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## Context Sensitive Health Informatics: the Role of Informatics in Global Pandemics

Romarc Marcilly, Linda Dusseljee-Peute, Craig E Kuziemy, Xinxin Zhu,  
Peter L. Elkin, Christian Nøhr

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## Context Sensitive Health Informatics: The Role of Informatics in Global Pandemics



Editors: Romaric Marcilly  
Linda Dusseljee-Peute  
Craig E. Kuziemsky  
Xinxin (Katie) Zhu  
Peter Elkin  
Christian Nørh



The COVID-19 pandemic has disrupted many global industries, none more so than healthcare, and has necessitated the need for health informatics innovations that can bridge time and space to provide timely care. It has also emphasized the need for a system-level informatics infrastructure to support the healthcare management of populations at a macro level, while also providing the necessary support for front line care delivery at a micro level. However, the need for change at a fast pace does not remove the need for an evidence base to support health technologies. This raises fundamental questions about how the informatics tools required can be delivered at pace without compromising the quality and safety of such tools.

This book presents papers from the biennial conference on Context Sensitive Health Informatics, CSHI 2021, held as a virtual event on 15 and 16 November 2021. The theme of the 2021 conference was: The Role of Informatics in Global Pandemics, and this book includes 18 papers on a variety of topics, divided into 4 sections: health information management in the COVID-19 context; implementation of new practices and technologies in healthcare; sociotechnical analysis of task performance and workload in healthcare; and innovations in design and evaluation methods of health technologies.

The book provides an overview of innovative health information systems rooted in robust scientific research on context and health information technology, and will be of interest to all those working in the field of health informatics.



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CONTEXT SENSITIVE HEALTH INFORMATICS:  
THE ROLE OF INFORMATICS IN GLOBAL PANDEMICS

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# Context Sensitive Health Informatics: The Role of Informatics in Global Pandemics

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# Preface

This volume presents the papers from the International Conference on “Context Sensitive Health Informatics” held virtually in November 2021.

Context Sensitive Health Informatics concerns health information technologies and their environments. Environments may be people in various roles, such as citizens, patients, users, designers, and evaluators, but also non-human constructs such as organizations, work practices, guidelines and protocols, buildings and markets.

The conference is endorsed and organized by the International Medical Informatics Association (IMIA) working groups “*Human Factors Engineering for Healthcare Informatics*” and “*Organizational and Social Issues*”.

The CSHI 2021 conference is sponsored by Lille Academic Hospital, the Federative Research Structure for Health Technology” (SFR-TSM), and the ULR 2694-METRICS research unit. We would like to thank the sponsors for making it possible to organize the conference and publish the proceedings.

We would also like to thank the IMIA for their editing assistance, especially Elaine Huesing and Susan Martin.

We thank the students and researchers who, despite the virtual organization of the conference, submitted their research papers to this conference. We also want to thank the members of the Scientific Program Committee for their efforts in establishing the content of the conference and all the reviewers for providing constructive feedback to the authors. Their excellent work has significantly improved the quality of conference.

Romarc Marcilly  
Linda Dusseljee-Peute  
Christian Nøhr  
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September 2021



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# Introduction

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# The Importance of Contextual Understanding in Solving the Last Mile Problem

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**Abstract.** The COVID-19 pandemic has disrupted many global industries and shifted the digital health landscape by stimulating and accelerating the delivery of digital care. It has emphasized the need for a system level informatics implementation that supports the healthcare management of populations at a macro level while also providing the necessary support for front line care delivery at a micro level. From data dashboard to Telemedicine, this crisis has necessitated the need for health informatics transformation that can bridge time and space to provide timely care. However, health transformation cannot solely rely on Health Information Technology (HIT) for progress, but rather success must be an outcome of system design focus on the contextual complexity of the health system where HIT is used. This conference highlights the important roles context plays for health informatics in global pandemics and aims to answer critical questions in four main areas: 1) health information management in the covid-19 context, 2) implementation of new practices and technologies in healthcare, 3) sociotechnical analysis of task performance and workload in healthcare, and 4) innovations in design and evaluation methods of health technologies. We deem this as a call to action to understand the importance of context while solving the last mile problem in delivering the informatics solutions that are needed to support our public health response.

**Keywords.** Pandemic, context, health transformation, health IT

## 1. Introduction

The COVID-19 pandemic shifted the digital health landscape by stimulating the delivery of digital care. When doctors' offices and other care delivery services were forced to close or greatly reduce in person service delivery, digital care delivery became an essential part of the healthcare delivery system [1, 2].

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COVID-19 has resulted in almost 4.5 million deaths worldwide. In the USA alone, as of June 17<sup>th</sup>, 2021, over 600,000 people have died from COVID-19 - a rate roughly ten times greater than seasonal influenza deaths [3, 4]. Over 33 million have contracted the infection and a substantial portion of those suffered persisting post-acute symptoms [5]. While COVID-19 case rates and death rates are declining in the US, they are accelerating in other countries such as India. There is a pressing world-wide need for effective therapies [6, 7]. Most who die from the COVID-19 suffer from acute respiratory distress syndrome (ARDS) and respiratory insufficiency related to the associated cytokine storm [8].

COVID-19 has focused the importance of informatics driven support for pandemic response. From Telemedicine to COVID 19 research databases the field has risen to the occasion [9, 10]. The pandemic impacted medical education and here Biomedical Informatics rose to the occasion and developed online learning platforms using participatory design to engage our students from home [11, 12]. Using these techniques our field has stepped up and led biomedicine in weathering the challenge of the pandemic.

The early results on digital care delivery to support global responses to COVID-19 have been mixed. One on hand informatics-based solutions played a fundamental role in the pandemic response that achieved several successes. At a macro level informatics driven solutions were the basis for disease surveillance, contact tracing and vaccine uptake tracking [13-15]. At a micro level informatics solutions enabled patients to access healthcare services through virtual care delivery and telehealth [2, 16]. However, challenges were also identified across the informatics spectrum including a lack of informatics infrastructure or frameworks, data standard or harmonization issues, lack of a skilled informatics workforce, and ethical issues [17]. The COVID-19 driven increase in virtual care delivery raised questions about the design and delivery of virtual care delivery, including patient-provider communication [18].

The informatics response to COVID-19 has reaffirmed one of the foundational problems in medical informatics – “the last mile problem”. This problem refers to the difficulty in implementing and integrating informatics models, tools, and approaches into actual care delivery settings so that meaningful outcomes are achieved. The last mile problem is very much central to health system transformation initiatives. Informatics models, tools, or theories alone will not transform healthcare delivery but rather they must lead to meaningful impact at social, policy, economic, cultural, and other levels.

One of the most talked about phenomena in medical informatics are unintended consequences (UICs), which refers to the outcomes that occur but that were not anticipated when implementing health information technology (HIT) [19, 20]. UICs occur because while HIT is a crucial part of healthcare delivery it is only one part of the system of systems that defines healthcare delivery. HIT’s interaction with other system components is what leads to UICs [21]. Informatics solutions for COVID-19 have led to UICs including provider fatigue and burnout and inequality in access to digital care delivery [17, 22].

A key contributor to the last mile problem is a lack of understanding of the contextual system where HIT is implemented and used. HIT are not generic tools and cannot be implemented without due consideration of the contextual environment where it will be used. We cannot just copy and paste a successful HIT application from one setting to another while expecting success to amplify accordingly. Global health systems can have differences in how healthcare services are funded, delivered, and evaluated. To that end, contextual understanding must be part of any informatics-based implementation.

## 2. Context Sensitive Health Informatics

The Context Sensitive Health Informatics (CSHI) Conference began in 2013 to provide an arena for presenting research on the contextual nature of HIT implementation. CSHI embraces the messy nature of healthcare delivery and the diversity of settings where HIT is implemented and used. CSHI strives to contribute methods and scientific evidence to advance our understanding of the role context plays in HIT implementation.

Context becomes important when we distinguish automation and transformation. The former is about using technology to digitize existing processes or services whereas the latter is using HIT to achieve a fundamental change to the value statement and means by which services are delivered [23, 24]. This difference is important as health innovation projects can include tasks such as workflow and processes redesign, which requires a greater degree of contextual understanding. HIT should not merely automate existing tasks but rather should help healthcare delivery reach new heights. However, we cannot do that by solely focusing on technology as a driver of health innovation as that may emphasize technology at the expense of contextual considerations such as people, process, and organizational and social considerations.

A key aspect of studying context is recognizing that HIT is implemented and used in a complex system of systems that represent clinical, organizational, technical and policy aspects of healthcare delivery [21]. System context is not about any one system component on its own but rather tries to understand the interactions that occur across system components. Failure to account for how system components influence and reshape context through interactions with each other is a significant barrier to solving the last mile problem. It is therefore necessary to use innovative methods to consider all these components during the design, evaluation and implementation of HIT.

The CSHI 2021 conference highlights the important role context plays for health informatics in global pandemics and aims to answer critical questions in four main areas: 1) health information management in the covid-19 context, 2) implementation of new practices and technologies in healthcare, 3) sociotechnical analysis of task performance and workload in healthcare, and 4) innovations in design and evaluation methods of health technologies. CSHI 2021 provides scientific insight on informatics support for pandemic management and continues the work started at CSHI 2013 (Copenhagen, Denmark), CSHI 2015 (Curitiba, Brazil), CSHI 2017 (Hong Kong, People's Republic of China) and CSHI 2019 (Lille, France).

## 3. The Role of Informatics in Global Pandemics

The COVID-19 pandemic has highlighted the important role that context plays in HIT implementation. Contextual considerations of the role of informatics in managing global pandemics includes:

1. The importance of equity cannot be understated. While informatics solutions such as virtual care enabled patients to access healthcare services during lockdowns it often resulted in uneven access to services. The digital divide was an ongoing problem during informatics responses to COVID-19. We need to ensure that informatics solutions enable better access to care delivery for everyone rather resulting in equity issues for certain patient populations.

2. Not all healthcare services transitioned effectively to digital delivery. Complex physical assessments can be challenging to do digitally. We cannot simply use technology as a complete replacement for tasks that are best delivered via human touch. The COVID-19 mediated transition to digital care delivery resulted in a lot of trial and error to determine what worked best in certain contextual situations. Going forward we need evidence as to which clinical processes transition well to digital delivery and which ones should remain face-to-face.
3. Public and clinical informatics systems must be better coordinated. COVID-19 illustrated that gaps exist in the connection between micro level clinical care and public health at the macro level. These gaps impacted pandemic management by making contact tracing and disease surveillance difficult. A well-connected health system is the underpinning of an efficient pandemic response.
4. Health transformation must focus on meaningful outcomes of care delivery. While technology may automate a specific process, healthcare transformation occurs at the system level and we must account for all system components (e.g., human resource, organizational, financial, political, technological) during health transformation efforts.
5. Automation happens in the moment. Transformation happens over time. Digital transformation of processes such as decision support or patient-provider communication is a formative task that takes place over a continuum. Health transformation cannot be implemented or evaluated as a one-off event but rather must be done under principles of a learning health system [25].
6. Understanding context requires meaningful engagement with all users of HIT. This includes providers, patients, policy makers, decision makers and any other end users.

#### **4. Future Directions Towards Solving the “Last Mile Problem”**

The COVID-19 pandemic reaffirmed that healthcare delivery is complex and that contextual variation contributes to the complexity. Healthcare is delivered in complex systems and until we understand these systems and the role that context plays in these systems; we will continue to have problems with health transformation. Health transformation cannot rely on HIT to guarantee progress or success, but rather success must be an outcome of system design. However, system design is challenging due to the need to purposefully design for the contextual environments where healthcare services are delivered. We must resist the urge to focus on technology and instead focus on the contextual complexity of the health system where HIT is used. HIT failures are rarely due to bad technology per se but rather are due to a lack of contextual alignment with the setting where the HIT is used. Informatics projects or research may start starts on the fast track in solving the first mile problem only to fail to deliver in the last mile. A lack of attention to context is often the barrier that prevents HIT from solving the last mile problem. Do not underestimate the role that context plays in HIT implementation as context is always a factor.

Without due attention to context in how we design, implement, and evaluate HIT we will continue to struggle with the last mile problem. These challenges also present opportunities for various stakeholders such as vendors and public health decision makers

to foster and support innovations and health system transformation for a better health system for everyone. Future research is needed to better understand the human factors and sociotechnical issues related to how to use HIT to meaningfully connect individuals with our public health authorities in times of crisis such as a global pandemic. The CSHI is committed to reporting new developments and progress in future medical informatics conferences.

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# Health Information Management in the COVID-19 Context

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# Legal Matters: The Legal Context of Health Informatics in Global Pandemics

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**Abstract.** Law and regulation have not received much attention as part of the context shaping and being shaped by health informatics. Telemedicine, data, devices and software, and electronic health records (EHRs) are examples of how technologies are affected by privacy, intellectual property protections, and other law and regulation.

**Keywords.** Health informatics, law, regulation, telemedicine, privacy, medical devices, software, electronic health records, privacy, vendor contracts, intellectual property, ethics, ELSI, COVID-19

## 1. Introduction

In a time of COVID-19, ethical, legal, and social issues related to health informatics are increasingly apparent, social determinants of health are glaringly relevant, access to care is difficult, and the need for data to track and treat public health crises is abundantly clear. Even though healthcare is among the most regulated sectors, the *legal* part of ethical, legal, and social issues has not received the very welcome attention paid to the ethical and social, yet as policy advocates recognize, law and regulation are significant to the context of health informatics.

Health informaticists have been grappling with ethical, legal, and social issues (ELSI) for about a half-century.[1] Legal scholars, too, have discussed many of the issues, albeit from a different perspective and over a shorter time period. These scholars and new law school initiatives in digital health, artificial intelligence, robotics, privacy, disparities, and Big Data have been producing legal analyses and recommendations relevant to health informatics. With contact tracing and vaccine passports, as well as various algorithmic and digital developments, they have been paying even more attention.

This paper sketches how policy, law, and regulation contribute to the context of health informatics. Telemedicine, data, devices and software, and electronic health records (EHRs) in the US serve as examples of how technologies are affected by privacy, intellectual property protections, and other law and regulation. I discuss the role of law as part of the context of health informatics by putting together these four examples in one paper. They are drawn primarily from my own health informatics publications because those include numerous citations and an extensive reference list is beyond the page limits of this paper.



## **2. Telemedicine**

Regulatory changes contributed to the astronomical increase in telemedicine use during the first months of the COVID-19 pandemic.[2] To facilitate access to care and data, US regulations and enforcement regarding reimbursement, privacy and data sharing, licensing, credentialing, supervising non-physician providers, and previously established doctor-patient relationships were relaxed. As this is being written, it is predicted that these policies will continue and that telemedicine will remain popular. Patients like the convenience and administrators and vendors like the economics.

As with the regulatory environment, broadband policies also affected telemedicine's uptake. Technology infrastructure may not seem related to health policy, yet funding affects its availability for healthcare. Lower income and rural patients without technologies for video had telephone visits,[3] so were less able to meet the widely recognized standard of care of telemedicine being equivalent to in-person visits.[2] Though voice visits are preferable to no healthcare at all, policy regarding technology and access contribute to disparities regarding access related to locale, income, and also to disabilities. Hearing, speech, dexterity, cognitive, and vision impairments create difficulties with telecare, likely more so with voice-only care.[3, 4]

## **3. Health Data**

Privacy has gotten extensive and widespread discussion with growing public attention to social media and smartphone apps. Much discussion focuses on intrusive marketing and targeted advertising, secretive data collection, both business and governmental surveillance, and unsuspected use of data for automated decisions affecting all aspects of our lives. These kinds of concerns influence attitudes towards vaccine passports and contact tracing for COVID-19 control. The privacy regulatory environment in regards to healthcare contributes to how and why these issues arise.

Data privacy in the US is regulated, when it is regulated, by sector. Different national laws pertain to financial data, health data, student data, genetic data, etc. Where data originate affects how privacy is regulated nationally. (State laws are different in each state.) The Health Insurance and Portability Act (HIPAA) governs clinical data generated by "covered entities" (generally, health care providers). Research involving human subjects is regulated through the Federal Policy for the Protection of Human Subjects, known as the Common Rule, which covers data protection for healthcare research subjects. Both require that people give permission for identifiable data to be released; both specify how data are to be de-identified or anonymized for purposes for which permission is not required, thereby implicitly defining "privacy" in terms of identifiability, permissions, and kinds of data. Neither protects de-identified data, even when combined in ways that may lead to re-identification or implicating people other than the ones represented in the data. The two sets of rules may be difficult to reconcile with each other and with other regulations. Data governance regimes juggle these differences with the result that privacy regulation impedes data sharing for research, public health, and patient care, while not much protecting patient privacy.[5-7]

Data related to health but collected by social media, fitness and other devices, and smartphone apps generally are not regulated at all. Commercial entities that provide these services are bound by their privacy policies, which are enforced by the Federal

Trade Commission, if enforced at all. People usually are given no choice but to click through consent to an end-user license agreement (EULA) to use the device or participate in social media. EULAs may or may not include a privacy policy that may or may not be honored, and that almost certainly are not widely read or understood.[7, 8]

Data from all these sources are sold and combined in ways that make it easier for even de-identified data to be identified. Data from commercial products are incorporated into patient records, as patient-generated data is recognized to be important for monitoring social determinants of health and real world data, and for better control of chronic disease. Distinctions between the different regulatory categories of data are thus blurred as all data are becoming health data.[8]

Privacy regulation—what is regulated and what is not—has facilitated an active market for all sorts of products and services sold to promote healthy lifestyles, empower people to control their health, enable people to share health-related information ranging from genetics to shopping habits, keep track of children and people with dementia, and improve hearing, limited only by the imagination of creative entrepreneurs. Appealing health-related apps benefit many happy customers and create opportunities for collecting and selling data in ways that can both help and, though legal, harm people.

#### **4. Devices and Software**

Technologies now being sold to improve lifestyle and health are popular for good reason. They keep track of voice, breathing, retinal patterns, vital signs, gait, diet, exercise, and sleep patterns. They may help detect potential health problems or enable people to monitor various conditions unobtrusively during their daily routines. They remind people to take medications and alert caregivers if there are problems. Some simply are fun. Most fall outside the scope of health data privacy protections, which are targeted towards patient record information, not daily life activities and measurements. Indeed, most are not regulated at all. The Food and Drug Administration (FDA), which is responsible for overseeing not only medications but also medical devices, does not classify them as such because they are not intended to be used in diagnosis, cure, mitigation, treatment, or prevention of a disease. This means that HIPAA does not apply to them. It also means that they are not vetted by the FDA as being safe and effective.[4,8] Like the market for data, a lax regulatory environment enables commercial health informatics applications to flourish.

Regulation has been more pertinent to software-based devices that clearly are part of clinical settings, what is known as “software as a medical device (SaMD).” The FDA waived the usual regulatory approval process for these and other devices because of the COVID-19 public health emergency. Recently, the FDA proposed ending regulatory review and making that waiver permanent. The new process would make precertification possible for software such as for AI and machine learning. Since 2017, the FDA has been developing a software precertification program to make regulatory oversight of software based medical devices more streamlined and efficient. As with the precertification initiative, the recent proposal was that products substantially like existing products and that rarely are associated with adverse events would not need regulatory review. This includes artificial intelligence programs that physicians can use to help them detect cancers, respiratory diseases, broken bones, and other findings on

medical images. Digital devices to be exempted from review include ones that manage the safety of drug infusions, monitor fetal heart rates, and deliver behavioral therapy for psychiatric patients. The intent is to promote innovation and quickly get devices to market, another way the regulatory environment shapes health informatics.[9]

For reasons discussed above for other apps and devices, legal and ethical issues are rampant for COVID contract tracing and vaccine passports promoted for public health and opening up the economy. They raise privacy, safety, efficacy, surveillance, and equity concerns, including geolocation tracking and segregation due to inequities of vaccine and smartphone availability.[10] When predictive algorithms based on machine learning are used, it may be impossible to know just how they arrive at their results.

Another way regulation is relevant to devices and software is through intellectual property law. To reward innovators for new products and services, trade secrets, patents, copyrights, and contracts all prevent disclosure of how these technologies function. Software, especially, is opaque, more so with advances in artificial intelligence and machine learning. Intellectual property protections make it difficult to know what data were used to create models, how they were trained and tested, and, in the case of machine learning, why and how they work. Contracts protect vendor interests with non-disclosure clauses, such as for EHRs, that prevent disseminating knowledge of hardware and software problems.[11]

## **5. Electronic Health Records**

It is by now common knowledge in health informatics that electronic health records have significantly changed clinicians' work while improving some aspects of care and being detrimental to others. The regulatory environment contributed to this phenomenon. EHRs are not regulated, except in so far as the meaningful use/promoting interoperability criteria for certification and reimbursement reporting requirements are ways to regulate.[8] Without incentives and penalties established by the federal government to promote adoption of electronic health records through the 2009 HITECH Act, electronic health records likely would not be as widely used as they now are. Incentive payments based on certification and meaningful use criteria emphasized some areas of functionality, which necessarily diverted attention from others. Although there are many benefits of current systems, among the pitfalls are increasingly arduous and clinically irrelevant documentation requirements that take time away from patient care, which, together with alert fatigue, contribute to burnout, and have motivated physicians to leave practice or influenced their choice of specialty.[12] There has been little attention to interoperability (one of the reasons why EHRs have been promoted), to usability, and to compatibility with clinical thinking and workflow, although all are getting more attention than previously.[11] Further, as mentioned above, intellectual property protections included in vendor contracts contribute to continued concerns. It is impossible to consider virtually any aspect of electronic health records that is not influenced by regulation and its (un)intended consequences.

## 6. Conclusion

The Context Sensitive Health Informatics conference call notes that COVID-19 made it clear that health informatics innovations need to bridge time and space with infrastructure that supports the healthcare management of populations at a macro level while also providing the necessary support for front line care delivery at a micro level, all while insuring quality and safety. Law and regulation are crucial to shaping, and themselves are shaped by, these efforts. They are part of the context of health informatics.

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# Opportunities to Improve COVID-19 Dashboard Designs for the Public

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**Abstract.** Many organizations created COVID-19 dashboards to communicate epidemiologic statistics or community health capabilities with the public. In this paper we used dashboard heuristics to identify common violations observed in COVID-19 dashboards targeted to citizens. Many of the faults we identified likely stem from failing to include users in the design of these dashboards. We urge health information dashboard designers to implement design principles and test dashboards with representative users to ensure that their tools are satisfying user needs.

**Keywords.** Consumer health informatics, dashboards, human-centred design

## 1. Introduction

The coronavirus or COVID-19 pandemic was an existential threat that exposed vulnerabilities in our public health response systems. People and organizations struggled to understand and adapt to the rapidly changing clinical climate. Health organizations, public health officials, and other stakeholders recognized an urgent need to broadcast information about outbreak status, transmission rates, and vaccinations. Many developed dashboards in an *attempt* to communicate this information with the public. It is unclear, however, whether dashboards (1) are commonly adopted by users; (2) efficiently communicate relevant trends and patterns; or (3) satisfy users' information needs.

A dashboard is “a visual display of data used to monitor conditions and/or facilitate understanding” [1]. COVID dashboards displays and features vary across products from tables of statistics with icons (e.g., [2]) to static charts and maps, to interactive visualizations. COVID dashboards also vary by scope, data domain, or span. For example, some focus on micro-systems (e.g., hospital or city) whereas others focus on macro-systems (e.g., country or continent).

Dashboards proliferated during the pandemic, but as the old adage goes, “just because you can, doesn't mean you should”. Organizations often fail to communicate key information, rarely revise their dashboards designs after release, and even decommission their dashboards despite ongoing need (e.g., [3]). Using a set of published dashboard heuristics, we examined COVID dashboards to understand their shortcomings and recommend what designers can do to improve their effectiveness.

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## 2. Methods

Our team of user experience experts assessed COVID dashboards holistically using Dowding and Merrill's 10 Heuristics for dashboard visualizations [4] (Table 1). These heuristics are based on a subset of Nielsen's heuristics [5] and several heuristics specific to information visualization [6]. Two inspectors (HM, SZM) independently examined a sample of 5 dashboards available to Canadian citizens (e.g., regional, provincial, international) to identify heuristic violations. Rather than critique a single dashboard, the purpose of this evaluation was to summarize common usability violations across products and organized by heuristic. Hence, each inspector documented violations and generated opportunities for improvement separately. Due to space limitations, we jointly selected exemplars from the independent evaluations for the results section.

