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Original Article

Social practices of nurse care coordination using sensor technologies – Challenges with an alert system adoption in assisted living communities for older adults

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ABSTRACT

Objectives: From the view of everyday practices and the socio-technical coordination lens, this study aimed to analyze the gap between creators' intention and the users' implementation (mainly nursing staff and social workers) of an alert system in assisted living communities.
Methods: Qualitative methods were employed by way of five user interviews and focus groups with six system developers. Modeling instruments were applied for data collection to analyze the different clinical workflows versus the expectations of the system development team.
Results: Results indicate that the clinical workflow changed over time, which led to a mismatch of nurse care coordination, social practices, and technology use. The results show different mental models of the socio-technical practice. Applying the coordination theory, the following recommendations could be developed to overcome the mismatch. First, it is recommended that nursing staff set goals together. Second, a communication rhythm with the nursing staff and developer teams should be established, with guided questions to facilitate the conversation, to shed light on the different workflows and the difference in social practices when using sensor technologies or alert systems. Third, a checklist for new employees should be created so they know how and on which devices to use the alert system. Fourth, the user experience with the alert system should be improved (e.g., an improved user interface).
Conclusions: This work indicates recommendations to close the mental model gap to overcome the mismatch between optimal use of the alert system and how the nursing staff is actually using it.

What is known?

- Implementation of digital technologies in healthcare can come with unanticipated socio-technical issues in terms of how the human and technical components function together. Issues when implementing a new digital system meant to improve work coordination can affect the social practices of the organization. For example, it may cause an increase in work with disproportionately few benefits.

What is new?

- We studied the specific challenges of alert system implementation in an assisted living community with older adults. While research on alert systems in labs shows evidence that it works, the real world is more complex. Our results indicate that nurses do not use the alert system as expected by the software developer teams. This study reveals the difference between the mental models of the two groups.
- This study also shows the different workflow practices applied by the nursing staff. Nurses created a new work routine that was not congruent with the developers' idea of proper use of the alert system. The alerts came on devices that the nursing staff did not use, and the devices that they did use were not equipped to receive the alerts. Nursing staff experienced too many false

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alerts and other issues that led them to create new work routines.
- This work indicates recommendations to close the mental model gap to overcome the mismatch between optimal use of the alert system and the way in which nursing staff is actually using it.

1. Introduction

Health management of older adults in assisted living facilities is a leading issue in the health care community. In particular, chronic illnesses in older adults are a significant challenge, with nearly half (45%) of Americans suffering from one chronic illness and 30% of Americans suffering from multiple chronic conditions [1]. One solution to monitoring and managing chronic illnesses is to use sensor systems [2]. Such health management sensors can help establish care and medication routines as well as notify caregivers of unforeseen and new issues with patients. However, Ackerman et al. [3]. point out challenges of such systems since implementation can come with unanticipated socio-technical considerations, such as nursing staff not using the technology as expected by software developers. Several issues can arise when implementing a new digital system meant to improve work coordination, such as an increase in work for some in the organization and disproportionately few benefits [4]. In addition, and often overlooked in such studies, is the difference between the ideal workflow that the system development team develops in the lab and the actual everyday or social practices of the nursing staff who use digital technologies in their daily work.

In this study, we aimed to examine how nurses use an alert system in an assisted living community and detail the intricate issues that can arise from a broader socio-technical ecology. The case focuses on aging in place with a care coordination model that has been using sensor technologies for over 15 years [5,6]. In these years, organizational changes happened such as new employees and a new overall organization of the facility (read Case description section for more details). In recent years, the technology adoption rate dropped. The creators of the alert system assumed that the organizational change may have an impact on how the newly hired staff nurses adopt and use the technology in their social practice. Hence, they are interested in the question of what is happening in the nurse care coordination practice after the organizational change. The central research questions (RQ) that guided this study are as follows.

RQ 1. How do nurses use the alert system in their daily work (social practice) in an assisted living facility after the organizational change?

RQ 2. How well does the use of the alert system, as anticipated by the researchers and system developers, fit with the actual use and social practices of nurses after the organizational change?

2. Research background and theoretical concept

We conceptualize health care technologies embedded into assisted living facilities as socio-technical systems in which a group of people communicate with each other and execute actions using different technologies on a daily basis through their social practices [7]. A health management system with sensor technology, and consisting of patients and several caregivers, falls within the aforementioned criteria. The issue with developing and implementing a health management system in a highly social environment is reconciling the complex and sometimes conflicting social aspects with the myriad of technical components and features [3].

2.1. Analyzing everyday practices in socio-technical organizations

Organizational units such as assisted living facilities are intricate ecosystems of coordination, cooperation, communication, and technology involving rules that naturally evolve over time in social practices [7]. Integration of technology in any organization—as a system of goals, activities, actors, and interdependencies—requires a careful analysis of the organization's dynamic parts, such as features of the technology, stakeholders, work procedures, and skill of actors [8]. However, unlike technology, which can be carefully crafted with a specific purpose in mind, the social practices (i.e., human communication, cooperation, and social behavior) cannot be designed but evolve in the organizational context. Humans can adapt and adopt new motivations [7]. Such social dynamics get enhanced through changes in the organizational context e.g., a constantly changing staff team or a management change.

