Infrastructure for Health Care Simulation: Recommendations from the Model for Telecare Alarm Services Project

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Abstract - *In Norway, a recent health reform targeting coordination and continuity of care has urged municipalities to manage telecare alarms related to an increasing number of welfare- and sensor technologies in citizens' homes. In this context, the research project "Model for Telecare Alarm Services" has the aim to study the organization and operation of existing telecare alarm services and identify new service models of the future. In the project, simulation of health care services was used when key informants from municipalities, end-users, research partners and industry tested different models for future telecare alarm services. This paper presents the technical and physical infrastructure of a clinical laboratory environment for simulation of health care services, with recommendations based on experiences from the project.*

Keywords: Health Care Simulation, Technical Infrastructure, Telecare, User-centered Design

1 Introduction

Telecare technology is used to support communication between citizens in home environment and health care services [1]. This type of technology is considered an important remedy to cope with significant challenges of an increasing number of older people due to societal demographic changes [2]. An overall goal is to enable people with physical or medical limitations to live self-dependent in their own home as long as possible [3]. In Norway, a health reform [4] was adopted in 2012 to improve the continuity of care and collaboration across the traditional health care services. Services that for several years were carried out in hospitals were transferred to municipalities. Today, municipal health- and social care services are responsible for a 24/7 service in emergency primary health care. In addition, due to an increased number of telecare- and sensor technologies in citizens' homes, many municipalities are preparing for establishment of a service for management of alarms. In many cases, this requires re-organization of the already existing health and care services.

In this context, the research project *Model for Telecare Alarm Services* aimed to explore, evaluate and propose models for telecare alarm services. 18 municipalities, 2 research institutions and 1 industry partner participated in the research project from 2015-2017, where the aim was to study how existing telecare alarm services in Norwegian municipalities were organised and operated. In an early phase, workshops were organised together with health care professionals, operators at existing telecare alarm services and representatives from patient organisations with focus on challenges in already existing services and user needs. In addition, critical factors were identified for the design of new models for future telecare alarm services [5][6][7][8]. Later in the project, the industry partner (Imatis) developed an information and communication technology (ICT) system prototype with a smartphone application for telecare alarm services. During the development process, three simulations with participants from the project's partners were run in a clinical laboratory environment, with a home-based alarm scenario involving new technology handled by telecare alarm service operators and municipal home nursing service.

During the preparation and the execution of the simulations in the clinical laboratory, the research team reflected on the infrastructure and lessons learned that were considered useful for future simulations of health care and related technologies. This paper presents recommendations for a technical and physical infrastructure for simulation in a clinical laboratory environment based on the experiences from the *Model for Telecare Alarm Services* project. The following two research questions (RQs) were addressed in this study:

RQ1: What technical and physical infrastructure is suitable for simulation of telecare alarm services?

RQ2: What are the lessons learned that could be transferable for simulation of other health care contexts?

Following this introduction, an overview of related research is presented. In the next section, the technical and physical infrastructure for simulation in clinical environment will be described. Later, the discussion reflects on lessons learned from carrying out the simulations during the project. Finally, the conclusions are drawn regarding the characteristics of a technical infrastructure for simulation in clinical laboratory environments.

2 Research background

User-based simulation refers to the participation of end-users in an evaluation and test of an application in a clinical laboratory or hospital-like environment [9][10][11]. Participants are asked to perform a role-play and do tasks described on a task-list, or to use a system in a clinical environment, while being observed and recorded. The goal is to identify system flaws, cause of errors or difficulties in the use of the system, but also analyzing how the introduction of new technology influences the existing clinical workflow. Measurements are performed on time for task solving and errors. The aim is to provide a better understanding of the interaction between end-user groups, clinical workflow and technology involved when defining and executing tasks and accessing information.

This kind of simulation is recommended when a test in real clinical environments is unsuitable for legal, ethical or privacy reasons that may negatively affect the protection of patients [9]. Therefore, a simulation of a health care environment is important for creating a realistic scenario generally safe for health professionals and patients. In addition, the use of actors is recommended for some situations, such as in the patient-like role [10][11][12] Simulations are most often made in clinical laboratory settings, which have the strength of providing a controlled environment for the variables studied. A weakness of the laboratory environment can in some cases be the influence of observation on the behavior of the participants, such as the Hawthorne effect [13].