**Table 1.** Dowding and Merrill's 10 Heuristics for Dashboard Visualizations [4] (p. 513-514).

Heuristic	Description
1. Visibility of System Status	"The system should always keep user informed about what is going on through appropriate feedback within reasonable time"
2. Match Between the System and the Real World	"The system should speak the user's language, with words, phrases, and concepts familiar to the user, rather than system oriented terms. Follow real-world conventions, making information appear in a natural and logical order"
3. User Control and Freedom	"Users should be free to select and sequence tasks (when appropriate), rather than having the system do this for them. Users will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Users should make their own decisions regarding the costs of exiting current work"
4. Consistency and Standards	"Users should not have to wonder whether different words, situations, or actions mean the same thing."
5. Recognition Rather than Recall	"Make objects, actions and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for the use of the system should be visible or easily retrievable whenever appropriate"
6. Flexibility and Efficiency of Use	"The system should offer users several options when it comes to finding content. Users should be able to achieve their goals in an efficient manner"
7. Aesthetics and Minimalist Design/Remove the Extraneous (Ink)	"Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility. Present the largest amount of data with the least amount of ink"
8. Spatial Organization	"Relates to the overall layout of a visual representation and refers to how easy it is to locate an information element in the display and the distribution of elements in representations" [3] (p. 514)
9. Information Coding	"Refers to the use of symbols or representations to aid perception"
10. Orientation	"Provision of support for the user and help to orientate them in the visualization"

## 3. Results

### 3.1. Visibility of System Status

Generally, COVID-19 dashboards effectively communicated system status visually (i.e., displayed throbbers to indicate the data was loading). Some dashboards initially loaded slowly but responded more quickly with subsequent tasks. For some dashboards the currency of the data was not obvious. That is, data labels said "new" without qualifying the date of collection or reporting).

### *3.2. Match Between the System and the Real World*

Many dashboards included technical jargon, but neglected key information needed for strategic decisions. For example, one dashboard had tabs arbitrarily labelled (e.g., “Admin0”), that when selected, allowed users to drill down in the data [7]. Another dashboard listed some of the total cases as “epi-linked”, but did not include a definition for this term [8]. Many displays included raw data (the numerator) without the population size (the denominator), thus preventing any comparison between regions. Finally, rather than summarizing measures (e.g., 182.8 million), dashboards often included numbers with an excessive level of precision (e.g., 182,825,864). Larger numbers are harder to compare [9]. Therefore, dashboard designers should strive to summarize large numbers.

### *3.3. User Control and Freedom*

The dashboards we reviewed rarely included “accelerators”, keyboard shortcuts, or other affordances for power users (e.g., control + z, browser back button). Some dashboards included “home” buttons that only worked on a portion of the dashboard (typically a map). Users typically had no way to restore the dashboard to the default view (e.g., [8]).

### *3.4. Consistency and Standards*

There was little consistency across dashboard designs, and we identified missed opportunities for countries to standardize displays for their citizens. For example, the Canadian provinces and territories could have created a standard design with the flexibility to provide regional context (e.g., locally relevant resources and population specifics). A standard design with configurable controls could enable users to easily drill down in the data for regional trends, such as epidemiologic patterns within cities (e.g., [10]). Also, within the same dashboard, two similar looking figures had a note below to indicating that the scales on the Y axis differed, which could easily be overlooked [8].

### *3.5. Recognition Rather than Recall*

Many dashboards exceeded the display capacity of a single screen, forcing users to scroll or switch between screens (e.g., [11]). If users cannot see all data on a single screen, they must recall information from their working memory to compare and analyze values. Similarly, if filter settings, column headers, and labels are not on-screen, users may struggle to integrate data or recognize when they are looking at a subset of the data. One dashboard used a date legend (i.e., M/D/YYYY) [7], but rather than requiring users to recall the date format, the date display could be disambiguated (e.g., 3-Jul-2021, 3 July 2021) to facilitate comprehensibility [12] and free up screen real estate.

### *3.6. Flexibility and Efficiency of use*

Dashboards designers rarely included features that predicted user needs, added value, or connected users with related resources. For example, designers could have re-directed online traffic to local testing locations or symptom screening questionnaires. In many cases it appeared that the dashboards were islands unto themselves, lacking connections to helpful information about their source data or validation methods.

### 3.7. Aesthetics and Minimalist Design/Remove the Extraneous (Ink)

Many dashboards included unnecessary or excessive words, graphics, and visualizations that distracted from the main message. For example, one dashboard used valuable screen real estate for unintuitive or minimally valuable icons (e.g., [8]). Some displays extended beyond a single screen leaving information “below the fold” [11]. Additionally, designs tended to display everything at once, rather than using a progressive disclosure strategy.

### 3.8. Spatial Organization

Dashboards ranged from simple and uncluttered to busy and disorganized. Some dashboards allowed users to modify the display such as column size (e.g., [8]). Unfortunately, these options offered little value, and in some cases, could not be easily undone. Dashboards with maps occasionally included additional information as a transient “mouseover” note. However, users either had no way to capture the information in a snapshot, or the message altered the underlying map.

### 3.9. Information Coding

Dashboards rarely indicated when officials implemented new public health protocols or lifted restrictions, making it impossible to ascertain the public health impact of policy interventions. When reporting daily statistics, dashboards rarely included graphic depictions of trends (e.g., [11]) such as arrows to indicate directionality.

Colour was another common problem with COVID-19 dashboards. Many dashboards used red to convey the number of COVID-19 cases and/or had black backgrounds. In terms of colour semantics, in Western cultures red is often associated with danger [13] and black with grief. Additionally, some paired red with green, creating a problem for people with colour-blindness [14]. Finally, some developers used the same colour to encode several different meanings simultaneously.

### 3.10. Orientation

Our experts generally agreed that most of landing pages we reviewed helped orient users by including clear titles and maps. However, when users applied filters, this compromised orientation. In one dashboard example, when a geographic filter was applied, it applied the filter to each section, rather than keeping the geographic section highlighted and in view [11].

## 4. Discussion and Conclusion

There has been rapid growth in COVID-19 dashboards designed for the spectrum of health care stakeholders (e.g., epidemiologists, public). However, our UX experts agreed that many dashboards violated dashboard design heuristics indicating frequent usability issues that may have created challenges for citizens. Thus, many dashboards likely performed as suboptimal communication tools amidst this global pandemic.

It is even more problematic when we consider that the target user of these dashboards is often the healthcare consumer. Over half of Canadians have inadequate



numeracy skills [15] and even more struggle with low health literacy [16]. Yet, while many developers ostensibly created dashboards to inform and empower the public, few leveraged lessons learned from usability research. The accessibility issues and jargon instead risk potentiating an existing health literacy gap. Based on the shortcomings observed, it is doubtful dashboard designers used a human-centred design approach [17]. Therefore, many of these dashboards may have generated more confusion than clarity in an already sensitive, stressful, and uncertain time. In conclusion, we believe that dashboards could be valuable components of public health initiatives and communicate crucial information with their users. However, to achieve this and empower health care stakeholders, it is vital that developers adopt a human-centred approach. Our public health campaigns as well as our design and communication strategies should be evidence based and engage users throughout the development lifecycle.

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# “Japan LIVE Dashboard” for COVID-19: A Scalable Solution to Monitor Real-Time and Regional-Level Epidemic Case Data

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**Abstract.** Under pandemic conditions, it is important to communicate local infection risks to better enable the general population to adjust their behaviors accordingly. In Japan, our team operates a popular non-government and not-for-profit dashboard project - “Japan LIVE Dashboard” - which allows the public to easily grasp the evolution of the pandemic on the internet. We presented the *Dashboard* design concept with a generic framework integrating socio-technical theories, disease epidemiology and related contexts, and evidence-based approaches. Through synthesizing multiple types of reliable and real-time local data sources from all prefectures across the country, the *Dashboard* allows the public access to user-friendly and intuitive disease visualization in real time and has gained an extensive online followership. To date, it has attracted c.30 million visits (98% domestic access) testifying to the reputation it has acquired as a user-friendly portal for understanding the progression of the pandemic. Designed as an open-source solution, the *Dashboard* can also be adopted by other countries as well as made applicable for other emerging outbreaks in the future. Furthermore, the conceptual design framework may prove applicable into other ehealth scaled for global pandemics.

**Keywords.** Emergency response, pandemic, dashboard, digital communication, sociotechnical approach

## 1. Introduction

Digital communication has opened new frontiers in the field of pandemic management. Fagherazzi et al., 2020 [4] have addressed the critical roles and transformative effect of digital health initiatives purposed for COVID-19. One of the most novel initiatives since the appearance of the COVID-19 pandemic is interactive dashboards which are aimed at tracking real time case reporting to the public. Examples of global interactive dashboards dedicated to COVID-19 include the *World Health Organization (WHO) Coronavirus Dashboard* [10], the *Johns Hopkins University Dashboard* (recorded >3 billion page views) [3], and *Our World in Data’s COVID-19 Statistics and Research*. The extremely high total of web hits is testament to how much public attention these dashboards have attracted and their significance as a pandemic risk communication channel for the general

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population. However, the examples above are not designed for live updates at a sub-national (i.e. regional) level.

As of Sept 2021, Japan has declared five major states of emergency and about 50% of the Japanese population were fully vaccinated. The hosting of the 2021 (2020) Summer Olympics and the increased circulation of new SARS-CoV-2 variants (including the Alpha and Delta strains) posed great challenges for local disease management, healthcare service operation, and socioeconomic stability in Japan. Yet no curfew has been enforced and no travel restrictions have been put in place for domestic travel throughout the pandemic. As such, local interventions rely heavily on the population's voluntary response [6] and this necessitates a credible and reliable channel of communication to enable the general population to understand the latest situation of COVID-19 in their country. In this paper we document our practical experience in conceptualizing, designing, and operating a real-time and regional-level COVID-19 epidemic monitoring platform – "Japan LIVE Dashboard" for COVID-19. Through addressing the sociotechnical and context sensitive aspects of the *Dashboard* design, this paper will also be useful for researchers in understanding the role of informatics in the global pandemics.

## 2. Concepts, Design and Methods

When designing the *Dashboard*, we critically reviewed existing theories, methods, and practices in relation to user experience (UX) design, socio-technical approaches and disease analytics as applied to digital platforms (in consideration of the specificity of COVID-19 disease communication context). The conceptual design of the platform is portrayed in Figure 1. To investigate the role of digital communication in the face of pandemics, we paid close attention towards a system-level infrastructure purposed for the designated epidemic case communication at an individual-level.

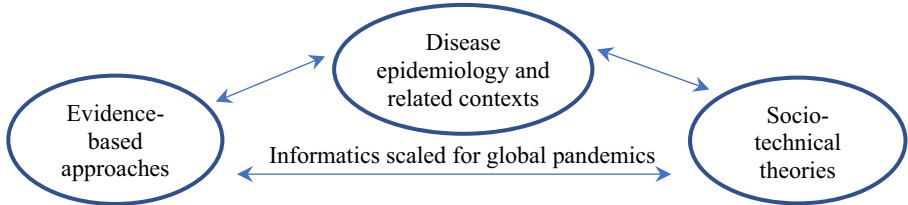


Figure 1. Design concept.

- *Socio-technical theories*. Pandemic informatics tools are designed to allow users from diverse backgrounds and with different needs to achieve the same task – understanding the latest pandemic status. Recognizing the essential human-computer interactions in the application context, social-technical approaches [1] emphasising the interrelationships between technology and its social environment were adopted.
- *Disease epidemiology and related contexts*. Informatics scaled for global pandemics should be context-sensitive [9], therefore, disease-related characteristics, transmission dynamics, and trustable up-to-date information sources are essential when building informatics for pandemics.
- *Evidence-based approaches*. An evidence-based approach [7] has never been more important when dealing with matters of life and death. By drawing upon

the best available science and evidence-based methodologies, one can work towards informatics scaled for global pandemics.

Apart from the above concepts, in the design phase, special emphasis was placed on high-quality data collection, effective visualization and efficient communication. Several key design features tailored to communicate the current pandemic situation include: (i) a dynamic and interactive dashboard that can visualize case data and statistics from regional areas in real time; (ii) data collection with spatial and temporal scales that potentially allow linked-data analysis among datasets; (iii) a multi-language design; and (iv) an adaptive open-source framework that can be applied to other countries or redeployed to track future epidemics. R Shiny and multiple data visualization and analytics packages, such as "incidence", "EpiEstim", "echarts4r", were incorporated to develop the Dashboard. The automatic deployment workflow is elaborated, as follows. Website data update script operates every 15 minutes to monitor the live data sources using a serverless computing service offered by Amazon Web Services (AWS) Lambda. When there are any data updates, an automatic "Pull Request" will then deliver to our designated GitHub repository, generate the correct format for data visualization, and merge new live data into the main data frame via GitHub Action. Subsequently, CircleCI pipeline will be triggered to update the application on the web server.

### 3. Results

Figure 2 shows the graphical user interface of the *Dashboard* (<http://COVID-2019.live/en/>). It was rolled-out on 31 Jan 2020 in Japan, with a speed that was unprecedented at such an early stage of the pandemic. At the time this paper was published, the *Dashboard* has registered more than 30 million views globally, with 98% of recorded accesses from domestic users. At the peak of the pandemic, the number of views reached 140,000 per day. This established infrastructure will continue to serve as a major COVID-19 communication tool in Japan until the end of this pandemic. The source code of the platform can be found at the following link (<https://github.com/swsoyee/2019-ncov-japan>).

*Socio-technical aspect.* Both social and technology aspects were considered interdependently to enable an effective human-computer interactive design. On the social front, we assessed wide Japanese online users' expectations on tracking updated COVID-19 information and aimed to report both country-level and prefecture/regional-level visualizations, statistics and trend projections. All these can be presented under variable epidemic time scales. In addition to the Japanese language, options in English and Chinese further add to its accessibility and community uptake. On the technical front, it is imperative to incorporate intuitive visualizations to effectively communicate complicated disease data with a wide spectrum of online users. Therefore, simple statistics (such as moving average and incidence rate per 100,000 population), choropleth maps, histograms, and infection heat maps were employed.

*Disease epidemiology and related contexts.* Meaningful COVID-19 disease characteristics and its associated issues that drew public concerns were incorporated into the design. We curated case data on infections, PCR tests, recoveries, deaths, and vaccinations from the real time COVID-19 communication media (including *News Digest Japan*, the Japanese government (at the national and regional levels)). Since its

first introduction, this interactive *Dashboard* has gone through five major iterations to respond to the exigencies of the pandemic at any given time. For future pandemic applications and reproducibility, the versions of these iterations have been documented, and these can be modularized and re-deployed flexibly to other national contexts at different stages of future epidemic outbreaks.

*Evidence-based approach.* Epidemic theory and dynamic data management were taken into consideration. The epidemic curve illustrates the distribution of the onset of new cases in a graphical format, whereas the time-varying reproduction number [2] is computed to indicate the effectiveness of control measures. Furthermore, we observed that the available case data, reporting structures and formats of these online sources have shifted rapidly as the pandemic situation has evolved. As a result, an automatic and semi-automatic approach for data curation was utilized throughout the course of the pandemic. Automatic web crawling and cross-checking programs were designed to search the latest updates from the designated sites and ensure data consistency drawn from various sources. In order to maintain information integrity and credibility [8], the *Dashboard's* site manager manually reviews discrepancies and verifies the data on a daily basis.

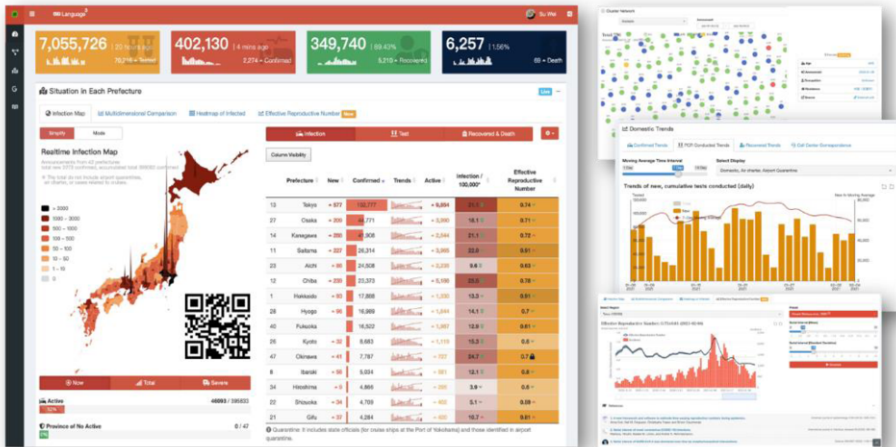


Figure 2. Screenshots of the "Japan LIVE Dashboard" for COVID-19.

We evaluate the readiness of the *Dashboard* by comparing the case reporting data with the official media and demonstrated a close alignment of reporting accurate case situations in the face of the pandemic. All the data are stored in a machine-readable format, updated in real time and made publicly accessible [5]. The data we collected can serve as a coordinated data repository for ongoing and future disease epidemiology and modeling studies and can thus be potentially used in combination with other disease related datasets with spatial or temporal scales.

#### 4. Discussion and Conclusion

Sociotechnical and context-sensitive aspects of digital health were considered in the development of the "Japan LIVE Dashboard" project. Through integrating socio-

technical theories, disease epidemiology and related contexts, and evidence-based approaches, the digital health conceptual design framework presented proves potentially applicable to other ehealth scaled for global pandemics. Furthermore, the *Dashboard* provides a scalable solution to visualize local COVID-19 data within a given country's subnational divisions (e.g. states, regions, and even cities) which allows public health authorities, researchers, and the general public to easily understand the evolution of the pandemic. Importantly, the program code for this project is all open source and was written with ease of adaptability in mind. Color, pattern, or shade of all graphical displays in relation to disease variables are adjustable according to user design preference. The digital platform described here is also transferable to other countries and can thus play an important communication role in assisting with future public health emergencies. In the future, this platform could be redeployed to enable investigation of the influence of societal factors on the spread of COVID-19 in Japan. Future study directions include understanding online user preference in obtaining disease information and investigating how to communicate more complicated disease analytics to diverse online population.

## Acknowledgements

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# Information Chaos: An Adapted Framework Describing Citizens' Experiences with Information During COVID-19

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**Abstract.** With the onset of the coronavirus pandemic, clinicians, public officials, and citizens alike struggled to stay abreast of the constant and evolving stream of information about the clinical manifestations of illness, epidemiology of the disease, and the public health response. In this paper, we adapted (i.e., added and modified elements) Beasley and colleagues' information chaos framework to understand the context of citizens' experiences with information during the COVID-19 pandemic. We will show how our adapted framework can be used to characterize information associated challenges observed during this time and the possible impact of information chaos on peoples' cognition and behaviours. Ultimately, we believe that research will benefit by adopting a more holistic perspective using the information chaos framework than strictly studying the independent factors in isolation.

**Keywords.** Consumer health informatics, information chaos, information overload, infodemic, COVID-19, coronavirus

## 1. Introduction

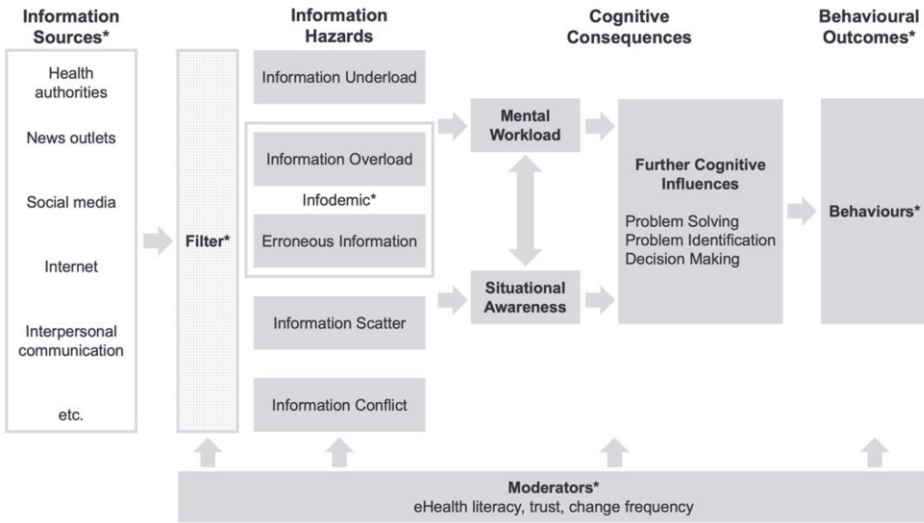
Humans living in the information age must process an overabundance of data. When the volume of data exceeds our processing capabilities, we face "information overload" [1] whereby excess information can adversely affect personal well-being, innovation, decision-making, and productivity [2]. In health care, information overload can have a pernicious effect upon population health outcomes [3]. Everyone struggled to stay abreast of the constant and evolving stream of medical information during the COVID-19 pandemic [4]. Although information overload is arguably the most commonly known, there are many other kinds of information hazards that can also have consequences.

Beasley and colleagues introduced the concept of "information chaos" – a framework for characterizing information hazards primary care providers face that

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impair cognition and decision-making [5]. They argued that information chaos is “comprised of various combinations of information overload, information underload, information scatter, information conflict, and erroneous information” and that it can negatively affect physician performance and patient safety [5]. In this paper, we adapted Beasley’s framework to describe citizens’ experiences managing information during the COVID-19 pandemic and to illustrate how information chaos can influence behavioral outcomes (Figure 1). We selected Beasley’s framework as the basis for this work because of its emphasis on the role of information itself, how it is processed, and the risks of information hazards. We also drew inspiration from other health information seeking models (e.g., [6]) because of their emphasis on the context, influencing variables, and the individual’s agency. There are five concepts in this framework: (1) sources; (2) filter; (3) moderators; (4) hazards; and (5) behaviours. First, citizens received information from a variety of sources. Second, citizens filtered information for processing. Third, there were contextual factors (i.e., “moderators”) mediating information processing. Fourth, there were multiple information hazards – including “infodemic”, one we introduced. Finally, there were downstream behavioural outcomes. Next, we will apply this framework to illustrate how information chaos may have impeded cognition and public safety during the pandemic.



**Figure 1.** The information chaos framework for citizens’ experiences with information during COVID-19, adapted from Beasley et. al’s framework [5]. \* = components added or significantly different from the Beasley et al.’s framework [5].

## 2. Information Sources

Citizens had to choose from many different information sources – some of questionable quality – during the pandemic. For example, citizens could use information provided by health authorities (e.g., national public health agencies, the World Health Organization [WHO]), public news outlets, social media (e.g., Twitter, Facebook, TikTok), the internet, and interpersonal communication (e.g., conversations, messaging apps).



In our adapted framework, citizens had agency and participated in health information seeking, data consumption, information creation, and signal propagation. Individuals decide which health information to consume [6], so we included the concept of a filter in our framework to symbolize this decision-making process (see Figure 1).

### 3. Moderators

Moderators are external forces that influence internal system behaviour. Moderators acting on citizens during COVID-19 affected the entire information lifecycle, including the filter stage (see Figure 1). eHealth literacy, trust, and change frequency were likely the most influential moderators, but there are also other possible contextual and personal moderators (e.g., see [6]) as well. First, eHealth literacy is “the ability to seek, find, understand, and appraise health information from electronic sources and apply the knowledge gained to addressing or solving a health problem” [7]. Thus, eHealth literacy can influence the choice of information sources, comprehension, and decisions leading to behavioural outcomes (e.g., wearing a mask, physical distancing). Second, trust in information sources varies. For example, globally, 44% of people trust the news most of the time but only one in four people trust news sourced from social media [8]. If people do not trust a source, it is unlikely to pass their filter. Third, the rapid changes to information likely contributed to uncertainty, skepticism, and change fatigue.

### 4. Information Hazards

#### 4.1. Information Underload

Information underload is “when necessary information is lacking” [5]. Citizens struggled with information underload throughout the pandemic; they did not have the information they needed at all times. For example, initial lack of information about disease virulence and mechanisms of transmission crippled early public safety measures. As the situation progressed, people wanted to learn about vaccine options, efficacy, and adverse effects.

#### 4.2. Information Overload

Information overload occurs when data passing through the filter exceeds citizens' capabilities “to organize, synthesize, draw conclusions from, or act on” [5]. Quantity and relevancy can contribute to information overload. In a global health crisis, it is important to keep citizens abreast of an evolving situation with frequent updates. However, whether it was bulletins from work, broadcast media, social media, or print media, we struggled to keep up. People were more likely to report sentiments of information overload if they received or accessed COVID-19 information at a high frequency [9,10] and also if the information source was broadcast media [9].

