Engaging Stakeholders to Design an Intelligent Decision Support Tool in the Occupational Health Context

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Abstract
This paper presents a case study for the hands-on creation of an intelligent decision support tool (IDST) for occupational health (OH) physicians. We addressed this challenge through an iterative design process consisting of three phases with different levels of stakeholder involvement, spanning from understanding the context to developing the concept and consolidating the design. We identified a set of design considerations that focused on enriching data collection, improving the accessibility of information, and blending the decision support into the workflow. To demonstrate these insights, we developed the concept of an AI-based OH consultation, called ConsultAI. ConsultAI is a conversational assistant that can provide real-time decision support to OH physicians during clinical interviews. Based on this case study, we discussed stakeholder engagement in the design of IDSTs for OH physicians.

Author Keywords
Intelligent decision support tool; artificial intelligence; stakeholder engagement; occupational health.

CSS Concepts
• **Human-centered computing ~ Human computer interaction (HCI)**;

Introduction

In many industrial regions, workplace development has switched from productivity-oriented to sustainability-focused, where very much attention has been paid to improve health and promote a safety and health-oriented culture in the workplace [1]. As a result, a number of digital technologies have been investigated to improve the effectiveness of occupational health (OH) services. For example, human-computer interaction (HCI) systems such as activity trackers and exergames are increasingly utilized to blend healthful behaviors into the workaday context for preventing work-related suboptimal health status (e.g., [9–11]).

In addition to preventive healthcare, OH services also provide medical care for employees. In this context, OH physicians play a crucial role in diagnosing and treating occupational diseases, work-related illnesses and injuries, and conducting fitness-for-work physical examinations and reintegration to work plans [1].

Digital health technologies designed to support medical care practices have also been investigated extensively. Even six decades ago, Ledley and Lusted [6] envisaged computing systems as intelligent decision support tools (IDSTs) to assist with difficult decisions in clinical settings. Over recent years, the adoption of electronic health records and the rapid advance of artificial intelligence (AI) facilitate applications of IDSTs to medical decisions. Subsequently, many IDSTs have been introduced to provide insights on, e.g., patient diagnosis, probability of prognosis, and treatment options [13]. However, their usage rarely generates desired results. Musen and colleagues [7] showed that IDSTs commonly failed in adapting their technical features to specific medical contexts (e.g., OH).

Designing IDSTs for OH physicians is challenging. For instance, company doctors usually make decisions and recommendations based on multiple considerations, including both health and work-related information [12]. One potential solution to address complex needs in such a specific medical context is understanding opinions from multi-stakeholders [4]. Linking this to the HCI aspect, we set out a case study to investigate engaging stakeholders in designing an IDST that can be easily adopted and beneficial to OH physicians' work.

To this end, we carried out this study with a variety of stakeholders from a Dutch OH service company. We applied three levels of stakeholder engagement [2] into different phases of the design process, in order to understand the context, develop the concept, and consolidate the design. Our study resulted in a set of design considerations and a novel IDST design (namely: ConsultAI). ConsultAI features a dashboard with a conversational assistant that can be used during OH clinical interviews. ConsultAI leverages HCI and AI to enrich data collection, improve the accessibility of relevant information, and blend intelligent decision support into physicians' workflow.

The contributions of this case study are twofold: 1) It presents an approach to engage stakeholders in the design process of an IDST for a specific medical context (occupational health); 2) It describes the implications to the IDST design in the OH context by using a novel design concept (ConsultAI) as an example.

Methods

Background and Stakeholders

This case study was conducted at Human Total Care (HTC), an occupational health and safety service

