A Human Factors approach to medication administration in nursing homes

by

Kristian Ringsby Odberg

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University of Stavanger
NO-4036 Stavanger
NORWAY
www.uis.no

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Summary

Medication administration causes a significant number of healthcare-related adverse events in primary care. In recognition of this, the World Health Organization has instigated a worldwide effort to reduce avoidable medically related harm by 50% over the period 2017−2021. A Human Factors approach has proven appropriate in research and clinical improvement across healthcare domains.

The paramount aim of the thesis is:

"To use a Human Factors approach to explore the complexity of the medication administration process in nursing homes, thereby contributing to the prevention of adverse drug events"

To accomplish this, a qualitative mixed-methods approach was applied, with observations and individual interviews from two different nursing home wards. The data were analysed using qualitative content analysis.

Three objectives are addressed in the study:

1. To contribute to in-depth knowledge of the **characteristics** of medication administration and **interruptions** in nursing homes.
2. To expand the knowledge of the **nurse role** during medication administration in nursing homes.
3. To explore the **dynamic interactions of stakeholders and work system elements** in the medication administration process in a nursing home.

The objectives are responded to in three papers.

Paper I describes the administration of medications in nursing homes. It shows that the complexity of medication administration is ingrained in the work system of the nursing homes and consists of persons, tasks,

tools and technology and the physical environment and how these elements interact. Furthermore, different types of interruptions are characterised; active, passive and technological. Some interruptions may have positive outcomes, but most interruptions have adverse outcomes and have become normalised in the nursing home work system.

Paper II describes the nurse role during medication administration as compensating, flexible and adaptive. During medication administration, the nurse continuously compensates on an individual level to match skills and competencies with the surrounding staff. Nurses are flexible when engaged in teams and adjust task delegation according to the professions present. At an organisational level, the nurse adapts to the changing workload and report staff stability as critical to safely manage medications.

Paper III applies SEIPS-based process modelling to map out facilitators and barriers to safe medication administration in a nursing home ward. Most of these are associated with the elements "tools & technology" and "tasks" in the SEIPS work-system and are mostly present during ordering and transcribing of medications in the medication administration process.

In summary, the complexity of medication administration in nursing homes reflects the characteristics of the persons, tools & technology, tasks and organisation that interact and adapt according to shifting circumstances. There are six stages in the medication administration process with over 60 associated facilitators and barriers. The nurse has a central role, compensating for variations in competence and being flexible to meet the demands of the patients. Efforts to improve medication safety in nursing homes should target specific types of errors and be multifaceted.

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Part 1

1 Introduction

This thesis contributes to the prevention of adverse drug events in nursing homes by exploring the complexity of the medication administration process in nursing homes using a human factors approach.

Traditionally medication administration is described as the process where a professional healthcare worker prepares and give medicines to the patients. Research suggests medication administration has more nuances and is an ingrained part of the regular workday of the staff (Carayon, Wetterneck, Cartmill, et al., 2014; Jennings, Sandelowski, & Mark, 2011). Tasks related to medication administration are often difficult to separate from other work processes involved in the daily care of the patients, indicating an underlying complexity.

Moreover, medications are commonly used in nursing homes, and medication-induced injuries, known as adverse drug events, is a concern. Nursing home patients are especially vulnerable to adverse drug events, due to a series of individual factors such as frailty, disability, a high prevalence of comorbidity (Violan et al., 2014) and a high incidence of polypharmacy (Herr et al., 2017). Patients with chronic diseases often use so-called high-risk drugs such as opioids, antipsychotics, antidepressants, antiepileptics and anti-infectives (Field et al., 2001). Psychotropic drugs are known to increase the risk of falls and cognitive impairment (Al-Jumaili & Doucette, 2018; Ryan, Kidder, Daiello, & Tariot, 2002). Also, age-related physiological changes increase the risk of drug-drug interactions (Gallagher, Barry, & O'Mahony, 2007).

There are also system-level factors associated with an increased risk of adverse drug events in nursing homes such as staff competence, unclear procedures, inadequate staffing, high workload, time pressure, interruptions during medication administration and inadequate interprofessional collaboration (Al-Jumaili & Doucette, 2017).

Adverse drug events may result in additional monitoring, interventions, hospitalisation or death (Handler, Wright, Ruby, & Hanlon, 2006). Reports document that about one-third of all adverse drug events are associated with medication administration errors and as such are preventable (World Health Organization, 2016). Non-preventable adverse drug events are such as most adverse drug reactions with unintended consequences (Aronson, 2009).

A systematic review found that 13−31% of the residents in nursing homes experienced medication administration errors, but that the incidence of serious adverse drug events was low. This may have been due to underreporting rather than a low frequency of serious outcomes (Ferrah, Lovell, & Ibrahim 2017). Most estimates of adverse drug events in nursing homes range from 1.2 to 10.8 incidents per 100 resident-months (Al-Jumaili & Doucette, 2017).

Consequently, The World Health Organization (WHO) has promoted an effort to reduce preventable medically-related harm by 50% over the period 2017−2021 (World Health Organization, 2017). Vital in this effort is a shift in focus from the individual to the system, and that Human Factors is acknowledged as essential in efforts to improve patients' safety (Carayon, Wetterneck, Cartmill, et al., 2014; Carayon, Wetterneck, Rivera-Rodriguez, et al., 2014).

The goal of Human Factors is to improve the design of the work systems so people can perform healthcare processes safely. The System Engineering Initiative for Patient Safety model (SEIPS) (Carayon et al., 2006) facilitates investigation into complex systems such as nursing homes, by visualising how the elements (persons, physical environment, tasks, tools & technology, organisation) in a work system, interact to produce work processes, such as medication administration, and specific outcomes. Human Factors also describe an analysis classification system (HFACS) for healthcare that can be used to classify and categorise errors into four hierarchical tiers (Diller et al., 2014): Tier one: Unsafe acts, tier

two: Preconditions for unsafe acts, tier three: Supervision and tier four: Organisational influences.

The different tiers complement the framework of the SEIPS-model, by taking a more causal approach elaborating on how errors may occur and relate to characteristics in the work system of the SEIPS-model.