#### 4.3. Erroneous Information

Erroneous information, or misinformation, can be unintentional or intentional (i.e., disinformation). Citizens undoubtedly encountered and suffered from erroneous

information during the COVID-19 pandemic. We added an “infodemic” construct (see Figure 1) given that an infodemic is defined as “too much information, including false or misleading information, in digital and physical environments during a disease outbreak” [11]. Infodemics can compromise public trust in health authorities, leading to risky behaviours, and prolonging or potentiating outbreaks [11]. For example, erroneous information circulated about how the illness spread (e.g., only in cold weather), effective prophylactic measures (e.g., garlic), and treatments (e.g., spraying bleach on oneself) [12]. Social media users were more likely to report hearing misinformation about the pandemic [8]. Lies spread faster than the truth [13] and erroneous information on the internet can be nearly impossible to purge. Fortunately, some social media platforms are now taking action such as flagging false claims [14] or suspending users.

#### *4.4. Information Scatter*

Information scatter refers to the distribution and fragmentation of information in multiple locations [5]. Information about the pandemic was often fragmented amongst various information sources which contributed to the cognitive overhead. Beasley and colleagues’ posited that users having difficulty finding the information they need, even within the same resource, is also a phenomenon associated with information scatter [5].

#### *4.5. Information Conflict*

Information conflict occurs when users are “unable to determine which data are correct” [5]. Because the science was evolving rapidly during the pandemic, recommendations were subject to change, which contributed to confusion [9]. For example, although health authorities did not clearly and consistently recommend donning masks initially, this recommendation later changed. Additionally, initially droplets were the suspected transmission mechanism, but later it was found to be aerosols [15].

### **5. Cognitive Consequences and Behavioural Outcomes of Information Chaos**

As in Beasley and colleagues’ [5], we applied a human factors engineering approach to model the consequences of information chaos and we extended this model to include behaviours. All hazards here were present throughout 2020 and varied as a function of information source and individual. These hazards undoubtedly influenced citizens’ mental models, cognitive workload, situational awareness, emotional state, and eventual decision-making. Therefore, it follows that information chaos likely influenced peoples’ behaviours (e.g., adhering to safety protocols, vaccine hesitancy).

### **6. Discussion and Conclusion**

We adapted the information chaos framework and integrated health information seeking components to a contemporary public health context – COVID-19 – to illustrate the possible impact of information sources, consumer filters, information hazards, and moderating variables upon individual behaviours, epidemiologic patterns, and downstream public health outcomes. We also made several notable adaptations to this

theoretical framework including the addition of information sources (i.e., where information comes from), a filter (i.e., whether people consume the information), and behavioural outcomes (i.e., what people do because of this information) as well as modifying the moderators (i.e., external contextual variables mediating information processing). A unified theoretical model to describe how information channels, hazards, and mediating forces influence behaviour, epidemiologic patterns, and population health could be a powerful tool for public officials in information campaigns and strategies.

While this model has face validity, future research is warranted to test its construct validity and predictive strength. We also need to investigate the interaction between variables and whether more integration with health information seeking models (e.g., [6]) is necessary. Finally, although researchers are exploring many of the factors described in our adapted framework independently, we believe a more holistic perspective of the potential interactions between variables may provide a more comprehensive representation of citizens' experiences during the pandemic.

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# Implementation of New Practices and Technologies in Healthcare

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# Persuasion Tactics in the Implementation of Large-Scale EHR Suites in Public Healthcare

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**Abstract.** Large-scale electronic health record (EHR) suites have the potential to cover a broad range of use needs across various healthcare domains. However, a challenge that must be solved is the distributed governance structure of public healthcare: Regional health authorities regulate hospitals, municipalities are responsible for first-line healthcare services, and general practitioners (GPs) have an independent entrepreneurial role. In such settings, EHR program owners cannot enforce municipalities and GPs to come on board. Thus, we examine what tactics owners of large-scale EHR suite programs apply to persuade municipalities to participate, how strongly these tactics are enforced, and the consequences. Empirically, we focus on the Health Platform program in Central Norway where the goal is to implement the U.S. Epic EHR suite in 2022. Theoretically, the paper is positioned in the socio-technical literature.

**Keywords.** EHR suites, Epic, persuasion tactics, pressure, socio-technical, technological determinism

## 1. Introduction

The overall goal for large-scale electronic health record (EHR) suites is to cover a broad range of use scenarios for healthcare workers in hospitals, nursing homes, home-care services, and general practitioner (GP) clinics. Such a wide scope implies that the EHR suite can be used as the primary system in entire healthcare regions to ensure a seamless information flow among the various domains. This is supposed to provide quality and safety in treatment and care of all steps of a patient's pathway throughout the healthcare service.

However, a challenge that must be solved is the distributed governance structure of public healthcare (as in the Scandinavian countries): Regional health authorities regulate hospitals, municipalities are responsible for first-line healthcare services, and GPs have an independent entrepreneurial role. In such settings, EHR program owners (typically anchored in regional health authorities) cannot force municipalities and GPs to come on board, but must rely on willingness and persuasion tactics. This is not straightforward given the scale and risk of such projects as well as the diversity of the stakeholders. Thus,

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we ask the following research question: What tactics do owners of large-scale EHR suite programs apply to persuade municipalities to participate, how strongly are these tactics enforced, and what are the consequences?

Empirically, we focus on the Health Platform program in Central Norway where the goal is to implement the U.S. Epic EHR suite in 2022 [1,2]. The owners of the program (the Central Norway Regional Health Authority and Trondheim municipality) face the challenge of persuading the 64 municipalities and the many GPs in the region to participate. Although many municipalities have decided to participate, others are exploring alternatives. Theoretically, this paper is positioned in the socio-technical literature, meaning that technology always must be understood in its social context [3].

## 2. Methods

We adhere to an interpretive research approach, which considers a phenomenon from a variety of viewpoints [4,5]. In particular, we contrast the overall aim of the Health Platform program with the responses of three municipality consortia considering whether to participate in the Health Platform program.

The data collection consists of three one-hour interviews with key informants during spring 2021. The informants represent three different municipality consortia in Central Norway, each consisting of 6 to 12 municipalities. We label informants coordinators due to their long professional experience with EHRs and their role in advising directors, politicians, and municipal councils about the Health Platform program and possible alternatives. In one interview, two informants participated. In the text, we refer to the informants as Coordinator 1 to Coordinator 4. The first and second authors conducted and recorded the interviews over Zoom. We include six interviews conducted with Health Platform managers in 2018, nine interviews with GPs in Central Norway in 2019, and interviews with 10 healthcare professionals in Tromsø municipality during autumn 2020 as background sources. All interviews were transcribed for analysis.

## 3. The Health Platform program and municipalities in Central Norway

The Health Platform is a regional program owned by the Central Norway Regional Health Authority and Trondheim municipality. It is also a pilot for the national goal of “one citizen - one record”. In 2019, the program signed a NOK 2.7 billion (EUR 270 million) contract with Epic Systems Corporation to acquire and implement the Epic EHR suite in the whole region, including all hospitals, GP clinics, nursing homes, and home-care services. The number of healthcare workers in the region totals around 44,000 [1,2].

A suite system, Epic is largely self-contained. Most of the functionalities needed by health personnel are supposed to be provided by Epic, either as ready-for-use functionality or through configuration. However, because for the most part Epic is a hospital-oriented system, some functionality for municipalities must be developed, for instance, related to case management, medication, and welfare technology integration.

The Central Norway Regional Health Authority and Trondheim municipality will start implementing Epic in the three regional hospitals and in Trondheim municipality in 2022. Subsequently, the implementation process will continue in the other municipalities. Health Platform management has pointed out that a crucial point in the preparations is to ensure that the municipalities buy in to the Epic solution as soon as possible to create

stability and predictability for the program. If more municipalities and GPs participate, the region will realize more benefit from the Epic EHR suite.

Similar to municipalities in the rest of Norway, the 64 municipalities in Central Norway are the lowest administrative and politically elected level. They are responsible for providing first-line healthcare services to citizens in the local community. This responsibility includes managing nursing homes and home-care services, as well as providing public health services. Municipalities also have binding agreements with GPs. When specialized treatment is needed, citizens are referred to tertiary care facilities, i.e., one of the three hospital trusts in the region, which (as in the rest of Norway) are governed by the state through a regional health authority.

For the hospitals in the region, replacing their current EHR, which they share, is a pressing matter. For the municipalities, however, the situation is slightly different. Although their current systems in nursing homes and home-care services (Profil, Gerica and Cosdoc) lack up-to-date functionality and well-developed integration capabilities, there is no urgent need to replace them. Similarly, GPs have quite modern systems with which they are satisfied.

Despite this, the Health Platform management emphasized from early in the project that the goal of the program is not necessarily to meet each and every specific requirement of each user domain. The goal is to create a comprehensive health service that connects hospitals, nursing homes, home-care services, and GP clinics. The aim is to provide all health personnel—and patients—with complete and up-to-date information about the patients' condition and medication. Many municipalities responded very positively to this aim and indicated immediately that they would participate in the program.

However, other municipalities have increasing concerns. A key issue is that the municipalities do not know the specific functionality they will get until they go live, because much of the software for the municipalities still must be developed. In addition, integration with the national welfare technology hub, which enables integration between EHRs and welfare technologies in the municipalities, will not be delivered in the first round. Moreover, as go-live approaches, politicians in the municipalities are increasingly realizing that transitioning to Epic will require a huge effort, and the investment and operating costs will total much more than the cost of the municipalities' current EHRs. Therefore, some municipalities are exploring alternatives. One alternative is the so-called "zero-alternative," which implies continuing to use their current EHR systems. Upgrading these systems with national integration modules may facilitate the flow of information among the use domains; for example, a national shared medication list for patients is being tested in another health region. Essentially, this alternative is about establishing interoperability between the systems and to focus on standards that vendors should adhere to.

The Health Platform program and Trondheim municipality reacted immediately to the exploration of the zero-alternative. According to informants, it instigated "frenetic" meeting activity between them and the potential "breakout municipalities" to convince these municipalities that Epic is the better alternative. The owners have, according to informants, stated the benefits of the Epic EHR suite quite strongly, for example, arguing that: "It is the only alternative for a future-oriented EHR." "It will revolutionize the healthcare service." "It is a choice between the Stone Age and the 21st century."

According to our informants, to motivate municipalities to opt in, there is "enormous hype" about the benefits of sharing information. This hype has influenced some municipalities. One informant said, "My colleagues in other municipalities say that the



municipalities have no choice; we just have to do this, and we are stupid if we do not join because then we will be left behind” (Coordinator 1).

For some of the municipalities that have opted in, the exploration of the zero-alternative is a nuisance. In response to a presentation of Epic and the zero-alternative, Coordinator 2 stated that a municipal health director said, “I don’t understand why you are talking about these alternatives; it is just confusing. We shall have Epic.”

Many municipal councilors and politicians are also motivated by a sense of community and belonging. They consider the Health Platform program a Central Norway (Norwegian: “Trøndersk”) project and argue that they should stick with the other Central Norway municipalities. Moreover, some act out of blind solidarity with Trondheim municipality because it is the largest municipality in the region. According to one informant, other municipal directors find the program overwhelming. These directors do not think that their municipalities have the competence and resources to participate. Furthermore, these directors have problems raising these concerns in public, i.e., in the county municipal director committee. If they do, they will be blamed for not being in step with the rest of the region.

Given the size and ambition of the program, there are concerns about whether the municipalities have the necessary competences. Therefore, those that are undecided appreciate a careful assessment of the alternatives. The lack of sufficient competence in the municipalities combined with considerable pressure to opt in mean that some municipalities may wake up to an unpleasant surprise after implementation, as one informant put it.

Traditionally, the acquisition of EHRs has had a strong foothold in the professional practices with deep knowledge of use scenarios, technologies, and users, but the political dimension of the Health Platform program has become more explicit. Coordinator 4 said, “The Health Platform program has become politics. It is really very strange; we must not forget the users who are going to work with this.” Coordinator 1 argued along the same lines: “When municipal directors and councilors involve themselves in the purchase of subject matter systems, all the warning lights should flash; we have never experienced that before. Then the end-user perspective is no longer in focus, and other concerns have taken precedence.” It is telling then that Trondheim municipality will not have a finalized system when they go live. This is very unusual, as Coordinator 3 pointed out: “Trondheim municipality is quite brave to start first and implement Epic before it is fully developed. We dare not be so forward-leaning.”

Not surprisingly, the owners are very active in interaction networks, and arenas for promoting the Health Platform program, because they have a strong interest in getting the municipalities on board. These arenas include those run by the Norwegian Association of Local and Regional Authorities and the County Governor. Coordinator 2 said, “I am puzzled that both the Norwegian Association of Local and Regional Authorities and the County Governor let their arenas be used for this interest exclusively. As a result, this makes it difficult for the municipalities to withstand the pressure, and it is difficult for them to see that there are any alternatives.”

#### **4. Concluding discussion**

We contend that the recent tactics to persuade municipalities to participate have taken technology deterministic [6] proportions. Epic is presented as the only alternative, and the municipalities’ participation is largely taken for granted. From early in the project,

the municipalities' participation has been considered a condition for success in the Health Platform program, i.e., to create a comprehensive health service in Central Norway. Therefore, the recent reservations among some municipalities—manifested through the exploration of the zero-alternative—threatens the program's success. This puts pressure on the Health Platform program to persuade the municipalities to opt in, apparently through increasingly stronger slogans, such as “this is the future,” “not falling behind,” and “revolutionizing healthcare.” The tactics also put pressure on the municipalities that want to explore the zero-alternative before they decide what to do. This suggests that opting in has never been a real option. The municipalities' participation has largely been taken for granted, and some municipalities are now asking themselves, what is the consequence of *opting out*?

Presently, there is a strong “alliance” [7] among the Health Platform, Trondheim municipality, and the municipalities that have opted in. In this alliance, participation translates into “solidarity” with Central Norway and with the municipalities that have decided to implement Epic. Through the possibility to promote the Health Platform on their arenas, the alliance has also received approval from the Norwegian Association of Local and Regional Authorities and the County Governor. Obviously, such a strong network is hard to withstand, although the presence of the zero-alternative provides some counterweight.

However, the combination of a large-scale system, promotion efforts characterized by technology determinism, and a lack of competence in the municipalities creates an unpredictable cocktail. The sheer size of Epic questions whether there is sufficient professional competence in the municipalities to handle the implementation and future operation. In addition, given how the Health Platform program has increasingly turned “political,” municipal politicians have been heavily involved in decision-making processes that normally are run by professional users and subject matter specialists. The consequence is that decisions may be made without proper professional advice. It is telling that the municipalities are asked to buy in to a system that they have not yet seen in real life. This is a glaring deviation from traditional municipal purchasing practice, typically characterized by caution and frugality.

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# Current mHealth Use in Dutch Dementia Care: A Guide to Action!

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**Abstract.** *Objective:* To report underlying factors that hinder or advance mHealth implementation and use in Dutch dementia care. *Methods:* 44 dementia experts (healthcare professionals, informal caregivers, dementia case managers, and researchers) completed a questionnaire as part of a wider Delphi study to share their experiences with, thoughts on, and proposals for mHealth use in Dutch dementia care. A SWOT-framework is used to categorize the experiences, thoughts and proposals. *Results:* Four strengths, twelve weaknesses, thirteen opportunities and six threats for the current use of mHealth in Dutch dementia care were identified. *Conclusion:* Identified weaknesses highlight the importance for a guide for action for everyone involved in design and implementing mHealth for older adults with dementia. It is critical to raise awareness of mHealth's availability, improve its design, and continue to address the needs of older adults with dementia.

**Keywords.** mHealth, dementia, care, SWOT, COVID-19

## 1. Introduction

The number of available mHealth applications is ever-increasing as a result of individuals being more tech-savvy and the intensive use of smartphones, tablets, and other devices. In the field of dementia, mHealth applications are developed to address the needs and wishes of patients, (informal) caregivers, and health workers. Dementia care can utilize mHealth for cognitive training, activities of daily living, health and safety monitoring, leisure, socialization and navigation [1]. For (informal) caregivers, mHealth can provide resources, just-in-time information to solve problems, and stress reduction strategies [2]. Health workers that deliver primary healthcare services feel that mHealth leads to new ways of communication and relations with clients and throughout communities [3].

The coronavirus disease of 2019 (COVID-19) pandemic urged a digital revolution in dementia care [4]. Due to measures such as social distancing, research into technology to monitor older adults with dementia and improve distance communication increased [4]. In line with this demand, the purpose of this study is to report underlying factors that hinder or advance generic mHealth implementation and use in Dutch dementia care. This study is part of a larger Delphi study performed during the COVID-19 pandemic aiming

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to develop generic guidelines for the design of mHealth for older adults with dementia. A survey explored the participants' experiences with and thoughts on current mHealth use and proposals for future mHealth use in Dutch dementia care.

## 2. Methods

### 2.1. Questionnaire development

Data were gathered in a larger study on prioritizing potential barriers for older adults with dementia when using mHealth applications. In the introductory questionnaire of that study, demographic data and insights in mHealth experience were gathered from participants. Participants were informal caregivers, district and hospital nurses, geriatric specialists, researchers, and/or case managers and recruited (a) actively via email which led to snowball sampling as requests were forwarded to colleagues and (b) passively through organizations related to dementia care. The following four open-ended questions were asked: (1) What is your experience with the use of mHealth with elderly people with dementia, (2) What is your opinion on current mHealth applications for people with dementia, (3) Which barriers related to aging and dementia influence the use of mHealth, and (4) What are your suggestions for mHealth applications that can play a positive role for elderly people with dementia. The questions were pilot tested with eight dementia experts and was sent out using Castor EDC [5]. One question was added based on pilot feedback.

### 2.2. SWOT-analysis

The demographic questions were analyzed using descriptive statistics. The responses to the open-ended questions were categorized by TE and AY, using the SWOT framework, as either a Strength, Weakness, Opportunity, or Threat for mHealth use in Dutch dementia care. Afterwards, through thematic analysis, similar responses were grouped within each category of the framework by TE and discussed within the research team. To categorize the reported types of mHealth, responses were mapped on earlier defined mHealth types: perform daily activities, maintain social interaction, aid memory, engage in leisure activities, track location, and monitor health [6].

## 3. Results

The expert group (n=44, response rate=81%) consisted of seventeen case managers, fifteen hospital or district nurses, one geriatrician, five researchers, and six informal caregivers. Most were female (90.9%) and aged between 21-70. With respect to technology use, all participants used a smartphone and 66% reported having mHealth experience.

Participants indicated an increase in video calling on smartphones and tablets by older adults with dementia during the COVID-19 period as a medium for *maintaining social interaction* with family, friends, healthcare professionals and other (informal) caregivers. However, the older adults with dementia experienced barriers such as anxiety, agitation, and suspicion while video calling. During the COVID-19 pandemic, mHealth

was also introduced to *engage in leisure activities* such as virtual museum visits and games which caused enthusiasm among users as activities during the pandemic were limited. *Memory aid* was already used mainly for reminding the older adults with dementia of upcoming events and to take their medications. Family members or informal caregivers already used *tracking* interventions to follow the location of older adults with dementia, and sensors to *monitor health* and behavior.

Four strengths, twelve weaknesses, thirteen opportunities and six threats were identified by the dementia experts and mentioned various times (Table 1).

**Table 1.** Strengths, weaknesses, opportunities and threats for the current use of mHealth in Dutch dementia care according to dementia experts (from most to least mentioned).

<b>Strengths</b>	<b>#</b>
1. <i>Availability</i> - To minimize social isolation, give daily structure, train memory, monitor health circumstances, and facilitate distance communication, various mHealth applications can be offered based on the user's needs and wishes.	21
2. <i>Support in early stages of dementia</i> - When mHealth is introduced early in the disease's progression, the user with dementia is or becomes comfortable with a smartphone or tablet and when some form of roadmap is offered on how to utilize it, mHealth can provide support.	11
3. <i>Enjoyment</i> - Older adults with dementia seem to enjoy the use of mHealth.	3
4. <i>Cost-effective</i> - mHealth can be cost-effective for healthcare organizations.	2
<b>Weaknesses</b>	
1. <i>Currently inaccessible</i> - Current mHealth applications are for many people with dementia inaccessible, frequently overly complicated, and require a high level of cognitive ability.	13
2. <i>Creates more burden for caregivers</i> - People with dementia require support for using mHealth, which increases the burden of (informal) caregivers.	10
3. <i>Resistant to use</i> - Older adults with dementia can be resistant to mHealth due to (performance) anxiety or suspicion as the technology is unknown to them.	9
4. <i>Difficult to set-up</i> - Setting up mHealth requires too many actions (for example charging/updating).	4
5. <i>Lack of awareness</i> - Implementation and adoption is affected by the caregivers' or health workers' lack of awareness of or interest in mHealth.	4
6. <i>Leads to frustration</i> - Introducing mHealth to older adults with dementia is difficult and can lead to frustration.	3
7. <i>Not appropriate for advanced stages</i> - Healthcare workers often see people with further stages of dementia in which case the use of mHealth might not be appropriate.	3
8. <i>Lack of evidence</i> - There are many apps and tools to support dementia care, but an overview (what is available) and evidence for successful implementation is lacking.	2
9. <i>Limited use in home care</i> - mHealth use in home care settings is currently limited.	2
10. <i>Feel no need to use</i> - People with dementia often do not feel the need to incorporate technologies in daily life, partially due to dementia.	1
11. <i>Not meeting the needs</i> - Current mHealth apps do not fully cover the needs for dementia care.	1
12. <i>Organizational pressure</i> - Organizational pressure to implement mHealth can lead to implementation issues and frustration for/of health workers and people with dementia.	1
<b>Opportunities</b>	
1. <i>Improve app design</i> - Zooming in on personal qualities, motivations, and capacities of (informal) caregivers and persons with dementia, as well as their influence on technology use, can improve mHealth design.	17
2. <i>Focus on requirements</i> - mHealth should require minimal actions, be provided on easy-to-use smartphones and remotely accessible by health workers or (informal) caregivers.	14
3. <i>Teach (informal) caregivers</i> - mHealth should be introduced early on in the course of dementia, and (informal) caregivers should be available and trained on its use.	12
4. <i>Failure-free distraction</i> - mHealth should be failure-free with positive feedback, provide pleasure and distraction, not confront dementia patients with their limitations, add to their quality of life, and be stimulus poor.	8
5. <i>Focus on needs</i> - People with dementia could gain from mHealth that provide games for memory training and support, reminisce, and reminders	8
6. <i>Integrate in daily life</i> - mHealth can be successful for people with dementia when it is integrated in their daily routine and provides reminders and support for daily activities, scheduling and signaling deviations in daily processes.	5

7. <i>Awaiting a more tech-savvy future</i> - Future older adult generations will be more tech-savvy which may have a positive influence on tablet and smartphone use.	3
8. <i>Create more awareness</i> - The use of mHealth can be improved by raising awareness of the tools available to healthcare professionals	3
9. <i>Counter problem behavior</i> - mHealth can have value when it is used to counter problem behavior such as agitation in older adults with dementia.	3
10. <i>More financial support</i> - It is important to allocate more budget for mHealth initiatives and establish a robust business strategy to assure successful adoption of mHealth.	3
11. <i>Adjust research focus</i> - Research should not only focus on functional aspects of mHealth, but also on experiences with using technology.	2
12. <i>Inclusion during implementation</i> - People with dementia should be able to test and experience what mHealth has to offer and should not be left out of mHealth implementation processes.	2
13. <i>Interoperability</i> - mHealth should interoperate with current resources in dementia care.	2
<b>Threats</b>	
1. <i>Not owning a device</i> - mHealth implementation is hindered when older adults with dementia or (informal) caregivers do not have interest in using or owning a smartphone, tablet or WiFi access	29
2. <i>Stage and type of dementia</i> - Health workers often visit older adults with more severe stages of dementia, which makes introducing mHealth and teaching them new skills more difficult	16
3. <i>mHealth works temporarily</i> - mHealth works temporarily due to apraxia, decreasing learnability and impaired cognitive function of dementia patients.	16
4. <i>Demographics</i> - Opportunities to use mHealth depend on demographic factors of dementia patients such as having a spouse or child(ren), financial situation, and living situation.	5
5. <i>Physical limitations</i> - Having a tremor or decreased fine motor skills hinders the smartphone or tablet use by patients with dementia.	4
6. <i>Panic and mistrust</i> - Decreased problem-solving abilities of dementia patients leads to panic and mistrust when mHealth fails.	1

#### 4. Discussion

This paper discusses a subset of findings from a wider Delphi study identifying factors that influence generic mHealth implementation and use in Dutch dementia care. Apart from utilizing mHealth to prevent social isolation, provide daily structure, memory training and monitoring health conditions, dementia experts have seen an increase in mHealth use by dementia patients, healthcare providers and family caregivers to maintain social interaction (video calling) and to engage in leisure activities (such as virtual museum tours). This increase was a result of the COVID-19 restrictions, as older adults with dementia were not able to interact with family, friends and others involved in their care in person.