3 The health care simulations

Three simulations with task-based scenarios of models for telecare alarm services were executed in the Clinical Laboratory of the University of Agder (UiA) in Norway during April, September and November of 2016. The simulations were led by a research team consisting of people with health and technology background. Between 16 and 25 people from the project's partners participated in the simulations.

3.1 Telecare alarm technology

In the first simulation, digital mock-ups were used with graphical sketches managed by the test leader, to create the scenario and simulate the workflow for the handling of a telecare alarm. The moderators used a chat-channel to manage time-synchronization between actual information exchanged between the participants in the different test rooms. In second and third simulations, participants used a technology under development provided by the industry partner consisting of a smartphone application and prototype of an ICT system for alarm service operators.

3.2 Simulation scenarios

The scenarios tested, as role-play in the laboratory, included triggering of an alarm by a patient at home and the following interaction with the telecare alarm service based on different models for how to operate the service. The contact between the telecare alarm service operator and the response team for handling the alarm was also part of the scenarios, taking into account the organization of home nursing services, as well as the telecare alarm service. The scenarios also included scheduling and visiting a patient's home when necessary due to medical reasons. In that case, the status of the situation was reported back to the telecare alarm service operator. The information flow between the operator and the response team was made of electronic messages that represented the tasks to be executed and transmitted through mobile devices (e.g., smartphone and/or tablet).

3.3 Technical and physical infrastructure

The Clinical Laboratory facilities used in the simulations consisted of 3 separate test rooms and 1 observation room. The technical and physical infrastructure for the simulations is illustrated in Figure 1. The Test room 1 represented the patients home, Test room 2 the telecare alarm service and Test room 3 the office of the municipal home nursing services. In each test room, there was a separate recording camera source. In the observation room, the simulation was followed simultaneously on 4 monitors, one for each camera source and one monitor merging and showing all sources simultaneously. Between the Test room 3 (where the smartphone application was tested) and the observation room there was a one-way mirror that allowed the observers to closely follow the simulation process.

In the Test room 1, the patient (played by different participants throughout the different scenarios) used a Safemate geolocation alarm device [14] to trigger an alarm. The device was equipped with phone connection capability and allowed the voice communication between operator and patient. In the Test room 2, the ICT system for telecare alarm service was accessed and used in a laptop PC, but also shown on a Smart board display on the wall. In the Test room 3, the home nursing service used a smartphone or a tablet device for accessing the test application. The observation room had a desktop PC connected to four monitors, allowing the observers to remotely follow the technology interactions and work processes between the test rooms. The zooming and operation of the fixed cameras was made in the observation room for recording purposes.

The observation room and the test rooms were connected with a dedicated segment of the secured LAN infrastructure of the Centre for eHealth at UiA, making use of VLAN technology.