2.2. Coordination theory as a theoretical lens to capture everyday practices

Implementing health management systems, in general, requires researchers, developers, staff nurses, and others to coordinate their work. More specifically, the implementation of alert systems in assisted living communities affects the everyday practice and clinical workflow of nursing staff and social workers. To understand the staff's everyday practice, we apply coordination theory. Malone and Crowston [9] were the first to deliver a prominent coordination theory. Coordination is defined as "the act of working together harmoniously" (p. 358). There are four components of coordination: a) goals, b) activities, c) actors, and d) interdependencies. According to this theoretical approach, actors are people in different job roles. Interdependencies are managed through shared resources, for example, systems that people (e.g., nurses) use to accomplish specific tasks. Coordination theory helps to understand the everyday practices of nursing staff and social workers, that is, how they use the alert system in their daily work. The alert system is the shared resource in which the interdependencies between the actions of different nursing staff, the director of nursing, and others are built and manifested.

From this lens, people and technology only exist in relation to each other ("socio-material assemblages") [10]. As we apply it as a *practice theory*, the main interest is not to interpret a phenomenon, but to describe how human and non-human parts function together to drive their experiences.

2.3. Context and case description

The alert system adoption was studied in an assisted living facility with older adults. This site has 54 apartments and 60 residents [5,6].

In detail, researchers developed an in-home system with sensors and automated health alerts for detecting early signs of illness and functional decline in older adults. Research suggests that sensor data has been perceived as valuable by clinicians to determine the potential change in the residents' daily health status and the data trends help nurses to determine potential deterioration in residents' health [11–13]. The sensor technologies have been designed as a clinical decision-making support system for nurses and social workers. The project included an interdisciplinary team of engineers and computer scientists along with the clinical team of nurses, social workers, physical therapists, and physicians. The clinical team worked with the interdisciplinary research and system development team together to design the alert system and adjust it to meet their workflow demands as clinical and technology advances were made in the 15 years before this study.

The alert system in the reported care facility receives data from three types of sensors to measure the biometric status of the residents: motion sensors, depth sensors, and bed sensors. Motion sensors detect movement in specific rooms. Passive infrared motion sensors capture room specific information (e.g., bathroom activity) as well as overall activity level [14]. The depth sensor detects falls and monitors changes in gait (walking speed, stride length, stride time). More specifically, the depth sensors collect a resident's gait data in the form of non-identifiable silhouette-like images to measure walking speed and other gait parameters. Fall risk of the resident is predicted through the automatic assessment of gait speed. The bed sensor, placed under the mattress, captures the ballistocardiogram and respiration signals and extracts heart rate, respiration rate, restlessness in bed, and sleep patterns [15].

The alert system continuously analyzes the sensor data and then sends health and fall alerts to the staff of the facility. The alerts include, but are not limited to, whether residents fall or are waking up more frequently during the night. These alerts are intended to provide more accurate and more immediate care. If the sensors detect any questionable activity in the residents' room, then the system sends a text and/or email alert to the facility's staff. The alert system sends health alerts to nurses and staff each time a change is detected in the sensor data pattern. The alerts are sent through emails with embedded hyperlinks that connect to a web-based interface showing visualizations of the sensor data. In the case of fall alerts, since the system can produce some false alarms, the staff receives an email or text message alert containing a video clip of the event. To protect the privacy of the subject, these videos contain silhouette-like images which help the staff to identify whether the fall is real and take immediate action or dismiss the alert if the alarm is false [16]. Residents are recruited to be monitored by sensors. As of this study, 35 residents have consented with 33 currently active and 2 pending. The sensors are located inside the residents' apartments and, thus, capture activity within the apartment only.

The sensor system developed for this facility began in 2005, with health alerts developed through iterative direct care clinician input and ongoing adjustments to improve system performance. Over the past 15 years, researchers Skubic [16] and Rantz [17] worked together including many other researchers to develop and refine the design and implementation of the health alert system. For many years, the clinical staff was university employees, working closely with the researcher and system developers as well as the private company that runs the housing facility. Through this partnership, the assisted living facility was designed as a living lab to test different care models as well as new technology to support the care.

However, in the last year, the private company assumed responsibility for the management of the clinical staff. The facility continues to be run by professionally trained nurses, but not the same nurses were involved in the development and refinement of the alert system. During this change, the role of coordinator and communicator between the researchers and the assisted living facility vanished, and no replacement was hired as a co-hire between the care facility and the university's researchers. At the same time, the technology adoption rate dropped. The creators of the alert system assumed that the organizational change may have an impact on how the newly hired staff nurses adopt and use the technology in their social practice.

3. Methods

3.1. Research design

We applied a qualitative study [18,19] including interviews and walkthrough method to capture the everyday practice of nursing staff and how they adopt the new technology in their daily work. In detail, we applied the general procedures of the socio-technical walkthrough (STWT) methodology, in short STWT [8] captures goals, roles (actors), activities, entities (e.g., technology use), and interdependencies. STWT models the study participants' everyday practices, how and how often they use the technology, and activities they conduct with the technology. More specifically, data collection was conducted through individual interviews. We also received additional material on how the participants use the system by having them walk us through their daily work [20,21]. For data analysis and mapping an STWT, we used the SeeMe modeling approach [22]. SeeMe maps three main elements of a socio-technical system (roles, activities, and entities) and how they interact with each other.

