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CONTEMPORARY CLINICAL DECISION SUPPORT SYSTEMS: A PRELIMINARY REVIEW AND RESEARCH AGENDA

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Research in Progress

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Abstract

Clinical decision support systems (CDSS) improve healthcare delivery by providing data-driven opinions to care providers throughout the entire care process. The Information Systems (IS) community has produced many works on the subject in the last decade, and it is necessary to comprehensively examine the current state of research to determine the most promising themes to explore in future research. In this short paper, we conducted a literature review of the past five years to synthesise research efforts. By reviewing a preliminary sample of papers, we found that three major areas may be of interest to the IS Community: 'Positive' and 'negative' CDSS discontinuance, patient-centric value creation of CDSSs and the role of policy-makers in mitigating harmful social effects of CDSS policies. This research-in-progress will hopefully lead to the creation of a research agenda for CDSSs.

Keywords: Clinical Decision Support, Discontinuance, Value Creation, harmful social effects.

1 Introduction

Clinical decision support systems (CDSS) are health information technologies designed to improve healthcare delivery through the technological enhancement of medical decisions by providing insights from targeted clinician knowledge, extensive patient databases and analysis of patients' electronic health records (Sutton et al., 2020). CDSSs use different analytical techniques on a variety of pathologies (Souza-Pereira et al., 2020), and the use of this health information system (HIS) is continuously evolving as the panorama of emergent technologies in information systems (IS) changes their shape (Mahadevaiah et al., 2020). The spotlight on this health information technology (IT) is warranted by its potential to shape how we experience care as patients, deliver care as medical staff and manage it all as care-providing entities. The data-heavy dependence on these systems indicates that the digitalisation of healthcare will require patients to take a more active and proactive role as actors who can provide data valuable to their personal care and the care of others as time goes on (Hermes et al., 2020).

The potential for application of these systems is well-recognised with the significant level of investments worldwide. Global healthcare leaders invested heavily in artificial intelligence (AI) systems during the Covid-19 pandemic, with 75% of large organisations interviewed with annual revenue above the US$10 billion mark investing over US$50 million in AI technologies for clinical and non-clinical purposes and 73% of all organisations expecting rising investments levels in the upcoming years (Deloitte Consulting LLP, 2021), and big tech companies have recently decided to increase their influence in the healthcare industry with strategic mergers and acquisitions (Bain & Co., 2022). Healthcare entities are answering the call of global policy-makers to progressively adopt meaningful use of Electronic Health Records (EHR), Electronic Medical Records (EMR) and Health Information Exchange (HIE) platforms (A recent example is a proposal for the European Health Data Space (Directorate-General for Health and Food Safety, 2022)) after public investments have previously encouraged the proliferation of electronic health records systems in hospitals (Setia et al., 2020). The level of financial and legislative backing can be only described as a natural response to a progressive shift to a better, more sustainable, and, more importantly, universal level of care. Better because it wishes to be able to achieve lower levels of mortality and better quality of life in all stages; more sustainable because it aims to reduce the level of strain on national economies as populations increase and demand for public healthcare increases year-on-year; universal as emerging economies push to achieve comparable healthcare performance indicators as their more established counterparts. As of 2017, almost half of all US hospitals implement some form of CDSS capability, and yet these systems suffer from use, design, maintenance, financial viability issues (Sutton et al., 2020).

IS research has previously suggested focusing on components of HIS that pose the highest impact potential through influencing care providers' decision-making and the interdependence with other components (DesRoches et al., 2010). However, it is also noted that the consensus in IS community is that investing in patient record digitisation, EMR, medical records, and HIE platform access will not lead to obvious, powerful benefits until the decision support component is adequately implemented and used (ibid). The research, therefore, implies the need for a focus on CDSSs to pave the way for integrated, widespread use. Despite this, few works have focused on systematically investigating the state of IS research on CDSSs. Most studies only focus on evaluating innovative custom-built solutions despite CDSSs comprising interdependent components (Souza-Pereira et al., 2020). Such review is also essential, given that medical staff must come to terms with their new roles in teams of humans and machine actors working together to make accurate, efficacious, and responsible clinical decisions (Buch et al., 2018).