1.1 Medication administration

The underlying notion of medication administration rests on the premise that all staff handling medicines follow the six 'rights' taught and practised throughout education programmes; 1) the right patient, 2) right medication, 3) right dosage, 4) right route, 5) right time and 6) right documentation (Yoost, Crawford, & Castaldi, 2015).

This thesis deconstructs the medication administration process in six consecutive stages (Carayon, Wetterneck, Cartmill, et al., 2014) from ordering, transcribing, dispensing, and preparing to administering and observing.[1]

1) *Ordering* is when the physician decides what medicines to prescribe, with details such as dosages and timing. This is often done in collaboration with the registered nurse.

2) *Transcribing* is the formalising of the orders into an electronic medication administration system.

3) *Dispensing* is when the registered nurse checks the prescribed medication list against the electronic medication administration system and dispenses the medicines in pill boxes.

[1] Stages 3 and 4 are reversed in the PhD-study compared to Carayon, Wetterneck, Cartmill, et al. (2014) due to contextual differences. The pharmacy is less involved, and dispensing is therefore a primary task for the nursing home staff, when multi dose is not involved.

4) *Preparing* is when the registered nurse readies the medication for ingestion and performs a double-check before administration.

5) *Administering* is the actual delivery of medications to patients.

6) *Observing* entails monitoring the patients for effects after they take the medicines and the subsequent documentation.

1.2 The Norwegian setting

In Norway, there are approximately 40 000 nursing home patients that each uses on average seven different medications. The majority are long-term residents (32 000) aged 80 years or older. To care for these patients, there are approximately 140 000 full-time equivalents across registered nurses, nurse assistants and healthcare personnel without specific education (40 000). On average, the medical doctor has 0.49 hours per resident/per week available, but there are large variations (Ministry of Health and Care Services, 2015; Statistics Norway, 2019).

Audits from the Norwegian Board of Health Supervision from 2008-2010 in 67 nursing homes found deviations from standards in medication management in 51 (76%) of the nursing homes examined (Norwegian Board of Health Supervision, 2010). The deviations were associated with unclear lines of responsibility, time pressure, lack of competence, poor interprofessional collaboration, variations in observing and documenting the effects of medications, poor availability of vital patient information due to multiple documentation systems and separate documentation system for the medical doctor.

The Norwegian national legislation regulates medication administration in nursing homes in detail, highlighting tasks related to ordering and requisition of medicines, preparing, double-control and administration of medicines (Regulation on Medication Administration, 2008, section 3). The regulation also states the responsibility of managers to ensure medication administration is carried out properly in accordance with

laws and regulations (section 4). Healthcare personnel are responsible for administering the correct drug to the right patient, using the right dose, at the right time and in the correct way (section 7) (Regulation on Medication Administration, 2008).

The elderly population in high-income countries is growing, increasing the pressure and demands on collaboration between primary and secondary healthcare (Cardoso, Oliveira, Barbosa-Póvoa, & Nickel, 2012; Monkerud & Tjerbo, 2016; Rechel et al., 2013). In Norway, as in many other countries, reforms add to this pressure through the stated objective of transferring care closer to where the patients reside. Consequently, nursing homes are required to receive patients from hospitals at an earlier stage. These changes have led to Norwegian nursing homes, often receiving patients with ongoing comprehensive medical treatment and multiple diagnoses (Syse & Gautun, 2013). The development has resulted in increased complexity of the nursing-related tasks, and an associated need for training and more competence among the staff of nursing homes in general (Glette et al., 2018).

The education of registered nurses includes a mandatory drug dose calculation test that must be passed without error, as well as a course in pharmacology. Training in medication management continues in practice throughout the education, but barriers such as lack of time, poor availability of guidelines and lack of knowledge pose barriers to bridging the theory-knowledge gap (Lim & Honey, 2014). Simonsen (2016) concludes that medication knowledge is unsatisfactory among nursing students as well as among registered nurses and that there is a considerable risk of medication errors.

Over the last decade, there has been a national effort in Norway, "In safe hands", to improve patient safety (Ministry of Health and Care Services, 2019). Some specific measures relate to medication administration in nursing homes and include correct drug use and reconciliation of medication administration records. Furthermore, different municipalities

implement measures to improve patient safety. Consequently, quality improvement in nursing homes varies. A lack of registers leads to a failure to document any changes related to medication safety in nursing homes (Ministry of Health and Care Services, 2016; Norwegian Institute of Public Health, 2013).

1.3 Rationale

Prior studies on medication administration in nursing homes have focused on different aspects, such as:

- **The numbers of adverse drug events and medication administration errors in nursing homes are uncertain**. Indications are that these numbers mirror or exceed those from the hospital setting (Al-Jumaili & Doucette, 2017; Ferrah et al., 2017; Keers, Williams, Cooke, & Ashcroft, 2013b).
- **The use of electronic medication administration systems** may reduce concerns about committing errors (Alenius & Graf, 2016). Further investigations are needed to evaluate the use of electronic administration systems and possible effects on medication administration errors and patient safety (Fuller, Guirguis, Sadowski, & Makowsky, 2018).

- There seems to be a low adherence to **guidelines** on medication administration (Lapkin, Levett-Jones, Chenoweth, & Johnson, 2016). Some suggest the introduction of safety checklists to evaluate nursing practice and to improve the medication administration process (Qian, Yu, Hailey, Wang, & Bhattacherjee, 2018).

- **Nurses are central** in the medication administration process and responsible for safe medication administration, and need to possess sound clinical reasoning (Eisenhauer, Hurley, & Dolan,

2007; Rohde & Domm, 2018). Nurses also need sufficient **knowledge** to assess the risks of medication administration in a relevant context with a learning climate and professional environment allowing for the development of nursing skills and knowledge (Smeulers, Onderwater, Zwieten, & Vermeulen, 2014).

- **Adequate staffing** seems to be a key issue in relation to safe medication management in nursing homes (Glette et al., 2018; Simmons et al., 2016).

- The medication safety of the patients in nursing homes depends on the **competence of the staff** and their documentation and knowledge of the patients' condition. Nurses and managers need to be aware of factors contributing to adverse events (Andersson, Frank, Willman, Sandman, & Hansebo, 2018; Glette et al., 2018).