The findings show that there is still a need to raise awareness of mHealth’s availability for dementia care. For example, some dementia experts see for example “providing memory support” as a strength of current mHealth use, while others saw this as an opportunity. However, the findings also imply that there is a growing interest in using mHealth among dementia experts, as they highlight particular scenarios, for example to counter problem behavior of their clients, in which situations they feel mHealth might be useful. Experts also suggest the implementation of remotely controlled mHealth, which they might have brought up as a result of COVID-19 restrictions. This rise coincides with a Norwegian study that found a 17 percent increase in caregivers’ interest in technology to aid dementia care during the COVID-19 pandemic [7].

To enhance effective implementation and use of mHealth, the data emphasize to focus on user needs and requirements, provide failure-proof content, and personalize the design of mHealth. These findings are in line with those of a prior study in which 53 potential barriers to mHealth use for older adults with dementia were identified [8].

A limitation of this study is the exclusion of the intended user group, people with dementia, as inclusion of this group might have led to additional insights. In addition, thirty-four percent said they had no prior experience with mobile health. However, those participants might have been unaware of the wide range of technology that can be classified as mHealth.

We identified four strengths, twelve weaknesses, thirteen opportunities, and six threats based on the input of dementia experts, which can serve as a call to action for everyone involved in the development and implementation of mHealth for Dutch dementia care. Some responses were observed more frequently than others, but we recommend that all observed flaws and prospects for improving mHealth use in dementia care in the Netherlands should be critically evaluated.

## 5. Conclusion

mHealth can be utilized in early stages of dementia and might be cost-effective. Identified weaknesses highlight the importance for a guide for action for everyone involved in design and implementing mHealth for older adults with dementia. It is critical to raise knowledge of mHealth's availability among dementia experts, improve its design, and continue to address the needs of older adults with dementia.

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# Capacity Building in Preparing the Health Workforce to Deliver the Digital Future

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**Abstract.** Programs supporting the necessary combination of digital, organizational, and cultural transformational change, motivating and engaging the workforce, are scarce. This discussion paper reports on the initial experiences from a competency development program aiming at building capacity within the workforce, leaders, and organization in secondary healthcare to navigate and facilitate digitally transformative healthcare systems. The program aims to support employees and leaders who i) understand digitalization in and of practice, ii) reflect and approach digitalization in a critical and ethical way, iii) are curious and maintain a growth mind-set, iv) engage in development and implementation of digitalization, and v) can convey and communicate digitalization. The insights from the prototype can be useful in further promoting sustainable digitalization within healthcare and supporting leaders in their conduct and management of digital health initiatives.

**Keywords.** Competency development, digital skills, healthcare

## 1. Introduction

“When change is greater than learning, we are in trouble!” [1]. The rapid technological development necessitates the need to provide the workforce with broad frameworks or principles (i.e. mind-set), rather than in-depth experience with specific technologies or products [2]. New technologies change the ways in which we interact, work, and communicate, placing high demands for new competencies for all professions at both the employee and leadership level [3,4]. This requires both strategic directions for competence development as well as concrete and practice oriented programs and education directed at the daily practice of employees and leaders, encompassing both technological, cultural, and change management elements. However, such programs are scarce in Denmark. This discussion paper reports on the development and prototyping of a format to support cultural and digital transformational change, motivating and engaging the workforce in secondary healthcare in Central Region Denmark, one of five health regions in Denmark responsible for providing secondary healthcare for 1.3 million citizens. The insights and recommendations can inform further efforts in capacity building in preparing the health workforce to deliver the digital future.

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## 2. Prototype programs for capacity building

In 2018, at the initiative of the Executive Board in Central Region Denmark, a survey was conducted on how to lead in digitalization processes - how leaders in the health region understood digitalization management and how they worked with it on a daily basis. Based on these findings, the project *Leading in Digitalization* was initiated to strengthen and support the leaders of Central Region Denmark (formal and informal) in relation to the development, implementation, and application of digital solutions, both within Central Region Denmark and across healthcare sectors.

The purpose of the project *Leading in Digitalization* was to develop and test a concept for improving competency and capacity to navigate digitalization among leaders in the healthcare system. The program was rooted in the HR Group (responsible for management development in the health region) and IT department, within the Central Region Denmark, and the first prototype was supported financially by the Danish Ministry of Health. The project aimed at expanding existing leadership programs with a particular focus on the management task of leading within an increasingly digitalized healthcare system, including i) providing an understanding of the technological opportunities and how the technology can effectively support workflows and good patient care, ii) to distribute methods for leading and activate processes for engaging citizens in the development and application of citizen-related digital technologies, iii) strengthening the skills to facilitate processes of digital change and transformation, iv) practice specific competencies in adopting and implementing digital solutions and tools, thereby acting as role models for other healthcare professionals, and v) to strengthen communication skills of leaders and employees in the context of digital transformation.

In 2019 the first prototype of the program was developed and tested [5]. Fifty board members, directors, managers, and key employees from all levels of management and with various experience in leading in digitalization participated. The first prototype consisted of two formats: one with management chains vertically engaged (i.e. hospital director, department management, daily management and key employees participating as a group) and one with participants out of pure curiosity and resonance (individual participation).

Based on the findings from the first prototype, a second prototype was devised, further informed by The Topol Review [4] and inspired by the efforts made by the NHS Digital Academy and NHS Health Education England [6]. The aims remained the same but the format was adapted to accommodate the insights gained from the first prototype; the main focus was on engaging vertical management chains as well as the individual and structural prerequisites to engage in the program [7].

Leading in Digitalization 2.0 takes departure in specific practice founded projects and in the individuals engaged in these projects, i.e. the project is the participating entity. The program offers module-based inspiration, knowledge, and tools, as well as sparring, facilitation, guidance, and process support for leaders and key employees throughout the process. During the program the project participants work to set clear goals and a catchy title, see the strategic development paths for the project, and reflect on which opportunities and challenges the project will encounter along the way. The participants gain experience with participant involvement, communication, implementation and digital imagination through five modules of each one day. The program spans approximately six months; the first four modules with one month intervals and the hind module approximately two months after. Table 1 describes the overall content of the modules.

**Table 1.** Content of the five one-day modules in the program *Leading in Digitalization*

Pre-module	Citizens and digitalization	Culture and Communication	Implementation	Hind module
The problem behind the problem	Digital personas Etnoraid	Turbo design sprint	Pre-mortem Benefits	Presentation mindset
Need statements	Empathy mapping	Graphical facilitation	Management	Improvement mentality
Business Model Canvas	Patient stories Citizen involvement	Storyboard Digital consideration	Implementation tools Case stories	Digital imagination

The format is highly interactive and the participants work on their projects throughout the modules culminating in a creative presentation of the projects process in the hind module. The projects were guided through a set of criteria throughout the program (see Table 2). Every project is assigned a multidisciplinary team, a “satellite”, that facilitates and ensures a focus on communication, navigation, and interconnection, through guiding and supporting the management chains working on the specific projects. These satellites are designed to secure support and knowledge into the process - on the project’s premises, culture, facilitation style, and based on the needs of the project.

**Table 2.** Criteria designed to ensure a connection between strategic initiatives and focus areas of the Central Denmark Region and management of the effort of digitalization.

Criteria
1 Involvement of at least two departments with the same area of competence from other units in the region
2 Locally anchored facilitators
3 Coherence with the digitalization strategy of the region
4 Organizational anchoring in the management chain and board
5 Project focus in relation to internal challenges
6 Set concrete and viable, as well as desired, goals for the project
7 Use new forms of organizing – new ways of working
8 Clear communication about the project, a communication platform or storyline to develop along the project
9 Establish a clear and captivating title for the project
10 Ensure patient/citizen involvement

### 3. Experiences so far

The program was designed around three guiding structures: i) departure in specific, practise oriented projects, ii) participation as a vertical management chain, and iii) supporting systems for the individual projects during the program. By summer 2021 six different projects have participated in the program.

The insights and recommendations for capacity building are based on i) the design team’s experience on how to support the people and organization in the process of attaining value creating digitalization, ii) participant self-scores, and iii) insights obtained through participant observations during the program as well group and individual interviews with participants and course managers conducted during spring 2021 by

authors SE and CL for their master thesis in educational science. All participants gave informed consent prior to participating and data collection.

### *3.1. Project oriented*

As the participants join the program with a project relevant in their daily practise, they are highly motivated in engaging in the program. Encompassing time to work in the project groups during the modules of the program was effective and appreciated by the participants. Participants emphasize that it was appreciated that the program allowed room for the projects to reflect and plan the project visions. As collaborative time is very often sparse in clinical practise, supporting the project groups with facilitated room for reflection and discussion is highly effective when aiming at supporting development and change. The participants used the course content within the course modules, applying it to their own project and process, which is conducive for transfer [8]. The participants applied both knowledge and methods between the modules in their daily practise, e.g. drawing story boards to facilitate communication and involvement from colleagues.

### *3.2. Vertical management chain*

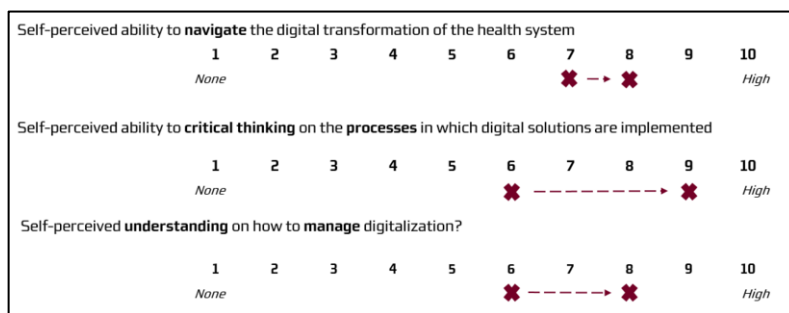
Participating as a vertical management chain appears beneficial for the implementation process and minimises the need for translation and transfer after the course modules, as it is common for other competence development programs. Vertical management chains are also relevant in decision making. Participants were not stopped in their processes because they had to wait and ask for permission – the decision competence and employee perspectives are integral parts of the project group allowing agile processes and seemingly enhancing motivation and job satisfaction.

### *3.3. Supporting systems - Satellites*

The significance of the satellites is seen on several levels. As the satellites are comprised of people from across the organization (i.e. IT, HR etc.) as well as external capacities, the satellites provide valuable feedback and insight for the organization into how leaders and employees manage and navigate digitalization in practise. The format creates an agile, fast-moving and “in time” access to knowledge and network, as well as training in accessibility, to dare move beyond of culturally knowledge spheres and thereby expand the projects’ and organizations self-understanding. From the project perspective, gaining value from the satellite requires engaged and relevant competencies in the satellite as well as alignment of expectations and continuous progress of the projects.

## **4. Effects of the program and further development**

The participants increased their self-perceived ability to navigate the digital transformation of the health system, critical thinking on the processes in which digital solutions are implemented, and their understanding of how to manage digitalization. A strong focus on communication and cultural change and development alongside with the technical elements seem to be consistently important factors for all the projects.



**Figure 1:** Median self-scores from participants based on 19 baseline answers and 16 follow up answers.

Despite having very different points of departure, the projects had achieved the goals they set initially and were working towards either more ambitious goals or to applying their solutions in different settings or contexts, thus supporting the transition towards delivering the digital future of healthcare.

In moving forward in developing and improving the prototype, particular attention should be given to specifying the role of management and leadership in the implementation phase as well as facilitating opportunities for leaders and employees to gain knowledge on relevant and emerging technologies, e.g. image recognition, machine learning, virtual reality etc. Revisiting the criteria throughout the program heightens the projects' self-awareness as well as supporting the implementation and dissemination. Supporting opportunities for exchange of experiences between the projects of the program in order to expand perspectives and cross fertilize ideas throughout the program is highly relevant and establishing network groups could be pertinent.

The prototype was an attempt to build capacity to support and address the digital and cultural transformation healthcare is facing. The initial experiences reported in this paper have been encompassed in the further development of the program. We encourage others to adopt a similar approach in building and developing programs focusing on promoting a combination of digital and cultural transformational change, motivating and engaging the health workforce to deliver the digital future.

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# Context-Sensitive Implementation of Clinical Pharmacy Missions Within an Academic Hospital

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**Abstract.** Clinical pharmacy activities contribute to improve patient safety. Yet, the work system's characteristics influence how clinical pharmacy activities are performed and conversely clinical pharmacy causes that work system to evolve. This exploratory study aims to identify the different ways in which clinical pharmacy activities are performed in different units of a large academic hospital. Interviews and observations have been performed to identify in each ward the clinical pharmacy activities implemented and how they are carried out.

**Keywords.** Clinical pharmacy, ethnographic method, context, pharmaceutical analysis, pharmaceutical intervention

## 1. Introduction

Clinical pharmacy “is a health science discipline in which pharmacists provide patient care that optimizes medication therapy and promotes health, and disease prevention” (American college of clinical pharmacy [1]). Several studies have shown that clinical pharmacy contribute to reducing the cost of care [2], but also the number of medication errors [3], the number of adverse drug reactions [4] and finally the length of hospital stay and the mortality rate [5]. Implementing a new practice, such as clinical pharmacy, in a highly complex work system needs the anticipation of the profound impact on work processes, or possible conflicts with existing organizations, facilities, and beliefs. The new work practice causes that work system to evolve; conversely, the characteristics of the work system will influence how the new work practice is performed. In the field of clinical pharmacy, several factors are known to facilitate, affect, or hinder the setup of clinical pharmacy: political factors (e.g., legislative framework, political drive, financial support from the government and/or hospital administration) [6–7], factors related to human resources (e.g., workload/available human resources ratio, definition of tasks) [6–

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8], factors related to the training and recognition of clinical pharmacists (e.g., existence of specialized academic programs, recognition of degree and position, salary) [6–9], factors related to communication (e.g., between pharmacists, between pharmacists and physicians, or with institutions about the benefits of clinical pharmacy) [6–9], and factors related to the work organization (e.g., presence of the pharmacist in or outside the clinical department, access to patient information) [6,8,10]. This exploratory study aims to identify the different ways in which clinical pharmacy is performed in a large university hospital along with contextual factors that may influence how it is performed.

## **2. Study context**

Clinical pharmacy is particularly well established in Anglo-Saxon countries, where the pharmacist is an integral part of clinical services and whose role is valued. In France, it is still a young discipline. In 2011, a decree entrusted hospital pharmacists with the task of analyzing drug orders [11]; in 2016, clinical pharmacy missions were included in the missions of hospital pharmacies [12]; and finally, in 2019, the clinical pharmacy missions to be carried out were made explicit in the law [13].

The pharmaceutical analysis of orders is the core mission of clinical pharmacists that may lead to a pharmaceutical intervention (i.e., an advice given to the relevant clinician to adapt the treatment or monitor its effects). This activity can only be really performed when the orders are computerized. At Lille academic hospital, the clinical pharmacy roll-out follows that of the computerization of the prescription of medicines. It has been developing since 2015. Today, approximately 1350 beds are supervised by the 12,8 full-time equivalents pharmacists of the clinical pharmacy department. A clinical pharmacist will oversee one or more clinical units.

## **3. Method**

First, in order to have a broad view on clinical pharmacists' activities and to identify the different ways clinical pharmacy is implemented, an exploratory interview was conducted with the right-hand woman of the head of the clinical pharmacy unit. Then, semi-structured interviews were led with clinical pharmacists working within units representing the diversity of the hospital's care offer. Using open-ended questions, the aim was to identify the different work systems, especially tasks performed, work environment, organizations and actors involved in clinical pharmacy activities. The SEIPS (Systems Engineering Initiative for Patient Safety) model was used to structure the data analysis [14]. Interviews were audio-recorded and transcribed. Tasks observations of the clinical pharmacists' activities were performed to enrich the collected data.

## **4. Results**

A total of 11 interviews were conducted for an average duration of 70 min. in 11 clinical units where clinical pharmacy missions are implemented. Four observation sessions of the tasks of 3 clinical pharmacists were performed (average duration = 165 min.).

Five different work systems were identified. Four out of these five work systems were identified as performing pharmaceutical analysis (Table 1). The fifth work system has a clinical pharmacy activity but limited to the management of high-severity alerts delivered by the computerized system. We will focus the description on the other 4 systems and their work organizations supporting the clinical pharmacy activity.

**Table 1.** Clinical pharmacy activities performed in addition to pharmaceutical analysis along with some elements of the work organization/environment, this according to the unit.

Care units	Clinical pharmacy activities	Elements of work organization/environment
Surgery (Including: neurosurgery, digestive, trauma surgery, orthopedic and septic surgery units)	Entry medication reconciliation (except orthopedic and septic surgery units) Pre-anesthesia pharmaceutical consultation (only in neurosurgery unit) Therapeutical education (only in trauma surgery unit)	Weekly contribution to clinical staff
Geriatrics (Including: geriatric medicine, post-acute and rehabilitation care units)	Entry and discharge medication reconciliation Medication review	Office in the care unit or in the building
Medicine (Including: neurology, hematology, gastrology hospitalization units gastrology consultations units)	Entry and discharge medication reconciliation (discharge only in neurology unit) Therapeutical education (only in neurology and in gastrology consultations units)	Weekly contribution to medical rounds
Penitentiary unit	Therapeutical education	Distant from the hospital building

Overall, communication within the four clinical units is mainly carried out *via* mediated communication (through the electronic health record) when the pharmaceutical intervention is non-urgent or does not need explanation nor to be debated. On the contrary, verbal communication (face-to-face, phone call) is preferred when the intervention is urgent, requires explanation or can lead to a debate on its legitimacy. But there are some specificities according to the work systems.

One of the clinical units is geographically distant from the hospital building, the penitentiary unit. Exchanges between professionals from the unit and clinical pharmacists are mainly limited to those described above.

The other three work systems have organized dedicated synchronous timeslots for clinical units' professionals and clinical pharmacists to discuss synchronously patients' treatments face-to-face. These synchronous communications are organized very differently in the three work systems. But they all allow clinical pharmacists to be directly involved in the therapeutic decision making and to contribute while being aware of the therapeutic objectives for the patient. Awareness of the therapeutic objectives is one of the essential elements to be able to perform the deepest level of prescription analysis, level 3, recommended for patients by the SFPC [15].

Very often, geriatricians are professionals convinced by clinical pharmacy, especially because elderly take many drugs and clinical pharmacy usefulness is quite obvious. It was the first clinical unit to implement medication review in Lille academic hospital: a regular meeting is organized for discharged patients. Moreover, pharmacists in geriatrics are now the only clinical pharmacists to have their office in the care unit or at least in the geriatrics building. Unlike others clinical pharmacists who have their office in the central pharmacy building. Pharmacists in geriatrics are then more willing to gather pharmaceutical interventions to then meet the prescriber face-to-face, while the other

pharmacists tend to call the prescribers more than they try to meet them as central pharmacy is not at walking distance from the care units.

In medicine units, residents oversee the daily medical rounds. Once a week, a medical round takes place with the head of the department, the doctors and the students. The clinical pharmacist systematically participates in this medical round and therefore can contribute to the therapeutic decisions of the patients.

In surgery units, clinical pharmacists contribute to therapeutic decisions during the weekly clinical staff meeting. But clinical pharmacists express that influencing and changing decisions is not easy. The clinical meeting is structured by the medical point of view, with clinical pharmacy as the “cherry on top”. Representations of clinical pharmacy and its contribution are changing but slowly.

## 5. Discussion and conclusion

This exploratory study was conducted to identify the different ways in which clinical pharmacy activities are performed in a large university hospital along with contextual work factors that may influence how they are performed. Results show that a wide variety of clinical pharmacy activities are performed, and that the way they are performed are related to contextual factors of the clinical department. The clinical units concerned are those with computerized therapeutic prescriptions. Some of the units, corresponding to a first work system, remain on a reactive management of the alerts issued by the computer system to adapt the treatments in case of problem. The other four work systems identified engage in anticipatory treatment adaptation activity. Four different work organizations are described for which either the existing organizations have impacted the implementation of clinical pharmacy, or conversely the implementation of clinical pharmacy has impacted the existing activity.

In the penitentiary unit, geographical constraints do not facilitate face-to-face exchanges between the clinical staff and the clinical pharmacist. For units within the hospital, according to the interviews, physicians' perceptions of the benefits of clinical pharmacy have a strong impact on the clinical pharmacy implementation. In surgery, clinical pharmacists participate in the medical staff meeting. However, the meetings are still strongly structured by the doctors, as are the decisions that are finally made. A change in representation is slowly taking place. In medicine and geriatrics, therapeutic decisions are made jointly by physicians and clinical pharmacists, respectively with the pharmacist taking part in medical rounds and dedicated medication review meetings, and in geriatrics even providing the pharmacist with an office on site now.

The main limitation of this study is that, for reasons related to the sanitary context of COVID-19, it was not possible to carry out as many observations as desired in the clinical units. Interviews with clinical pharmacists were therefore preferred. This may represent a bias since this method mainly reflects the perception of clinical pharmacists of their own activity and not their actual activity. Nevertheless, the data collected through interviews with clinical pharmacists converge strongly with those collected during the observations, ensuring a good validity of the data collected. Furthermore, to our knowledge, the main advantage of this study is that it maps the implementation of different clinical pharmacy missions in a large academic hospital.

The next steps in this study are to identify in more detail and in a structured way the factors that influenced the implementation of clinical pharmacy missions in the departments. As clinical pharmacy is a quite new activity in France, its implementation



and heterogeneity could be explained by the opportunities clinical pharmacists have to disclose to potentially uninformed medical and paramedical teams their abilities within care unit. The perception and the understanding those teams have of the clinical pharmacists' missions will be investigated.

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# Sociotechnical Analysis of Task Performance and Workload in Healthcare

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# How Demanding Is Healthcare Work? A Meta-Analytic Review of TLX Scores

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**Abstract.** This study establishes how demanding healthcare work is experienced to be and whether nurses and physicians experience different levels of workload. A meta-analytic review was conducted of 87 studies that reported Task Load Index (TLX) scores for healthcare work. Of these studies, 37 were conducted in real-life settings and 50 in lab settings without real patients. In real-life settings, clinicians experienced a workload with a mean TLX of 49 (on a 0-100 scale). Divided onto staff groups, the mean TLX for nurses was 63, which was significantly higher than the mean of 40 for physicians. Among the six TLX subscales, the main contributors to workload were mental demand, temporal demand, and effort. They were higher than physical demand and frustration. The clinicians experienced their performance – the last subscale – as closer to poor than good in 38% of the studies conducted in real-life settings. The difference between nurses and physicians was consistent across all subscales, except mental demand. Finally, it is methodologically important that TLX scores appeared not to transfer directly from lab to real-life settings. To reduce the risk of errors and burnout, new healthcare procedures and technologies should be evaluated for their impact on workload.

**Keywords.** Workload, psychological stress, physicians, nurses, NASA-TLX

## 1. Introduction

Excessive workload increases the risk of errors and burnout, thereby harming patients as well as healthcare staff [1, 2]. Accordingly, it is important to know the workload imposed by healthcare work and how it is experienced by physicians, nurses, and other staff. Without such knowledge, risks may go unnoticed. With it, the high-workload areas can become the target of efforts to reduce workload. For example, electronic whiteboards are often introduced to reduce workload by improving communication and overview [3, 4]. This study establishes healthcare clinicians' workload by reviewing published Task Load Index (TLX, aka NASA-TLX) scores.

TLX [5] measures self-reported workload. Self-reported workload is important because clinicians who experience their workload as excessive will behave as though they are overloaded, irrespective of the objective task demands. Among the measures of workload, TLX is so widely used that de Winter [6, p. 293] has stated that “workload has become synonymous with the TLX.” Workload emerges from the interaction between the demands imposed by work tasks and the skills, behaviors, and perceptions of the staff performing the work [5]. A TLX score is the mean of six subscales: mental demand, physical demand, temporal demand, effort, performance, and frustration. Each subscale

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is measured with a single item that has the endpoints ‘Low’ (0) and ‘High’ (100), except that performance has the endpoints ‘Good’ (0) and ‘Poor’ (100).