3.2. Participants and sampling procedure

This study was conducted at an assisted living home for older adults that is located in a midwestern state in the United States. In total, we interviewed five of the staff, each fulfilling a different role in the care facility. We interviewed a) the facility manager; b) the director of nursing (DON), who oversees the entire nursing staff; c) the onsite social worker (SW), who works directly with patients and their families regarding physical therapy or doctor appointments; d) one licensed practicing nurse (LPN), who organizes the on-floor process of helping residents; and e) one nursing staff (frontline staff), who works with the LPN to care for residents. To analyze the nursing staff's everyday practices using the technology, user experience research shows that five interviews are sufficient to explore the most critical issues [23].

As mentioned previously, the residential care facility went through an organizational change, and with it, the rotation of nurses increased. Four of the staff interviewed had fewer than six months of experience working in the facility and none were part of the iterative development activities for the sensor system. Only the facility manager, who was not a routine user of the sensor alerts, had been working in the facility for at least three years. All of them knew the alert system and indicated that they used it to some degree. The participants were interviewed separately to maintain individual perceptions of the organization's social and technical ecosystem.

The reader may wonder why we did not interview the residents. They are not the *end-users* of the system—it is not meant for them to use, although they do benefit from the system. The system is developed for supporting the nursing staff and others to prevent fall risks of the residents.

3.3. Data collection

In phase 1, we conducted in-person, semi structured, one-on-one interviews [19]. Participants were asked to narrate their experiences and challenges with the system in their everyday practice. The interview questions prompted the participants for the description of their daily activities, work procedures, and potential difficulties in completing those procedures. In detail, the interview protocol covered four parts. Part I asked the participants about their daily work procedures at their workplace and how they interact with the technology. For example, they were asked to describe their primary activities and responsibilities at work. They were asked, "What can you do and not do with the technology?" Part II focused on the participants' experience with the technology. The following questions are examples of what they were asked. How easy or difficult is it for you to work with the technology? Is there anything that hinders you from using the technology? Part III probed for the

participants' opinions. For example, they were asked what they want to do differently with the technology. Part IV sought out the participants' reflection by posing questions such as, "Is there anything related to the technology that you want to share with us that we have not asked you today?" The open-ended interview protocol was adjusted during the interview process to encourage users to elaborate on their experiences and tell us their stories with the technology.

In addition to the interviews, we observed the interaction of the participants with the technology during the interviews. The participants walked us through their activities related to the technology, such as how they receive alerts through emails, how they check an alert, how they confirm the validity of the alerts, and how they submit feedback for their actions taken to acknowledge the alert.

The interviews lasted from 30 to 60 min and were conducted by a lead interviewer in the presence of an observer at the assisted living home.

In phase 2 data collection included a focus group with the alert system development team for a duration of 60 min. The six people consisted of three professors responsible for the design of the alert system and three graduate assistants, who developed and maintained the alert system. Three evaluators presented the real workflow with the alert system experienced by the nursing staff and others. The focus group occurred approximately three months after the interviews were conducted. This was the time it took to complete the data analysis (i.e., qualitative coding and building the model) from phase 1 for presentation to the development team in phase 2. During this focus group, we gathered data on how the development team reacted to the real workflow and how expectations, anticipation, and real workflow may differ or not.

3.4. Data analysis

Interviews were analyzed using Herrmann's SeeMe modeling technique (as part of the STWT) to identify interaction with the alert system [22]. Our reason to choose the SeeMe modeling method over other tools is the ability it offers to notate uncertainties, incompleteness, and vagueness in the human-nonhuman relationship including the complexities of their work processes related to the alert system. The artifact of the SeeMe modeling method is a diagram that helps to visualize the everyday practices and relationships of humans, technology, and work. It includes relations, arbitrary decisions, and conditions between roles and activities through a visual representation instead of text only. The result is a diagram that visualizes the relationship between human work, activities, and technology.

Interview videos and transcripts were each analyzed while simultaneously diagramming the participants' work procedures and interactions with the technology. We performed the process in an iterative manner by revising the diagram with each interview. The data analysis was performed by the lead interviewer and the observers who were present at the interview. The final diagram was discussed and revised by the entire research project team to incorporate missing perspectives if any. The focus group with the system development team, that developed the sensor system, was recorded. Data analysis included the similarities and differences between the expectations of the system development team and the real workflow to identify potential challenges and issues for further development.

To ensure validity and reliability of the collected data, we used triangulation that ensures the richness of data and interviewed each of the staff positions at the facility: the manager, DON, SW, LPN, and FL [18].

The results were visualized in a diagram [22]. The diagram provides a representation of the everyday practices of the organization's social and technical ecosystem, which allows both the interviewers and members of the organization to see which technology is being used, who is using it, and how it is being used (read Results section).

3.5. Ethical considerations

An Institutional Review Board (IRB) approval was obtained before the study was initiated to address the privacy and ethical concerns of participant interaction. Participants were informed of their rights in advance, and consent was obtained by providing participants with a written consent form; the team was granted a waiver of documentation by the IRB (meaning signatures of participants were not required).

4. Results

We first present the everyday practice from the perspective of the five different interviewees' roles in the care facility. We then present the results from the view of the software development team.