- **Interruptions** during medication administration are described as a harmful factor for patient safety, but more studies are needed to comprehend the phenomenon and the effects on clinical practice (Hopkinson & Jennings, 2013; Lee, Tiu, Charm, & Wong, 2015; Monteiro, Avelar, & Pedreira, 2015).

Together, these diverse aspects point to complexity in how it is possible to describe and comprehend the medication administration process in nursing homes. Medication management in the nursing home setting is complex, and there are indications that errors are common and similar to those occurring in the hospital setting (Edgar & Harvey, 2010). Each stage of the medication administration process has areas for improvement (Pirinen et al., 2015), and factors that may influence medication administration is poorly understood (Marchon & Mendes Jr, 2014; Parry, Barriball, & While, 2015). In addition, there are few studies

investigating medication management and errors in the nursing home setting (Edgar & Harvey, 2010; Marchon & Mendes Jr, 2014).

Some advocate that research into the medication administration process in nursing homes should shift focus from error as an event, to the interactions and relationships between persons, environment and processes (Andersson et al., 2018; Parry et al., 2015). Applying a Human Factors approach may, therefore, facilitate investigation into the whole of the work system and patterns of interactions.

1.4 Aim, objectives and research questions

The paramount aim of the thesis is

"To apply a Human Factors approach to explore the complexity of the medication administration process in nursing homes, thereby contributing to the prevention of adverse drug events."

To answer the overall aim, the thesis has three objectives:

1) To contribute to in-depth knowledge of the **characteristics** of medication administration and **interruptions** in nursing homes.

2) To expand the knowledge of the **nurse role** during medication administration in nursing homes.

3) To explore the **dynamic interactions of stakeholders and work system elements** in the medication administration process in a nursing home.

1.5 The composition of the thesis

The thesis consists of two main parts. Part I first describes the theoretical framework, the methodology and results, before discussing the findings in relation to theory and possible implications. Part II consists of three scientific papers, which constitute the empirical basis for the thesis.

Paper I: Medication administration and interruptions in nursing homes: a qualitative observational study

> Odberg, K. R., Hansen, B., Aase, K., & Wangensteen, S. (2017). Medication administration and interruptions in nursing homes: A qualitative observational study. *Journal of Clinical Nursing*. doi:10.1111/jocn.14138

Paper II: A qualitative study of the nurse role during medication administration

> Odberg, K. R., Hansen, B. S., & Wangensteen, S. (2019). Medication administration in nursing homes: A qualitative study of the nurse role. *Nursing Open, 6*(2), 384-392.

Paper III: A work system analysis of the medication administration process in a Norwegian nursing home

> Odberg, K. R, Aase, K., Hansen, B.S., & Wangensteen S. (2019). A work system analysis of the medication administration process in a Norwegian nursing home. *Applied Ergonomics* (revised)

2 Theoretical perspective

This chapter introduces Human Factors as the overarching theoretical discipline permeating the thesis. This is followed by a description of complex adaptive systems as a way of defining complexity and elaborating on some of the mechanisms taking place in the work system outlined in the SEIPS-model (Figure 1). Lastly, it gives insight into the normalisation of deviance as a possible explanation for how staff adapt to changing work system configurations over time.

2.1 Human Factors

The SEIPS-model (Holden et al., 2013) is used as the overarching framework in the papers and the thesis and does not inhabit any predictive qualities as is often the hallmark of theories. Frameworks excel at simplifying, explaining and showing inter-relations. They may serve as orientation maps that provide the opportunity and freedom to ask questions and search for answers. The descriptive nature of the SEIPS-model is reflected in how arrows point in all directions, hinting at the interconnectivity of the elements in the work system rather than implying causalities. In order to discuss different types of potential medication administration errors and adverse drug events, the Human Factors Analysis Classification System in healthcare (HFACS) is introduced as a complementary framework in the thesis (Diller et al., 2014).

Human Factors is a multidisciplinary discipline and is concerned with the understanding of interactions among humans and other elements of a system. It applies theory, principles, data and design optimisation for human well-being and overall system performance (International Ergonomics Association, 2019). Originally Human Factors played a vital role in ergonomics and engineering, but over the decades it has become increasingly widespread across a variety of settings as diverse as the

cockpit of an aeroplane, a business organisation, a nuclear power plant or a nursing home ward. Human Factors is about designing systems that are appropriate to people's needs, abilities and limitations. These may be cognitive, physical or organisational. Processes, such as medication administration, lead to people interacting with the system through performing tasks and creating outcomes (Dul et al., 2012).

Employing a human factor systems approach aims at grasping the complexity of medication administration. The approach is recognised as appropriate across all health care domains (Gurses, Ozok, & Pronovost, 2012; Norris, 2012; Russ et al., 2013). Human Factors includes three core principles (Dul et al., 2012): 1) **Systems orientation** – performance is a result of interactions in a sociotechnical work system where the person is one of several components. 2) **Person-centeredness** – efforts must be made to support humans through the design of capable work systems.3) **Design-driven improvements** – Person-centred design of work structures and processes can improve outcomes.

The System Engineering Initiative for Patient Safety (SEIPS) is a Human Factors model that has proven useful when applied in healthcare research, education and practice (Carayon, Wetterneck, Rivera-Rodriguez, et al., 2014; Gurses et al., 2010; Pronovost et al., 2009; Shekelle et al., 2013; Sittig & Singh, 2009; Wooldridge, Carayon, Hundt, & Hoonakker, 2017; Xie & Carayon, 2015).

The basis for the SEIPS-model lies in the structure-process-outcome approach to healthcare quality proposed by A. Donabedian (1978). The structure is represented by the "**sociotechnical work system**" (left-side in Figure 1). The work system produces work **processes** (in the middle of Figure 1), which shape **outcomes** (right-side in Figure 1) (Holden et al., 2013). The internal/physical and external environment, tools and technology, tasks and organisation (Holden et al., 2013) interact and influence the person(s) at the centre of the model.