This study reviews published TLX scores to establish the workload experienced by clinicians. To obtain information about the different dimensions of workload, the review is restricted to studies that include values for the six TLX subscales. The study seeks to answer two research questions:

- How demanding is healthcare work experienced to be?
- Do nurses and physicians experience different levels of workload?

Furthermore, the study distinguishes between workload measurements obtained in real-life settings and in lab settings (i.e., in experiments that do not involve real patients). This distinction helps avoid undue transfer of TLX scores between the two settings.

## 2. Method

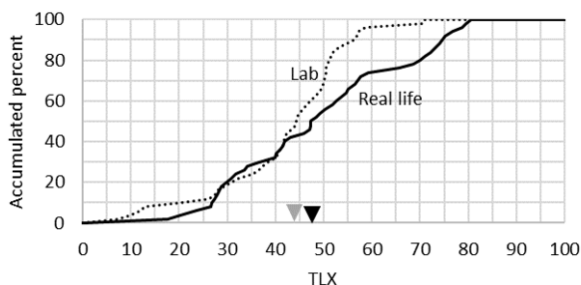
The authoritative reference for TLX is Hart and Staveland [5]. Thus, the three primary inclusion criteria for this study were that papers cited Hart and Staveland [5], were about healthcare, and reported empirical values for all six TLX subscales. The values had to be raw TLX ratings; papers that reported weighted ratings for the subscales were excluded because weighting was infrequent and has been depreciated [7]. The papers also had to have at least five participants, be published in journals, edited books, or conference proceedings in the period 1990-2019, and be in English. When a paper existed in multiple versions, only the most extensive version was included. Initially, Google Scholar was searched for the papers that cited Hart and Staveland [5]. Of these 9647 papers, 86 met the inclusion criteria. One paper reported from 2 studies, for a total of 87 studies.

The data analysis had four steps. First, the papers were coded. This involved extracting the number of study participants, the numerical endpoints of the rating scales, the participant group, the setting (lab or real life), and the values of the TLX subscales. Subscale values were extracted for each condition for which such values were reported. Second, the subscale values were rescaled to the 0-100 range, if another range was used in the study. Third, TLX was calculated as the mean of the subscales. Fourth, a value for each study was obtained by taking the mean across the study conditions, thereby making the analysis independent of the number of conditions in the studies. Each of the 87 studies contributed to the analysis with a score for each subscale and a TLX score.

## 3. Results

Of the 87 studies, 37 reported from studies conducted in real-life settings. These 37 studies involved 5739 participants. The remaining 50 studies were conducted in lab settings and involved 1454 participants. Figure 1 shows the distribution of TLX. The median TLX score was 44 (lab) and 47 (real life), whereas the mean TLX score was 42 (lab) and 49 (real life). Table 1 shows the distribution of the six TLX subscales for the studies conducted in *real-life settings*. One in five studies found that the workload was 70 or more for mental demand, temporal demand, effort, performance, and overall TLX. In 38% of the studies, performance was closer to poor than good. The subscales differed significantly,  $F(5, 32) = 11.76, p < .001$ . Bonferroni-adjusted pairwise comparisons

showed that mental demand, temporal demand, and effort were higher than physical demand and frustration and that performance was lower (i.e., better) than mental demand. The subscales also differed significantly for the studies conducted in *lab settings*,  $F(5, 45) = 18.00, p < .001$ . However, the pairwise comparisons showed a different pattern for physical demand (it was lower than all other subscales), temporal demand (it was lower than mental demand and effort), and performance (it did not differ from mental demand).



**Figure 1.** Accumulated distribution of TLX,  $N = 50$  (lab) + 37 (real life) studies. The triangles indicate the median for lab (gray) and real-life (black) studies.

**Table 1.** Distribution of TLX and its subscales in real-life settings,  $N = 37$  studies

Percentile	MD	PD	TD	EF	PE	FR	TLX
10th percentile	32	18	21	30	11	20	27
20th percentile	36	24	31	39	23	24	30
30th percentile	45	30	41	45	24	28	36
40th percentile	55	33	49	48	28	31	42
50th percentile (median)	62	40	56	54	39	39	47
60th percentile	63	45	63	60	45	46	53
70th percentile	70	50	67	62	70	52	57
80th percentile	77	61	70	74	77	58	70
90th percentile	81	71	76	82	80	68	74
100th percentile	88	84	87	86	88	80	80

Note: EF – effort, FR – frustration, MD – mental demand, PD – physical demand, PE – performance, TD – temporal demand, TLX – task load index

Table 2 shows the TLX data divided onto nurses, physicians, and other study participants. The ‘other’ group mainly consisted of lab studies with student participants. There was a significant effect of participant group on TLX for the studies conducted in *real-life settings*,  $F(2, 34) = 10.74, p < .001$ . Bonferroni-adjusted pairwise comparisons showed that nurses (63) experienced significantly higher workload than physicians (40) and other participants (40). With nurses experiencing 58% higher TLX scores than physicians, the difference in workload was not just statistically significant but also large. There were also significant effects of participant group on mental demand, physical demand, temporal demand, effort, performance, and frustration,  $F(2, 34) = 3.43, 6.00, 7.10, 6.66, 10.54,$  and  $11.72,$  respectively (all  $ps < .05$ ). Bonferroni-adjusted pairwise comparisons showed that all subscales, save mental demand, were higher for nurses than physicians and that all subscales, save mental and physical demand, were higher for nurses than other participants. The largest subscale difference concerned performance. Physicians (30) experienced that they performed twice as well as nurses (65) did. As a result, performance drove TLX downward for the physicians, but upward for the nurses. For the *lab studies*, there was no effect of participant group on workload,  $F(2, 47) = 0.24,$

0.49, 2.36, 0.02, 1.16, 2.62, and 0.24 (all  $ps > .08$ ) for mental demand, physical demand, temporal demand, effort, performance, frustration, and TLX, respectively.

**Table 2.** TLX and its subscales (mean  $\pm$  standard deviation) for participant groups

Group	Studies	MD	PD	TD	EF	PE	FR	TLX
<i>Lab</i>								
- Nurses	2	53 $\pm$ 3	22 $\pm$ 13	62 $\pm$ 7	50 $\pm$ 1	47 $\pm$ 17	55 $\pm$ 14	48 $\pm$ 9
- Physicians	22	49 $\pm$ 18	32 $\pm$ 14	42 $\pm$ 13	39 $\pm$ 12	39 $\pm$ 12	40 $\pm$ 11	42 $\pm$ 12
- Other	26	46 $\pm$ 18	34 $\pm$ 17	39 $\pm$ 16	48 $\pm$ 18	46 $\pm$ 21	35 $\pm$ 14	41 $\pm$ 15
- Total	50	47 $\pm$ 18	32 $\pm$ 16	41 $\pm$ 15	48 $\pm$ 16	43 $\pm$ 17	38 $\pm$ 13	42 $\pm$ 13
<i>Real life</i>								
- Nurses	14	67 $\pm$ 18	54 $\pm$ 20	66 $\pm$ 14	66 $\pm$ 16	65 $\pm$ 21	56 $\pm$ 15	63 $\pm$ 14
- Physicians	16	53 $\pm$ 15	33 $\pm$ 12	46 $\pm$ 16	48 $\pm$ 11	30 $\pm$ 17	32 $\pm$ 11	40 $\pm$ 9
- Other	7	49 $\pm$ 21	34 $\pm$ 25	39 $\pm$ 27	47 $\pm$ 21	38 $\pm$ 32	33 $\pm$ 21	40 $\pm$ 22
- Total	37	58 $\pm$ 18	41 $\pm$ 20	52 $\pm$ 20	55 $\pm$ 17	45 $\pm$ 27	41 $\pm$ 19	49 $\pm$ 18

Note: EF – effort, FR – frustration, MD – mental demand, PD – physical demand, PE – performance, TD – temporal demand, TLX – task load index

#### 4. Discussion

Healthcare has a mean TLX of 49 in real-life settings. For comparison, the mean TLX reported from real-life settings across a range of domains is also 49 [8]. However, the workload in healthcare is not uniformly high. In 20% of the reviewed real-life studies, TLX is 70 or more. For example, Sönmez et al. [9] report a mean TLX of 80 for nurses working in a variety of hospital units. In addition, TLX is 58% higher for nurses than physicians. Physicians, for example, experienced a TLX of 48-54 (depending on their level of experience) after the introduction of an electronic whiteboard [3]. Nursing is a high-workload job, so much so that nurses' mean experience of their performance is closer to poor than good. The higher workload experienced by nurses than physicians is consistent across all subscales, save mental demand.

Staff-group differences aside, workload in real-life healthcare settings is mostly about mental demand, temporal demand, and effort. By contrast, physical demand and frustration contribute less to workload. These subscale patterns show that the demands imposed by healthcare work are mental and temporal to a larger extent than physical. Two other inferences should also be noted. First, clinicians try to compensate for high demands by expending extra effort in an attempt to maintain their level of performance. With effort as a main contributor to their workload, clinicians are straining themselves, thereby suggesting a small margin between their workload and overload. Second, even with the extra effort, 38% of the real-life studies find that clinicians experience their performance as closer to poor than good. This could indicate that many clinicians have adopted suboptimal behaviors, such as shortcuts, to cope with their workload [10]. The pattern that frustration is a modest contributor to workload suggests that the high demands are so common that clinicians have come to perceive these demands as integral to the normal state of affairs. In general, frustration ensues when events unexpectedly thwart goal attainment [11]. That is, high demands cause less frustration if they are normal to the extent of being expected. In healthcare, it appears that high workload is sufficiently common to make frustration a modest contributor to workload.

This meta-analytic review has several implications for research and practice. First, the workload in healthcare is sufficiently high to be a risk factor that increases the likelihood of errors and burnout, more so for nurses than physicians. Consistent with

previous studies [1, 2], the TLX subscales indicate that clinicians are straining themselves and may be adopting suboptimal behaviors to cope with their workload. Second, there is a need for procedures and technologies to help reduce workload in safe ways. These procedures and technologies may simplify tasks [4] or provide early warnings of possible overload [12]. Relatedly, new procedures and technologies should be evaluated for their impact on workload. If introduced without evaluation, it may go unnoticed that a staff group gets overloaded. The associated risks may dwarf the benefits of the procedure or technology. Third, the TLX scores reported in this study (Tables 1 and 2) can serve as reference values against which to evaluate local TLX measurements. Such comparison against an independent corpus may be preferable to the effort of establishing a local point of reference. Fourth, TLX scores obtained in lab and real-life settings appear to differ. Possible explanations for this difference include that some tasks may be studied more in one or the other setting. In addition, real-life settings involve more multitasking and genuine consequences [8]. The workload difference between real-life and lab settings precludes direct cross-setting comparisons and complicates the pre-implementation evaluation of how procedures and technologies affect workload.

The review results should be interpreted with certain limitations in mind. The reviewed TLX scores concern the workload perceived during selected work tasks. These tasks set the context for the measurements but have not been specified in the review, except by distinguishing between nurses' and physicians' tasks. In addition, only one source (Google Scholar) was searched for papers to include in the review and only one person (the author) coded these papers.

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# Data Work in Health Care: The Case of Medical Secretaries

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**Abstract.** This paper investigates the often neglected area of data work by medical secretaries, specifically in the context of hospitals in Denmark. Since the 1930s medical secretaries have played a steadily more central role in meeting the growing need for health data. With electronic health records (EHRs) and promises of data automation, the profession has been put at risk of redundancy. While there is a considerable base of research on the datafication of health care, the data work emerging from datafication remains undescribed. Hence, we are conducting a socio-technical study of clinical-administrative data work in contemporary Danish public hospitals. In this paper we present early insights of this research, indicating the vital role of medical secretaries' data work in securing clinical information at the point of care.

**Keywords.** Data work, EHR, electronic health record, administrative work, hospitals, socio-technical research, medical secretaries

## 1. Introduction

Since the 1800s the interconnected trends of standardization and scientific medicine have increased the need for nonmedical administrative skills and human resources in hospitals [1, 2]. Along with the introduction and explosive development and scope of standardized health records, new professions have emerged to meet the demand for more and better data in health care [1], [3]. The rise of data as the new “oil” of the information economy [4], along with widespread digitalization, has become evident in health care and in the broader society in many countries [5,6]—including the strategies of the Danish government [7].

Data, including health data, is not simply pumped out of the ground to flow frictionless through organizations, as the oil metaphor might suggest. As the emerging field of critical data studies argue, data is entangled in the contexts of its production and use; it requires hermeneutic judgement and situated work [8]. Thus, the concept of “raw data” is an oxymoron [9]. Large-scale data is a product of the work of many people and professions [10], creating new professions [3] and leading older professions to take on new tasks [10]. In this study we apply a broad definition of data work, which we refer to as “any activity related to creating, collecting, managing, curating, analyzing, interpreting, and communicating data whether these are facts, numbers, letters, or symbols that describe an object, idea, condition, situation, or other factors” [3].

Especially since the 1950s, with the increasing rate of progress in scientific medicine, medical secretaries have been at the center of data work at Danish hospitals and instrumental to meeting the increasing need for situated data work, data quality, and data management at the ward level.

Fewer studies have focused on understanding the work of medical secretaries than have focused on the work of physicians or nurses. This could be due to the lower number of medical secretaries, but it may also be because medical secretaries and other administrative workers are more likely to be invisible in the eyes of managers and researchers [11-13]. The terms used for clerical and administrative workers in hospitals vary by country [1, 14, 15], also making research difficult to compare.

Studies of medical secretaries in the context of Danish public hospitals argue that the profession carries out a wide range of patient-oriented and health-administrative tasks and support to clinicians' work, stretching far beyond simply "being secretary to the physician" and transcribing medical notes [16, 17]. Some studies argue that medical secretaries are central to the work in and around patient records [18]. Studies highlight medical secretaries acting as "'organisational glue' or [the] connecting thread between other professional groups at the hospital" [19]—a quality partly attributed to the decentralized distribution of medical secretaries at ward level in Danish hospitals, which affords deep domain knowledge of the medical specialty they work in. Other studies argue that medical secretaries do not solely operate in administration; that they are positioned at the "'intersection' of formally separate but practically enmeshed practices, namely administrative and clinical work" [20]. Thus, they support and are a direct part of clinical work, making professional judgements informed by a unique combination of knowledge about medicine, administration, and care pathways [20, 21]. The work of medical secretaries, however, as that of many other clerical workers, often gets relegated to the background [16, 17, 22], regarded as automatable, routine work of little value [23], [24]. In Denmark, new electronic health record (EHR) systems have been partly financed through the redundancy of medical secretaries. This occurred most recently between 2017 and 2018, with the implementation of the EPIC EHR system in two Danish regions.

This paper presents early insights from a 2021 study of medical secretaries' data work in Danish hospitals. Their data work is an interesting case for understanding the changing role of data work in digital health care. The study is part of a larger research project<sup>1</sup> investigating new knowledge and skills required to work with data in an increasingly digitalized health care sector and how this new kind of data work impacts professions.

## 2. Methods

This study's empirical data derive from participant observations (eight days) and in situ interviews in four hospital departments at in- and outpatient clinics (two in cardiology, one in neurosurgery, and one in diagnostic imaging) using two EHR systems in three different hospitals in two regions in Denmark. Also, two interviews were conducted with representatives of HK-DL, the union of medical secretaries, at the national ( $n = 1$ ) and regional level ( $n = 4$ ).

Participant observations were carried out by job shadowing medical secretaries in different functions, spending two days at each department. The purpose of engaging in multisite observation was to observe their data work across different technological and organizational contexts to gain a broad understanding of their work and to identify relevant emerging categories during the early stages of a sociotechnical study.

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<sup>1</sup> The project is funded by the Independent Research Fund Denmark (grant 0132-00200B: "Making Data Work Visible"). See <https://projects.au.dk/datawork>.

During observation, extensive handwritten notes were ‘jotted down’ [25] and subsequently typed. Collected data also comprise a range of relevant documents identified during observation. Field notes and documents have been coded and categorized. While the process of analysis will continue as the fieldwork and research continues, the following example represents one emerging category present in the data.

### 3. Results and analysis

A significant part of medical secretaries’ data work takes place within and in relation to the EHR ensuring that EHR data is complete, updated, and correctly coded. Correct and updated data is vital in relation to clinical work, patient safety, and the financial management of the department, emphasizing the importance of the data work performed by medical secretaries in making sure that EHR data is “trimmed” [18]. However, a maybe less obvious set of tasks that our study shows is undertaken by medical secretaries involves instances when the technical infrastructure does not allow for data to “flow,” requiring data to be moved manually through the system to enable access to the right data at the point of care. These cases are the focus of this article.

Weak interoperability between hospitals’ digital health care systems, municipalities and general practitioners (GP) creates a need for manually supported processes to be performed by medical secretaries. In the case of a cardiological department, to initiate the clinical decision-process based on a referral, an ECG must be included in the referral from the GP. However, one medical secretary in this study explained how this is often not the case. The seemingly simple problem of obtaining an already existent ECG from a GP triggers a wide range of tasks: creating a correspondence note, follow-ups, telephone calls with the GP, receiving faxes of the ECG (which often cannot be sent digitally between the GP and the hospital), scanning the document and attaching it to the patient’s EHR, finally enabling the further processing of the referral. Similar tasks are required when weak interoperability between health care institutions and IT systems means that image data from the radiology department must be transferred to DVDs and forwarded to outside specialist clinics or are received at the hospital on DVDs. Both are examples of how the data work of medical secretaries supports clinical care by providing needed clinical information at the point of care—information that would otherwise be unavailable in clinical work due to weak interoperability.

Our study suggests that, in addition to bridging the gaps in data journeys, medical secretaries often play active roles in supporting the ongoing digitalization of department workflows to close gaps in data journeys. In one department, a medical secretary had initiated the digitalization of the patient-surgeon preoperation conversation, which simplified the process for both the clinical and administrative context. In another department, the head medical secretary persuaded clinic management to take advantage of an EHR update to fully abandon paper-based workflows. In a third department, which still maintained a substantial number of paper-based processes (e.g., in relation to the visitation process), medical secretaries maintained two parallel data flows: one digital and one paper-based. The medical secretaries in the department presented as a form of collegial care—a way to help the clinical staff “make things run smoothly,” although it created a considerable amount of work (e.g., printing referral data, preparing for clinical personnel, and entering visitation data back into the EHR) for the medical secretaries. One of the medical secretaries stated that the clinical personnel “could probably learn how to do it [the digital workflow], but we have prioritized speed,” adding that “maybe

we are wrapping them in cotton wool.”, suggesting that medical secretaries play a significant role in the digitalization process at the departmental level.

#### 4. Discussion and Conclusion

In the opening of this article, we pointed to the problematic view that sees data as something that flows frictionlessly through organizations. Based on insights from our fieldwork, we show how medical secretaries' data work is integral to enabling the movement of data and the ongoing development of procedures and workflows for data work.

While continuous threats of being “automated away” remain, medical secretaries in Danish public hospitals have been able to adapt and remain essential despite technological and organizational changes. They have evolved from “physician’s secretary” to health administrative coordinators in a health sector that aims to become data-informed, if not data-driven.

As shown in multiple studies [26, 27], both technical and socio-technical issues often arise when EHR systems and workflows collide, leading to unintended consequences and errors; the new system fixes one set of problems only to create others. We argue that medical secretaries in Danish hospitals play a vital role in mitigating both technical and sociotechnical issues.

Several studies emphasize that health-administrative personnel play a vital role in creating and sustaining cohesion in hospitals, such as health information managers in Australia [1] and secretaries in Norway [14] and in Denmark [16, 17, 19, 20]. While clinical work is documented through, for example, DRG codes, the administrative tasks (e.g., follow-ups and telephone queuing to gather missing data) taken to bridge gaps in data journeys remain informal. Thus, medical secretaries' data work runs the risk of becoming invisible when designing and implementing EHRs and other technological and organizational changes. This calls for further investigation and illumination of the data work of medical secretaries.

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# How Socio-Technical Factors Can Undermine Expectations of Human-Robot Cooperation in Hospitals

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**Abstract.** This research analysed human–robot cooperation and interaction in the basement of a Danish hospital, where kitchen staff and porters conducted their daily routines in an environment shared with mobile service robots. The robots were installed to ease the everyday routines of kitchen staff and carry out physically demanding tasks, such as transporting heavy cargo between destinations in the hospital basement. The cooperation and interaction were studied through ethnographic inspired fieldwork and the results highlighted how robots affect the real-life environments into which they are gradually moving. The analysis revealed how the great human expectations of robots clashed with reality and identified three key elements that influence human–robot cooperation in hospitals: 1) environmental factors, 2) behavioural factors and 3) factors related to human reliance on robots. We emphasise the importance of considering socio-technical factors when deploying robots to cooperate with humans in hospital environments.

**Keywords.** Socio-technical factors, expectations of mobile robots in practice, hospital, human-robot cooperation

## 1. Introduction

Robots have gradually moved out of controlled settings, such as laboratories and industry, into everyday real-life environments, including homes, workplaces, cultural institutions and public arenas—not least hospitals, which is the setting with which this paper is concerned. As robots increasingly enter new application areas—‘the wild’—with diverse actors and unexpected responses, research on the relationship between humans and robots in real-life settings become more vital. Hence, knowledge about human reactions and behaviour towards robots in complex environments, and the influence of robots on the environment with which they interact, is essential. Robots are entering diverse social arenas, while most of the existing research within the field of human–robot interaction, which forms the basic understanding of how people interact and engage with robot technology, is concerned with controlled robot settings such as laboratories and industrial environments. There is a lack of research investigating how robots affect the uncontrolled environments in which they are deployed and therefore a lack of insights into what to expect when humans and robots cooperate in complicated environments and real-life work settings, such as hospitals. As a consequence, hospital staff tend to have greater expectations of robots than the robots are able to meet in practice. Hence, understanding

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the nuances and complexities of how humans and robots interact in hospitals (environments that are not highly structured, controlled or designed for robots originally developed to engage in industrial settings) is valuable for designing future human–robot cooperation-friendly hospital environments focused on socio-technical factors.

This paper reports findings from an ethnographic inspired study of hospital staff cooperating with mobile service robots in a hospital basement. The paper shows how challenges occur in human–robot teamwork in a hospital environment that is not designed for mobile robots, highlighting the socio-technical factors relevant to the robots' impact on the context of which they are a part. Mobile service robots were installed in the hospital basement to improve the physical wellbeing of a specific group of human service workers—hospital kitchen staff—by carrying out demanding physical tasks, such as transporting heavy cargo between destinations in the hospital basement.

## **2. Background**

Related work within the field (mobile robots among humans in everyday environments) has researched how mobile robots affect the environments in which they are deployed. It has been known for some time that robots can change routines, affect activities and influence responsibilities; for example, Forlizzi researched the social impacts of mobile robots in homes and found that robotic vacuum cleaners could change peoples' cleaning activities and routines, influencing who held the responsibility for a household's cleaning tasks. In addition, the robot affected the nature of these tasks—not least the home ecosystem—as the social and cultural context of the home was modified by the presence and assistance of the robot [1]. Robots affect and impact the environment of which they are a part, which was also demonstrated in early work by Sung et al., who argued that domestic mobile robots could change household routines and established how techno-enthusiasts tended to assign names, identities or/and personalities to their robots, leading to acceptance of domestic robots and emotional attachment to the technology [2].

When concentrating on mobile robots in work settings it becomes clear that a number of researchers have attempted to better understand the consequences of deploying mobile robots in dynamic work environments. Their research has shown how human perceptions of robots differ on account of the working environment and how the composition of those environments influence how humans use and experience robots. Early research by Mutlu and Forlizzi (2008) examined how different staff groups within a hospital perceived the same mobile service robot differently depending on different levels of acceptance of disturbances within their working environments across hospital wards [3]. Ljungblad et al. researched the reactions of hospital staff towards a mobile service robot in a hospital and proposed four different perspectives that staff might take in perceiving a robot, respectively an alien, a machine, a worker and a work partner. These perspectives can change over time, such as if a person develops a closer working relationship with the robot [4]. The recognition that robots affect the environments in which they are deployed laid the groundwork for our research, which investigated how robots impact the environment and what to expect when they are released into the wild.