4.1. Perspectives of clinical users' everyday social practice — overview

It is important to emphasize that the results show how the interviewees experience the relationship between alert systems, work, and organization, in other words, their everyday practice. The everyday practice can differ from the optimal or ideal workflow that the researchers and system development team has developed. The result of the nursing staff's everyday practice shows potential differences between the nursing staff experience and intended use by those who designed the technology, e.g., the creators and developers at the university; see Fig. 1.

The elements in the everyday practice diagram (Fig. 1) represent the user roles (the red ovals), work, activities or tasks (the yellow rectangles), and technologies or tools (blue rectangles) within the organization of the care facility. The red boxes represent portions of practices isolated to specific staff roles, which means different participants experience different relationships between the alert system and their work. In addition, the green speech bubbles represent portions of interview quotes.

4.1.1. Everyday practice: the relationship between work, technology, and organization

The best method for outlining the perspectives of the everyday practice of nursing staff (Fig. 1) is to start with the activity from left to right (yellow). The nursing staff *receive alerts* through their *smartphones*. The old smartphones could receive the alerts via *email* or *text messages* (SMS), whereas the new smartphones can only receive the alerts via *email*. Nursing staff prefer receiving the alerts via text message (SMS) or pagers; they find it more efficient since it can be checked immediately instead of searching through all kinds of email. After nursing staff *receive an alert*, they *check alerts* and *notify colleagues* that they will conduct *resident care* (i.e., physically attend to the resident). The notification of the colleagues happens through the use of *staff text messages*. Finally, after resident care, nursing staff *report the resident's condition* with the digital application called PointClickCare that is an app on their *smartphones* for *officially reporting tasks and documentation* (see the larger blue rectangle).

The interviewees said they mainly pay attention to alerts received on their smartphones, but this is only one of several ways to receive alerts. Another option is that they *check pages*. Pages are

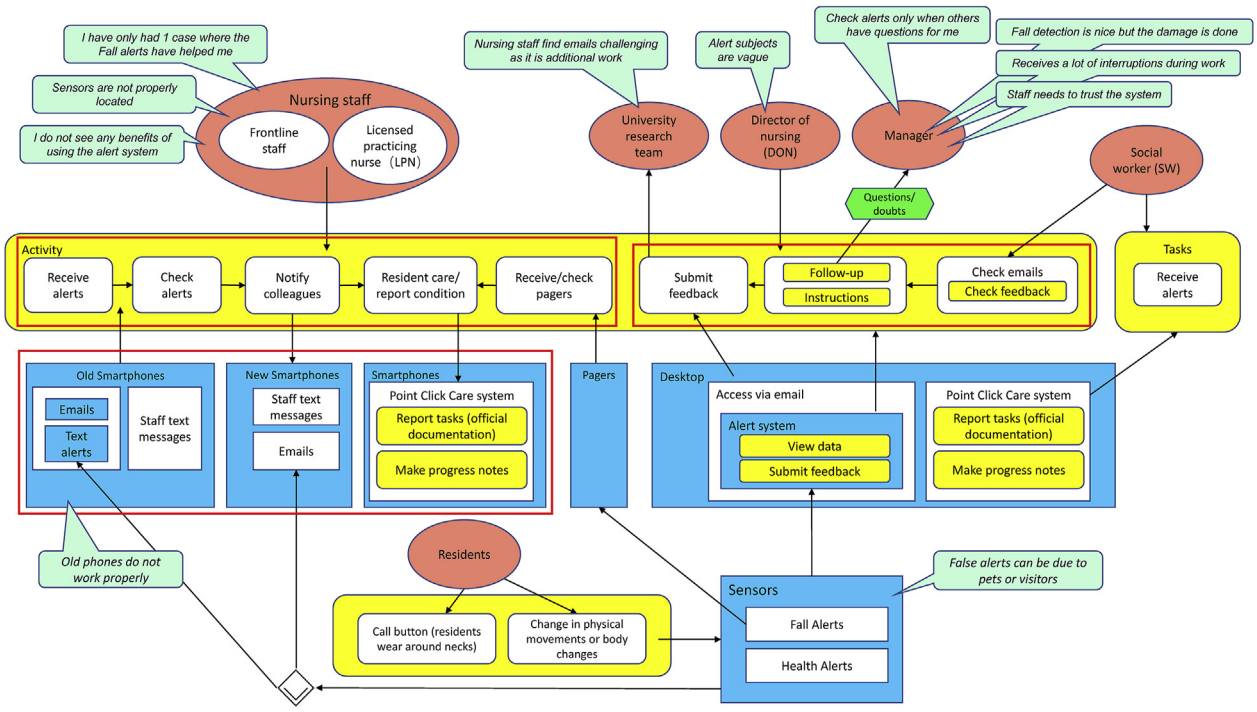

Fig. 1. Everyday social practices of nursing staff with the alert system in an assisted living facility.

instant messages that they receive on *pagers*. Each member of the nursing staff is equipped with a pager, including the DON. These pagers are activated via a call button, which residents wear around their necks. Residents can press the call button which sends a page to the nursing staff. Only the LPN and frontline staff respond to these pages, despite the DON receiving them. In responding to the pages, nursing staff follows a similar workflow as they do with smartphone alerts; they notify colleagues via *staff text message*, apply necessary *resident care*, and *report condition* via the *PointClickCare* software system.