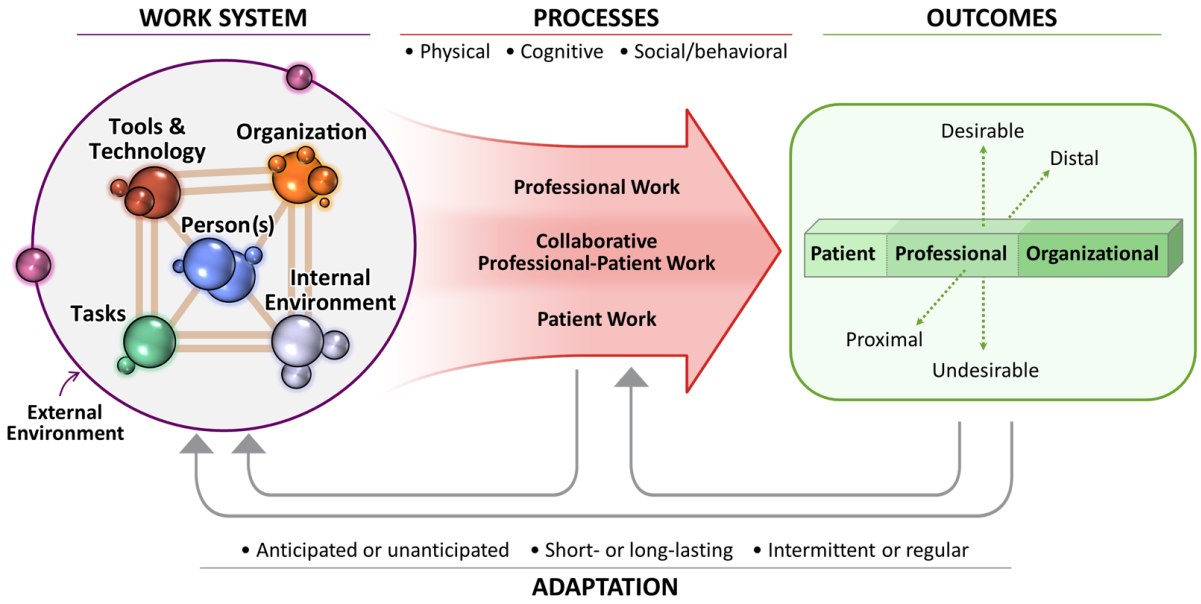

Figure 1: A Human Factors model of the work system, processes, outcomes and adaptations, the SEIPS 2.0 model
(Holden et al., 2013)

The person/team is at the centre of the work system, i.e. the nurse, physician, patient or a group of individuals (e.g. team, organisational unit). By placing the person(s) at the centre of the model, it fits with the second principle of a Human Factors approach and the underlying assumption that the design of healthcare systems should support people. The individuals can be professional healthcare workers such as medical doctors, registered nurses or nurse assistants, or they can be non-professionals such as the patient or a family caregiver (Holden et al., 2013). The individual or team can exhibit cognitive, physical and psychosocial characteristics. Examples of these characteristics may be age, experience, competence, knowledge, training, education, or collective level characteristics such as team cohesiveness and role distribution (Holden et al., 2013; Salas, Sims, & Burke, 2005).

The internal or physical environment describes the environment in which the healthcare worker provides care. It includes characteristics

such as lighting, noise, temperature, layout, space, distances and air quality (Carayon, 2011; Holden et al., 2013).

Tools and technology revolve around the equipment and medical devices the healthcare personnel utilise in their daily work. Some examples are information technologies such as medical electronic administration records, medical devices such as the blood glucose meter, or tools for mobilising patients out of bed. These can be characterised according to usability, familiarity, functionality, portability and so forth (Carayon, 2011; Holden et al., 2013).

Tasks are the activities or specific actions within work processes, such as medication administration. Attributes describe the difficulty, complexity, variety, sequence and potential ambiguity of the given tasks (Carayon, 2011; Holden et al., 2013).

The organisation component in the model refers to the collective structures that guide and organise time, space, resources and activities. Examples can be work schedules, patient safety culture, type of management, policies, training opportunities for the staff and resource availability (Carayon, 2011; Holden et al., 2013).

The external environment reflects that no institutions exist in a vacuum and that external forces on a macro-level such as political, societal and economic factors continually exert influence.

The **processes** in the model can be broken down into physical, cognitive and social /behavioural performance processes (Holden et al., 2013; Karsh, 2006). The processes can result in accomplishing goals or outcomes. Multiple agents are often engaged simultaneously in the work processes. Three categories of stakeholder interactions exist along the continuum of engagement; professional, patient and collaborative work. In **professional work,** the primary agent is the professional health care provider or professional multidisciplinary team providing health care or healthcare related work for the patient(s). In this thesis, medication

administration is investigated as the primary work process, defined as professional work relating to the work system. **Patient work** involves active engagement from the patient, family caregiver or other non-professionals involved in healthcare related work. **Collaborative work** is a mix of the two categories, where both professionals and non-professionals are involved and actively engaged in health-related care (Holden et al., 2013).

Work outcomes describe outcomes for patients, professionals and organisations, and are defined as states or conditions resulting from the work process. Outcomes can be desirable or undesirable. However, they can also be important indicators of performance, quality and safety (A Donabedian, 1988; Holden et al., 2013; Holden et al., 2011). Direct outcome measures can be challenging to measure, but by focusing on processes in the work system, one may identify barriers and facilitators towards safe care (Wooldridge et al., 2017).

2.1.1 Balancing the work system

The work system (Figure 1) in any organisation is dynamic and contextually dependent; any changes in a work system element interact and produce changes elsewhere in the work system (Carayon, Wetterneck, Rivera-Rodriguez, et al., 2014; Holden et al., 2013). Varying configurations of the work system depicts how processes or performance are shaped at a given moment. According to Holden et al. (2013), these interactions are what defines the Human Factors discipline.

All these possible interactions also force researchers to make choices. Not all work system elements are as essential in different work processes or situations, and it is critical to prioritise which possible interactions are relevant. Priorities may include the strength of the interactions; some work system interactions will only have a weak influence and can be disregarded. The set of relevant interactions is dynamic and will change according to the type of work processes, timeframe and situations.

These dynamic interactions, which are typical of complex systems, are mentioned as a possible limitation and challenge in Human Factors literature when employing the SEIPS-model. The different elements of the work system interact and continuously shift over time, so circumstances and processes involved can only procure accurate descriptions as snapshots (Holden et al., 2013). Also, the SEIPS-model provides a descriptive framework to contemplate the work system rather than being a prescriptive theory postulating how changes in one factor may influence other factors or specific outcomes. Although this may be considered a limitation, it is also a strength since the model is generic and adaptable to a wide range of contexts and situations (Carayon et al., 2006).