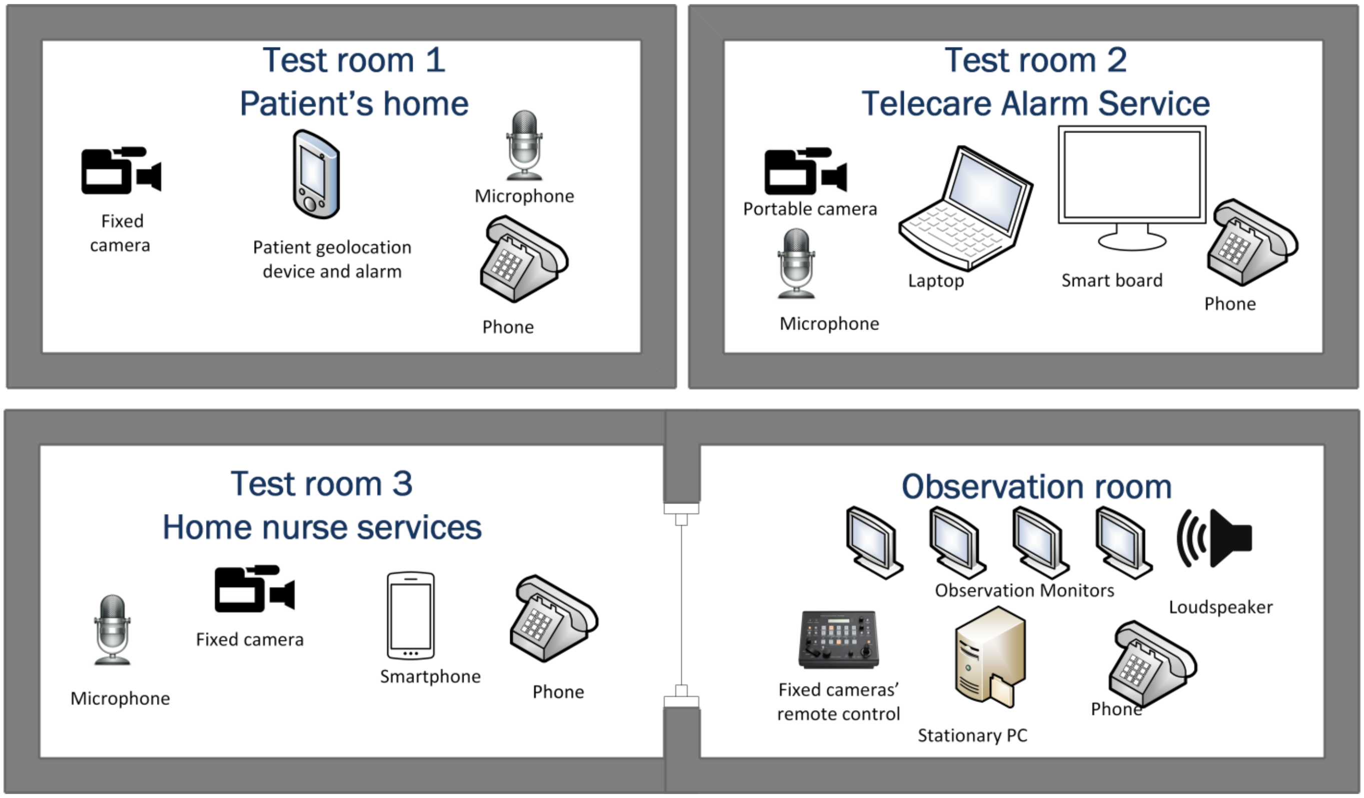

Figure 1. The technical and physical infrastructure for the simulations.

This connection was also used for the IP-based streaming of video and audio signals from the test rooms to the observation room. The recordings from the audio-visual sources were merged into one file in F4v video format, using Wirecast [15] as a capture software tool. The purpose was to ease the retrospective data analysis, having just one file including multiple video perspectives with a single audio channel.

3.4 Technological materials

For replicability and information purposes, the technological material used during the simulations is presented below grouped by rooms.

Test room 1:

- Safemate geolocation device.
- Fixed Camera: SONY BRCZ330 HD 1/3 1CMOS P/T/Z 18x Optical Zoom (72x with Digital Zoom) Colour Video Camera.
- Sennheiser e912 Condenser Boundary Microphone.
- Landline phone communication.

Test room 2:

- Laptop for the Telecare Alarm Service ICT system.
- Smart board display 65"
- Portable Camera: SONY HXR-NX30 Series.
- Logitech 886-000012 Boundary Microphone.
- Landline phone communication.

Test room 3:

- Samsung smartphone with the Telecare Alarm Service application activated (and a tablet device)
- Fixed Camera: SONY BRCZ330 HD 1/3 1CMOS P/T/Z 18x Optical Zoom (72x with Digital Zoom) Colour Video Camera.
- Sennheiser e912 Condenser Boundary Microphone.
- Landline phone communication.

Observation room:

- Stationary PC: Mac Pro
- Monitor: 3x HP Compaq LA2405x
- 27" Mac Monitor
- Streaming: 2x Teradek RX Cube-455 TCP/IP 1080p H.264.
- Software Wirecast 4.3.1.
- Landline phone communication.

3.5 Simulation procedure

The scenarios were performed as a group simulation with interaction between the test rooms by use of technology. Each scenario had a description of a context and a situation to be handled. One moderator from the research team and the participants in groups of 3-5 people were placed in each test room, also in the observation room. The scenario was repeated at least once and for each repetition the roles of the participants within each group were swapped. When the next scenario was tested, the participants also changed test room, so each group played the different roles assigned to the simulation. Each scenario had assigned roles, with a separate task list for each role. The moderator asked the participants to think aloud [10][16] and speak freely during the simulations.