When staff, such as the DON and SW, check the email for alerts, they also *check feedback*. Feedback means they read feedback about the patient, e.g., "patient has reduced pulse due to medication." This feedback is relevant for them since it shows the relationship between the patient's history and the current alert. The interviewees reported that a person with a health alert needs to be checked on immediately and determine if urgent care is needed. However, a reduced pulse history due to medication could mean that it is a false health alert that needs no urgent action.

The feedback can come from the alert system (as P1 and P3 said) or from information submitted by staff through the PointClickCare application. Then, these staff conduct *follow-up* or *instruction* activities. Follow-up activities are conducted by the DON by checking with the nursing staff about the resident's overall vitals. Instructions are given to the nursing staff and include specific tasks to address the residents' potential issues. Instructions are created and overseen by the DON. Both the DON and SW end this process by *submitting feedback* to the university's system development team. The feedback form is an optional field in the alert system application. Staff assume that feedback will immediately be sent to the university team so that they use the feedback to improve the software user interface. Staff send regular feedback about patient conditions to inform about the quality of care and hope that the system development team uses the feedback to remove the false alert history. However, the software team does not use the feedback button in this way; they rarely look into the information sent via the feedback button.

4.1.2. Alerts

From the perspective of the clinical users, health alerts are sent when the sensors detect an issue with a resident, which can include potential falls, stride/gait issues, or health changes such as reduced pulse, increased respiration, reduced activity, etc. The interviewees said that the alert system sends two kinds of alerts, *fall and health alerts,* that are sent through *emails and text messages* (see Fig. 1). DON and SW check these alerts which are accessed via *desktop* computer on a daily basis. On the desktop computers, there are mainly two applications of interest: *emails* (through which they receive the alerts), and *PointClickCare* for the DON, SW, and manager to do their daily work in which they *make progress notes* for each resident (e.g., if the nursing staff was already in the room helping with resident's needs). The interviewees reported that the health alerts are sent via *emails* to the *DON, SW, and manager* and that the nursing staff do not receive them. The frontline staff reported they only receive the fall alerts, not the health alerts (see clubbed bold, red box). On the other hand, the system development team reports that the health alerts are also sent via email to the nursing staff. Here the first contradiction can be identified. Although the nursing staff can technically receive the health alerts via email, they reported that they factually do not or cannot use the email alerts and mainly rely on the text message alerts. Later in discussion with the system development team, they clarified that the health alerts are sent via email to special tablets that were distributed to the facility. However, the current nursing staff do not use those tablets; they were either not aware of them or they found them not to be useful nor convenient.

4.2. Illness detection

The staff believe that the alert system has benefits that improve the lives of residents. Several participants noted the system's ability to preemptively detect illnesses, specifically urinary tract infections. P1 stated before the system, "*[If the patient had a] urinary tract infection (UTI) … We didn't know until they were sick. You know, usually, confusion's that first sign or symptom of a urinary tract*

infection. Well, if you have an Alzheimer's patient … they can't tell you they're having symptoms."

The alert system has allowed the nursing staff to catch these symptoms earlier. P3 reinforced this benefit by saying, "*A lot of times I go back and see … do they have a UTI … sometimes we caught it*." P1 also highlighted the benefit of the stride and gait alerts. Of stride and gait alerts, P1 says, "*as soon as we get one of those alerts … we will track it."* The issue of fall detection from the system was discussed the most by users. P1, P2, and P4 all made comments on how fall detection has proven beneficial. P1 coupled the stride and gait alerts with resident fall by noting that "*within three weeks … they'll have a fall*." As a result, they can then get residents the care needed. P2 noted faster response times with the fall alerts, stating, "*it's going to improve our response time … and there's a lot of research that suggests that the quicker we get there, the better the outcome*." Finally, P4 said, "*I love the fact that the alerts are out there because in the past since I have been here, we have caught some of the falls on there and been able to get in there before you know anything too serious has happened*." Fall detection has proven to the staff to be of value in caring for residents.

4.3. False fall alerts

False fall alerts were the most mentioned issue with the system, as all five participants mentioned them. P1 mentioned, "*a lot of [fall alerts] are the animals that jump up on the furniture."* P3 said, "*pets walking across the floor or someone throwing a blanket … those are a lot of [the false fall alerts].*" P4 also said, "*… and when you are looking into an alert … it seems to pick up everything moving in the room*." P5 continued with this theme stating, "*I also get pages but nine out of ten times they are not real … they are just people, blankets, and dogs.*" P2 expressed concern about the consequences of too many false fall alerts. P2 worried there might be, "*some alarm fatigue when it comes to the fall alerts … since we are still getting pets and laundry.*" P2 continued by saying, "*it's a dangerous game to play … [because] if two out of those twenty alerts are false, it's going to go to the bottom of the list*." The false fall alert issue is present across each role in the organization and could lead to overlooking a real resident fall. While only four to five fall alerts are sent each day, the staff feel that too many alerts are sent and cause alert fatigue. It is perceived as too much extra work for the nursing staff.

4.4. System user interface and sensor placement

Two participants mentioned the user interface as a benefit. P2 mentioned a change in the ways in which staff received information. P2 stated, "*[We] used to receive density maps … and now it's pushed to text, it seems to be a lot more friendly for them*." Additionally, P3 explained, "*it gives the graphs, which I like.*" These two participants seem satisfied with the data they receive from the system.