2.1.2 Adaptations

In the SEIPS 2.0 model (Figure 1), arrows depict adaptation flow between the work system, the processes and the work outcomes. These feedback loops may be intended or unintended and visualise how persons in the work system adapt to balance the work system. The balancing of the work system may be described as decreasing the distance between work as done and work as imagined, as in the resilience theory (Fairbanks et al., 2014; Hollnagel, 2012). Work-as-imagined and work-as-done are theoretical constructs aiming to put words to how relative hierarchical levels interact in real life. A common example is how management introduces a new tool or technology, while the staff do not understand the purpose or lack training in the intended use and end up creating workarounds, increasing the overall workload.

Adaptations can be divided into: 1) long-term intended actions such as the introduction of quality improvement programmes or the introduction of new technology. 2) Short-term, reactive and intermittent actions akin to first-order problem-solving behaviour (Tucker & Spear, 2006). Examples are how staff members solve problems that arise during their workday due to faulty equipment, poorly designed health information

technology, a change in workload or an unexpected event. This illustrates how a change in one or more of the work system elements induces the person(s) in the centre to make ad-hoc adaptations or workarounds to balance the work system (Holden et al., 2013). These adaptations are a natural part of the socio-technological (Wilson, 2000) system and a significant contributor to the overall perceived complexity.

According to Hoffman & Woods (2011), processes in complex systems are characterised by variations which drive people to change and adapt in order to meet both short-term and long-term fluctuations. This everyday coping of dynamic events is described as performance variability, and entails the individual adaptations and how the surroundings react. Performance variability in a system should aim at being proportional to the complexity of the system, having enough flexibility to meet changes and unforeseen events (Braithwaite, Wears, & Hollnagel, 2016; Hollnagel, 2009, 2014). Performance variability may, therefore, be positive or negative in socio-technical systems. If a system lacks resources such as human competence or appropriate technological tools, it may follow that the overall performance variability is inappropriate to meet the demands of the system complexity. Four basic abilities need to be present in the socio-technical system to enable functional adaptive behaviour on an individual and organisational level. 1) The system needs to respond to regular and irregular events. 2) It must be able to monitor any changes. 3) It must be able to learn from the past, both what went wrong, but also what went right. 4) It has to be able to anticipate changes and developments in the future, both short-term and long-term (Hollnagel, 2009).

The following sections describe HFACS as a complementary human factors framework to gain insights into different types of errors and at how they may relate to characteristics in the work system.

2.1.3 A human factors classification of errors

The Human Factors Analysis Classification System (HFACS) for healthcare (Diller et al., 2014) is based on earlier work on root cause analysis by Chapanis & Safrin, (1960) and Reason, (1995), dividing errors into four hierarchical tiers.

Tier one describes different types of unsafe acts categorising them as errors or violations. Tier two lists different preconditions for unsafe acts, while tier three relates to different aspects of supervision on a middle management level. The fourth tier concerns broader organisational influences on the level of resource management, organisational climate and processes. Each of the categories within the four different tiers relate to elements described in the work system of the SEIPS-model.

Tier one: Unsafe acts

According to the HFACS, there are five types of unsafe acts in tier one. Decision-based errors, skill-based errors, perceptual errors, routine violations and exceptional violations (Diller et al., 2014).

Decision-based errors occur when healthcare personnel lack information, knowledge or experience to perform the set task.

Skill-based errors occur when healthcare personnel engage in repetitive tasks familiar to them and requiring little attention. Automated behaviours are susceptible to attention or memory failures that are enhanced if staff are interrupted or distracted while engaged in the task work.

Perceptual errors may happen if one or more of the human senses are compromised. An example can be if a staff member misunderstands a message due to a noisy environment and proceeds to fill in the missing information they subconsciously perceive as correct.

Violations are divided into routine violations and exceptional violations. Routine violations are often accepted by all the staff members and the management as a bending of the rules, or workarounds to enable smooth operation. Exceptional violations, on the other hand, represent wilful actions that are not part of the normal behaviour nor condoned by either colleagues or management (Diller et al., 2014).

Tier two: Preconditions for unsafe acts

The HAFCS describes different preconditions for errors and violations in tier two. These preconditions relate to environmental factors, the condition of the operator and personnel factors.

Environmental factors are related to the physical environment (noise, temperature, interruptions, lighting, layout etc.) and the technical environment (design of equipment, technological solutions, IT-systems etc.).

The condition of the operator concerns the mental, psychological and physical state of the healthcare provider. It may be that the nurse is experiencing fatigue or stress, has some cognitive impairment or has poor eyesight. All these conditions may affect planning and actions.

The last precondition described covers personnel factors, outlining factors that may affect communication, coordination and planning among staff-members. Examples are poor availability of vital information, direct miscommunication, and failures to work as a team. This includes failures related to anticipating the patients' needs or planning appropriately (Diller et al., 2014).

Tier three: Supervision

Tier three of the HFACS relates to how the frontline workers, such as the nurses, nurse assistants and doctors at the nursing homes, are the recipients of different possible latent failures attributable to their supervisors. There are four subtypes; leadership, operational planning,

failure to correct known problems and supervisory ethics. These subtypes are found in the element "organisation" in the SEIPS-model.

Failures of leadership relate to the supervisors providing inadequate training, guidance or oversight. This may lead to the staff members using past practices and intuition rather than following standards set out in procedures or guidelines.

Operational planning is about how the management ensures that the staff members are aware and capable of doing their work. It includes the scheduling and assignment of tasks to the right individuals.

Failure to correct known problems comes down to whether the management rectifies known problems within their assigned area. An example of this is if the management are aware of an equipment failure or a lack of competency in the staff, and neglect to address the issue.

Supervisory ethics are relevant if the management chooses to disregard rules and regulation. An example may be that the management permits individuals to perform tasks beyond their legal scope or qualifications (Diller et al., 2014).