3.6 Ethical considerations

This research study was approved by the Norwegian Centre for Research Data [17] with project number 44494. All participants received oral and written information about the project and they signed a consent form.

4 Discussion

This paper has presented recommendations for a technical and physical infrastructure for simulations in a clinical laboratory environment based on the experiences from the research project *Model for Telecare Alarm Services*. The preparation and the execution of the simulations led to a series of reflections and lessons learned by the research team that are considered useful for future simulations of health care services and associated technologies.

The two research questions (RQs) formulated at the beginning of this paper are answered below based on the study. RQ1 asked about a suitable technical and physical infrastructure for simulations of health care. An infrastructure suitable for the simulations of health care would be one that firstly allows flexibility in interaction between participants and technology within a clinical simulated environment for the related work processes. Secondly, the infrastructure should allow the research team to collect high-quality data for an effective retrospective analysis under more dynamic and cognitively demanding conditions than individual testing in usability laboratory, crucial to avoid interference and distortion of the simulation results. Thirdly, it is recommended that the audio and video sound from each test room are collected both in separate files and as one synchronized file, to allow a detailed retrospective analysis from each test room, but also the simultaneous interactions between the test rooms involved. In addition, the data should be collected through multimodal channels (e.g., video and audio), having the necessary tools to synchronise audio and video signals with sufficient quality and avoiding network latencies.

RQ2 asked about lessons learned that can be transferable for simulations of other health care contexts. One lesson learned is that the technology is necessary for the interaction between participants but it is not the only focus when simulating the workflow of health care specific processes [11]. The use of low fidelity software, such as mock-ups, early prototypes and systems under development together with end-user groups simulating current and future health work processes, provides a useful insight on how the technology would impact work processes in a real clinical setting. This is a relevant factor to consider due to user acceptance of new technology [18]. As simulations are usually more difficult to perform due to ethical and legal issues in real clinical environments with patients and health care professionals, the clinical laboratory represents the environment where health professionals and patients interact with each other and through the technology. Moreover, the fact of having health care professionals and representatives from end-user groups (e.g., patients, close relatives and volunteers) to experiment in different workflow processes gives an understanding of how the workflow and corresponding procedures can be optimized, and the potential impact that the technological solutions can have in real settings. Another lesson learned was that group-debriefing participants after each tested scenario, was very useful and provided information for subsequent system development and modelling of telecare services. Finally, due to the difficulties of recruiting participants and the discomfort of having to unnecessarily repeat simulation sessions, a redundancy in data collection is strongly recommended using two or more independent sources of data storage to avoid accidental data loss.

This study on the technical and physical infrastructure for simulation of health care had some limitations, such as including data from only one research project. However, several simulation sessions were made within the project, which provided rich experiences regarding the technical and physical infrastructure. The simulations informed the development of prototypes from early low-fidelity mock-ups to wireframes and functional prototypes. The empirical research data from the user workshops and simulations regarding clinical workflow and functionality of telecare alarm technology under development are not in the scope of this paper, as the main focus is the technical and physical infrastructure for simulations in clinical laboratory environments.

5 Conclusion

This study was conducted as part of the research project *Model for Telecare Alarm Services*, with the aim to provide experiences on technical infrastructure for simulations in clinical laboratory environments. The main contribution of this study lies on the descriptions of a proposed and tested technical and physical infrastructure for simulations and the sharing of lessons learned that are transferable to other health care services research projects. Health care technology is widely used by multiple user groups and when designing, testing and evaluating such technology, there is a specific need to balance the interface design and functionality on the one hand and taking into consideration how the technology would adapt to existing or proposed clinical workflow on the other. Simulations in a clinical environment are essential to analyse not only the interface design of the technology, but also the interactions between end-users, devices and their impact in associated work processes. These simulations are enabled by a laboratory environment, where the research team has full control over all steps of the simulation scenario, including tasks and interactions between the test participants and the technology used. Low-fidelity technology prototypes allow for low-cost scenario simulations where end-user can influence the development of the technology and associated work processes. The simulation infrastructure provided sufficient control over the factors involved and at the same time provided the flexibility to dynamically adjust the environment for adequate data collection. The results presented are in line with other studies on simulation in clinical environments [10][11]. Future research agenda of the authors includes testing of the physical and technical infrastructure with other types of scenarios, also focusing on procedures and methodology of simulations in clinical environments.

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