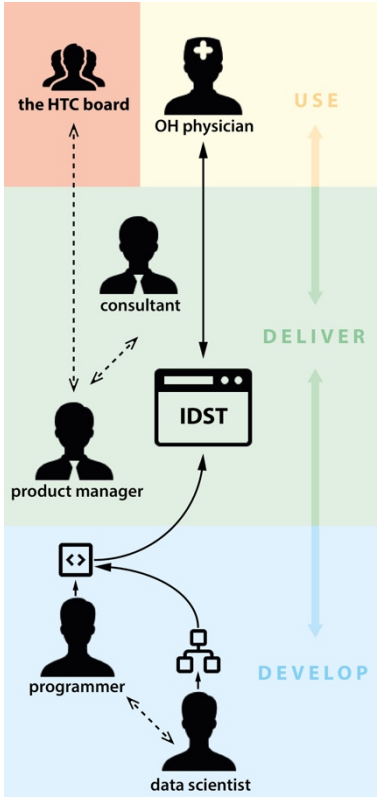

Figure 1: A visualization of existing experiences and relationships between stakeholders in HTC.

provider from the Netherlands. At HTC, one of the primary services is accommodating physicians to the working population. OH physicians are specialized in managing work-related conditions, illness prevention, pre-employment medical assessment, rehabilitation strategies, as well as helping employers identifying risks for the health and safety of their workers [1]. HTC uses electronic health records systems and decision support tools for facilitating OH physicians' daily work. Over recent years, HTC has investigated employing AI to further support absence management. From HTC's perspective, this study meant to research the next generation of IDSTs, which could be easily adopted by OH physicians in their work.

As shown in Figure 1, besides design researchers, five parties of HTC were involved in this project as stakeholders. Next, we outline our stakeholders' prior experiences with this design context.

- ***Occupational health physician:*** Both senior and junior OH physicians were involved in the research. All of them used electronic health records in their daily work, and few had experiences with using newly developed IDSTs.
- ***Research and development (R&D) consultant:*** One R&D consultant supported our design. At HTC, the role of R&D consultants is two parts. First, they interact with health professionals to help them solve problems of using the software. Second, they work together with the software developing teams to revise and improve the current solutions.
- ***Product manager:*** Two product managers were interviewed in the early design phase, and one of them participated in the entire design process. At HTC, product managers usually own one or more OH software. They supervise the development of the software from a higher level than R&D consultants. They regularly discuss with stakeholders as indicated in Figure 1 and report software research and development plans to the board of directors.
- ***Software programmer:*** One software programmer attended research activities at the beginning of our design process. The programmer worked on the maintenance of the software and also investigated the possibility of adding new features to the software-based services of HTC.
- ***Data scientist:*** Two data scientists were actively involved in this study. As part of the R&D department of HTC, data scientists work on modeling algorithms to provide predictions for OH professionals to support their decision-making tasks.

Design Process

We drew on literature that describes multiple levels of stakeholder involvement to help us develop this case study. According to Arnstein [2], the continuum of engagement can be described at three levels, including *consultation*, *collaborative partnership*, and *shared leadership*. This paradigm has been widely utilized to support stakeholder engagement in many different types of activities, such as participation of governance [3], health interventions [14], environmental management [8], etc. In this project, we wanted to involve stakeholders for supporting the design process of IDSTs for OH physicians. As shown in Figure 2, we mapped the three levels of stakeholder engagement with different phases of our design process.

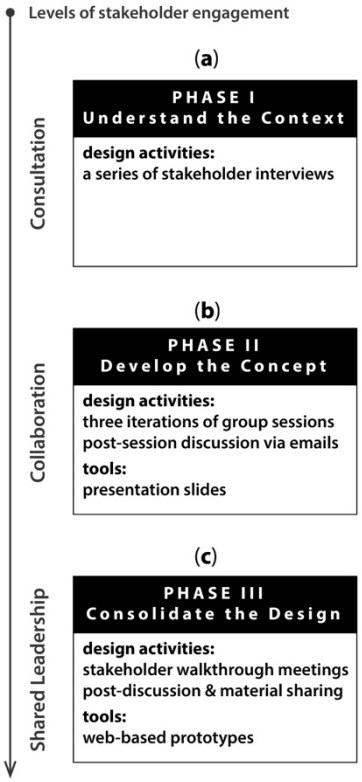

Figure 2: The design process of this case study.