Tier four: Organisational influences

This tier is concerned with how decisions of upper-level management may affect supervision and personnel management and are found under the element "organisation" in the SEIPS-model. The first sub-type involves resource management and the allocation and maintenance of human resources, budgets and equipment design. It is concerned with the balancing of quality versus cost-effectiveness. The second sub-type introduces the concept of organisational climate as a set of variables that influence the staff performance. A concern is how the culture of the organisation focuses on patient safety. The third sub-type, operational processes, elaborates on aspects such as time-pressure, procedures, oversight and risk management (Diller et al., 2014).

2.2 Complex adaptive systems

As patient safety gained importance in the western world, the shift from an individual focus towards a system focus also underscored the complexity of healthcare systems. In a nursing home, there are multiple professional stakeholders involved in multiple processes simultaneously. Regulations, rules and guidelines govern the persons and the system. The municipality and the healthcare personnel must act justifiably. Tasks are performed in different environments, and often a variety of tools and technology is involved. Complexity is commonly defined as a system comprised of many parts with many interactions (Simon, 1996). The Complex Adaptive Systems theory describes nonlinear systems in which diverse agents interact and are capable of spontaneous self-organisation. This description is also suitable for social organisations such as in health care, in that they are dynamic systems able to adapt and evolve with a changing environment (Matlow, Wright, Zimmerman, Thomson, & Valente, 2006; Rouse, 2008).

Complex adaptive systems are nonlinear and dynamic, and system behaviour may appear random, meaning that the behaviour of the individuals in the system may appear random and unpredictable but follows an internal logic. Complex adaptive systems are composed of individuals following physical, psychological or social rules rather than external demands, and the individuals adapt to each others' behaviour. Also, individuals are intelligent and can learn from the past. The learning often results in a self-organisation where patterns of behaviour emerge. These patterns may be healthy or unhealthy for the organisation. In the complex adaptive system, there is seldom a single point of control, and the system behaviour may, therefore, be unpredictable. As a consequence, the behaviours of complex adaptive systems are more susceptible to influence rather than control (Rouse, 2000).

If one imagines nursing homes as a complex adaptive system, they are first and foremost composed of the professional stakeholders; the nurses, nurses' assistants, medical doctors, and other staff members. Each of these staff members is an individual with different competencies, personalities and inclinations regarding how they perform according to the job description. Since they are individuals, one cannot always predict their behaviour over long intervals of time. In relation to unforeseen activities, individuals react and adapt to the changing environment in a nonlinear way. Adaptations can be found both at the micro-level (individuals) and the macro-level (organisation). The changes and perturbations in complex adaptive systems are possible to monitor to a certain degree. By observing and studying changes and adaptations, it is possible to research, manage and plan accordingly on an organisational level (Tan, Wen, & Awad, 2005).

Complex adaptive systems in health care portray the dynamic properties of the system and the varying characteristics, deeply ingrained in social practices. Simultaneously one has to consider a multitude of forces, variables and influences in ongoing processes, and that unpredictability and uncertainty, therefore, are normal (Braithwaite, Churruca, Long, Ellis, & Herkes, 2018). Examples of forces and influences can be the economic situation, availability of staff in case of illness, and the introduction of new information technology, changing guidelines, new patients or a lack of competence among the staff relative to the demands of the practice.

2.3 Normalisation of deviance

The normalisation of behaviour deviating from the norms is not necessarily bad and can be a normal part of a complex adaptive system that is beneficial for the organisation. An example is when the staff discover pathways or workarounds that are more safe or efficient than

the original way of doing things. The normalisation of deviance may explain why staff members invent workarounds and creative solutions, bending the rules and guidelines. In most cases, it is to adapt to a changing work system configuration and to minimise the difference between work as done and work as imagined (May & Finch, 2009).

The normalisation of deviance is about the social organisation of the work and how tasks become routine practices in everyday life, and how these embedded practices are sustained in the specific social context (May & Finch, 2009).

Sometimes the normalisation of behaviour that deviates from the norm may create vulnerabilities in the work system, thus creating opportunities for the staff to commit medication administration errors. This is exemplified by institutions where high workload and a lack of staff over a long period lead to situations where double-control of medications is routinely skipped. Over time, this may become a routine violation where the bending of rules becomes habitual. Another example is how staff find workarounds to tasks they perceive as overly complicated or inappropriate. Over time, intentional deviations practised by an entire group become normalised. The personnel no longer regard acts that violate the rules or guidelines as unacceptable, but rather as the new routine. The new normalised behaviour may increase the likelihood of future errors in the work system (Banja, 2010). Multiple violations or lapses may coalesce and enable the occurrence of adverse events. This vulnerability usually has a long incubation time before any adverse events manifest. The prime example of how normal behaviour drifts into disaster is the Challenger catastrophe. Stress tolerances of a critical O-ring were over several years, kept "within tolerances". The problem was that the limit of tolerance kept stretching, and when disaster struck, the limit of tolerance was reached. This was not recognised by key personnel in time, due to the normalisation of this evolving deviance (Vaughan, 1997).

The normalisation of deviant behaviour among healthcare personnel is characterised by the fact that the nurse or physician rarely have any criminal or malicious intent and may be explained through three mechanisms: 1) socialisation, 2) institutionalisation, and 3) rationalisation (Ashforth & Anand, 2003). 1) Socialisation is about the unwritten rules or codes of conduct followed by the people in the work system. Some behaviour is rewarded or punished, thus determining whether a newcomer joins a group by adopting the existing deviant behaviour. 2) Institutionalisation is the exposure of deviant behaviour, often performed by an authority that explains that "this is how we do it here", as the organisational norm. 3) The rationalisation is a process where the individuals argue internally that certain deviances are legitimate, acceptable and in some cases necessary to carry out normal operations (Banja, 2010).

These three mechanisms work in parallel and mutually reinforce each other. Remedying the normalisation of deviant behaviour calls for strong leadership with a commitment to patient safety – a commitment that transfers to the staff and that is consistently renewed over time. Moreover, psychological safety and a non-punitive culture are imperative if an organisation wishes to avoid the normalisation of deviant behaviour (Banja, 2010).

3 Methodology

This chapter describes the philosophical underpinning of the study, gives details of the overall design, the theoretical framework, pilot study and the methods used, the recruitment stage, data collection and analysis. Lastly, it concludes with reflections around the trustworthiness of the study, and methodological reflections on what was done and what might have been done differently.