Against this state of the art, we ask the following questions: What is the current state of IS literature in relation to CDSSs? What are the gaps in this research stream? What are the recommended next steps in CDSS use that the community can harness to extend its research? In this paper, we present the initial findings of our research in progress that, in its final form, will hopefully create a research agenda in CDSSs that informs future research. Drawing from a selected sample of journals limited in time, we perform our initial research, followed by a preliminary overview of the gaps identified and related research questions. Finally, we present our analysis and proceed to delineate the subsequent phases of our research. This review, when completed, will provide valuable insights into the strategic side of Clinical Decision Support Systems and their relative components.

2 Literature Review Method

As this review seeks to identify those studies that explore the strategic use of CDSSs and related components regardless of differences in study design and other elements, we performed our literature review with a structural approach, which allowed us to initially assess which themes should be pursued from a more stringent initial research to then expand it to a larger sample of papers. Our process of selecting, processing, and reviewing papers is depicted in Figure 1. To perform our literature search, we decided to limit our search to the use of Scopus for our preliminary analysis, given the wide accessibility of our target journals on the platform and the limited range at the current stage of our research. We used the advanced search query function to build our initial query and all subsequent queries that came with each search refinement stage. The following terms were used for our final query used in our preliminary study: "clinical decision support" OR "electronic health records" OR "health information exchange" OR "Hospital Information exchange". These terms refer to the main classes and do not refer to any specific technology, as we programmed a more in depth-research of CDSS components (e.g. AI interaction) at later stages of research maturity. Searches were limited to the presence of any of these terms in either abstract, title, or keywords. The search was conducted in September 2022 and yielded 1487 results. We then limited our analysis to only those papers published in the last five years (from 2017 onwards to focus on the most recent findings; the search will be expanded as mentioned in the last section of this paper), and only included research papers in the IS basket of eight and select journals recommended by special interest groups (SIG) in the field of Health Information systems, Decision support, and human-machine interaction as suggested on the official website of the Association for Information Systems (AIS), which include journals such as Decision Support Systems, AIS Transactions on Human-Computer Interaction, and Journal of American Medical Informatics Association (Association for Information Systems, 2011).

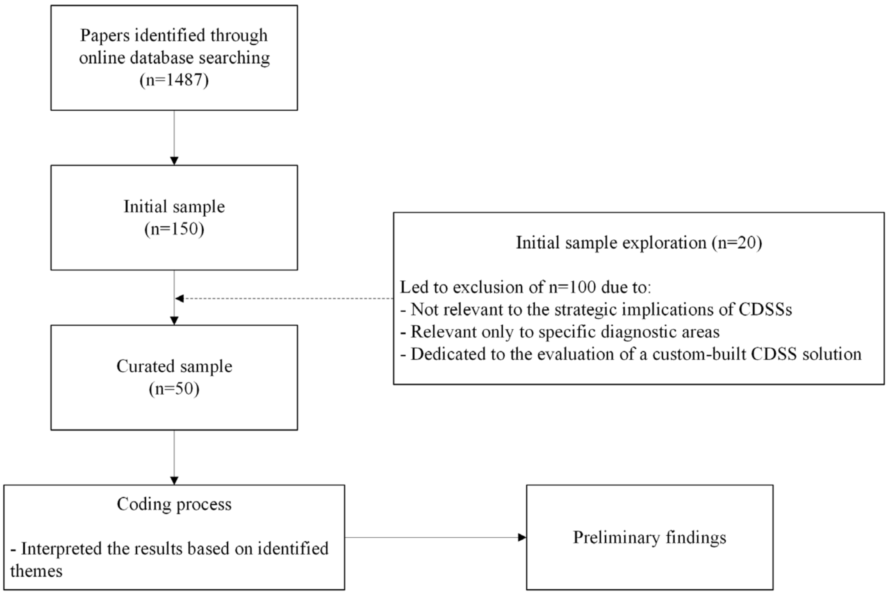

Figure 1 – Preliminary literature review process

After the initial search, we examined the articles' abstracts to establish potential criticalities during the review process. We filtered out all those papers that study a CDSS that is not applied in the real world (e.g., created as a prototype for the purpose of research experiments), and we believe they only have the potential to marginally provide strategic inputs on the use of CDSSs in general. We also removed those CDSSs that focused only on particular clinical workflows, as research reports how the current state of CDSS implementation appears to be fragmented for this reason (Laka et al., 2022). Because we were not interested in evaluating and comparing the quality of individual CDSSs, we opted to take them out of the equation. CDSSs are constantly evolving as new analytical methods and emerging technologies also rapidly evolve (Mould et al., 2016), so we expected this trend to be represented even outside of our initial sample. We then analysed the abstracts of the 150 most relevant papers and created a curated sample of fifty papers. We then again examined the refined list of papers, allowing us to identify our preliminary findings.

