

## Project Description

### **Technological Implementation: Researching Leadership and outcomes of renewed EHR systems in hospitals (EHRimpl)**

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**Societal perspective and relevance:** One of the most important and enduring challenges of digital era governance is how to manage the implementation of new digital systems substituting old ones (Hansen et al., 2019). In the present digital era most organizations are deeply dependent on digital systems in their daily routines and the simultaneous renewal of digital systems while maintaining high service quality, data security and performance is a major managerial challenge involving difficult trade-offs and paradoxes (Hansen & Nørup, 2017; Mathiassen et al. forthcoming; Wimelius, 2011). The objective of the *EHRimpl* research project is to enhance leading edge scientific knowledge concerning how to manage the processes of digital renewal. An important contribution of the project will be to examine to what extent recommendations from the generic change management literature developed in the pre-digital era can be usefully transferred to processes of digital renewal, to what extent they need translation and reinvention and to what extent we need to develop entirely new theories of change management in this context.

The study addresses an important knowledge gap in the literature. Studies of EHR (Electronic Health Records) system implementation have almost exclusively analyzed the transformation from paper to digital systems, while studies of more recent renewal of EHR systems are rare (Hertzum & Ellingsen, 2019 is a recent but rare exception) and tend to be small scale case-studies. This is a serious knowledge gap since it is a core managerial challenge in present society that has proved difficult to cope with. In the hospital sector as well as in many other sectors, there have been massive challenges associated with the implementation of renewed major information and communication technologies (ICT) such as EHR systems (Wachter, 2015). It applies internationally in both the private and public sectors and examples are abundant; the problems of implementing a new EHR system (Sundhedsplatformen) in the Capital Region of Denmark being the most recent example in the Danish context (Rigsrevisionen, 2018), but numerous other hospitals have faced similar implementation problems (Boonstra, Versluis & Vos, 2014; Hansen & Nørup, 2017; Hertzum & Ellingsen, 2019; Pedersen, 2017).

**Objectives and research questions:** There are several reasons why the implementation of such systems often goes wrong (Hertzum & Ellingsen, 2019; Priestman et al., 2018; Ross et al., 2016), but this project focuses on the management of the process. The objectives of the *EHRimpl* project is to *(a) develop international cutting-edge scientific valid knowledge of the factors important to improved performance in the short- and medium term when managing the implementation of renewed EHR systems and (b) to disseminate this knowledge through feedback to practice, the scientific community,*

*students of public management and the public at large.* The analytical focus of the research project is at the hospital departments and their management of the implementation process (Pihlainen et al., 2016; Van Wart, 2013; Yukl, 2013). Other factors including the management at the level of the hospital and the region are treated as important contextual factors to be accounted for. Thus, the primary research question is: *What implications do different leadership styles have in the implementation of the EHR system at clinical departments for the short and medium performance of the new EHR system?* Performance is conceptualized and measured on several dimensions using both objective and subjective measures. The foundation of our performance concept is based on an adapted version of the Technology Acceptance Model (Davis, 1985; Venkatesh & Bala, 2008; Venkatesh & Davis, 2000; Venkatesh et al., 2003). Four performance measures will be used: (1) Perceived usefulness, outcome impact and ease of use; (2) Patient involvement; (3) clinical quality and (4) the productivity of the departments. Both “subjective” (surveys) and “objective” (register) data will be used and triangulated to ensure internal validity of findings.

Empirically the EHRimpl project takes advantage of a unique opportunity to analyse two specific cases - the implementation process and the short- and medium-term outcome of renewed EHR systems at the hospitals in the two Regions of South and North Denmark. The Regions will implement a new EHR system delivered by the same supplier (Systematic A/S) at the hospitals in the two Regions. The EHR system will be the primary daily IT tool for the doctors, nurses, secretaries and other staff at the hospitals in the regions. The implementation process starts in the fall 2020 in the Region of Southern Denmark (SDR) and in the fall 2021 in the North Denmark Region (NDR). The process is organized in two different ways, which means that the two cases provide a unique opportunity to conduct a natural experiment. In SDR a gradual approach has been decided while in NDR, the implementation takes place in all hospitals at the same time. Thus, the two empirical cases provide an unusual promising opportunity for analysing technological renewal in hospitals.