Sensor placement in the rooms was a concern among participants. P4 said, "*Eight out of 10 falls are in the bath and that is where the sensor does not pick it up. The way sensors are angled, it covers only a certain area and does not pick up other areas.*" P5 also noted the physical placement of sensors, stating, "*they do not fall where sensors are. A lot of falls are in the bathroom. The bathroom is a very dangerous place … When sensors are not picking falls as expected … I don't think we fully utilize the sensors*."

P4 and P5 do not think that sensors are placed in a way that appropriately detects residents' falls.

4.5. Alert reception

Participants seemed more reliant on their pagers (instant messages received on pagers) to detect falls. P5 said, "*I find about falls from the texting on work phones*." Furthermore, P4 claimed, "*Sometimes we'll get that page before we get that fall alert*." Additionally, P4 mentioned a problem with work-issued phones. According to P4, there are two types of work phones that staff use to communicate (older phones and new phones), mentioning that no one wants to use the old phones because "*their charge was not picking up*," that is, the charge runs out too quickly. This leads to higher use of the newer phones, but P4 states, "*the new phones we only get [alerts] as email*." P1 and P4 expressed concerns about time being an issue. P4 said, "*I don't like it that we are not getting text alerts on all the phones because we are not able to check the emails … there are so many emails and one has to scroll through them to see which is the current one*." P1 stated that a big issue with staff interaction with the alert system is time. P1 said it is additional work and the nursing staff do not sit down much. Furthermore, P5 said they feel the organization is understaffed, which they attribute to financial issues. "*Six people for one nurse is a lot … it's money*."

4.6. System information

The final issue involved the alerts themselves, primarily the lack of clear information they provide. Using an example, P1 said, "*I don't know what [a specific topic] means … They're just so vague.*" P1 also said that they usually need to seek clarification about what certain alert topics exactly mean. P3 also expressed confusion with some information in the alerts when saying, "*it will say … 1247 hits. What exactly does that mean?*" Furthermore, repetition seemed to be an issue. P1 explained these issues by saying, "*Even though I submitted feedback … we get the same [alerts] over and over.*"

Additionally, P3 expressed frustrations with the frequency of information. Regarding archived information, P3 noted, "*I'd like to see a 'look back' period of … two weeks … instead of the 20th and then again on the 27*th*. That can be a little more beneficial to me because that way I can see a pattern*."

P3 was under the impression that they could only look at specific dates, one at a time. It is entirely possible that this individual did not understand exactly how to do what they wanted (proper training might be needed). From what P3 described, it sounds like they want a look-back period similar to an online bank statement in which users can select two dates and see every transaction between those two dates. The users may not know all of the capabilities of the system.

4.7. The view of the system developers and research team: differences in system use

After mapping the everyday social practice of the nursing staff, the findings were presented to the system development team. The following paragraphs outline the findings in regard to the difference in how the system developers perceive the original intentions of the system and how the staff interact with the system. After the organizational change (management change) in the assisted living facility, one difference was in the form of how the university team theoretically imagined and anticipated the system to work and how the staff use the system.

One of the leads of the system development team mentioned that the system was designed to send alerts to the staff's smartphones. "*They get [the] alert at home … so [they] can choose to answer.*" (R1) This is the first indication of how the organizational change impacts the nurse care coordination between intended use and actual use of the alert system. According to the staff interviews, staff members choose work smartphones at the beginning of each shift. As the older phones lose charge too quickly, the staff prefer and choose new smartphones over old ones. However, the new

ones cannot receive the alerts via text message, and this seems to be one reason why the adoption of the alert system decreased. Alerts received via email tend to be overshadowed by many other emails, while text alerts are better organized focusing on one particular case. In discussion with the system development team, it sounded that they were under the impression that staff used the smartphones also at home to access the alert system, or that they used their smartphones. However, both assumptions are incorrect.

There is a difference in intended system use and actual everyday practice. When presented the alarm fatigue from false fall alerts, the university team was curious why staff were not able to use the system features to determine a real fall, such as replaying the fall video to see whether it is an actual fall or simply a pet or laundry thrown on the floor. "*They're not even looking at the phone?*" remarked R2.

This indicates two findings. First, the system development team designed the fall alert videos to be easily accessible. However, with most of the staff using the new smartphones (due to the older phones not holding a charge), they usually only have access to the fall alerts via email. As several of the participants pointed out, they rarely have time to sit and actively check email.

Second, the new management (after the organizational change) changed the smartphone technology for the nursing staff. This triggered a kind of disconnect between the university team's intentions of the alert system and the ways in which nursing staff receive alerts. It aligns with Ackermann et al. [3] findings that health care professionals tend to develop workflow habits that do not align with system intentions. The fast-paced nature of health care for older adults prevents the nursing staff from taking the time to view the fall alert videos.

Another difference between the nursing staff's practice and the system development team's intention was the feedback feature of the alert system. As P1 mentioned, they were tired of receiving the same alerts even after submitting feedback through the system. This view suggests that P1 assumed that their feedback was sent back to the university team. However, the presentation and discussion with the system development team revealed that this was not the case. "*We didn't know that*" explained R3.

The difference between intended use and everyday practice became clearer as more information was provided by the researchers. The system development team designed the alert system with the feedback option meant to act as a log for resident health. However, the new staff, hired after the organizational change, believed that feedback was going back to the university team to improve the system and to acknowledge that the staff had attended to the issue.