Finally, we proceeded with the coding of the final sample of fifty articles. Our analysis included the authors of the papers, the year of publication, the journal where the article was published, the main research methodology, the theory or theories used, the main actors involved, and a simple summary of the research findings. We then categorised our papers into different themes by following an iterative process and with active discussion with our colleagues. Our results were processed into three preliminary findings.

3 Preliminary Findings

Our literature analysis was guided by the view of responsible information systems (RIS), therefore, making a world a better place with information systems (Pan and Zhang, 2020, Davison et al., 2023). In this research in progress paper, we focused on the three preliminary findings on CDSSs in relation to the RIS: continued vs discontinued use, value creation for CDSSs from the patient's perspective, and the policy-maker's role in mitigating harmful social effects of CDSSs national policies.

3.1 Continued Use vs Discontinued Use

We identified several papers dealing with the sub-cycle of continuance, specifically with the theme of frequency and degree of use and the analysis of different agonising and antagonising factors (Abouzahra et al., 2022, Liang and Xue, 2022). For example, papers explored the impact of specific design elements (Gardner et al., 2019) or social constructs on the frequency of use. Much less coverage is reserved for the phase of **Discontinued Use** or discontinuance of an information system, which Furneaux and Wade (2011) refer to as the cessation of use of an information system. When trying to understand the reason for this lack of coverage, we initially came up with a logical explanation for why discontinuance is less pronounced in research. The investment in CDSSs, or the meaningful use of digital healthcare systems, is financially incentivised and endorsed by government agencies (Marcotte et al., 2012).

In the only paper in our sample that explores the discontinuance of a health information system (Politi et al., 2022), the authors briefly explored what we will refer to as 'negative' discontinuance, or in the specific case, the discontinued use of HIE when EHR is introduced contemporarily. The authors imply that this is an unintended consequence of the user's cost-benefit analysis, as they argue that physicians would ideally use both systems simultaneously, as these two better support the information needs of clinicians and ensure a better quality of care. However, the definition of discontinuance provided by Furneaux and Wade (2011) does not imply whether discontinuing a system is positive or damaging to the organisation. In truth, discontinuation may be harmful and lead to loss of investment, such as could be the case of system substitution mentioned above, with previous research identifying the premature end of an IS life cycle came about because of internal and external factors, such as users experiencing what IS research refers to as the 'dark side of information technology use', characterised by emotions such as stress, adverse psychological outcomes, or reduced productivity and performance (Tarafdar et al., 2019, Tarafdar et al., 2015). These negative phenomena "have the potential to infringe the well-being of individuals, organisations, and societies" (Tarafdar et al., 2015, p.161). As a result, increasing attention is paid to researching dark side phenomena at both individual and organisational levels in IS discipline, including focusing on HIS. An example of this focus comes from Califf et al. (2020), who describe how stressors borne from technology use, when appraised as either beneficial or harmful by the user experiencing technostress, may give rise to either positive or negative emotional states. The study built a holistic technostress model that considered the experience of nurses interfacing with an EHR system, acknowledging the positive and negative outcomes into separate sub-processes. The study took the first step towards recognising the role that technology plays in inducing stress in its users and demonstrated this through interfacing with the healthcare environment, which is well-known to be amongst the top stressful environments. We argue that these factors, as many others currently unexplored, either contribute to the discontinuance event or may even be a direct result.

Furthermore, Politi et al. (2022) explored discontinuance under the organisational level (substitution of a system for a different one moved by an IS utilitarian view); we think that, at the very least, exploring the role of individuals may help promote progress in the field. From the perspective of patient-centred healthcare, the contribution of personal health metrics needs to remain stable and reliable over time (Mathioudakis et al., 2016). Therefore, it may be helpful to explore the decision of patients to discontinue their data streams which feed clinical decision support systems and help these learn over time.

Discontinuance and end-of-life decisions require careful consideration to avoid negative repercussions on the organisation's information and resource management capabilities (Furneaux and Wade, 2011). Organisations risk a substantial loss of investment due to premature discontinuance of a system (Beatty and Williams, 2006); therefore, the logical benefit of focusing on the study of discontinuance of CDSSs and its components is to help organisations monitor for potential causes for premature abandonment, avoiding possible snowball effects where if enough patients opt out of health data communication, this ultimately results in the lower predictive power of the system, and worse performance overall for those who remain.