**Theory and hypotheses:** We build on the theoretical traditions of (1) change management (Stouten et al., 2018), (2) innovation diffusion (Berry & Berry, 2018; Rogers, 2003) and implementation of innovations (Damschroder et al., 2009; Vedung, 2016; Winter, 2015) and (3) the EHR implementation literature (Hertzum & Ellingsen, 2019; Priestman et al., 2018; Schmidt et al., 2019). In all three traditions, a number of factors that tend to be important to the implementation process have been uncovered. Recent reviews (Priestman et al., 2018; Ross et al., 2016) found very few studies of the management of digital renewal of EHR systems, since most research has focused on the transformation from paper-based to digital systems. One recent study of EHR implementation in a hospital, however, found a positive association between the short-term performance of the implementation process and four types of leadership styles (Van Wart, 2017) often claimed to be important in change management: Mobilizing initial support, participative leadership, directive

leadership and locally adapted implementation strategies (Hansen & Nørup, 2017). Based on the EHR implementation literature, we furthermore expect that clinicians' (doctors, nurses and other health professionals working with patients) use and satisfaction with the old EHR system will influence their perception of the new system. Five hypotheses will be tested:

**Hypothesis 1:** There is a positive association between initial support for an ICT innovation before the implementation and the performance of the ICT innovation after the implementation.

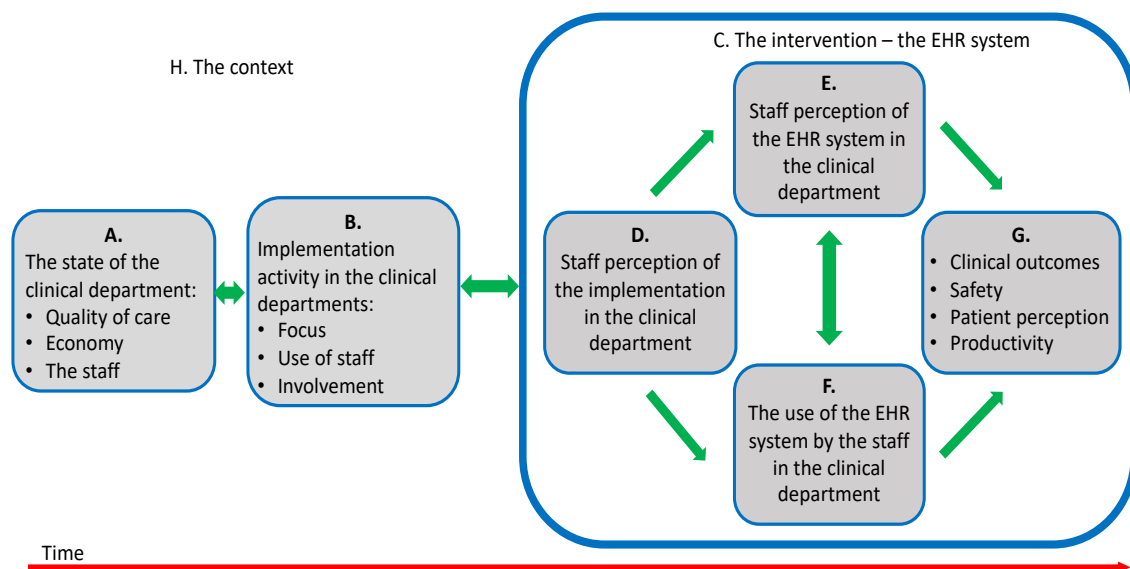
**Hypothesis 2:** There is a positive association between higher levels of directive leadership of the employees during the implementation process and the performance of the ICT innovation after the implementation.

**Hypothesis 3:** There is a positive association between higher levels of participative leadership with staff involvement in and influence on the adaptation of the ICT innovation during the implementation process and the perceived performance of the ICT innovation after the implementation.

**Hypothesis 4:** There is a positive association between an implementation strategy that has been adapted to the specific department and the perceived performance of the ICT innovation after the implementation.