Phase I: consult stakeholders to understand the context. To identify design challenges from such a complex background, we carried out a series of stakeholder interviews (Figure 2(a)). First, we conducted in-depth interviews with two product managers, where they showed the current software systems and elaborated on the technology roadmap of HTC. Second, we consulted a software developer and two data scientists, who provided technical views into the design context. This helped us in learning the constraints and opportunities of an IDST in occupational medicine. Third, we followed our inquiry with a R&D consultant, who had a close touch with both the software team and health professionals in HTC. Based on her feedback, we formulated questions for OH physicians. Fourth, we conducted four interviews with our end-users: OH physicians, to get a better understanding of their experiences with digital medical records and IDSTs. Insights from the aforementioned interviews were synthesized as an OH physician workflow map (Figure 3). We used this map to analyze design challenges. Also, it supported our collaborations in the next design phase.

Phase II: collaborate with stakeholders to develop the concept. In this phase, we conducted three iterations of group sessions with stakeholders to ideate possible designs. Our initial plan was to involve all five parties in the development of the concept. However, it was challenging to include developers and physicians due to their busy schedule. Eventually, we had one physician who joined the third group session to discuss the concept with us. Unfortunately, no software developers could not be involved in the rest of the study. Figure 2(b) shows that setups of all three group sessions were similar. To start, we presented the slides to stakeholders, which contained the analysis of OH physician workflow (Figure 3), the recap of the previous session, and several design proposals. The presentation aimed to facilitate collaborations on ideating design concepts. Each group session took 1-1.5 hours. Afterward, a summary of the meeting was sent to all participants through email. Therefore, we were also able to gather stakeholder feedback between the sessions to modify our design proposals.

Phase III: share the leadership with stakeholders to consolidate the design. At the start of the third phase, we confirmed a design concept called ConsultAI. It was then implemented as a web-based prototype (Figure 4). As shown in Figure 2(c), based on the prototype we conducted stakeholder walkthrough meetings [5] to demonstrate the concept and stimulate discussions on how to improve the applicability of the design. In this phase, we proposed to share the leadership to consolidate the design with stakeholders. We assumed it would encourage all the stakeholders to become more proactive in suggesting ideas and collecting references to this study. In addition to attending meetings, therefore, stakeholders sent us some further suggestions with various materials which they thought would be useful, such as newsletters, scientific articles, and commercial examples related to our design. Based on such multi-perspectives, we aimed to consolidate the design of ConsultAI with a clear use scenario that is valuable for the next step.

Results

Design considerations

Stakeholder interviews generated qualitative insights into the HCI design of IDSTs for OH physicians, which can be classified into three aspects.

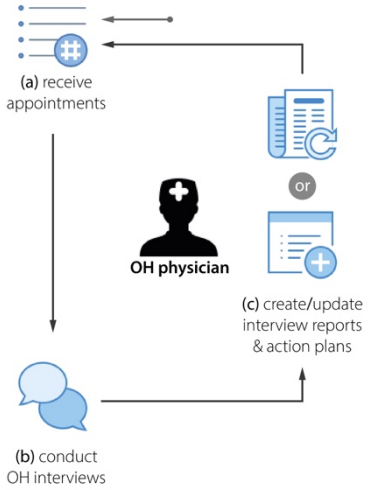

Figure 3: A visualization of the workflow of OH physicians in HTC.

Enrich data collection for predictive modeling. First, it is suggested that data collected from the patients should be enriched to support the improvement of predictions from IDSTs. As described by the data scientists: *"We now only have one-off data from triage intake, which limits possibilities and accuracy of the data models."* The OH physicians also stated that they could not rely on the intelligence-generated diagnosis and prognosis, as the data based on was not sufficient so far. Therefore, they usually ignored the predicted information from IDSTs. For example, *"The triage data only reveals one part of the fact, so it isn't enough to make any accurate predictions. Plus, as a company doctor, I need to understand more, such as how the employee works with co-workers and the employer."* Both data scientists and OH physicians acknowledged that incorporating more data into algorithms, models, and systems would be beneficial to the context. E.g., personal health data collected by health monitoring devices, data from monthly surveys on work satisfaction, etc. However, such data collections should be consented by employees and not violate any data privacy and ethical regulations for work and healthcare purposes.