Such discontinuance discussed above is only one side of the coin, as discontinuance can also be the natural conclusion to the life of a system that has already run its course. Rezazade Mehrizi et al. (2022) provide an exemplar of what we would argue is a 'positive' discontinuance, as it explores the common situation of a legacy system being replaced by a newer, more adequate system and judges the adjuvating and adversarial role of the habits that individual users inherited from the older system. Just like organisations need to discontinue old legacy systems to keep their competitive stride and avoid productivity loss (Holland et al., 1999), caregiving institutions may have to discontinue CDSSs in favour of newer systems that can guarantee a higher quality of care or better financial performance.

As we acknowledge the existence of a 'positive' and 'negative' discontinuance, we argue that future research should focus on the phenomenology behind each of these. We, therefore, propose the following research questions to guide future research on CDSSs and related components' discontinuance: (1) What are the drivers of positive discontinuance of clinical decision support systems and their related components? Similarly, (2) what are the drivers of the negative discontinuance of clinical decision support systems? (3) What are the effects of a premature discontinuance of a clinical decision support system? (4) How does switching from a legacy CDSS to a new one affect the whole process of care?

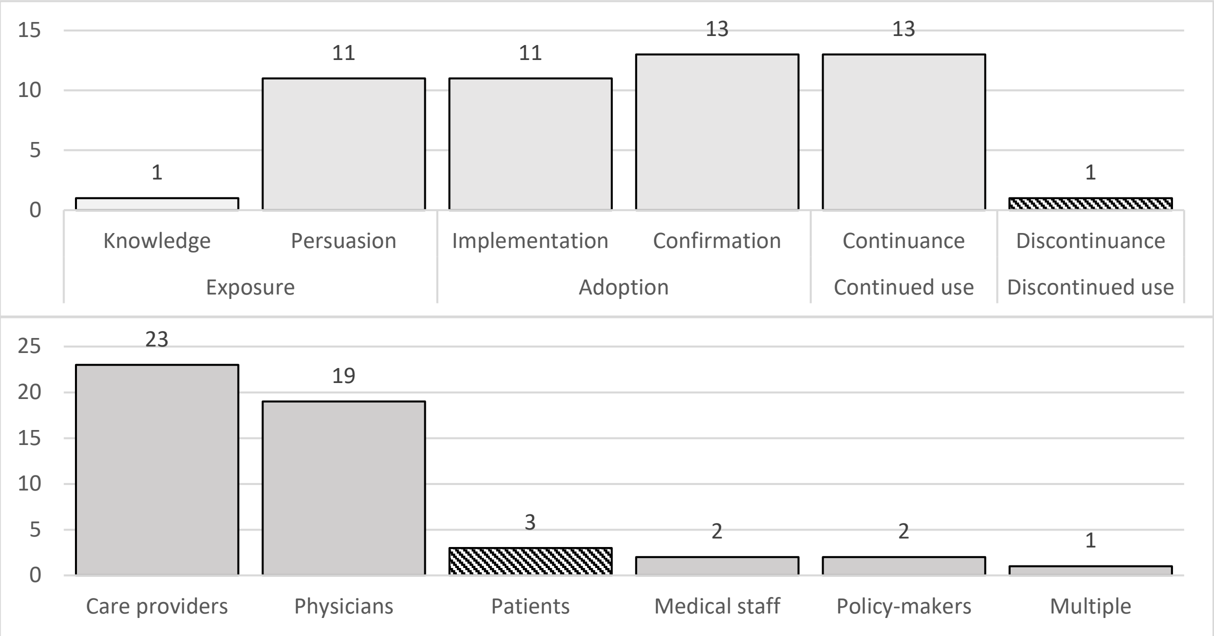

Figure 2 - Distribution of phases and sub-phases in the IS Use life cycle and actor distribution of our preliminary papers sample.

3.2 Value Creation of CDSS from the Patient's Perspective

Our sample of papers dealt with a handful of primary stakeholders either as subjects of the papers' studies or as the intended recipient of the papers' key takeaways. Most articles focused on the general perspective of hospitals, hospital managers, or physicians-users of CDSSs and their components. Figure 2 shows the distribution of the main actors in our sample. Among the categories that were missing the most, we noticed the lack of papers examining the **perspective of patients**. Papers that were part of this stream focused chiefly on determining the factors contributing to patient acceptance of health information system components (Park et al., 2022a, Yaraghi et al., 2019). Moreover, we looked at the papers that attempted to assess the impact of CDSSs and related components and found that most either assessed the financial efficiency of health information technologies (e.g. Qi and Han, 2020) or analysed the contribution of CDSSs to specific performance key performance indicators, such as hospitals readmissions (e.g. Park et al., 2022b).