**Hypothesis 5:** There is a positive association between clinicians' use and satisfaction with the current EHR system, and the perceived usefulness and usability of the replacement EHR system.

Besides testing the hypotheses, the reasons why managers often do not follow the recommendations from the change management literature will be examined and the extent to which we need moderated or entirely new theories of change management.



**Figure 1.** Relations between leadership, the implementation of the EHR system in the individual clinical departments, the perception of the staff and the quality of care examined in the study.

*Conceptual model:* The three research traditions mentioned above indicate a number of other factors to be controlled for in the analysis. We have elaborated a conceptual model (see figure 1) to account for these factors. The implementation and change management activities at the level of the clinical departments (B) and its impact on the staff's perception of the EHR system (E) and in the end the impact on the quality of care, safety and productivity (G) is the central relation in our model. But the model also considers the impact of the point of departure within the clinical department with regard to the economic situation, quality of care and staff characteristics (A), the functionalities of the EHR system (C), the perception of the implementation of the EHR system (D), the use of the EHR system among the members of the staff in the department (F), and the overall context of the health care system (H).

**Research design, methods and work packages:** The research design is essentially an upscaled and improved version of a research project conducted by two of the participants in 2015 which only included one hospital and the short-term performance and did not include register data (Hansen & Nørup, 2017; Nørup & Hansen, 2015). The primary analytical units of the research project are the clinical departments. With this departmental focus, we analyze how the implementation of the new EHR system is managed (WP1 & 2), how it is put into use (WP3) and the short- (after 3 months) and medium-term (after 15 months) consequences of these processes (WP2 & 4). We also include pre-implementation measures of the situation at department level before take-off based on register data (WP4). While we have a departmental managerial focus, we need to take the broader multi-level character of the implementation process into consideration as illustrated in Figure 1, box H (WP1). The context includes decisions at the regional and hospital level, but also the basic features of the collaboration with Systematic A/S – the company delivering the EHR system. *Mixed methods:* The research project is designed as a mixed methods research project (Creswell & Clark, 2017; Teddlie & Tashakkori, 2009) utilizing both quantitative and qualitative data. The following data are generated: (a) *Register data (see WP4):* We use register data from the Regions at the departmental level to provide indicators concerning both the situation in the departments before the implementation and indicators concerning output and outcomes of the process after the implementation (see table 1). (b) *Survey data (see WP2 and WP4):* We do three surveys with the employees at the clinical departments. One four weeks before the implementation, one 3 months after the implementation and one 15 months after the implementation (see table 1). We will also do a survey with patients 15 months after implementation to elicit if and how they use the EHR systems component for patients (see table 1). (c) *Documents, observations and qualitative interviews (see WP1 & WP3):* Qualitative case-studies at three selected departments will be conducted during the implementation process to uncover the challenges of the implementation process, challenges in how the EHR system is put to use and challenges related to the management process (see table 1).

The research is organized in four Work Packages: *WP1: Analysis of implementation activities in the clinical departments (WP1-responsible: Assistant prof. Kasper T. Elmholdt is responsible for the data generation. Assistant prof. Tilde M. Bertelsen and prof. Morten Balle Hansen, AAU, COMA takes part in the data generation:* WP1 monitors the implementation process at three clinical departments (a medical, a psychiatric and a surgery department in each region) from an organizational managerial perspective by conducting 72 interviews, observations of selected processes and analyzing documents. WP1 focuses on (1) how the strategic intentions with the new EHR system at regional- and hospital level system are translated into front-line practices, and (2) how the individual departments manage and organize the implementation and change process. WP1's main focus is on box B, while the larger context (box H) of the regional implementation process will be included to understand the multi-level dimensions of the implementation process. WP1 follows the implementation process as it is tailored and adapted in collaboration with Systematic A/S.