Another difference is the use of terms, as in the system developers use different terms than the staff. This may not be a big issue, however, it is an indicator for potential misunderstandings. It seems that the two worlds of a) the system development team b) the nursing staff at the care facility speak different languages. Since language is an important factor in feeling understood and appreciated, this can complicate or even negatively impact the staff training of the alert system adoption.

During the presentation, the university team asked if the interviews had resulted in any feedback on linguistic alerts. In its early stages, the alert system used highly visual density maps to convey information. The university team updated the system to convey information through text-based alerts (i.e., linguistic alerts). P2 and P3 both said that the alerts have improved over time, with P2 specifically mentioning that the alerts evolved from confusing density maps to text-based alerts.

Another terminology issue was that the university team members were not aware that the primary nursing staff were referred to as *frontline staff*. When describing the everyday practice, the university team was confused by who the frontline staff were. For example, R1 asked, "*Staff … meaning … the people who sit at the desk?*" All five interviewees used this term during the interview process. After the change from the university to the private company, the term *frontline staff* was used to refer to the nursing staff. Before the organizational change, they had been called *nursing aides*.

5. Discussion and recommendation

The findings contribute to socio-technical research by reconfirming existing socio-technical challenges. As Ackerman et al. [3] stated, the issue with socio-technical systems is attempting to anticipate how the human and technical components will function together. Such an approach can be used to showcase the differences between the actual everyday practice of nurses and the workflow anticipated by system designers or others. This approach may help to overcome a disconnection and to improve the nurses' care coordination and system adoption.

This study examined the everyday social practice of how the nursing staff use the alert system including the relationship of technology, work, and organization. This was of interest after the care facility transitioned to new management (read Case description section). An important aspect of implementing a tool in a highly collaborative environment is to ensure that everyone benefits from it [4] – which is not the case in this studied case. Applying the coordination theory, the following issues can be summarized based on the Result section.

Goals. After the organizational change, the alerts and content of alerts continued to be clear to the system developers but not to the nursing staff anymore. The result indicates that the goals of using the alert system are not always clear to the employees in the care facility. New nurses create a new routine around the alert system and tend to stick with it. To overcome this hurdle, regular communication between the system development team and the employees in the care facility is important. It needs a kind of planned rhythm, such as a recurring monthly (or even biweekly) meeting online or in-person with the agenda that the nursing staff and the system development team talk about the goal of the alert system. First, the developer team presents their goals, then the nursing staff is invited to explain how they understand the goals and discuss whether the goals make sense for them in practice.

Activities. The emerging, rather new, workflow of staff nurses, as developed after the organizational change, is rather *messy*. Different nursing staff have quite a different workflow. Although overall the workflow may seem very similar, it may differ greatly in its detail and, as is said, the devil lies in the details. To overcome this issue, a regular monthly meeting can be implemented in which the nursing staff and social workers describe how they use the alert system and what has been changed since the last meeting. The system development team can use the STWT method to visualize the staff's social practices and can then identify potential gaps between their expectations and the nurses' use of the alert system. These meetings should be guided by questions, such as the following: Describe your work in the last week. Think about when you came to work and what you have done first, second, and so on. How have you used the alert system? What problems occurred (if any) when you used the alert system? How have you dealt with the problems? If you haven't used the alert system, why not?

In addition, under the new organization, nurses have more time issues during work (e.g., larger caseloads). We did not speak with the new management, but we assume that a private company operates under economically driven factors i.e., fewer nurses, higher caseloads. It should be questioning whether such new work conditions are useful for its nurses and quality of care. In addition,

the false alerts make the nurses' work even harder, not easier. To overcome this issue, we again recommend using a guiding question during the regular monthly meetings. The question to ask is, "On a scale from 1 to 10 (10 = highest), how much work overload do you experience?" We also recommend using the system usability scale [21], which is a 10-item scale that is easy to use, in each meeting. This will allow the usability score of the system to be tracked over time to see how it is changing. The results can be used to initiate a conversation regarding potential problems.

Actors (people in job roles). Under the current structure, there is no clear communication *within* the workflow, and nursing staff do not fully understand the system workflow. The plan of the system developer does not pay attention to the change of the nursing staff devices and the nurses do not know that they should report the new devices to be integrated into the alert system. This may be an explanation of the decrease of alert system use. In addition, there is no communication *about* the workflow. The different actors (nursing staff, DON, and system developers) do not talk and do not reflect about the workflow. The results of which are that main aspects of the workflow remain unknown to the nurses and different actors have different workflow perspectives, but no one has an overview about the entire workflow. Nobody has an overview of what the others do or can do, with the alert system. To overcome this challenge, a monthly or biweekly meeting is needed to discuss the nursing staff's social practices and to talk about the workflow. We recommend using the following guiding questions: Tell us about your individual everyday workflow (this may the same question as introduced previously under *Goals*); let's identify how the individual work practices are similar and different to each other; let's discuss what we can learn from each other to improve the workflow and the use of the alert system.

For new employees, training on how to use the alert system and providing staff a better workflow overview (i.e., the overall function of the system) may help them to adopt the technology better than they do today. The training should be evaluated to be sure that it does result from inappropriately trained nurses.