IT valuation has been a crux of IS research since the '90s and the early 2000s when IT's ability to deliver innovation was first questioned (Farbey et al., 1994) with thought-provoking pieces (Martin, 2007, Lucas Jr, 1999, Carr, 2003). Since then, the IS research community has contributed to an extensive body of research that defines IT-based value in organisations by explaining the role of IT resources in the value creation 'black box' (e.g. Nevo and Wade, 2010). Gerow et al. (2014) have previously focused on the alignment of IT and the relationship with firm performance in terms of better financial performance, where IT can help firms achieve better profits through lower costs or increased revenue streams, better productivity, or the variation of either input, outputs or a combination of both and improvement of benefit for customers, or the improvement in benefit that comes with a purchase. The authors also demonstrated that the alignment of IT resources and IS strategy with these performance indicators has been prioritised and has been shown to increase performance. Value is ultimately in the eyes of the beholder, and IS research has recognised the importance of expanding the concept of value to encompass the value perceived by not just businesses and organisations but also a second, equally as important type of arbitrator, which are customers. Indeed, this theme of value expansion in Kohli and Grover (2008) set our necessity to identify those metrics of value that go beyond financial performance, instead focusing on those intangible elements that make IT truly "valuable" to the final arbitrators.

Identifying value in healthcare is an ongoing interdisciplinary effort conducted over the past two decades (Porter, 2009, Porter and Teisberg, 2006, Choi et al., 2004). Of particular interest is the analysis of Porter (2010), which proposed that the only way to measure value in healthcare should be to define the performance in terms of patient benefit since healthcare stakeholders do not benefit from a shared goal that unites them on which organisations can base their strategies, including IS strategies. Thus, with the priority of creating value for patients comes the necessity to build a strategy aligned with patient needs. The author explains that reporting healthcare performance requires a comprehensive view of all services or activities that determine if the patient's needs are met. Often, this is not the case, and performance only covers certain billed elements, is limited by the researcher's view on a single department or condition, and does not consider the effect on the entire care process (Porter, 2010). It is logical to imply that improving the value of HIS requires us to define a better reporting system towards a patient-oriented system that covers the entire care process (Ash et al., 2004), which would agree with calls for a more generalised theory approach suggested by Chiasson and Davidson (2004) and would explain the urgency in defining better global health metrics and strengthen the accountability of the global health metrics enterprise space (Shiffman and Shawar, 2020)

In the optics of patient value creation, CDSS aims to reduce the required inputs for comparable levels of care and improve outcomes for patients, not just for initial diagnoses but throughout the entire care process; for example, CDSS contributes to lower readmissions (Park et al., 2022b, Setia et al., 2020). By examining the papers in our sample, we realised that papers tended to either focus on measuring financial efficiency in general by comparing it with different levels of HIS integration (Setia et al., 2020) or dealt with particular phases of long-term care combined with different complexity levels of HIS integration (Ding and Peng, 2022). So far, no study has explored the impact of CDSSs and related components over the entire care journey, particularly from patients' perspectives. We recommend that future research focus on identifying the systematic contribution of CDSSs on the entire process of care through the eyes of patients in order to meet patient's needs and create value for them, the ultimate objective of health care (Porter, 2010).

Rethinking the way IS research evaluates the financial, productivity and patient benefit performance of CDSSs, for example, could mean comparing patients with different care requirements, identifying which phase of care produces the most improvements or negative repercussions when exposed to CDSS implementations, different conditions that span multiple departments and specialists, and different age groups. The main benefit of analysing the value creation process for patients would be overcoming situations where performance evaluations of CDSSs return mixed results. We argue that mixed results in studies surrounding the usefulness of CDSSs (e.g. Alami et al., 2020) come from an incorrect approach to defining patient value.

We propose these research questions to promote discussion on CDSSs' ability to create value for patients: (1) How do CDSSs create value for patients? (2) what characteristics of CDSS contribute the most to the creation of value for patients?