*WP2: Analysis of staff perception of the implementation in the clinical departments (WP2 responsible: Associate prof. Iben Nørup (responsible for statistical analysis), Assistant prof. Tilde M. Bertelsen (responsible for data generation) and prof. Morten Balle Hansen, AAU, COMA):* WP2 analyzes how the employees in the departments perceive the EHR system and its use before and after its implementation and how they and their department leaders perceive the implementation process and its management. The analysis is conducted by means of survey data. These data will be triangulated with data generated in case studies and with register data in the overall mixed method design of the project. In relation to the model of our research project (see figure 1) WP2 will provide knowledge concerning boxes B, D, E and F in the model. We use an adapted version of a survey instrument used in previous research (Hansen & Nørup, 2017; Nørup & Hansen, 2015) and closely aligned with WP1 and WP3.

*WP3: Analysis of the use of the EHR system in the clinical departments (WP3 responsible: Assistant prof. Thomas Schmidt and prof. Christian Nøhr, SDU, MMMI):* Aspects of EHR use will be monitored by self-reported perceptions of usability by clinicians, and observations of task execution time to assess associations between staff attitudes of usability and task completion during implementation of a new system. Part of the WP2 survey will contain questions inspired by the Finnish usability surveys on clinical information systems (Kaipio et al., 2017) to be used in WP3.

*WP4: Assessment of changes in clinical outcomes, patient perception and productivity (WP4 responsible: PhD student Maja K. Rasmussen and research director Kristian Kidholm, SDU, CIMT):* Based on the register and survey data described below, WP4 will study the following relations in Figure 1: Change in clinical quality, safety, patient experience and productivity at the hospital level (G), Variation in changes in clinical quality, safety, patient experience and productivity at the level of the clinical departments. Relation between (E) staff perception of and (F) staff use of the system

and change in clinical quality, safety, productivity at hospital level (G). Generic outcome measures will be collected for all departments, e.g.: (a) Number of medication errors; (b) Number of labelling errors and (c) Number of missing information in patient records. Measurement of patient experience and satisfaction with having online access to their Patient Records will be made by use of an online questionnaire. Measurement of productivity includes both measures of (1) activity and measures of (2) the use of resources in the clinical departments. The following measures of (1) activity in the clinical departments and at the hospital level will be included in the study: (a) Number of admissions, (b) Number of outpatient visits, (c) Length of stay, (d) DRG (Diagnosis Related Groups) value of the hospital activity (admissions and outpatient visits).

**Organization and time schedule:** The project is organized as a collaboration between three research centers: Center for Organization, Management and Administration (COMA), AAU, Centre for Innovative Medical Technology (CIMT), SDU and Mærsk Mc-Kinney Møller Institutet (MMMI), SDU. Using their respective competences each center is able to provide different yet complimentary research profiles, which are much needed in this kind of research. COMA (Tilde M. Bertelsen, Kasper T. Elmholdt, Morten Balle Hansen & Iben Nørup), contribute with a strong research tradition on public leadership and the management of implementation processes. CIMT (Kristian Kidholm & Maja K. Rasmussen) contribute with strong research competences in Public Health and outcome measurement. And MMMI (Christian Nøhr & Thomas Schmidt) have leading-edge competences in the more technical aspects of EHR systems and their use.

*Project management team:* Research director Kristian Kidholm (CIMT) and Prof. Christian Nøhr (MMMI) will together with Prof. Morten Balle Hansen (COMA) as the project leader constitute the project management team with regular meetings 10-12 times per year. The management team and the project leader will ensure a tight coordination of WP activities, the implementation process and progress in the delivery of outputs.

*Managerial Advisory Board:* consists of 4-6 managers from RSD and NSD, including Niels Nørgaard Pedersen, RSD and Klaus Larsen, NSD, with regular meetings with the project management team 3-4 times a year. The managerial advisory board will ensure close practical alignment of the implementation and the research process and swift direct feedback from research findings to practice. Meetings will involve presentation of preliminary findings of particular interest to the implementation process.

*Scientific advisory committee:* with six international top researchers: Prof. Gro Berntsen, Norway; Prof. Lars Mathiassen, USA, Prof. M. Jae Moon, South Korea, Prof. Kjeld Møller Pedersen, Denmark, Prof. Janne Seemann, Denmark and Prof. Paul Turner, Tasmania have all confirmed to participate. The scientific advisory board will meet with the entire research team once a year at a seminar to discuss findings and mutual international research publications. The first and the last

seminar will be in Denmark, while the two others will be organized in connection with international conferences.