Improve accessibility to field knowledge and guidelines. Second, through interviewing different stakeholders, we found that occupational health service is a complex working context influenced by information from multiple resources. Especially for OH physicians, it is important to follow the guidelines and field knowledge in their decision-making process. The guidelines and field knowledge can refer to, i.e., the occupational health and safety legislation, the classification of complaints and causes (CAS code) [15], the health service contract with the employer, as well as the relevant findings from medical research. Also, our stakeholders stated that such information could be changed and updated frequently. With the current systems, nevertheless, it is challenging to find all these different types of information in daily practices. As one senior doctor said: *"When I meet my patient, I need to open different windows on my computer to look up many things, such as the legislation, the CAS code, the medical history, and so on. It is very time consuming and not easy to find the newest one. Then, next time I need to do that again!"* From the interview with the R&D consultant, we were also suggested to develop an IDST that could present up-to-date guidelines and knowledge on one integrated interface to the doctor.

Blend the decision support into physicians' workflow. Third, from this study we learned that there was a strong reason for introducing IDSTs into the context of OH. That is to improve work efficiency to compensate for the labor shortage of OH specialists. As the project manager indicated: *"Nowadays in the country we can hardly find a qualified doctor, let it alone a company doctor."* From the technicians' perspective, they also investigated new functionalities, aiming to improve doctors' work efficiency. E.g., the software developer said: *"We have developed a dashboard feature that presents information of the patients accompanied by AI-based advices. We hoped doctors could check all the information before they meet patients."* However, such a new development was not perceived positively by OH physicians. As they stated: *"All the appointments [with patients] occupy my work, I can hardly find time to check the information"*, *"It's difficult to memorize the information before seeing the patient"*. This is mismatching between technical features of IDSTs and real working

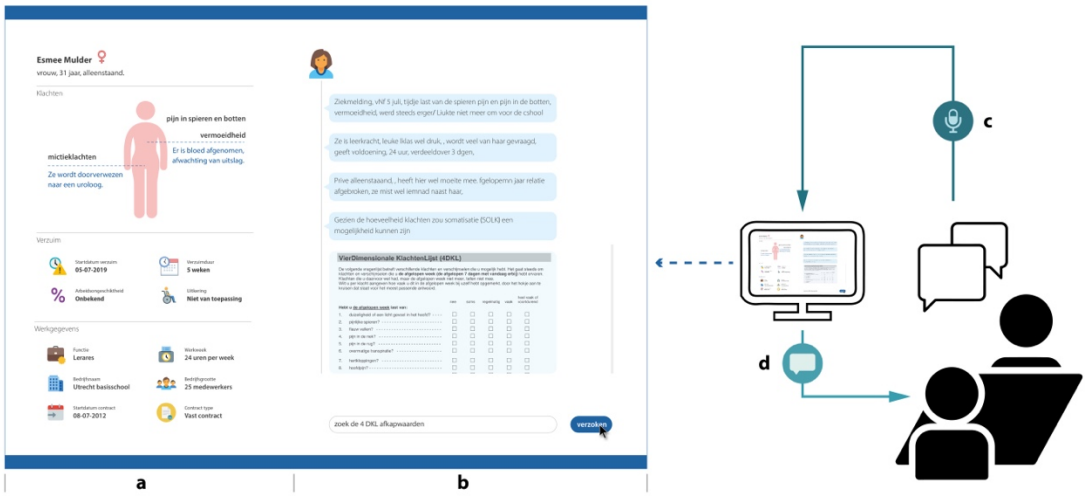

Figure 4: The ConsultAI system: left shows its user interface and right shows its information flow during a clinical interview.

scenario of company doctors. To fill in this gap, we can consider developing new medical technologies that can leverage system interactivity to facilitate and promote a new workflow. Another possibility is to add the technical components to the existing workflow and routine practices of OH physicians.