### 3. Methods

This study researched human–robot interaction and cooperation in a real-life work setting—a medium-sized hospital in Denmark—through an ethnographic inspired field study. In 2016, the hospital installed MiR Hook 100™ mobile service robots to relieve the hospital kitchen staff of the physically demanding task of transporting large carts with cutlery through the hospital basement. The basement is characterised as an unstructured real-life environment with mixed traffic made up of patients, clinicians, laboratory technicians, kitchen staff, porters, technical staff and workmen.

The ethnographic inspired field study, carried out in May 2020, consisted of 26 interviews with hospital employees (16 of whom were kitchen staff) recruited through snowball sampling with the aim of exploring their everyday practices and perceptions of working with the mobile service robots [5]. The study also included observations of two mobile robots performing their daily routines and tasks, operating without—and cooperating with—humans in the basement [6]. Finally, the kitchen staff took the First Author on guided tours during which they described their tasks and routines and explained how the robots were, or were not, involved in these [7][8]. The aim of mixing methods for data collection was to explore the setting; gain understanding of robots in the hospital; investigate the cooperation between this type of technology and humans; and to explore if human expectations towards cooperating with robots were concise, considering the robots’ impact on the work setting.

The empirical data was in the form of descriptive notes, photos, video clips and audio files (equal to 10 hours of audio). The audio was transcribed and analysed (according to Braun and Clarke’s techniques for thematic analysis [9]), along with the photographs, video and field notes. The empirical data was coded using themes identified in the data, which resulted in 64 codes, which were then organized into 12 themes (for an overview of these, see Table 1) that were reviewed to gain an understanding of how the robots affected the human-inhabited real-life work environment.

In this paper, we highlight three key themes in the following section.

**Table 1.** Overview of themes

Themes identified in the empirical data			
Reliance and trust	Attitude	Perceptions	Environment
Errors	Behaviour	Irritation/frustration	Division of labour
Conflicts	Workarounds	Tempo/pace of work	War stories
Break downs	Hand-overs	Safety	Technique

### 4. Results

#### 4.1. Adjustments

A primary finding was that the robots had difficulties adjusting to the basement environment and meeting the human expectations of them. The hallways were narrow and not designed for mixed traffic and were therefore divided into two lanes: one for vulnerable users, such as pedestrians and cyclists, and one for heavy users, such as the trucks used by the porters (see Figure 1). It was unclear to the informants in this study whether the robots belonged to the vulnerable or heavy user groups as they were not



formally assigned to either lane. In collaboration with the robots' developers, the hospital made changes to the hallway junctions, assigning robot lanes with the inscription MiR (the product name of the robot). These mark-ups were designed to inform people in the basement how the robots would make their way through the junctions, and the hospital expected that the robots would remain in their lanes.



**Figure 1.** Left: lanes marked for vulnerable and heavy traffic in the hospital cellar hallway. Middle: robot lane marked at a hallway junction. Right: robot driving through a hallway in the hospital basement.

However, this study found that the mobile service robots were unable to adapt to the environmental changes made by humans to ease their routines, such as by failing to drive in the assigned lanes as the humans expected them to. One of the reasons the robots did not use the lanes was that they had to adjust to factors within the hospital basement environment by avoiding porters on trucks, pedestrians, cyclists and items left on the floor. The narrow hallways also brought humans and robots close very close to each other, and if a robot came close to a human, object or item, its sensors would register a potential risk of causing harm, which would immediately make the robot stop what it was doing. These robotic stops would cause frustration and annoyance among the staff, who did not consider that the robots acted as they did in order to avoid harming their surroundings. The humans in the basement were simply unaware that their expectations of seamless, autonomous robot performance were unrealistic in practice.

#### 4.2. *Work-arounds*

A variety of factors, including the parties' mutual impact, affected human–robot cooperation in the hospital basement. As mentioned above, the environment was not suited to the robots, not least because the hallways could get crowded, such as when humans, who had their own daily paths through the hallways, took up space, hindering the robots in performing their tasks. When the mobile robots drove around the humans and other obstacles in the hallways, they would in turn affect the routines of the workers. The robots drove at a slow pace for safety reasons, and the workers in the basement became increasingly irritated and frustrated at sharing their workspace with the robots, not least because they had expected the robots to seamlessly integrate, for example by adjusting to the pace of the hospital staff. Frustrations developed among both kitchen staff (because the robots disturbed their routines and pace of work and thus reduced performance) and by the porters (who already had a tense relationship with the robots, simply by their presence in the basement).

During the field study, it was observed that eight out of the 16 kitchen staff chose to perform themselves tasks that the robots were supposed to do, because they felt they could not rely on the robots. Only by monitoring the robots on a tablet could the staff be sure where the robots were, but not how (or what) they were doing. Further, the robots

caused the workers' pace to slow, such as when taking up space in the hallway, driving around obstacles and not following lanes (often driving in the middle of the hallway), which made the workers unable to get around them and perform their tasks at the pace they wanted to. The workers had to adjust to the robots because the robots did not adjust to take seamless part in the shared work environment.

#### *4.3. Sabotage*

It was clear that the porters perceived the robots differently from the kitchen staff. The porters did not approve of the mobile service robots being part of their working environment because they had a large impact on the pace of the porters' working routines as they drove around the hallways at their programmed speed in order to avoid harming their surroundings. The porters also had limited options to get around the robots in the narrow hallways and did not benefit from their presence. Some porters were unwilling to adjust to the robots and would not hesitate to interfere or sabotage them, which resulted in the robots stopping in the performance of their tasks, and it was not uncommon for frustrated workers to turn off the robots, lock them in rooms or pour food into them. The interference and sabotage were a result of the robots affecting the workers' everyday routines. As a consequence, the kitchen staff became frustrated towards both the robots and the porters because they could not rely on the robots to complete their tasks in part due to the porters' actions. The kitchen staff were unable to trust the robots because they knew from experience that errors would eventually occur that would make the robots slow down, abort their missions or simply stop. The kitchen staff could not be sure what type of error (technical or human-triggered) the robots might have encountered, but they repeatedly experienced how the human presence in the basement affected the robots, which they had not expected would be an issue, when the robots were installed. Accordingly, the kitchen staff, who were supposed to benefit from the robots, could not trust them because of the actions of other humans and because they had higher expectations of the robots than the robots were able to meet.

### **5. Discussion**

The findings highlight the importance of considering socio-technical factors when deploying robots to cooperate with humans in hospital environments. One of these factors is the human expectations of the robots: the hospital staff expected the mobile robots to be a 'plug-and-play' solution, integrating seamlessly and aiding in the real-life environment. Our research has shown that human expectations of cooperating with robots in the wild may be greater than the robots can meet because of three dominant factors. First, the environmental preparations made by the hospital and the robot developers were ineffectual, yet resulted in raised hopes and great expectations from the hospital staff in the basement. Second, the robots were sensitive to staff behaviour, which caused frustration among the staff resulting in robots being prevented from performing their tasks. Third, the staff could not rely on the robots to aid in everyday work situations.

Hence, the robots did not adjust to the changes made by the developers and the hospital but rather to factors in the environment, such as human behaviour, without the staff realising it. Because of the nature of these adjustments, the robots did not drive in an advantageous, reliable way, as had been expected when they were installed, because the basement environment was not suited for this type of robot. In the given case, these

factors could not necessarily have been predicted in advance of deployment, as the hospital did not test the robots in a pilot implementation. If the hospital had tested the robots prior to installing them, the factors that were results of the dynamics and interactions between the actors (both humans and robots) and their actions, might have been discovered and suitable adjustments could have been made before the final installation of the robots.

The hospital staff would unintentionally leave items (boxes, containers, or components) in the hallways without reflecting on the consequences, as they were unaware of the robots being sensitive to obstacles and unaware that their behaviour would thus have a large impact on the behaviour of the robots. When the robots encountered obstacles that they were unable to avoid, they would simply stop and wait for the obstacle to disappear. This could lead to a robot not completing its tasks but rather simply standing still while running out of power. The hospital staff who were supposed to benefit from the robots therefore did not rely on them to do what they ought to because of the actions of other humans. The aim of deploying the robots in the hospital kitchen was to ease the burden on kitchen staff to perform logistical tasks in a time-efficient manner, but the assistance was shown to be complex as the kitchen staff found themselves becoming caretakers for the robots, despite the robots being deployed to take care of tasks. The intention of the human–robot cooperation in this hospital was that the robots would support and relieve the hospital kitchen staff, but the hospital kitchen staff instead supported and relieved the robots.

The lack of attention to socio-technical factors in deploying and using robots in this hospital was rooted in techno-optimism, great expectations and the opinions of technology enthusiasts who did not consider how to reorganise existing environments, routines and everyday structures. As argued by Blond et al. [10], the use and meaning of robots are created in practice and cannot be designed in advance. When robots move beyond highly structured environments, the visions and expectations of deploying them in real-life settings must be adapted to those settings. The human expectations of robots cannot be met if they are not considered in relation to the environment in which the robots participate.

Therefore, if robots are to succeed in engaging with real-life environments - rather than reflecting the aspirations of techno-enthusiasts who expect robots to be simple, automatic ‘plug-and-play’ solutions, without considering the robots’ requirements, human adaptations and environmental changes - attention must be paid to the practice in which the robots are to participate, including the socio-technical factors.

## **6. Conclusion**

In this paper, we have reported insights from research on how robots affect the real-life environments into which they are gradually moving. The findings showed that the cooperation between humans and robots in the hospital environment was fragmented because of limited attention having been paid to socio-technical factors. Knowledge of real-life environmental factors; human reactions and behaviour towards robots in complex environments not designed for robots; and robotic influences on the environment in which they act has been summarised, and we have identified three major factors that influence human–robot cooperation in hospitals: environmental factors, behavioural factors and factors related to human reliance on robots.

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# Impact of Electronic Medication Management on the Physical Location of Work in a Paediatric Setting

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**Abstract.** Electronic medication management (eMM) systems can have a significant impact on efficiency and safety. There is limited evidence on the effects of eMM implementation on the physical location of work. The objective of this study was to evaluate the impact of eMM and associated hardware implementation on the location of tasks performed by doctors and nurses. 41.5 hours of observation were conducted in the oncology ward of a paediatric hospital. Tasks, locations and resources used were recorded pre and post eMM implementation. Results showed that a wider variety of locations were used to conduct tasks following eMM implementation. Post-eMM, more tasks were performed in the hallway, where medication trolleys with attached laptops were situated, and in patient rooms where additional computers were installed, providing more opportunities for patient/carer and clinician interaction. The findings from this study reveal the impact that computer placement has on the location of work for doctors and nurses, and the importance of planning hardware placement for eMM implementation.

**Keywords.** Medical order entry systems, computers, implementation, observational study.

## 1. Introduction

Implementation of electronic medication management (eMM) systems in hospitals can lead to a reduction in medication errors, increased legibility of documentation and improved accessibility of information for users [1-3]. Studies evaluating the impact of eMM in paediatric hospitals have also found a reduction in adverse drug events and patient mortality following system implementation [4, 5].

With the implementation of eMM, many tasks that were traditionally done on paper in the ward can now be completed on a computer from any location. Qualitative studies exploring user perceptions following eMM implementation suggest that access to the system from computers located anywhere in the hospital was considered beneficial [6, 7].

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When investigating the impact of eMM implementation on clinician workflow, previous studies have focused on work efficiency [1] or errors and patient safety [2, 3, 8, 9]. To our knowledge, there have been no studies investigating the impact of eMM implementation on the physical location of work in the paediatric setting. This study aimed to determine how introduction of an eMM system impacted on the location of work tasks performed by doctors and nurses.

## **2. Method**

### *2.1. Study design and setting*

This study used a before and after study design and a non-participatory observational approach. Observations of doctors and nurses were conducted in a 20-bed oncology ward at a paediatric hospital in Sydney, Australia. Pre-eMM observations were conducted between March and June 2016 and post-eMM observations between August and October, 2018. Ethics approval was obtained from the Sydney Children's Hospital Network Human Research Ethics Committee (LNR/15/SCHN/171).

Prior to eMM implementation, the hospital had an existing clinical information system in place for pathology and imaging orders and results. Patient medication charts, progress/clinical notes, fluid balance charts, observation charts and chemotherapy protocols were paper-based and typically stored in folders in hallway workstations located outside each patient room. Computers were accessed via a central workstation. An eMM system and electronic patient notes were implemented in the oncology ward in August 2016 and electronic observation charts in April 2017. To facilitate access to the new system, the ward acquired medication trolleys with laptop computers, wall-mounted computers in all patient rooms, and a computer in the medication room.



















### *2.2. Participants and procedure*



Nurses and doctors were recruited opportunistically on the inpatient oncology ward. Five researchers with previous qualitative research experience independently shadowed doctors and nurses for a maximum of 2 hours at a time. Researchers recorded notes during observations with a focus on medication-related tasks that involved access to information or documentation. Researchers met periodically to discuss their observations and code findings into categories: actors, tasks, locations, and resources used. Observations ceased when saturation was reached. In total, 3 doctors and 6 nurses were observed pre-eMM implementation for a total observation time of 26 hours and 15 minutes. 5 doctors and 6 nurses were observed post-eMM implementation for a total of 15 hours and 15 minutes.

## **3. Results**







































Pre-eMM implementation, most tasks performed by doctors were conducted at the hallway workstation. Post-eMM implementation, doctors no longer conducted work in the hallway workstation, instead they conducted medication-related tasks from their office, the central workstation, or the computer in the patient's room (Table 1).



**Table 1.** Tasks and locations of information tasks performed by doctors before and after eMM implementation

Task	Location				
	Meeting room	Hallway workstation*	Doctors' office	Central workstation	Patient room
Ward round	 				
Review medications/ observations/ fluids					
Prescribe/ cease/ edit medications					
Review and record progress notes					
Execute plans (e.g. order tests, follow up)			 		

 indicates Pre-eMM and  indicates Post-eMM; \*Hallway workstation: pre-eMM implementation this was a folder stored outside the patient's room, post-eMM implementation medication trolleys with attached laptop computers were kept in the hallway.

**Table 2.** Tasks and locations of information tasks performed by nurses before and after eMM implementation

Task	Location					
	Meeting room	Hallway workstation*	Central workstation	Medication room	Cytotoxic room	Patient room
Ward round	 					
Check observations						 
Review and record observations and fluids		 				
Administer medication						 
Review medications		 	 			
Prepare medications				 		
Prepare chemotherapy					 	
Double-check medications				 	 	
Review pathology			 			
Review and record progress notes			 			
Check medication guidelines			 	 		

 indicates Pre-eMM and  indicates Post-eMM ; \*Hallway workstation: pre-eMM implementation this was a folder stored outside the patient's room, post-eMM implementation medication trolleys with attached laptop computers were kept in the hallway.

Similarly, pre-eMM nurses conducted many tasks at the hallway workstation and central workstation, but post-eMM, these tasks were conducted from multiple locations (Table 2). For example, reviewing and recording of observations and fluids pre-eMM were only completed at the hallway workstation, however post-eMM they were also done on the computer at the patient bedside. Pre-eMM medication preparation was only done in the medication room, however, post-eMM implementation, it was also conducted in the hallway using medication trolleys with attached laptop computers.

For both doctors and nurses, there was also an increase in the types of tasks that were conducted from the patient room using wall mounted computers.

#### **4. Discussion**

Implementation of eMM was associated with significant shifts in where doctors and nurses performed their work. The majority of task types that were largely conducted at the hallway workstation pre-eMM were conducted in a greater variety of locations post-eMM. For both doctors and nurses, many task types after eMM implementation were performed at the patient bedside, where previously, they were only performed in the hallway or central workstations. Introduction of medication trolleys with attached laptop computers resulted in some medication preparation by nurses being done in the hallway post-eMM as opposed to only the medication room.

For both doctors and nurses, computers at the patient bedside meant more tasks could be undertaken in patients' rooms. Previous Australian studies have found eMM implementation led to doctors spending more time with patients [1] and found that nurses have a preference for conducting tasks in patient rooms [10]. Conversely, a study in an emergency department found doctors and nurses spent less time on direct patient care post-eMM implementation, most likely because computers were positioned in a designated 'charting room', not in patient rooms[11]. Although we did not quantify the time spent on tasks in patient rooms, computers in patient rooms gave doctors and nurses more opportunities to perform work in those locations, providing patients/carers and clinicians with more opportunities to interact. Qualitative studies with patients and parents have found increased clinician communication and establishing interpersonal relationships to be important aspects of paediatric hospital care [12-14]. Consequently, providing doctors and nurses with more opportunities to interact with patients/carers, by placing computers in patient rooms, is likely to positively impact care for paediatric patients.

The infrastructure implemented with the eMM system allowed more flexibility in where medication-related tasks that required documentation and access to information, could be performed. Post-eMM implementation, we observed more variability in the locations of medication-related work, with almost all tasks conducted in multiple locations. Determining whether this increased variability was positive or negative for staff and patients was outside the scope of our study, but we recommend future evaluations of the placement of hardware on clinical workflow after eMM implementation.

This study was conducted in the oncology ward of a single paediatric hospital which may limit the applicability of results to other institutions. As this was an observational study, there is potential bias due to the Hawthorn effect [15], that is, participants may have changed their behaviours as a result of being observed. However, we expect this impact to be minimal as the information we collected related to tasks performed,



resources used and locations, and clinicians were aware that no assessments or evaluations of quality were being made. It is also important to note that workload and time taken to complete tasks were not measured, and patient experiences of the change in work location were not explored.

To conclude, this study showed the impact eMM implementation and placement of computers had on the location of doctors' and nurses' work. The increase we observed in the types of tasks performed in patients' rooms has potential positive implications for patients/carers, particularly in the paediatric setting, due to the value they place on interactions with clinicians. Future hospital implementations should evaluate computer placement choices to make the best decisions for clinical workflow specific to their department.

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Innovations in Design and Evaluation  
Methods of Health Technologies

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# Student Academy: A Pilot Design Thinking Workshop to Teach Community Medicine

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**Abstract** The medical literature shows that social determinants of health have a significant impact upon health outcomes. However, health professionals often lack the skills to address these determinants at the systems-level. Therefore, we developed a Design Thinking workshop to teach about health-related social needs and to practice designing person-centered solutions. We piloted the workshop with 53 medical and physician assistant students; 69.8% responded to the post-workshop questionnaire. Nearly 80% of students agreed the workshop helped them understand the effect of context on clinical outcomes and demonstrated how to design patient-centered solutions. However, only 50% of respondents anticipated using the Design Thinking methods in their future practice. We need to identify more effective ways to demonstrate the practical application of Design Thinking to clinical work settings.

**Keywords.** Usability engineering, implementation science, health systems science, quality improvement, health literacy, social determinants of health, Design Thinking

## 1. Background

Literature suggests that social and structural determinants of health (SSDoH) have the greatest impact upon health outcomes [1,2]. To improve population health and bend the cost curve, healthcare organizations must identify SSDoH affecting vulnerable populations and work with stakeholders to improve person-centered models of care. Unfortunately, American healthcare organizations rarely engage patients in shared decision making or proactively address the ecological factors impacting health [3-5].

Educators, policy-makers, and administrators have argued that durable change requires clinicians to lead transformation efforts [6]. If clinicians are to adopt this expanded role of professionalism, training programs must integrate SSDoH and implementation science into their curricula. We believe the combined disciplines of informatics, design, and human factors offer innovative strategies to add this educational content.

Person-centered care begins with acquiring an understanding of patients and their lived experiences. However, there is often a large socioeconomic and cultural gap between providers and their patients. Health professionals may not recognize their own implicit biases and struggle to build empathy without a shared frame of reference [7].

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Health professionals also do not emerge from training programs with the skills to diagnose and improve sociotechnical systems [8,9]. They need tools to identify and understand the cultural features and perspectives meaningful to patients.

The classic two-pillared medical education model of basic and clinical sciences does not include pedagogical tools to teach health system science. Therefore, we piloted a workshop to teach medical and physicians assistant (PA) students about SSDoH. Our intent was to provide an immersive educational experience with the following learning objectives: (1) describe how SSDoH affect health outcomes; (2) explain how person-centered care can improve quality; and (3) use Design-Thinking (DT) to identify unmet patient needs and create person-centered solutions. In the next sections, we describe our methods, share pilot data, and offer advice for incorporating DT into curricula.

## 2. Design Thinking and its Role in Health Care

DT is a systematic problem finding and solving process that emphasizes user-empathy and person-centered design methods (Figure 1) [10]. DT has been widely used in the fields of design, engineering, and business [11]. We hypothesized that health professionals could use these methods to understand and address the needs of vulnerable patients. While designers and health professionals have been investigating the broad applications of DT in healthcare, little data exists on its use in medical education to address SSDoH.



Figure 1. The Design Thinking framework adapted from Naiman<sup>11</sup>.

## 3. Student Academy: Community Medicine Workshop

A team of faculty from medicine, informatics, and design developed a virtual workshop targeting third-year medical and second-year PA students. The workshop included two parts: 1) a lecture and interactive activity on identity, privilege, and SSDoH; and 2) an introduction to DT methods for building empathy with patients, diagnosing user experience concerns, and engaging in person-centered problem-solving.

We used a mixture of teaching methods, including didactics, small group activities, and large group discussions (Table 1). Using a “flipped-classroom” approach, we distributed pre-session reading materials to students and focused our didactics on topics critical to reinforce learning objectives and set the stage for interactive work. A faculty member (SD) with public health expertise gave a keynote lecture describing SSDoH and the impact of structural racism and poverty on health. Our informatics and design faculty (BL, HP) gave a lecture on DT using real-life examples both in and outside of healthcare.

We gave students a hypothetical scenario: a 45-year-old Latina woman with diabetes and hypertension attending her first telemedicine appointment. We challenged students to creatively approach how they would provide a post-visit summary with laboratory

values, medications, and a care plan. Students worked in groups of five members to create three DT products: (1) a patient persona (i.e., archetype of a group with similar needs and behaviors); (2) a patient journey map (i.e., visualization of a user interacting with a system over time); and (3) a wish list (i.e., list of needs statements that describe the user, the need, and underlying goal) [12]. For each activity, we adapted instructions compiled by Banfield, Lombardo, and Wax [13].

**Table 1.** Agenda for the Student Academy Design Thinking Workshop (total time approximately 5 hours).

Duration (min)	Activity	Description
60	Small group activity: <b>Privilege &amp; identity</b>	Faculty guided learners through a simulation using limited funds to “purchase” existential societal privileges such as access to care or personal safety.
50	Lecture: Health as a function of Geography and Racialized Identity	Didactic lecture discussing the concentration health disparities concentrated in communities of color and how SDOH identified at birth determined health outcomes
50	Introduction to systems-thinking using person-centered design	Faculty introduced person-centered design and a hypothetical design challenge affecting a patient presenting to a telemedicine clinic for the first time
30	Lecture: DT to improve healthcare quality	An overview of the goals, methods, and outputs of DT; presentation of example deliverables
30	Small group activity: <b>Persona</b> development	Faculty guided learners to create a patient persona for a Latina female with diabetes and hypertension
40	Small group activity: <b>Creating a journey map</b>	Faculty guided learners to fill out a journey map describing a telemedicine visit
30	Small group activity: <b>Wish list</b> of design requirements	Faculty guided learners using the wish list method to draft requirements for a post-visit clinical summary

DT: Design Thinking

#### 4. Evaluation Method

We distributed a post-workshop survey that included questions with Likert-type scales and open-ended questions. The scaled items asked participants to (1) indicate how well the workshop met learning objectives; (2) if the teaching methods were effective; and (3) if they would use DT in practice. The open-ended questions asked participants to list workshop strengths and weaknesses. Medical and PA students took the same survey.