**Table 1: Time schedule for implementation process, research project and outputs from project**

| Year                                   | 2020 |    | 2021 |    |    |    | 2022 |    |    |    | 2023 |    |    |    | 2024 |    |
|--|------|----|------|----|----|----|------|----|----|----|------|----|----|----|------|----|
| Quarter                                | Q3   | Q4 | Q1   | Q2 | Q3 | Q4 | Q1   | Q2 | Q3 | Q4 | Q1   | Q2 | Q3 | Q4 | Q1   | Q2 |
| <b>A. Main activities imp. process</b> |      |    |      |    |    |    |      |    |    |    |      |    |    |    |      |    |
| 1. Region South DK                     | S    | O  | J&M  |    |    |    |      |    |    |    |      |    |    |    |      |    |
| 2. Region North DK                     |      |    |      |    |    | O  |      |    |    |    |      |    |    |    |      |    |
| <b>B. Data generation</b>              |      |    |      |    |    |    |      |    |    |    |      |    |    |    |      |    |
| 1. Pre survey 1 month WP2              | A&S  | D  | F    |    | S  |    |      |    |    |    |      |    |    |    |      |    |
| 2. Post survey 3 month WP2             |      |    | J&F  | M  | A  |    | F    |    |    |    |      |    |    |    |      |    |
| 3. Post survey 15 month WP2            |      |    |      |    |    |    | J&F  | M  | A  |    | F    |    |    |    |      |    |
| 4. Case studies WP1 and WP3            |      |    |      |    |    |    |      |    |    |    |      |    |    |    |      |    |
| 5. Survey with patients WP4            |      |    |      |    |    |    | J&F  | M  | A  |    | F    |    |    |    |      |    |
| 6. Collection reg. data WP4            |      |    |      |    |    |    |      |    |    |    |      |    |    |    |      |    |
| <b>C. Main outputs</b>                 |      |    |      |    |    |    |      |    |    |    |      |    |    |    |      |    |
| 1. Feedback to practice                |      |    |      |    |    |    |      |    |    |    |      |    |    |    |      |    |
| 2. Conference papers etc.              |      |    |      |    |    |    |      |    |    |    |      |    |    |    |      |    |
| 3. Scientific articles etc.            |      |    |      |    |    |    |      |    |    |    |      |    |    |    |      |    |
| 4. Final report                        |      |    |      |    |    |    |      |    |    |    |      |    |    |    |      |    |
| 5. Final conference                    |      |    |      |    |    |    |      |    |    |    |      |    |    |    |      |    |

**Note:** (A) EHR implementation in RSD and NSD. (B) Data generation research project. (C) Outputs from research project. Capital letters=month (J=Jan, F=Feb, M=Mar, A=Aug, S=Sep, O=Oct)

**Output:** The dissemination of the findings from the research project can be divided into three broad categories: (1) the deliverables to the Regions including quarterly direct feedback on preliminary findings, final report and conference (2) scientific conference papers, journal articles and a PhD dissertation. Early in the project, conference papers will be presented at conferences within the subfields of our three research centers: Public Management and Organization Studies (COMA), Public Health and Health Economics (CIMT) and Information Technology conferences (MMMI). At the end and in the years after the research project, scientific articles (at least six) will be published in high-ranking journals – both in journals within our respective subfields and in broader ranged scientific journals. (3) Dissemination of the findings through teaching (e.g. in master programs for public managers), communication to professional journals and in the media.

**Feasibility and risks:** The feasibility of the project is high since both the management in the two regions and the company Systematic delivering the EHR system support it. All three organizations have accepted to give full access to documents, register data and, within reasonable limits, the time of their employees. The feasibility is also high because of the participating researchers' previous experience with research in hospitals and because of previous tests of the survey instrument with a high response rate. The primary risk of the project is that the implementation process may be postponed, but there is currently no indication of that and delays of up to a half year is manageable within the time limits of the project.

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