Interdependencies. First, there are too many different digital technologies in use. There were at least four different tools, including older and newer smartphones, pagers, and emails. It was also discovered that there were tablets that the nursing staff did not even know existed. The current digital tools used by staff are not sufficient for the needs of achieving the goals or supporting the current workflow activities. For example, newer phones are incapable of receiving text alerts, which means nursing staff cannot accomplish the task at the same quality level. The *equipment difference* between the company-managed care and the university-managed care turned out to be a key difference in how the clinical staff used and accepted the alert system. For example, the alerts were sent to tablets (hiding in some closets), instead of sending them to the nurses' smartphones. Either nursing staff were not aware that those tablets existed or did not find them useful to carry during their work because they were too big or inconvenient. To overcome this hurdle, newer devices need to get new installments to work properly. We recommend the integration of a checklist for nurses outlining what to do when using a new device (e.g., smartphone, tablet, pager). We also recommend creating a checklist for the developer team reminding them to check which devices the nurses use. The dual notification tools clutter the communication ecosystem, so staff have too many devices relaying information. Simplifying the avenues from which staff receive notifications would allow them to focus on one tool for alerts.

Second, the sensors detect movement, but not all are actual falls, and those false alerts contribute to higher workload. Too many false alarms cause distrust of the fall alerts among the nursing staff. Additionally, falls that occur in the bathroom are not monitored by the system, which leads to further distrust in the system by the nursing staff. The alert fatigue from false alerts may have made the nursing staff more dependent on their pagers. This may be another explanation why the nursing staff do not see the benefits of using the system. From the staff's view, the alert system contributes to even more work, and they cannot see the benefit of the system. The nursing staff said they feel too busy to take time between all of their daily responsibilities to sit and access email alerts. This prohibits them from being able to watch the footage from fall alerts. The main problem is alert fatigue which was a consistent recurring issue within the interviews. While the video clip in the fall alert can help the staff to determine whether the fall is real, the staff rarely viewed the video clips due to not receiving them via text message. Also, the sensitivity of the sensors captures even the slightest motion triggers, such as a blanket falling on the ground which results in false alarms [17]. Furthermore, there were incidents that were not being monitored. This issue further distrust of the technology and thus decreased adoption and use. The nursing staff experience of many alerts they consider false contradicts the system development team who thinks that there are not many false alerts. However, this user experience study approach is not about what one group or another thinks or knows, it is rather about what the different groups experience and feel. Here the data show that a) what the nursing staff experience is very different from b) what the system development team thinks or knows. So, it is not what is true that matters; it is about what people experience, which is can be contradictory from different perspectives. At last, information that is sent with the alerts should be clearer, according to the interviewees. Information that is sent with the alert is too vague, and the look-back period is not customizable by the nursing staff. The vague alert topics confuse the DON and SW, leading to the facility manager getting involved. Additionally, the current *look-back period* is too granular. The SW expressed interest in an ability to check a patient's health alerts over a specific period instead of a single date at a time. Although the alert system supports this capability, the SW was not aware of how to accomplish it. To overcome these challenges, we recommend creating regular conversations (monthly meetings) with a representative of the nursing staff. In addition, instant feedback loops or an idea management system in which the nurses can recommend ideas on how to improve the use of the system should be implemented.

6. Limitations

This is a basic qualitative study. The number of interviewees and size of the focus group is limited. Although using so few interviews (in this case, five) has been validated in user experience research to detect major issues in technology adoption [23], we recommend additional data collection in the future after system improvements have been implemented.

7. Conclusion

This study explored the everyday practice of nursing staff in an assisted living facility after new management took over, and the alert system adoption decreased. The results of this study describe the everyday practices that may cause the decrease in technology use.

Overall, the everyday practice of the nursing staff and how they experience the system reveals major issues. It is possible that some of these issues can be easily resolved now that the different experiences have been uncovered and revealed. We argue that an empathy issue exists. Different lingo (e.g., technical terms) among the system development team and nursing staff may contribute to the disconnect between the facility and the system development

team. Nursing staff may feel that the system development team does not understand their work.

We suggest that system development and research teams should differentiate between their knowledge (i.e., what researchers think should happen) and what the nursing staff experience and how they see the technology (i.e., what is happening day to day). The system development team's mental model and the nurses' mental models of how to use the alert system can differ a lot. Identifying those potential differences and contradictory experiences is the first step toward greater technology acceptance and better integration of such systems into the nurses' everyday work practice.

This work can be used for other health-related technology integration projects as well. The method and practical implication may be useful to showcase the differences between the actual everyday practice of nurses and the workflow anticipated by system designers or others. This approach may help to overcome a disconnect, improve the nurses' care coordination, and to increase technology acceptance and adoption.

CRediT authorship contribution statement

Isa Jahnke: Conceptualization, Methodology, Writing. **Nathan Riedel:** Investigation, Writing. **Mihail Popescu:** Software, Resources, Writing – Review and Editing. **Marjorie Skubic:** Software, Resources, Writing – Review and Editing. **Marilyn Rantz:** Software, Resources, Writing – Review and Editing.

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Declaration of competing interest

Dr. Skubic and Dr. Rantz report small ownership in Foresite Healthcare, outside the reported work. In addition, Dr. Skubic, Dr. Rantz, and Dr. Popescu have patents: integrated sensor network methods and systems, and activity analysis, fall detection and risk assessment systems and methods, licensed to Foresite Healthcare.

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Appendix A. Supplementary data

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