#### 5. Findings

Fifty-three students participated in the workshop and 37 (69.8%) completed some or all of the survey (Figure 2). Nearly 85% of responses indicated the SSDoH lecture met the learning objectives. Eighty percent of respondents said the workshop helped understand the effect of context on patient outcomes and 80% said the workshop provided ways to design patient-centered solutions. Most learners (78.6%) said the workshop helped them reflect upon their own practice. However, many did not think persona development was a valuable activity and believed creating a hypothetical persona without gathering ethnographic data could perpetuate bias. Respondents proposed practical solutions to reduce bias such as providing specific patient details, distributing real-life cases, or

incorporating standardized patients interviews in the workshop. One learner wrote, *“most of us...come from rather privileged backgrounds and sometimes may not even be able to truly understand...the needs and lived experiences of the highly underserved populations of patients we work with every day.”*

Approximately, 50% of respondents anticipated using the DT methods from this session in their future practice. One student wrote, *“I do believe this topic is important, but I am not sure it is actually something I would do while taking care of my patients.”*

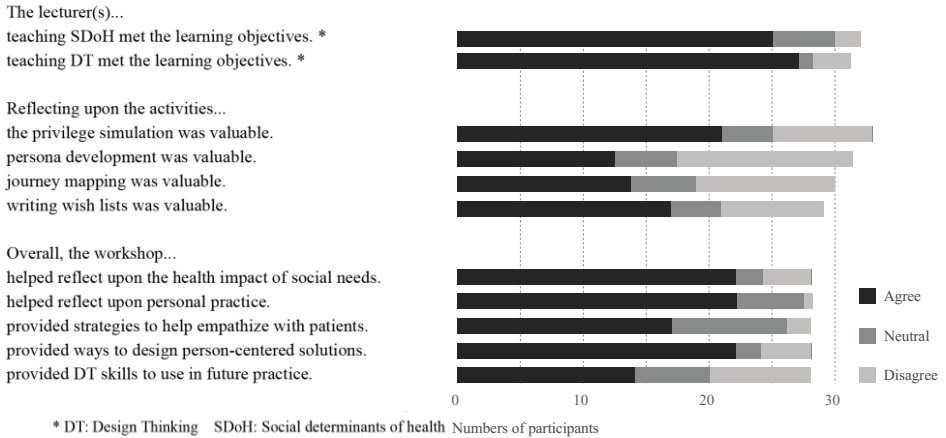


Figure 2. Summary of quantitative findings from the learner satisfaction survey (N = 37).

## 6. Discussion

**Principle findings.** Our workshop offers a dynamic approach for teaching about SSDoH and illustrating how to design systems-level solutions. The lectures and large group activities fostered dialogue around health-related social needs and the evolving roles for health professionals. The small group activities gave learners hands-on practice using visual design tools and applying systems engineering methods. Most students found the content valuable and agreed it provided insights on how they can design new systems. However, 50% of respondents did not see themselves using DT in their own practice. These theoretical concepts may be difficult to synthesize when learners are still learning foundational patient care concepts. Also, students may not be able to visualize the practical applications until having worked on real quality improvement projects.

**Implications and future directions for DT in curriculum.** The DT framework and methods are teachable concepts that faculty can use to introduce health-systems thinking, integrate multiple educational program objectives, and assess entrustable professional activities. It also complements other quality improvement paradigms (e.g., Plan-Do-Study-Act model) by operationalizing ways to incorporate person-centered design into planning and implementation phases. Finally, the virtual platform and interactive visual collaboration software enabled faculty experts around the globe to participate.

In the future, we need to illustrate the connection between these lessons, students’ future roles, and future behaviors. To make this curriculum more impactful, we need to find more opportunities to demonstrate the practical applications of DT in healthcare.

For example, we may link these lessons to other quality improvement projects. We also need to integrate ethnographic and “real-world” data to ground the instruction. Our workshop could include interactions with standardized patients, recorded interviews with real patients, or locally collected public health and community demographic data [14].

## 7. Conclusions and Limitations

We believe DT helps keep users at the center of the design process and promotes ideation to reach breakthrough innovations. This is critical when teaching health professionals about person-centered and context-sensitive care. However, there are limitations to this work. First, this was a pilot at one school; we need to test with more learners in other health professional roles. Second, the low participant response rate may have introduced a systematic bias (e.g., those less satisfied with the workshop were more likely to respond). Finally, it is important to objectively measure learning and behavior over time. For example, in future work, we should include pre/post attitude surveys, grade deliverables, and measure professional attitudes and behaviors among our graduates.

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# Aero-Sim: A User-Centred Testbed for the Evaluation of Devices as Protection from Droplets and/or Aerosol Contaminations

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**Abstract.** Concerns over high transmission risk of SARS-CoV-2 have led to innovation and usage of an aerosol box to protect healthcare workers during airway intubation in patients with COVID-19. However, only a few studies have examined the impact of these aerosol boxes on the dispersion of droplets and aerosols, which are both thought to be significant contributors to the spread of COVID-19. In addition, to our knowledge, only a few studies have included in the concerned testbeds elements of the work context, which nevertheless have an impact on the use of the device.

**Keywords.** COVID-19, evaluation, usability, simulation, aerosol box.

## 1. Introduction

The reports of health care workers (HCW) getting infected with Corona Virus in this COVID-19 pandemic are disheartening. Extensive studies and reports have found that the greatest risk of infection is during aerosol generating procedures such as intubation, bronchoscopy etc. [1]. With the growing number of cases, and increased infection of HCWs, the need for personal protective equipment (PPE) takes prominence. The sudden surge of patients brought about an unanticipated shortage in protective equipment needed to shield healthcare workers during intubations from a highly contagious virus. Several innovations were born as an immediate requirement to tackle the problem. One of these is the aerosol box that has become popular within the anesthesia community. The aerosol box is a transparent plastic box that can be placed over a patient's head and that incorporates two circular ports through which the clinician's hands are passed to perform the airway procedure [2].

This box potentially enables physicians to intubate patients while shielding themselves from exposure to viral contamination. Nevertheless, the benefit of such device as a barrier protection in addition to the use of a standard PPE is not fully known [3]. Furthermore, its use may add another layer of complexity to performing airway intubation [4].

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Several testbeds have been created to evaluate such type of devices [3, 5-6]. To our knowledge, few, if any, simulations incorporate elements of the work context. Yet these have a definite impact on the use of the devices. It is essential that evaluations include a broader experimental setting than just a technical testbed. This will ensure a certain representativeness of the real-life use of the devices. We designed a user-centred testbed for the evaluation of devices as protection from droplets and/or aerosol contaminations.

## **2. Work analysis**

### *2.1. Methods*

Semi-structured interviews were conducted based on an interview grid with healthcare workers who performed interventions such as airway intubation or mechanical ventilation, as it could potentially generate aerosols of virus-contaminated respiratory secretions. Anesthetists, pulmonologists, and ENT (Ear, Nose and Throat) specialists were the most exposed to droplets and/or aerosols. The objectives of the interviews were to identify and understand the procedures in the management of a contagious patient, the equipment and specific material used, the exceptions in procedures or materials and why.

### *2.2. Results*

One ENT specialist was interviewed, 2 anesthetists and 3 pulmonologists. ENT specialists, unlike other specialties, performed very few procedures on patients who were contagious or positive for COVID-19. In fact, operations were cancelled at the slightest risk. They were quickly excluded from the analyses. Anesthetists and pulmonologists had exactly the same recommendations and procedures for PPEs. PPEs (cap, goggles, or visor, FFP2 mask, gown, apron, gloves and overshoes) were available outside the rooms to avoid any contamination. Healthcare workers, therefore, dressed outside the rooms. Then, in the rooms during intubation, healthcare workers were bent over the patient's head, exposing them to droplets and/or aerosols. In an emergency, during intubation, the patient might not be fully asleep and therefore might have a cough reflex when the tube was inserted as it irritated the trachea. Extubating was also a risky procedure. Patients coughed a lot and couldn't be curarized.

In COVID-19 resuscitation wards, the number of staff per room was reduced to 2 persons. The rest of the staff had to stay in the corridor in front of the door to give the necessary material in case of need. Indeed, the resuscitation trolley was placed outside the rooms to avoid any contamination. In addition, in the COVID-19 recommendations, the use of a video-laryngoscope was requested as opposed to a laryngoscope. This avoided the need for the caregiver to position his or her head at mouth level and therefore had a slightly greater distance to the video laryngoscope screen. Finally, the whole system had to be connected before inflating the balloon because we knew that this was when cough reflexes could occur and at this moment it was already on circuit, so it projected even more.

Once the procedure had been completed and the patient's condition had been checked, the staff had to remove the PPE before leaving the room and put it in the waste bin. The removal of PPE should be done in an orderly fashion: the overshoes, the apron, the gown, the gloves, then the hand washing with gel and finally the removal of the mask and the visor and the cap by pulling forward.

### 3. User testing simulation

#### 3.1. Methods

The user testing technique was to (i) identify potential areas of contamination, (ii) test the usability of the device in an environment close to real settings, and (iii) target contexts where the risk of trans-contamination was high. Only professionals with experience in intensive care and who had been trained in the management of contagious patients (COVID or others) could be participants. Participants were randomly allocated to sequence ‘AB’ (intubation without aerosol box and then with aerosol box) and ‘BA’ (intubation with aerosol box and then without aerosol box). The evaluation was conducted in a simulation lab. The Figure 1 presents the different stages of the protocol.

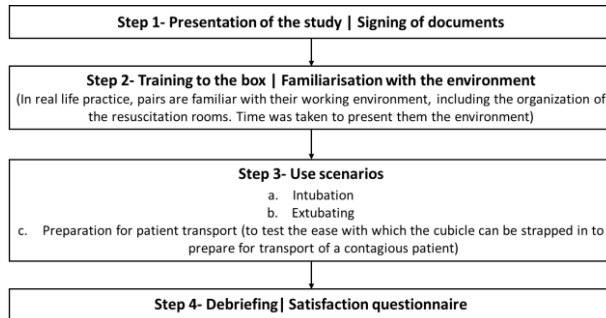


Figure 1. Different stages of the protocol.

Data collected included time for each action, the success/failure of the tasks, breach of PPEs, use errors, verbatims, and satisfaction.

#### 3.2. Results

The mean time to complete one session was 2 hours. The tests were done in pairs since real intubations were performed by 2 people most of the time: the professional who intubated and an assistant (often in charge of medication, oxygen, etc.). Three different anesthetists and 4 different anesthetist nurses participated in the study as professionals who intubated. This led to a total of 7 sessions. The assistant role was acted by an anesthetist or an anesthetist nurse.

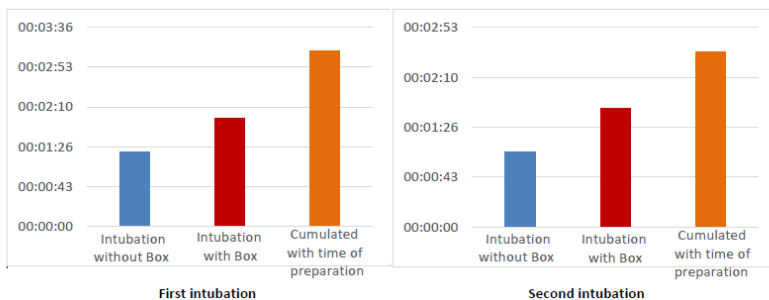
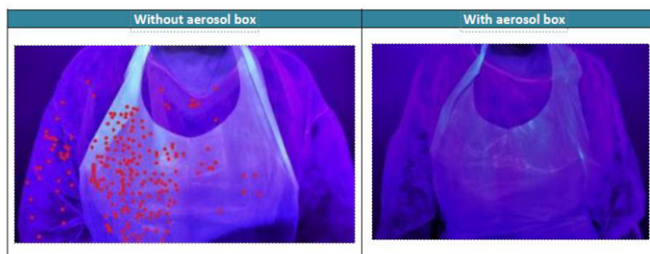


Figure 2. Mean time of intubation or intubation + preparation of box for the first and the second act.

The mean time of intubation differed according to the condition with or without the use of the box. Intubation with the aerosol box took longer than intubation without the box (Figure 2). Moreover, if we added up the time of installation and intubation when using the protective box, the time was doubled. There was no significant difference in the first intubation (Wilcoxon test,  $p=0,059$ ), while a significant difference appeared in the second intubation (Wilcoxon test,  $p= 0.03125$ ).

All participants successfully intubated the dummy with or without the box. The box was easily handled by the participants, whether it was to install it, remove it or strap it to the bed.



**Figure 3.** Example of projections observed with and without aerosol box after the intubation procedure

The aerosol box provided better protection for the participants in almost all areas of contamination (Example Figure 3), except for the hands. In fact, it did not reduce contamination since the hands were in the box during intubation. Without the aerosol box, splashes were found on the head (goggles and mask), neck, torso, arms and forearms, and hands.

Most of the participants used the box as recommended by the manufacturer, but some misuse was observed due to usability issues: diversion of the installation steps, use of the side ports for the intubation procedure instead of the one provided, passage of the material through the ports instead of through the notches provided for this purpose, extubating of the patient with the box already in the first stage of uninstallation, when removing the box after use place it on the transport trolley (which must be avoided due to risk of contamination). The aerosol box provided effective protection for operators by reducing splashes on the face and chest areas. But the observed misuses could have had an impact on the practice, both in terms of participant comfort and procedure time mainly, but to a lesser extent also in terms of risk of contamination.

Overall, the participants were satisfied. The protection is what they liked most and the security that the box provided. Its discomfort is what they disliked most, its weight “*it is heavy*” and its lack of space to handle the equipment.

#### 4. Discussion and conclusion

Clinical simulation has gained acceptance during the last decade as a powerful qualitative method for evaluating medical devices, but also clinical information systems [7]. A simulation has to be defined to re-create characteristics of the real world. This study was conducted to design a user-centred testbed for the evaluation of devices as protection from droplets and/or aerosol contaminations, while ensuring a certain representativeness of the real-life use of the device. It has been presumed that the aerosol box protects healthcare workers against droplet and airborne contaminations during intubation. Indeed, our simulation study found that a significantly greater number of body regions

were contaminated when performing intubation without the aerosol box compared with the aerosol box. However, our study also showed the importance of considering the work context and actual practices. Indeed, the positive results on the aerosol box efficiency were mitigated by misuses of the tool which could have ultimately increased the risk of contamination. Several participants deviated from the steps and procedure for using the box. In the simulation environment this did not prevent the accomplishment of the task but led to some adverse effects (e.g. contamination during the preparation of patient transport) which would have been dramatic in real life. Moreover, considering the entire time of the procedure (and not only the intubation time as usually in “technical” testbeds), the study also showed that intubations with the aerosol box took longer than intubation without the box when time is a critical issue in emergency situations.

The main challenge was obviously the availability of health professionals, both for first analyses to design the user-centred testbed and then for participation in the tests, especially in such a difficult period. The strong involvement of some healthcare professionals who were convinced by the innovation of the box (were even at the origin of the idea) made the project possible. But most importantly, after a first wave of COVID-19 where some new devices could be used in clinical routine without evaluation, there was a need here, from a regulatory perspective, to validate the box before a future use in real life. The design of these experimental situations is an opportunity to learn about procedures, real-life practices and facilities. This knowledge accumulates in simulation centres, and although the knowledge obviously needs to be updated regularly, it can easily be reused for other evaluations of similar devices. It could be relevant to capitalize on existing protocols with detailed versions which could be shared with the community (while paying attention to differences of contexts, cultures and healthcare systems).

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# Online Investigations on Optimizing the Danish Health Portal Sundhed.dk

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**Abstract.** In recent years, many people have experienced different problems and challenges in using the national Danish health portal sundhed.dk, as they find it difficult to obtain desired information about their own laboratory test results and treatment plans. Therefore, the aim of this study is to find solutions, to make patients laboratory results easily accessible and understandable for the users. To achieve this aim there will be used two participatory design methods, video observation and questionnaires. The results shows that only 43.5% normally understand their test results, whereas the remaining participants need help to understand their results.

**Keywords.** Participatory design, laboratory test, laboratory results, online health portal, video observations

## 1. Introduction

Over the past years, there has been an increased focus on development of the healthcare system and in Denmark new “Super Hospitals” have been built in all Regions. With these, the health service will focus more on outpatient- or day-treatment. With the reduction of hospital beds and admission time means that there will be an increased focus on telemedicine, as well as digitalization of health data [1] [2]. Patients will have an increased engagement and responsibility for their own course of treatment which will intensify the communication of patient data and laboratory test results via the national health portal sundhed.dk. Hence it becomes important that the information provided on the site is easily accessible and easy to understand for the patients. Communicating laboratory test results and information directly to the patient can reduce dependency of consulting their general practitioner or hospital clinicians. [3]

All Danish citizens above the age of 15 have access to a summary of their medical record and lab results on sundhed.dk where they can follow the progress of their treatments. This data comes directly from the hospitals’ electronic patient records; therefore, the text will consist of medical and technical terms, which makes it difficult to understand for ordinary citizens, without a health professional background. [4]

A study from ‘Syddansk Sundhedsinnovation’ shows that citizens often have difficulty understanding the medical terms, both in the medical records and in the explanatory texts. In addition, they also have difficulties finding the essential health information, due to problems with navigating on the website, naming of categories and the large number of advanced features. Therefore, several challenges are related to the actual finding of data. These are important for the citizens who are not used to the website

and to achieve the most out of their health record. The overall user experience also affects the citizen's understanding of data, and it is uncertain whether the provided data has the required quality. [4]

To improve the quality of communication of laboratory test results to ensure the patients get the right information from the data it is necessary to involve the patients. The aim of this project is to investigate the problems involved in finding and understanding the laboratory test results by using the national portal. In that way the user experience can be improved and might result in more independent users. To achieve this, citizens will be involved in the process to decode the actual needs of the general user of the site. [5]

The specific aims of this study are twofold. First to gain knowledge on citizens understanding of their laboratory test results, and second to evaluate online methods for engaging citizens/patients in a participatory design activity.

## 2. Methods

The patients are the best experts to determine what they understand by their test results and therefore it is essential to involve them in the development by participatory design methods. Stimulating participation has normally been achieved by methods that bring users together in physical workshops and meetings. However, due to the COVID-19 pandemic it has not been possible to plan activities where the participants and researchers can be together physically. We consequently planned for online activities. A basic consideration is to determine who the users are and how the contact to them can be established.

For the project, it has been chosen that the primary user must be the average Danish citizen who would like to see their laboratory results. All contact to the users has taken place through posts on social media and through acquaintances. All meetings with users have been online meetings. The specific methods applied in this study are video observations and questionnaires designed to explore the demands and needs of the various users.

### 2.1. Video observation

Video observation is a method that documents a segment of reality and communicates the message in a possibly understandable way to the recipient. The method was suitable for use in fields where human interaction takes place [6]. In this case, the method was used to observe the user's interaction with the website sundhed.dk and the use of it. A semi-structured script has been used for this method as seen in the plan in Table 1.

The script was divided into seven parts, with each of them having an estimated length varying from 2-10 minutes, depending on the content. The overall estimated time was set to approximately 45 minutes. Additionally, the script includes the interviewer and the respondent in those seven parts and how the notes would be taken.

This method allows the observer/interviewer to observe the whole-body language and the mimic during an interview, with an increased insight into the users' usage pattern. It will make it possible to distinguish from what they say that they do; think they do and really do in relation to the use.

**Table 1.** The plan for the script.

<b>Name</b>	Laboratory result interview
<b>Format</b>	35-45 min.
<b>Narrative</b>	The story of why we would like to develop the laboratory site, and how we will get to a solution
<b>Aim</b>	To achieve more user-friendly and understandable laboratory results on the website, so that users become more independent and comfortable in using it.
<b>Target</b>	That more users feel comfortable in the use of the website. Primarily increasing the independence and readability of lab results.
<b>Media/execution</b>	Optimally through the website (sundhed.dk), but with the possibilities now, it will be through our social circle.
<b>Target group</b>	18+ citizens, who are adults and therefore would actively consider their results (own health and they must take care of themselves)
<b>Style &amp; look</b>	Fresh, open/curious and cozy (the interview)
<b>Role distribution for the interview</b>	Primary interviewer, secondary interviewer, and observer/note taker/technical responsible person
<b>Recording</b>	To be declared (Depending on the participants)

As an interviewer it can be a tough situation to experience if there is a negative approach from the beginning of the interview with the user. It is also important to act encouraging and attentive, during the interview to ensure the respondent feels heard.

## 2.2. Questionnaire

In questionnaire surveys, larger groups of citizens are asked the same questions and to give their answers in some predetermined answer categories. The citizens are randomly selected in such a way that they reflect the study area, which gives an overview of their experiences and assessments. In this case the method was used to examine the knowledge and the opinions to the website. This will gain an increased insight into the comprehensibility of the laboratory response. [7]

In the formation of the questionnaire, considerations have been made about what is to be found out, as well as forming an impression of who the users are and what characterizes different segments within their usage pattern and familiarity with the portal [7]. Therefore, the focus of the questionnaire is on the individual user, to understand if there are groups likely to use the site and to get a sense of their background. The questionnaire is divided into 5 sections each with its own purpose as presented in Table 2.

**Table 2.** The purpose of the questionnaires

Page	Purpose
1	Knowledge of the project and the purpose of the questionnaire, and that the survey is anonymous. However, they have the opportunity to write or ask questions and they have the opportunity to see the result in the end. The section also states how many questions there are and an estimate of how long it will take to answer them.
2	General information about the users: Age, gender, and which region they are from.
3	Questions about the highest level of education and current employment to see the professional distribution of the user groups.



4	Questions about the laboratory answer page. Develop a basis for understanding the contexts surrounding the use of the site.
5	Get an assessment on the questionnaire to help with improvements.

### 3. Results

During the data processing from the two methods, it emerged that the data collected from the video observation could only contribute with limited information about the use, as they were sporadic and not countable. The statements from the participants all included different problem areas about the user interface, but due to the variation in the participants focus area it was not possible to pinpoint a specific problem. Therefore, they are not included in the following paragraph and the data displayed are exclusively from the questionnaire survey, freely displayed on Facebook. The data is shown in Table 3 and presents the questions and the corresponding answers from 100 participants. In relation to the data processing, it is mainly relevant to focus on the answers involving the laboratory results page.

The results showed that 83.7% know about the laboratory result site and 37.6% use it less than once a month and 24.7% between 1-3 times a month. There are 43.5% who normally understand their results, whereas the remaining need help to understand their results.

**Table 3.** The questions and their corresponding answers.

Question	Answer options	Percentage
<b>Have you heard about the laboratory response page on Sundhed.dk before?</b>	Yes	83,7%
	No	16,3%
<b>How many times do you use the laboratory answers page per month?</b>	Never	18,8%
	Less than once	37,6%
	1 - 3	24,7%
	3 - 5	9,4%
	More than 5 times	9,4%
<b>If there is something in your laboratory answers which you find difficult to understand or are unsure about, what will you do?</b>	I can normally understand my lab answers.	43,5%
	I will read the response text that they give on the page.	32,9%
	I will try to google to find the answer.	27,1%
	I will ask an acquaintance for help.	8,2%
	I will contact my doctor.	24,7%
	I will not do anything.	10,6%

### 4. Discussion

The design of the questionnaire could have been improved by including an option where the users could write down their own response to add more detailed inputs. This option was chosen not to be included from the beginning, as it was assumed it would not be used and contingent responses would be of less value. The focus was on the concrete answers as they are easy to quantify. In this way, the different groups can be delimited. It could have been relevant to restrict the age groups and make several divisions of them. Additionally, it would have been an advantage to include an answer option about the use

of sundhed.dk - whether they use it or not, if not, the persons could be excluded from the rest of the questions.

The results from the questionnaire showed that 16.3% had never heard about the laboratory results site. It also showed a clear picture of what people would do if they do not understand their results. 43.5% understand their results, while 24.7% would contact their doctor and 10.6% would not do anything about it. By looking at these results, obviously there is an issue with understanding the information in the site, therefore an external assistance is needed. It is obviously a problem for many citizens to understand the communication of test results. It is however not so obvious whether further education will solve these problems but should be investigated more.

## 5. Conclusion

The aim of this article was to gain knowledge on how citizens understand laboratory test results, and to evaluate online methods for engaging citizens/patients in a participatory design activity. The investigations have been carried out using the methods previously reviewed with varying results. Unfortunately, the investigation with video observation did not provide useful information to achieve the goal of the article.

Through the questionnaire, an insight was gained into whether this is an actual problem or not. The answers to the questionnaire show that several participants experience difficulties with the site and there are differences in how they handle these. A future initiative could be to refine the video observation method, to find out where things are going wrong and what can be done to solve the problems during the user scenario.

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# Evaluation of a Medication Robot Through Participatory Design Methods - A Case Study in Denmark

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**Abstract.** The demographics in Denmark are changing. People's life expectancy is increasing, which puts a strain on the home care resources. The aim of this article is to get a deeper insight to how a specific medication robot in elders' homes can be further developed and modified to create more independence. An insight to the end users is created through the use of participatory design methods. The methods illuminate the fact that the medication robots design is gawky, its alarm volume is too low, the robot itself is too big and that it lacks the functionality of being transportable.

