Intelligent Systems and Hospitals: Joint Forces in the Name of Health?

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Abstract. In recent times, intelligent systems based on artificial intelligence have gained relevance for a variety of industries. Their potential is particularly high in healthcare, where they could be used for prevention, diagnosis and follow-up-care. However, their adoption requires that healthcare delivery organizations are able to integrate the new technology into their processes, systems, and values – a task, that most hospitals have not yet been able to accomplish. To learn more about this issue, we conducted a systematic literature search and found, that little is known regarding the specific aspects that influence hospitals to continuously adopt intelligent systems. Based on this finding and drawing on the TOE and NASSS framework, we want to conduct semi-structured expert interviews with hospital management and physicians. The aim of our research is to analyse the specific requirements of hospitals and thus contribute to a theoretical foundation of intelligent systems' persistent adoption.

Keywords: Artificial Intelligence, Intelligent Systems, Hospitals, Adoption, Implementation

1 Introduction

Hospitals are an instance that helps to ensure the medical care of the population. These highly specialized organizations with complex processes are subject to constant technological change [1]. In recent times, another force has gained more and more relevance – also for medical applications: Artificial intelligence (AI) as the "science and engineering of making intelligent machines, especially intelligent computer programs" [2, p.2] enables systems to perform tasks we previously thought could only be performed by humans. Intelligent systems as the concrete implementation of AI rely on related technologies like deep learning, machine learning and natural language processing and differ from conventional systems as they are trained by the incoming data rather than being explicitly programmed. In this regard, intelligent systems can be distinguished from existing technologies as they are able to exceed human capabilities in a particular task, show a distinctive black box behaviour, adapt their actions continuously based on experience, derive their results statistically, and thus will unavoidably make mistakes [3–6].

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In order to better understand possibilities of AI for medicine, a vast amount of research is being done regarding the medical and technical feasibility of intelligent systems in this field [e.g., 7–9]. Accordingly, intelligent systems could be used to automatically make diagnoses, decide who should be admitted to hospital or to schedule operating rooms efficiently [10]. Hospitals increasingly attempt to adopt intelligent systems to ensure more effective care at lower costs. Nevertheless, many hospitals are currently unable to fully integrate the technology into their processes and exploit the advantages described [11]. So far, there is only little discussion in pertinent information systems (IS) literature that could help clinics to continuously adopt the new technology effectively. The only studies available deal with the integration of intelligent systems in general enterprises and do not consider the particular demands of hospitals [e.g., 12, 13]. As intelligent systems can be self-adaptive, non-transparent and biased [3, 4], hospitals with their human-centric processes indeed have specific requirements for the integration of AI applications (e.g., ethical evaluation, clinical approval, privacy concerns) and therefore require specific consideration [11]. Therefore, we would like to investigate, *which specific factors influence the decision and ability of hospitals to adopt intelligent systems and put them into routine practice?*

In order to gain initial insights regarding this research topic, a systematic literature review is carried out and first results are described. This research-in-progress work also discusses how subsequent qualitative expert interviews could be designed and evaluated to obtain empirical insights from practice. In that regard, we chose to bring together the *technological-organizational-environmental framework* (TOE) [14] and the *framework of nonadoption, abandonment, scale-up, spread, and sustainability* (NASSS) [15] as a larger conceptual basis [16]. While TOE is is widely used in pertinent IS research [e.g., 17–19] and helps to understand the readiness of an organization to adopt a new technology [e.g., 20–22], adoption research in health informatics shifted its focus from the pure adoption decision towards the abandonment and dissemination of health information technology (HIT) [23, 24]. We therefore included NASSS, which was originally developed for the healthcare context and which focuses on the implementation process of an HIT in clinical practice [15]. Both frameworks will be combined and expanded by evaluating the expert interviews in order to better understand the continued adoption of intelligent systems in hospitals.

2 Systematic Literature Review

In order to identify the relevant publications from pertinent disciplines (i.e., informatics, IS, medicine), a systematic literature review was carried out in May 2019 applying established guidelines [25, 26]. We started the review by defining a search term that comprised three components: (1) adoption, (2) intelligent system and (3) hospital. As continued adoption also requires the implementation into routine practice, implementation is added to the search string. Furthermore, as intelligent systems comprise a variety of technologies, the second component was extended by

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conducting an initial search in recent IS literature [3, 27]. The keyword hospital was discussed in the research team, to find synonyms and related expressions (i.e., terms referring to hospital, its environment, and stakeholders) to obtain an informed database on the still highly recent topic. This yielded to the following search query: *(("adoption" OR "implementation") AND ("intelligent system" OR "artificial intelligence" OR "deep learning" OR "expert system" OR "intelligent decision support system" OR "machine learning" OR "neural network") AND ("hospital" OR "clinic" OR "disease" OR "doc*" OR "health*" OR "medic*" OR "patient" OR "physician")).*

Next, appropriate databases regarding the topic were selected [26]. These included ACM Digital Library, AIS Electronic Library, EBSCOhost, ScienceDirect and WebOfScience as well as the library PubMed, which comprises biomedical literature. Moreover, we searched in the senior scholars' basket of journals to further extend the scope of our review. Due to the different technical requirements of the several databases, the search terms varied slightly. Furthermore, we limited our search to the years 2001 to 2019, as intelligent applications have gained considerable practical relevance within these years [28].