Design concept: ConsultAI

Based on interviews and group sessions, we decided to explore the OH practice setting of an occupational health interview (Figure 3(b)). This is an intensive task where the doctor needs to collect information about the patient as well as analyze and process it into a diagnostic report and treatment plan [12]. Therefore, we wanted to leverage HCI and AI to improve this working context. Stakeholder involvements resulted in a new design concept of IDST, called ConsultAI. As shown in Figure 4, ConsultAI is realized as a dashboard interface that can be used by the physician during the interview with the patient. ConsultAI consists of two digital elements: 1) On the left side it presents a summary of the patient (Figure 4(a)), including self-reported complaints, absence information, and work-related information; 2) On the right side it integrates a chatbot (Figure 4(b)) that provides useful information (e.g., AI-generated prognosis and diagnosis, medical field knowledge, OH work guidelines, etc.), according to the progress of the interview in real time. More specifically, we elaborate on the following HCI features of ConsultAI that map with our design considerations.

- ***OH Interview as an opportunity to enrich the OH database.*** We envision ConsultAI as an unremarkable data collector. Figure 4(c) shows that the system leverages speech recognition to record meaningful information automatically from the conversation between the physician and the patient. The collected data is then saved confidentially in the medical database for enriching short-term and long-term analyses.
- ***Easy access to relevant information without influencing the consultation.*** Due to the real-time analytics, ConsultAI queries related information according to the acquired data from the interview. The customized information is delivered through the chatbot interface at the right moment (Figure 4(d)). Thereafter, the physician can seamlessly incorporate received field knowledge and guidelines into the progress of the consultation.
- ***Intelligent decision support as an integral part of the workflow.*** In clinical settings, AI-generated

predictions and suggestions are usually presented as pre-acquired references [13]. Which makes intelligent support disconnected to the actual decision-making process. Instead of applying a static, one-time presentation, ConsultAI uses the chatbot to bring the prognosis, diagnosis, and AI-based advice to the physician in the workflow of the consultation continuously and task-dependently. Also, the chatbot interface allows OH physicians to discuss the predictions with the system, aiming to increase system's benefits and credibility to medical decisions.

At the end of the design process, our stakeholders expressed that ConsultAI could be meaningful to *improve physicians' work*, *open up new space for data modeling*, and *inform the changes of OH policies*. Based on this consolidated design proposal, we created a scenario (Box 1) to demonstrate the use of the ConsultAI system during the OH consultation.

Marly is a senior company doctor, who is interviewing her new patient, Esmee. To support the interview, Marly uses ConsultAI. As the first consultation, Marly takes a glance at the dashboard, which presents the summary of Esmee's reported complaints, absence history, and work information. This helps her get an overview of Esmee and find questions to start. During the interview, ConsultAI automatically records the conversation, extracts valuable information, produces suggestions, and presents them on the interface with a chatbot. Marly finds the suggestions fit the interview progress, and some of them are quite useful. They could inspire diagnostic direction, facilitate discussion, help with knowing new OH guidelines. Even when Marly mentions a questionnaire to learn more about Esmee's symptoms, the system automatically shows this questionnaire. ConsultAI pre-fills most contents of the consultation report according to this interview. Marly can then review and revise it, which reduces a lot of administrative work for her. Marly feels ConsultAI is unobtrusive and straightforward, and it improves her work efficiency.

Box 1: The scenario of using ConsultAI for an OH consultation.

Discussion, Conclusions & Future Work

This paper has reported a case study that investigated engaging stakeholders in designing an intelligent decision support tool (IDST) for occupational health (OH) physicians. By describing the design process, design considerations, and design concept of 'ConsultAI' we have exemplified how stakeholder engagement can contribute to the IDST design in a specific medical context. We have also provided implications and solution space to this design challenge, in terms of enriching the health and work-related database, supporting secure access to relevant information, and blending decision support into the workflow.

There were several lessons learned concerning stakeholder engagement in the design process. Firstly, the variation in the stakeholders helped us gain deep insights into the possibilities and constraints of the OH context, which was unfamiliar to us at the beginning of the design process. This has been shown from receiving convergent and divergent opinions on IDSTs in our stakeholder interviews. The analysis of those interview data facilitated us to draw a set of design considerations.