3.1 Philosophical underpinning

The epistemological perspective in the thesis is social constructivism. This implies that social constructs do not exist independently of the observer, but rather in a dynamic interplay partly created by both the observed and the observer (Kukla, 2013). Medication administration is not something one can entirely observe in nature; rather it is a phenomenon made up of a set of ideas. Presumably, medication administration is a real social phenomenon worthy of investigation, existing partly of actual structures and people in time and space. It is also a social phenomenon onto which the researcher imposes ideas and values. Some of those ideas and values necessarily must be culturally conditioned; some stem from theory within the field of research. Medication administration takes place in a system consisting of material parts such as buildings and tools, but also of parts less easy to pin down, such as professions, competence, organisational structures, and rules and so on.

Social constructivism as the epistemological basis implies an ontological ground somewhere between anti-realism and realism. Realism claims that the natural world is a construction built on human thoughts, and existence outside of our acknowledgement of the world is possible. Anti-realism claims that our perception of the world is a subjective social construction.

Epistemological beliefs are often based on ontological beliefs. Positivist epistemology flows from realist ontology, pursuing empirical facts corresponding directly to reality. In health research and social sciences, the term determinism is often analogous to positivism, referring to an expectation of mechanistic causal laws and variables — the goal of being able to explain phenomena, to be able to make predictions. Researchers count only objectively observable phenomena; empirical facts are said to use a quantitative methodology. This influences how you research a phenomenon. On the other hand, one can say that a qualitative methodology flows from an idealist ontology. These distinctions are not necessarily clear-cut, as qualitative data can be approached in a positivist, deterministic way, and quantitative data can be subject to qualitative analysis. (Bourgeault, Dingwall, & De Vries, 2010; Bryman, 1984).

As this study combines two qualitative methods, there was no need for different epistemological paradigms.

3.2 Study design

This thesis addresses the complexity in medication administration in nursing homes and a qualitative mixed methods design was appropriate (Morse, 2016).

The use of mixed methods is the incorporation of one or more methodological strategies employed in a single study, to gain comprehensive insights into a phenomenon. By combining methods, it is possible to access parts of phenomena that are hard to reach by a single method. Mixed methods research consists of a core project (QUAL) that may stand alone, and a supplemental component (qual) to expand the perspective of the core component (Morse, 2016).

Table 1: Overview of data collection methods, aims, research questions and analysis

	Ward A		Ward B		Aim	Research question	Analysis
	Obs (70h)	Int (n=10)	Obs (70)	Int (n=6)			
Paper I *Medication administration and interruptions in nursing homes: a qualitative observational study*	x		x		To contribute to in-depth knowledge of the **characteristics** of medication administration and **interruptions** in nursing homes.	How can the medication administration process in nursing homes be described? How can interruptions during the medication administration process in nursing homes be described?	Inductive content analysis
Paper II *Medication administration in nursing homes: A qualitative study of the nurse role*	x	x	x	x	The objective of this study was to expand knowledge of the **nurse role** during medication administration in the context of nursing homes.	How can the nurse role during medication administration in nursing homes be described?	Inductive content analysis
Paper III *A work system analysis of the medication administration process in a Norwegian nursing home*	x	x			To explore the **dynamic interactions of stakeholders and work system elements** in the MAP in a nursing home.	How can SEIPS-based process modelling visualise barriers and facilitators in the work system of a nursing home ward	Deductive content analysis

Data was collected from two different nursing home wards (Ward A and Ward B) in separate nursing homes and led to three papers utilising diverse parts of the dataset. Table 1 shows an overview of the papers with data collection methods, the total length of observations and the number of interviews in the two included wards. Paper I utilised data solely from the QUAL component. Paper II used both QUAL-qual data from both wards. Paper III deliberately used the QUAL-qual data only from Ward A. This was due to Ward A housing patients in need of more medical treatment than the patients residing in Ward B. When performing a SEIPS-based process modelling of the medication administration process, it is most appropriate as an in-depth investigation of a single case to increase the validity of the findings. The QUAL-qual data were mixed during the analysis in Papers II and III.

3.3 The use of theory

Using the SEIPS-model as the overarching framework coincides with the general intentions of a qualitative inquiry, to give a holistic account involving multiple perspectives of processes or a central phenomenon (Creswell & Creswell, 2017). The use of a theoretical framework may range from purely inductive approaches as in grounded theory to more deductive approaches where the aim may be to test a theory or hypothesis. Sometimes both inductive and deductive strategies may apply to a single approach, as in the case of the current study where the theoretical framework provides some deductive insights while allowing for inductive data collection and analysis. More specifically, the SEIPS-model informed the observation guide and the interview guide, as well as providing the theoretical framework for the analysis of Paper III.

In the thesis, the SEIPS-model used as a theoretical framework is not per se a theory dictating causalities or strong interactions. Instead, it is a framework pointing out how different aspects or interactions between individuals, environment, technology, organisations and tasks are interlinked with various processes producing various outcomes. It is a

system-oriented theory. When performing observations and conducting interviews, this model assists the observer in focusing on what is relevant. Thus, the model has a moderate top-down influence on observations but still may affect perception to a certain degree. On the other hand, there is firm bottom-up information in the collected data. The theory may affect the perception of the researcher, but not to the degree where findings are biased if the researcher remains aware of these issues.

3.4 Pilot study

Prior to the recruitment in the main study, a pilot study was conducted over five days in January 2016 in a nursing home facility in a separate municipality from the included wards. The pilot study included 20 hours of observations and four interviews with different staff members. The aim was to gain experience conducting fieldwork and to test the observation guide and the interview guide.

Experiences from the pilot study indicated that it was useful to keep a low level of abstraction in discussions with staff members or when interviewing them. Several questions in the pilot phase gave no real answers as the staff were unaware of the researchers' intention or misinterpreted. For example, when exploring themes such as teamwork in discussions, the staff gave more information when merely talking about "how we work together" or how we collaborate on certain tasks", as opposed to being asked about team structure. The first observation guide that was intended to be used throughout the study was unable to incorporate what happened in the wards. As a result, the guide was altered to be more open-ended, and thus more flexible for practical use.