Our procedure resulted in 2,174 publications, which were subsequently cleared of duplicates with the help of Citavi. As a next step, we scanned titles and abstracts according to inclusion and exclusion criteria to ensure that only publications relevant to the research questions are analysed [26]. In that regard, publications have been included (1) that clearly identify factors impacting the continued adoption of intelligent systems in hospitals. Furthermore, only publications are taken into account (2) which are fully reviewed and published in journals or at conferences. Irrelevant publications to this review are articles (3) solely focused on technical details concerning the development of intelligent systems. Applying the criteria on abstracts and titles left 59 publications for full text analysis. Examining the whole text, further reduced the number of relevant papers to 36. Additionally, we intend to conduct a forward and backward search based on the publications, which has not been carried out yet [26]. Nevertheless, some initial insights can be gained from the resulting set of publications.

As can be seen in figure 1, the application of intelligent systems in healthcare is a topic that has gained in importance within the last two years.

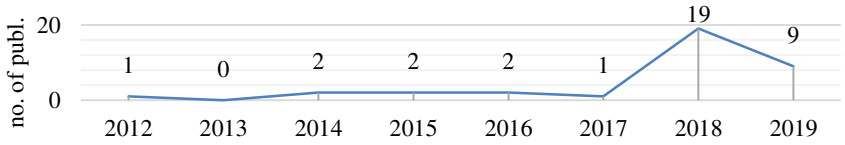

Figure 1. Number of publications per year as result of literature review

Regarding all 36 publications, a total of two were published at conferences and 34 in journals, of which most have a medical background. A detailed review of the literature reveals that many of the publications refer to medicine in general. However, some consider medical specialties and therefore show the wide applicability for AI in

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hospitals (e.g., radiology, oncology) [e.g., 29, 30]. Parties mentioned in the publications are doctors, nurses, patients and the management of clinics [e.g., 31–33]. Looking at the methodology, a majority of the publications are reviews and do not include empirical studies. In that regard, only two studies collected qualitative data [32, 34] and one had a mixed methods approach [35]. Furthermore, 31 of the 36 publications do not support their research with theoretical concepts at all. Despite the high scientific relevance of the topic, no publication could be found that provides empirically proven factors influencing the adoption decision or implementation of intelligent systems in hospitals and at the same time substantiates the findings with a theoretical background.

3 Further Procedure and Expected Contributions

Due to the lack of relevant literature, further qualitative-empirical research is necessary to gain a deeper understanding of the adoption mechanism concerning intelligent systems in hospitals [36]. In the next research step, we thus want to conduct semi-structured in-depth interviews with qualified stakeholders, who have expert knowledge of clinical processes, initial experience with intelligent systems, and who participate in hospital's decision making. In accordance with these requirements, we identified physicians and hospital managers, who have medical, technical, and strategical competence [37]. Taking into account the principles of Sarker et al. (2013), an interview guideline was prepared and tested in three initial interviews with two radiologists and one clinical manager [38]. Contact has already been established with other stakeholders who meet the aforementioned criteria. To evaluate the interviews, we intend to follow the steps of directed content analysis [39]. We base our research on the TOE and NASSS framework, to account for both the first organizational adoption decision as well as for the continued implementation of intelligent systems in a medical environment [16]. While the TOE framework covers readiness factors such as legacy systems or the managerial structure in an organization [14], the NASSS technology implementation framework considers factors as for example the value proposition or the adopter system (i.e., professional staff and patient), which determine the long-term integration of HIT [15]. Still, both frameworks only provide a generic theoretical basis and do not address the specific requirements of hospitals that seek to integrate intelligent systems. In line with directed content analysis, these frameworks will be used as a conceptual basis and be combined, adapted, and expanded through the semi-structured interviews [39]. To ensure validity of our qualitative research, we plan to apply investigator triangulation by involving multiple researchers in the study [40]. We also intend to further evaluate the publications found by literature review in order to integrate our findings with existing research.

The objective of this study is to identify the specific requirements hospitals face when trying to integrate intelligent systems in a medical setting and thus respond to the invitation of Davison and Martinsons (2015) to reflect explicitly on specific contexts when doing research [41]. Furthermore, we intend to conduct the first

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empirical study on the introduction of intelligent systems in hospitals, which is based on relevant theories [14, 15]. We hope that this will help us to understand the continued adoption of intelligent systems in hospitals and thereby contribute to the field of adoption and implementation research. Furthermore, we want to support clinical decision-makers to create the necessary conditions to effectively integrate intelligent systems into their work environment.

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