**Keywords.** Medication Robot, Participatory Methods, User Participation, Home care, Elderly

## 1. Introduction

As in most western countries, the average life expectancy has increased in Denmark which has resulted in more elderly people living in their own homes and receiving help from a home carer. Unfortunately the resources concerning home care have not been able to follow the increasing demand for help, which in some cases has led to poor working conditions, medications errors [5] and large financial expenses.

To overcome these issues, several technologies have been introduced to the home care market, including technologies that seek to make medication administration more secure and economically affordable. Among the many technologies on the market, medication robots have emerged, such as the MedimiSmart robot from TIM [1], Dosecare from Dosesystem [2] and the medicine dispensing robot from Evondos [3].

To clarify whether medication robots actually help with the mentioned issues, and how these robots potentially should be modified, to succeed user session [6], is used. Additionally the user involvement creates an environment where people like the elderly and home carer, are given more active roles, and thereby become co-creators in the process, instead of being passive participants. Reinforcing and expanding people's roles can eventually give them a higher sense of ownership of the process, resulting in a higher commitment and their answers not being based on what they believe others want them to say, but what they actually think.

This participatory design study is organized as a case study focusing on a specific medication robot. The medication robot from Evondos contains software that among other things [3] controls an alarm, which starts whenever it is time to take the medication

and the alarm continues until the user presses the green button. When the patient presses the button the robot dispenses the medicine in a small plastic bag. A home carer fills the robot, with rolls of plastic bag packed medicine, approximately every second week. By using the medication robot, the patient is thereby secured timely treatment.

The aim of this article is to produce new insight into how the medication robot can help the patient and how the robot might be further developed to become more beneficial for the end users.

## 2. Methods

Insight into users' behaviors and their context can best be achieved by the participatory design methods. However, the COVID-19 situation and complying with the appertaining restrictions, physical user contact was impossible to practice and consequently the participatory design methods have been altered, in order to conduct user sessions in an online setting. The reason for using these methods is due to the fact that they to a high extent, involve the primary and secondary users, which in this case are elderly people and the home carer.

### 2.1. Participants

Two informants participated in the user sessions, one home carer and one student who acted in the role of a persona [8]. Due to the COVID-19 restrictions it was not possible to visit the elderly in their own home and hence a university student was acting as a persona. She acted the role of Oda, an 82 year old woman, living in her own private home and receiving daily help from the home carer that helps her to remember to take her medicine. The home carer is employed in the public health care system in Denmark. She has daily interaction with elderly people which among others include assisting in medication administration. The COVID-19 restrictions also led to the interviews having to be held online via Zoom [4]. The online interviews were video recorded via Zoom, making it possible to see the video multiple times, and thereby pay attention to different or missed details.

### 2.2. The user session

In the sessions the participants were interviewed following a semi-structured interview guide and distribution of roles was made beforehand. The questions asked were formulated on the basis of the research questions, to ensure that the interview questions were directed towards the research area. The questions were, about design, user friendliness, sense of security, ethical issues and social status. Furthermore, the health professional was asked whether she would feel comfortable installing the medication robot and the persona was specifically asked about her personal opinion and perception of the medication robot.

The user session with the persona made use of pictures [7]. The pictures had been chosen on beforehand by the project members and were shown on the informant's screen. The pictures chosen all illustrated a specific topic in relation to the medication robot, in order to ensure that the participant's reflections, would be significant and relevant. The topics were different kinds of home technologies, like an activity watch, medication

robot, and other topics were different rooms like kitchens, bathrooms, living rooms and so on. The pictures were chosen with the purpose of getting information from the participants regarding where to place the robot and what the medication robots optimal design would be. The pictures were included in the interview by asking the informant to verbalize what reflections came to mind when looking at the illustrations. The reason for including visual imaging is that it can give a different perspective and new reflections.

### **3. Results**

The user sessions led to results divided in two sections, the first is what was learned from the users who participated in the interviews, and the second is based on the gained experiences from using the specific participatory design methods.

#### *3.1. From the informants*

The user sessions produced an insight into the specific and general perceptions of a home care staff and a persona and thereby providing knowledge and inspiration to how a medication robot, like the Evondos, could be improved. From the interviews, the most important lesson learned was that the robot itself is rather gawky in its design and that it lacks the functionality of being transportable. With a non-transportable medication robot is it not possible to hear the alarm when not at home, which results in the end user not being reminded about taking their medicine by the medication robot. It also became clear that a general issue of the robot was that it took up a lot of space, suggesting that the design and dimensions of the robot should be modified and changed. Furthermore, the volume of the robot's alarm was mentioned as a concern. The reason being that it seems unlikely that a person would be able to hear the alarm, if the robot is located in the kitchen, and you are in the bedroom, taking a nap. The fact that the robot dispenses the medicine in small plastic bags, was also a concern since the bags were seen as a challenge to open for elderly people with possibly crooked arthritis fingers.

The robot was seen as an invention that could replace some of the home carer's work tasks, making it beneficial to the municipality. Another lesson learned was that the primary end user could be people below the age of 75 without dementia since they are assumed to be more confident about technology than the ones with an age over 75. Thereby younger elderly will get a better outcome from the medication robot and become independent from the home carer. The reason why the medication robot is not the optimum solution for demented is that they need human contact and the medication robot could cause confusion.

Despite the challenges regarding the medication robot, it is still seen as a technology that can assist elderly in becoming more independent, and thereby be less in need of having home carers visiting several times a day. A fact that also can create beneficial economic advantages for the Danish municipalities, since the robot helps by saving time and money.

#### *3.2. From application of methods*

With the online user sessions, it can be difficult to detect the informant's body language it is only possible to see part of the informant, so it is not always possible to see their

gesticulation when they explain something. During the user sessions, the facilitator was interrupted in note taking, due to the complexity of having to write and keep eye contact with the informant at the same time. The tendency with the online interviews was that they were shorter than expected.

Including images in the user session resulted in giving the informant new reflections. In the beginning of the interview, the participant was shown a collage of pictures, which she referenced to later in the session. The pictures were also shown individually which gave the informant more specific reflections. During the session, the facilitator had at some points difficulties in asking questions in relation to the picture. Furthermore, it was difficult for the facilitator to keep an overview of how many and which pictures there are left if the facilitator does not share the screen that shows the images.

#### **4. Discussion**

Since the user sessions were conducted online, this might have influenced the results and the time consumption. During the online sessions, there was a focus on having eye-contact with the informants. This can have led to the informant being more focused on answering short and precisely, in relation to what the interviewer might want to hear, instead of prioritizing taking time to reflect on personal perception and considerations. An advantage by performing the session online is that it saves transportation time.

A way to prevent the potentially precipitated interview is by allowing the informant to have their camera turned off during the interview. This would relieve them from having to make eye contact and focus on how they physically represent themselves online and thereby make it easier to get in touch with their perceptions. As an alternative, the method Transect walk [9], could have been used. The method is overall based on interviewing while walking, which enables the informant to focus on where they are going and what they see, instead of having constant eye contact while speaking.

Using photos during the user sessions gave rise to many reflections but these reflections might have been stirred in a specific direction. The reason for this being that the pictures were chosen beforehand, so it was already decided from which images the informant had to reflect on, causing fewer diverting reflections. An alternative to this aspect could have been to let the informant choose themselves among many different pictures, which ones to reflect upon, in relation to the medication robot. This also might have helped in the process of creating a better coordination between discussing with the user and showing pictures.

The qualitative approach and the COVID-19 situation limited the participation to only two informants, which means there is limited generalized information about how the whole of a potential target group perceive the use of medication robots. For a study with higher external validity, a quantitative questionnaire [10], could have been included to give a broader understanding of what the majority of people think. Furthermore, none of the sessions included true primary users, which could have affected the results, since the gathered reflections and thought thereby are based on estimations and interpretations by the home carer and younger students in the role of a persona. To see the product in the right context it could have been beneficial to make a simulation [11] with an elderly person in the target group. This method could have shown if some of the mentioned problems, for example, the dosed bags, is an actual and realistic problem.

In spite of the methods having some downsides, they made it possible to get a new insight from a user perspective of how the elderly and health professionals perceive the medication robot.

## 5. Conclusion

Through participatory methods it is revealed that the issues: increase in the demand for help, poor working conditions and medication errors, can be solved with the medication robot. The issues being an increase in the demand for help, poor working conditions and medication errors. Elderly under 75 years old can be more independent with a medication robot and it can relieve the home carer's workload. But introducing a new technology is not without causing new challenges as well. For the Evondos medication robot to succeed it has to be modified to what the target group needs and wants. According to this study, the robot has to be smaller and have more functionalities, for example, to bring the medicine with you when you leave the home. The conclusion is that the medication robot is a technology that with adjustments can be an integrated technology resource in the home care market.

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# Assessing the Usability of a Tumor Dashboard for Multidisciplinary Care Teams for First Time Users; First Exploration of a Comparative Participatory Cognitive Walkthrough to Show Mismatches in Cognitive Models

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**Abstract.** Due to the COVID-19 pandemic, multidisciplinary team (MDT) meetings have to switch from physical to digital meetings. However, the technology they currently use to facilitate these meetings can sometimes be lacking, therefore many software companies have developed new software to ease our new digital workspace. In this study, we propose a new method, a comparative participatory cognitive walkthrough, which can show mismatches in cognitive models. To test our method, we tested the compatibility of EPIC EMR (EPIC Care) and the NAVIFY Tumor Board for preparing MDT meetings. The identified mismatches are categorized in the HOT-fit model by Yusof et al, a common way to evaluate if a healthcare information system fits with the healthcare professionals and the organization. In total, 16 mismatches were identified. These mismatches were discussed in a feedback session with an implementation manager of the NAVIFY Tumor Board. The proposed method seems to be a fast and cheap method to gain useful insights in how well new software matches with the software currently in use, by comparing the cognitive models in place when performing tasks involved with specific scenarios. The identified aspects can be of use for the development and adaptation of the new software, as well as provide guidelines on which aspects to focus on when training healthcare professionals to use the new software to have a smooth transition of software.

**Keywords.** Usability evaluation, Comparative Participatory cognitive walkthrough, UX research, MDT meeting, Tumor Board

## 1. Introduction

Compared to new technologies, the healthcare systems and technologies used in hospitals

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in the Netherlands are often dated. Therefore, many healthcare professionals want to switch to recently developed technologies (systems, apps, platforms) proven to be more efficient and beneficial for their work and to their organization. Even though these technologies score high on efficiency, often the usability and user-friendliness are not taken into account. For the implementation and acceptance of technologies, the importance of user experience is increasing.

Due to the COVID-19 pandemic, the use of online technologies that facilitate working remotely has become popular. For creating personal treatment plans for patients in cancer care, multiple, relevant healthcare providers from different fields of expertise (e.g. oncologists, radiologists, pathologists) are involved in the care process [2]. They discuss the diagnostic, treatment and after-care process in so-called multidisciplinary team meetings (MDT meetings) [3]. Usually, due to the complexity of cancer care and the continuously improving and expanding clinical expertise of healthcare professionals, an MDT meeting will be held with professionals within each hospital if possible, and regionally or nationally when more expertise is required [4]. In general MDT meetings would be a physical meeting. However, due to the COVID-19 pandemic, MDT meetings have been forced to switch from physical to digital meetings [5].

Some of the new technologies created are for facilitating online MDT meetings, such as Roche's Diagnostics' NAVIFY. For new technologies, especially ones created for a different country (US) in a different language and following different guidelines, it is difficult to find out its compatibility and usability when matching the software to the needs and practices of Dutch healthcare professionals. A usability evaluation method that supports research on all important aspects (usability, user satisfaction, learnability and structure) is cognitive walkthrough (CW). It is designed to see whether or not a new user can easily carry out tasks using a specific system [6]. With this method, an expert inspects the user interface of the software in a very structured manner from the perspective of the user, using specific scenarios, consisting of tasks and subtasks. Each subtask is then evaluated on different cognitive aspects such as recognition, awareness and mental feedback.

There are many different adaptations of the CW method, one of which is the participatory CW. With a regular participatory CW, end users and experts would collaboratively run through the application in a highly structured manner and evaluate each task and subtasks on several cognitive aspects. However, this method will not give you information about how usable and understandable a new software system is when compared to the software end-users are currently using. Therefore, in this study we have adapted the performance of the participatory CW by applying it in a comparative setting in order to gain sight into the mismatches in the user's cognitive model (their way of thinking) when they have been using a certain software and are trying out a new software based on scenarios. Furthermore, we will use the HOT-fit model, which is a common way of evaluating whether or not a health information system fits with the healthcare professionals and the organization, to categorize the identified mismatches and show their influence [7].

In this study, we propose a proof of concept for an adaption of the participatory cognitive walkthrough method. Our goal is to gain insights into the potential usability issues of the new software for new users that are used to the cognitive model of executing certain tasks in their current system. By mapping the current tasks for preparing a MDT meeting in a current setting with EPIC software to preparing an MDT meeting using the NAVIFY Tumor Board, we gain insights into the mismatches in usability for the transition from the current software to new software. Furthermore, we can identify what

type of issues and problems are encountered. With this information, we can show which challenges healthcare professionals experience when transitioning from using EPIC in MDT meetings would encounter when switching to using the NAVIFY Tumor Board.

With this knowledge, recommendations regarding additional functionalities and terminology can be formulated to fit the software to the healthcare process as it currently is. Furthermore, for training purposes, bottlenecks and other aspects that may require more attention can be identified.

## 2. Software

To test the participatory cognitive walkthrough and identify the mismatches in cognitive models, a case was used in which EPIC was the ‘old’ software, and Roche Diagnostics’ NAVIFY the ‘new’ software.

EPIC is one of the largest providers of health information technology to access, organize, store and share electronic medical records (EMRs) [8]. The EPIC EMR (EPIC Care) can keep community providers and caregivers up to date with an integrated portal that shows them their patients, lets them submit referrals, order laboratory tests and imaging, and more [9]. The Amsterdam University Medical Center (Amsterdam UMC) has used the EPIC EMR since 2013 [10]. Currently, EPIC Care, as being used in the Amsterdam UMC, does not have a dedicated module for creating and preparing MDT meetings.

The NAVIFY Tumor Board is a cloud-based workflow product that securely integrates and displays relevant aggregated data into a single holistic patient dashboard [11]. The NAVIFY Tumor Board is created to facilitate the preparation, discussion and decision phase of a MDT meeting for cancer care and can be integrated with the EMR [11]. Furthermore, based on the data entered, it can show for which recruiting studies a patient could apply, search for relevant study publications, and provide an interactive overview of the guidelines applicable to each specific patient.

Several studies on the usability of the NAVIFY Tumor Board have already been conducted [12-16]. Three of these studies were observational studies, one study was a prospective cohort, and one was a simulation-based study with structured scenarios, respectively. The results from these studies show positive outcomes in regards to efficiency and reduction of preparation time. No expert evaluation on the usability of the NAVIFY Tumor Board has been performed yet.

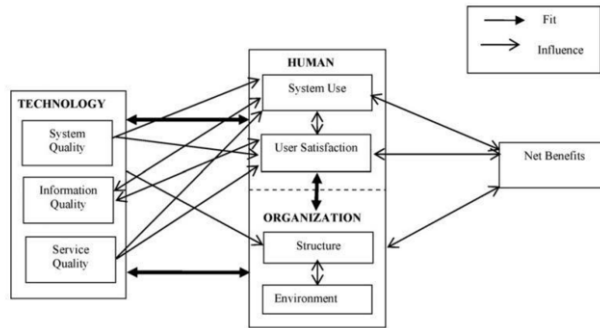
## 3. Proposed method

### 3.1. Comparative participatory cognitive walkthrough approach

In order to match the new software to the currently used one, first, scenarios need to be created. These scenarios will then be executed in two different sessions. The comparative participatory walkthrough consists of six phases. In phase one, a structured document and scenarios need to be prepared. In the second phase (the first walkthrough session), end users execute the scenarios using their current software programme (EPIC Care). Whilst executing the created scenarios, all tasks (assignment) and subtasks (steps with which the assignment can be completed) are recorded by the expert. For each subtask,

the expert also records encountered problems and inefficiencies. Phase three consists of specifying and structuring the identified main tasks in a new document. In the fourth phase (the second walkthrough session), the identified tasks from the first session are executed using the new software (NAVIFY Tumor Board). Whilst executing the identified tasks, the end user and expert compare the execution processes in the two different softwares. Difficulties, dissimilarities and dysfunctions are recorded and assigned a severity rate (as described by Nielsen) by the oncologist [17]. By executing the identified tasks of the current work process, an insight is gained into how well the new software supports the current task system. The fifth phase consists of mapping tasks and categorizing difficulties, dissimilarities and dysfunctions. In the last phase, the identified aspects are discussed with an employee from Roche Information Solutions in a feedback session, to gain further insights into these aspects and what can be done to avert or lessen the impact of the mismatches.

For this study, the recorded aspects are categorized using the HOT-fit model in which aspects are accommodated in the specific aspects within the ‘human’, ‘organization’, or ‘technology’ domain (see figure 1 [7]). The first author coded the identified issues and discussed the analysis with the fourth author.



**Figure 1.** Human-organization-technology-fit (HOT-fit) framework as proposed by Yusof et al.

### 3.2. Participants

In line with the participatory CW method, two participants performed the analysis. The first participant is the 3rd author, a 34-year old oncologist working at the Amsterdam UMC in the Netherlands with approximately one year experience in using Epic Care and no experience using the NAVIFY Tumor Board. The second participant is the 1st author, a 22-year old master’s student in Medical Informatics from the University of Amsterdam, trained in performing usability tests (specifically CWs), with little to no experience using EPIC Care and the NAVIFY Tumor Board.

### 3.3. Scenarios

Two different scenarios were used for the comparative participatory walkthrough. These scenarios were conceptualized by the 5th author, defined by the 1st author, and revised by the 5th author.

Scenario 1: ‘Patient A has had surgery for a colon carcinoma. The treating physician is wondering whether or not the patient would benefit from starting adjuvant systemic therapy (treatment to prevent the recurring of a carcinoma). Patient A is diagnosed as a

stage 2, high risk patient, therefore adjuvant therapy should be discussed in an MDT meeting.'

Scenario 2: 'Patient B has stage 4 colon carcinoma with synchronous metastases. Metastases are not well resectable, even after induction therapy. Therefore, it was decided to start palliative systemic therapy. The available information on different types of palliative therapy may not be up to date. Patient B could therefore be discussed in a national expert panel, in which new studies are also discussed.'

#### 4. Results

We encountered nine aspects categorized in Technology: information quality. Most aspects were dysfunctionalities (n=10), some were dissimilarities in the execution of tasks (n=3) or technical difficulties (n=3). In Table 1, the identified aspects are presented with their HOT-fit category. The implementation manager of the NAVIFY Oncology Decision Support portfolio from Roche Information Solutions, was asked to review and reflect upon these aspects. The status of the aspects (whether or not NAVIFY was aware/unaware of the aspect and if the system is able/unable to support this aspect) and the employee's comments are included in the column 'Status' and 'Review NAVIFY' in Table 1.

There were three potential usability issues of which NAVIFY was unaware (unaware/unable) of and three aspects that involved execution problems due to dissimilarities (aware/able). Lastly, the two aspects 'Indication for revision' and 'Treating physician' are aspects that have to be recorded in the EMR, due to legislations and should not be recorded in the NAVIFY Tumor Board according to the implementation manager even though the oncologist expected to be able to record this in the NAVIFY Tumor Board.

**Table 1.** Results from the comparative participatory CW and the review from NAVIFY

Aspect	HOT-fit category	Status	Review NAVIFY	Severity
Chairman MDT meeting	Technology: information quality - completeness	Aware Unable	Aware that one person has to be appointed chairman, but this is not possible in the software.	4
Referrer	Technology: information quality - accuracy	Unaware Unable	Unaware that it is important to record the referrer of the patient. Currently, only the physician that added the patient to the MDT meeting is visible.	3
Anamnesis	Technology: information quality - completeness	Aware Unable	Is added in the august/september update.	4
Family history	Technology: information quality - completeness	Unaware Unable	Unaware that family history can sometimes play an important role in the course of the disease.	4
Family risk	Technology: information quality - completeness	Unaware Unable	Unaware that family risk can sometimes play an important role in the course of the disease.	3

Patient's preferences	Technology: information quality - compatibility		Aware Unable	Assumed that the preferences of the patients were unknown before the start of an MDT meeting. Believed consultations with the patient would be held afterwards in which the patient could indicate their preferences.	3
Imaging	Human: system use - knowledge		Aware Able	Able to insert a URL from the PACS software in the patient file.	2
Indication for revision	Technology: information quality - compatibility		Aware Unable	This is considered preparation work before preparing the MDT meeting. This should be done in EPIC. This way, healthcare professionals can be notified of the required preparation before the MDT meeting.	4
Treating physician	Technology: system quality - ease of learning		Aware Unable	This should be recorded in EPIC.	3
Indication for rediscussion	Human: system use - knowledge		Aware Able	This can be realized by adding a patient to a new MDT meeting.	4
Finalizing the document	Technology: service quality - responsiveness		Aware Unable	Can only be realized when NAVIFY is fully integrated with EPIC.	3
Attendees	Technology: information quality - completeness		Aware Unable	Is added in the august/september update.	4
Searching patients	Human: system use - knowledge		Aware Able	A minimum of three numbers should be used when searching for a patient record number.	4
Information standard languages	Technology: system quality - ease of use		Aware Unable	The software will be available in Dutch somewhere next year.	2
Terminology	Technology: information quality - compatibility		Unaware Able	Unaware that this terminology could cause confusion. They will change these terms.	2
Saving recorded information	Technology: service quality - responsiveness		Unaware Able	Unaware of this problem. Passed this information to the software developers.	3

Depending on how structured the walkthrough sessions were, the complete process for executing the comparative participatory cognitive walkthrough takes approximately 25 hours (see Table 2).

**Table 2.** Comparative participatory cognitive walkthrough phases and execution time

Phase	1	2	3	4	5	6
Time	5 hours	1 hour	5-10 hours	1.5 hours	6-11 hours	1.5 hours

## 5. Discussion

In this study, an adaptation of a participatory cognitive walkthrough is proposed as a method to identify mismatches in cognitive models and potential usability issues new users of a system will encounter when switching to a new software programme or application.

With the comparative participatory cognitive walkthrough, holding two walkthrough sessions creates value. In an ordinary cognitive walkthrough (using only usability experts), a detailed analysis of potential problems results from the evaluation [18]. However, cognitive walkthroughs are tedious, discourage exploration and require detailed task description and user background details [18]. With our method, which involves both a medical specialist and a usability specialist, problems can be identified regarding terminology, lacking system functions or lack of data entry fields, the compatibility of the new software to the current work process, and how well the current steps can be executed using the new software (how many adaptations to the current work process are needed). For example, 'Family history' (status: unaware/unable) did not have a separate textbox. NAVIFY was unaware that, for some cancers, family history can contribute to a patient's treatment plan and should be recorded. This problem would not have been identified using an ordinary cognitive walkthrough without a medical specialist. As mentioned before, EPIC Care does not have a dedicated module for preparing MDTs, therefore, the identified tasks can be more tedious than necessary. However, our goal was to analyse the fit of two technologies and see which issues may occur when switching from one to another, not to evaluate the preparation process itself.

This quick (20-30 hours) evaluation method does not only benefit organizations looking for new software that matches the current work process well, but also for companies developing software. As mentioned before, there were aspects (n=3) that NAVIFY did not consider relevant when the opposite is true. These can be implemented in the following update. Furthermore, since the Tumor Board is still under development, many of the identified aspects (status: aware/unable, n=8), were already being considered by NAVIFY. Finally, the aspects with a status aware/able (n=3) are aspects that require more attention in training, since they are implemented, but in a different way than was expected by the 1st and 3rd author.

The use of this method to identify mismatches in cognitive models when switching to different software or a different application should be explored further. In this study we explored the adaptation of this methodology with two participants. Therefore, results could be biased or only represent the views and experience for two particular individuals. This study can be repeated with multiple participants and more scenarios to fully comprehend the mismatches in the work processes and cognitive models, and in which domain these problems occur. With this knowledge, mismatches can be averted or prevented so the software will be more compatible with the current work process, which can ease the implementation and result in a higher acceptance.

## 6. Conclusion

The proposed comparative participatory CW provided useful insights in how well new software (NAVIFY Tumor Board) matches with the software currently in use (EPIC Care), by comparing the cognitive models in place when performing tasks involved with a specific scenario. The identified aspects can be of use for the development and

adaptation of the new software, as well as provide guidelines on which aspects to focus on most when training healthcare professionals to use the new software in order to have a smooth transition of software.

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