticles, PsycInfo, PSYNDEX, Scopus, Web Of Science Core Collection, Medline), which were accessed using the ACM, Scopus, Ebsco and Web Of Science search interfaces. A total of 15,557 articles (approximately 50% were duplicates due to the many databases) were identified. Twelve articles were identified after two reviewers independently performed title-abstract and full-text screening.

The identified articles were analyzed using a qualitative meta-analysis (Stratton, 2019) implemented as a qualitative content analysis (Mayring, 2015). The structure of the influencing factors was based on the framework model used.

As a result, 27 influencing factors affecting physician acceptance were identified, across the levels of product, person, and institutional environment. Examples of influencing factors at the product level are „information quantity“, „information specificity“, or „integration into the current system“. Influencing factors at the person level include „trust in the system“, „clinical experience level“, or „consultation with patients“. At the institutional environment level, „social support“, „ICT infrastructure“, and „workflow“ were identified as influencing factors. Different requirements were found for the implementation of the 27 influencing factors. As some requirements compete with each other, such as the need for comprehensive or little information to be presented in the „information quantity“ influencing factor, translating and implementing them in practice is not trivial.

3.2 Semi-structured interviews

Based on the framework model, semi-structured interviews were conducted using rare disease Leukodystrophy to investigate which factors influence neurologists' acceptance of AI-CDSS.

The sample encompassed interviews with Dresden, Ulm, Dessau, and Aachen neurologists. In the first part of the questionnaire, the diagnostic process of rare diseases in medical practices was reconstructed, and participant's experiences (if available) and expectations of a CDSS for diagnosing rare diseases were collected. The second part of the questionnaire contained questions about factors influencing acceptance at the product, person, and institutional environment levels. To support understanding, a mockup of an AI-CDSS for Leukodystrophy (based on the initial results of the review) was demostrated, including features such as starting from the practice management system, data import, data entry, and presentation of the results.

The interviews were analyzed using qualitative content analysis using the „content structuring" analysis subtype (Mayring, 2015, p. 103). The starting category system was based on the framework model.

As a result, influencing factors were identified in all eight categories of the framework model. At the product level they include, for example, the „coverage of integrated rare diseases" in an AI-CDSS, the „handling of gaps in the knowledge of physicians," or „possibilities of text mining" in order to use existing documents. At the individual level, „knowledge of the frequency of rare diseases", „personal interest in the topic of rare diseases," or „prejudices and fears" are relevant. Influencing factors at the institutional environment level relate to „additional work for non-physicians", the „self-image of the medical profession", and the „flat-rate treatment system" in the German healthcare system. As the review results indicate, meeting the specific requirements associated with the influencing above poses significant challenges.

4 Transfer of results to other rare diseases

4.1 Transfer of literature review results

The search string and the inclusion and exclusion criteria for conducting the review did not contain any restrictions regarding specific diseases. Therefore, the identified factors influencing physician acceptance can be transferred to other rare diseases and diseases in general.

However, as the articles reviewed are almost exclusively qualitative studies, it is impossible to estimate the relevance of the identified influencing factors by the Leuko-Expert review or other rare diseases.

4.2 Transfer of semi-structured interview results

The questions in the first part of the questionnaire for the semi-standardized interviews related to rare diseases in general, whereas the questions in the second part were asked in the context of the Leukodystrophy. Since the interviews discussed to rare diseases in general and the factors identified in the evaluation of the interviews do not contain any specifics of leukodystrophies, the identified influencing factors can, therefore, be transferred to other rare diseases.

The exception is the „scope of data input" factor in framework dimension A1 (factors that affect the effectiveness of solving a task). This factor implies that all medical data required for correct diagnosis is requested. The medical data required for correct diagnosis varies between rare diseases, so it must be collected individually for each rare disease.

Similary to the Leuko-Expert review, due to the methodology of the semi-structured interviews and the qualitative content analysis limits to access the relevance of the identified influencing factors by the Leuko-Expert interviews or other rare diseases.

4.3 Recommended further steps

In summary, the influencing factors identified by the literature review and the semi-structured interviews can be transferred to other rare diseases. However, the medical data required for accurate diagnosis must be collected separately for each rare disease. It is important to note that the results of the Leuko-Expert project indicated that physicians have different opinions on the medical data should required for diagnosing of Leukodystrophies. Therefore, collecting these values should be based on the information provided by several physicians so that no relevant data remains unconsidered.