3.3 Policy-makers Role in Mitigating Harmful Social Effects of CDSS National Policies

Out of all the other actors represented in our sample, we decided to investigate another actor category in this preliminary research due to the central role they play when defining the healthcare system's direction (World Health Organization, 1995): policy-makers. Few papers have explored their perspective when reporting on CDSSs and their components. One such article by Klecun et al. (2019) explored the policy-makers’ role in implementing HIT and examined the relationship between policy-makers and the main actors that make up national healthcare panoramas. Governments exert institutional pressures to implement specific technologies like EHRs, and actors in the healthcare sector receive these pressures responding in turn with unique coping behaviours that influence the efficacy of the original policy. However, the papers in our sample did not explore the policy-makers’ role in causing and mitigating unintended **harmful social effects** when implementing CDSS policies.

Recent papers explored the unsuccessful implementation of national EHR databases, with the notable example of My Health Record, which was initially launched in 2009 as an opt-in digital health record system in Australia, which was then changed to an opt-out system with abysmal levels of adoption and collaboration of physician and patients alike. However, in recent years there have been many other unsuccessful eHealth implementation projects (Andargoli, 2021). IS Research is also familiar with government policies in other critical sectors. According to Marjanovic and Cecez-Kecmanovic (2020), Complex Adaptive Sociomaterial Systems (CASS) allow us to explain why and how open government data platforms create unintended harmful effects. This was the case with the My School platform, intended initially to achieve transparency, accountability and innovation of services, but caused harmful social effects to the Australian public school system, including its students.

We argue that researching potential harmful social effects of policies for CDSSs and all the other HITs used to collect data could give policy-makers a clearer view of all the social risks that may affect anything from large-scale adoption to the efficacy of CDSSs in achieving a better quality of care for patients. Examples of potential harmful social negative effects could be the stigma associated with circulating specific diagnostic history (Stablein et al., 2015)

We propose the following research questions to guide the exploration into the harmful social effects of CDSS policies: (1) What are the unintended harmful social effects of national policies on CDSSs? (2) What is policy-makers' role in generating harmful social effects from implementing CDSSs? (3) what are possible mitigation strategies for governments to limit the harmful social effects of CDSS implementation?

4 Subsequent Work and Potential Contributions

In this review, we sought to frame IS research's state of the art in addressing CDSSs and their related components. We attempted to identify specific gaps between the work of the IS community and what is needed for HIS to deliver the impact that governmental institutions are looking for and that people all around the globe want out of their healthcare systems. We offered a few preliminary insights on the existing HIS strategy, particularly around the voluntary and involuntary discontinuance of CDSSs and the value creation process for CDSSs from the patients' perspective. Still, there is much more work to do if we wish to provide a more comprehensive view of the actual state of the art.

Our work will proceed in two different stages to address current limitations. The first stage will consist of the refinement of the search process. We highlighted previously how we selected a final sample of 50 papers from an initial pool of 1489 papers published in the last five years. We plan to increase the initial pool of articles and the number of curated papers. Our initial pool will be expanded to include the last ten years, and we plan to refine our selection of journals to include more medical informatics journals. We also plan to refine our search terms by engaging in an iterative approach of refining search terms to include synonyms used in the field. Both our findings and research agenda will be updated to address what has not been covered in the preliminary stage. At the end of the first stage we will be able to produce a complete summary of existing research streams on CDSSs in IS, benefiting future efforts in the field.

In the second stage, we will either develop a framework that can be applied to our research findings and synthesise them while guiding future research or apply an existing theoretical lens to our specific topic. We envision two possible scenarios that stem from our preliminary findings in this short paper. First, we could articulate a theory that thoroughly examines the discontinuance process of clinical decision support systems and related components by focusing on the different factors that contribute to discontinuance, the effects of discontinuance of a legacy system on the incumbent system and the actors involved. We hope our work on these findings may contribute to developing a more refined strategy for implementing CDSSs that can more easily evaluate end-of-life risks. Second, we would like to contribute to the definition of unintended harmful social effects and the design of CDSSs, or even health information systems in general, in creating value for patients. We hope that by focusing on value creation for patients we will be able to influence future health information systems design positively. We also aim to shine a light on those harmful social effects that come with the implementation on a large scale of CDSS-related systems. Similarly, we envision similar outcomes for our future findings that will stem from the continuation of our efforts. This work, when completed, will hopefully allow caregiving institutions to unlock the potential of CDSSs to enable better care.

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