Secondly, the continuum of stakeholder engagement enhanced the design process and the adoption of the new IDST in the target context. Previous work [4] mainly took stakeholder perspectives to analyze the practice setting. Following [2], in this study we tried to involve stakeholders in the entire design process. Through experiencing different engagement levels, stakeholders became familiar with design-oriented tasks and confident to share opinions. In return, the collaboration between the design team and stakeholders became closer and more productive in generating concepts.

Thirdly, applying HCI design techniques supported stakeholders to engage in the design process. For this case study, we included several materials (e.g., mockups, prototypes) and methods (e.g., stakeholder walkthrough) in different phases. And we found they were useful to get stakeholders to become more and more engaged in thinking along with the design team.

This case study was set out to incorporate stakeholder opinions into designing IDSTs in a specific medical context. In the future, it would be worthy of exploring how stakeholder engagement could support the

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evaluation of new IDST designs. For instance, the inclusion of multiple perspectives might contribute to the development of experimental protocols. Stakeholders might also contribute to the data analysis of the design evaluation. For future study, therefore, we plan to explore with our stakeholders on the evaluation criteria and experimental plan of ConsultAI. We then plan to conduct experiments, taking ConsultAI as a research probe, to investigate how HCI can inform the AI development that can be well adopted by occupational health specialists for everyday work.

References

1. Benjamin O. Alli. 2008. Fundamental principles of occupational health and safety Second edition. Ilo.Int.
2. Sherry R Arnstein. 1969. A ladder of citizen participation. Journal of the American Institute of planners 35, 4: 216–224.
3. Claire Bishop. 2012. Artificial hells: Participatory art and the politics of spectatorship. Verso Books.
4. Gregory J. Downing, Scott N. Boyle, Kristin M. Brinner, and Jerome A. Osheroff. 2009. Information management to enable personalized medicine: Stakeholder roles in building clinical decision support. BMC Medical Informatics and Decision Making 9, 1: 1–11.
5. Bruce Hanington and Bella Martin. 2012. Universal methods of design: 100 ways to research complex problems, develop innovative ideas, and design effective solutions. Rockport Publishers.
6. Robert S. Ledley and Lee B. Lusted. 1959. Reasoning foundations of medical diagnosis. Science.
7. Mark A Musen, Blackford Middleton, and Robert A Greenes. 2014. Clinical decision-support systems. In Biomedical informatics. Springer, 643–674.
8. Mark S Reed. 2008. Stakeholder participation for environmental management: a literature review. Biological conservation 141, 10: 2417–2431.
9. Xipei Ren, Bin Yu, Yuan Lu, Biyong Zhang, Jun Hu, and Aarnout Brombacher. 2019. LightSit: An Unobtrusive Health-Promoting System for Relaxation and Fitness Microbreaks at Work. Sensors 19, 9: 2162. https://doi.org/10.3390/s19092162
10. Xipei Ren, Lotte Hollander, Rylana van der Marel, Lieke Molenaar, and Yuan Lu. 2019. Step-by-Step: Exploring a Social Exergame to Encourage Physical Activity and Social Dynamics among Office Workers. Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems - CHI '19: 1–6. https://doi.org/10.1145/3290607.3312788
11. Xipei Ren, Bin Yu, Yuan Lu, and Aarnout Brombacher. 2018. Exploring Cooperative Fitness Tracking to Encourage Physical Activity among Office Workers. Proceedings of the ACM on Human-Computer Interaction 2, CSCW: 1–20. https://doi.org/10.1145/3274415
12. Frederieke Schaafsma, Carel Hulshof, Frank van Dijk, and Jos Verbeek. 2004. Information demands of occupational health physicians and their attitude towards evidence-based medicine. Scandinavian Journal of Work, Environment and Health. https://doi.org/10.5271/sjweh.802
13. Edward H Shortliffe and Martin J Sepúlveda. 2018. Clinical decision support in the era of artificial intelligence. Jama 320, 21: 2199–2200.
14. Helene Starks, Jennifer L Shaw, Vanessa Hiratsuka, Denise A Dillard, and Renee Robinson. 2015. Engaging stakeholders to develop a depression management decision support tool in a tribal health system. Quality of Life Research 24, 5: 1097–1105.
15. UWV. 2002. Classificaties voor Arbo en SV.