Based on the framework model, the methodological approach in the Leuko-Expert project was designed to cover the range of influencing factors as comprehensively as possible to map the requirements of physicians for an AI-CDSS. On the other hand, the impact of the identified factors on physicians' acceptance of AI-based CDSS remained uncertain. However, understanding the relevance of these factors is important due to their potential to enhance software development, evaluation, and implementation.

If the AI-CDSS developed in the Leuko-Expert project is to be expanded to cover other rare diseases, or if multiple rare diseases are to be integrated into a different AI-CDSS, the influencing factors identified for leukodystrophies can offer a broad and reliable foundation for ensuring acceptance. It is advisable to proceed by standardizing the evaluation of the significance of influencing factors, in conjunction with in-

cluding open-ended inquiries pertaining to all facets of the framework model. The medical data required for the accurate diagnosis should be clearly speficied. The selection of subjects should be representative of the physicians within the target population. With this approach, the identified influencing factors can be integrated, weighted, and, if necessary, expanded. The AI-CDSS developed as part of the Leuko-Expert project can serve as a pilot study for the survey with minor adjustments.

5 Conclusion

The article demonstrate how the influencing factors identified in the Leuko-Expert project can be transferred to other rare diseases. It contributes to the technology acceptance literature. Transferring the results into medical practice could improve physicians' diagnostic processes for rare diseases and support promptly and effective treatment for affected patients.

References

Bürg, O. & Mandl, H. (2005). Akzeptanz von E-Learning in Unternehmen. *Zeitschrift für Personalpsychologie*, *4* (2), 75-85. https://doi.org/10.1026/1617-6391.4.2.75

Creswell, J. W., Plano Clark, V. L., Gutmann, M. L. & Hanson. W. E. (2003). Advanced mixed methods research designs. In A. Tashakkori & C. Teddlie (Eds.), *Handbook of mixed methods in social and behavioral research* (pp. 209-240). Thousand Oaks, CA: Sage.

DIN EN ISO 9241-11:2018-11 (2018). *Ergonomie der Mensch-System-Interaktion-Teil 11: Gebrauchstauglichkeit: Begriffe und Konzepte*. Beuth-Verlag. https://dx.doi.org/10.31030/2757945

Gühne, M. & Pietrzyk, U. (2023). Erste Ergebnisse der Analyse zur Akzeptanz eines KI-basierten Lotsensystems durch Neurologinnen und Neurologen bei Seltenen Erkrankungen. In Gesellschaft für Arbeitswissenschaft e.V. (Eds.), *Nachhaltig Arbeiten und Lernen, 69, Kongress der Gesellschaft für Arbeitswissenschaft* (B.5.2). Dortmund: GfA Press.

Kaplan, W., Wirtz, V. J., Mantel-Teeuwisse, A., Stolk, P., Duthey, B. & Laing, R. (2013). *Priority Medicines for Europe and the World – 2013 Update*. World Health Organization.

Mayring, P. (2015). *Qualitative Inhaltsanalyse. Grundlagen und Techniken*. Weinheim, Basel: Beltz.

Müller-Böling, D. & Müller, M. (1986). Akzeptanzfaktoren der Bürokommunikation. München u.a.: Oldenbourg.

Pietrzyk, U. & Gühne, M. (2022). Einflussfaktoren ärztlicher Akzeptanz KI-basierter Lotsensysteme bei Seltenen Erkrankungen. In S. Rehmer & C. Eickholt (Eds.), *22. Workshop Psychologie der Arbeitssicherheit und Gesundheit. Transfer von Sicherheit und Gesundheit* (pp. 181-184). Kröning: Asanger Verlag.

Romero-Brufau, S., Wyatt, K. D., Boyum, P., Mickelson, M., Moore, M. & Gognetta-Rieke, C. (2020). A lesson in implementation: A pre-post study of providers' experience with artificial intelligence-based clinical decision support. *International Journal of Medical Informatics*, *137*, 104072. https://doi.org/10.1016/j.ijmedinf.2019.104072

Stratton, S. J. (2019). Literature Reviews: Methods and Applications. *Prehospital and Disaster Medicine*, *34* (4), 347-349. https://doi.org/10.1017/S1049023X19004588

Ward, R. (2013). The application of technology acceptance and diffusion of innovation models in healthcare informatics. *Health Policy and Technology*, *2* (4), 222-228. https://doi.org/10.1016/j.hlpt.2013.07.002

Correspondence to:
TU Dresden, University of Technology
Faculty of Psychology
Working Group Knowledge-Thinking-Action
D-01062 Dresden
agwdh@tu-dresden.de