When the staff members were observed, they seemed eager and nervous the first few times. The use of a notebook seemed especially to put them on guard. These insights and experiences were acknowledged in the main study by taking the time to make small talk to the staff members, and only taking out the notebook when no one was around.

A convenience sample was utilised, and four participants agreed to interviews. When interviewing the staff members, it proved difficult to find the time and suitable locations on short notice, and interruptions during the interviews caused disturbances and loss of concentration in the participants. The interview guide also proved to be too detailed and was altered for the last two interviews to serve more as thematic guidance, thus changing the nature of the interviews from structured to semi-structured.

3.5 Selection criteria and recruitment

When choosing the study setting, several criteria influenced the final decision. Some reasons were based on practicalities such as relative proximity to the research institution so as to facilitate frequent observations. Other reasons were more strategic. Norwegian nursing homes differ in style of management, size and patient types. They are managed independently in each municipality, and a common task for Norwegian nursing homes is active treatment in addition to ensuring that the basic needs of the residents are satisfied (Malmedal, 2014). Nursing homes, in general, cater to elderly populations but are also common locations for rehabilitation, habitation, dementia wards, palliative care and care for special disabilities. In the current study, it was important to capture some of this variety to increase the trustworthiness of the findings. The current study, therefore, sought variation in the form of different municipalities and the type of nursing home wards, patients, and staff composition; two different nursing homes in two different municipalities in Eastern Norway were approached (Maxwell, 2008).

Initial contact with the nursing homes was made by telephone during December 2015. Senior managers at both nursing homes were informed of the objectives and form of the study; they agreed to participate and contacted the wards they deemed appropriate for inclusion. The PhD candidate then contacted the local management of the two wards and briefed them in person. They agreed to participate in the study, and the

PhD candidate arranged a preparatory meeting with the staff at the wards. The meetings took place at the respective wards, and staff were informed of the study and given the opportunity to ask questions. All the staff members were also informed that those working in full-time positions could be asked to participate in interviews at a later stage. After three months of observations, the staff members that fulfilled the inclusion criteria were asked to participate in the interviews. Criteria were that they had a regular position working 50% or more and that they had a role during the medication administration process. In all, 18 staff members, ranging from special care nurses, registered nurses, nurse managers, medical doctors, physical therapist, and nurse assistants were asked. Sixteen participants agreed to be interviewed (Table 2), and they were again informed of confidentiality and of the possibility to withdraw (appendix 3).

Table 2: Professions and distribution of the interviewed participants

	Ward A	Ward B
Professions of the participants that were interviewed.	1 MD, 5 RN's working only day shifts, 1 nurse assistant, 1 nurse manager, 1 physical therapist, 1 RN working night shifts only. (n=10)	1 MD, 1 nurse manager, 2 nurse assistants (one who works only night shifts), 2 RN's. (n=6)

3.6 Characteristics of nursing home wards

The nursing home wards referred to in the thesis are located in two neighbouring municipalities in Eastern Norway. One urban nursing home ward (Ward A) was located in a town of 30 000 inhabitants; the other nursing home ward (Ward B) was in a rural municipality with a total population of 4000 inhabitants distributed across a wide geographical area. Ward A was on the top floor of a building with relatively modern facilities. Ward B was part of a nursing home with

relatively old and worn facilities with variations in modern amenities such as functioning Wi-Fi or air conditioning. The two wards differed in many aspects (Table 3).

Table 3: Characteristics of Ward A and Ward B

Characteristics	Ward A	Ward B
Profile	Palliative care ward with patients in need of complex medical care	Special care unit for persons with dementia
Computer	Different software for electronic medication administration records	
Nurse structure	Primary care nursing	Group care nursing
Staff composition	Nurses, nurses with special competence, nurse assistants, physiotherapist, occupational therapist, chaplain, medical doctor.	Nurses, nurse assistants, medical doctor, healthcare students.
Access to MD	Permanent supervisory MD that resides in the same building complex.	Permanent supervisory MD residing outside of the building complex.
Regular employees	12	14 (across two wards)
Patient rooms	6	10
Type of patients	Palliative patients in need of complex medical care. Short term, from days to months.	Patients suffering from dementia, long-term. Traditional nursing home.
Administration	One nurse manager is responsible for the staff and shift rotations. One clinical nurse in charge of daytime shifts with overall professional responsibility.	One nurse manager is responsible for the staff and shift rotations and has overall professional responsibility.

3.7 Data Collection

The QUAL-qual mixed methods approach (Morse, 2016) to collecting data used partial participant observations (Hammersley & Atkinson, 2007) (core) and semi-structured individual interviews (supplemental). The study utilised a sequential approach (Morse, 2016) beginning with observations that led to insights informing the interviews taking place at the mid-point of the observation period. Information gained in the interviews further identified specific points to pinpoint in subsequent observations.

3.7.1 Observations

The study employed partial participant observations (Hammersley & Atkinson, 2007) in a form that allowed the staff to perform their regular work tasks uninterrupted, but the researcher interacted with the staff members during breaks or as part of the spontaneous natural social interaction. The interaction was often in the form of discussions and questions about their work.

Observations took place twice a week, 2-6 hrs a day totalling 140 hrs from April–November 2016. Most observations took place in the daytime shift and a few on the evening shift and initial hours of the night shift.

As observations progressed, some aspects of the medication administration process were challenging to pinpoint, and clarifications through questions and discussions with the staff members were invaluable. After a day of observations, the notes were transcribed, emphasising thick descriptions of events and situations. Quotations were included to give authenticity to the transcriptions (Lincoln & Guba, 1985).

Certain ethics proved decisive when striking a balance between the roles of involved participant and neutral observer. It was important to interact

with the healthcare workers in a humane, non-exploitative way while striving for neutrality as a researcher. If the staff regarded the researcher a fixture in the corner of the room, critical information might be missed. On the other hand, if the researcher became their "best" friends and confidants, the findings could be biased. Thus, research ethics principles guided the researcher's behaviour towards a middle way where participants parted with information while neutrality as a research observer was retained. This approach is methodologically described as partial participant observation, as the researcher was partly socially active with the research participants during the observations (Bourgeault et al., 2010). The researcher was presented to the staff as a nurse currently working on a project from the local university. By introducing the researcher as a nurse, the staff seemed to relax and somewhat lower their guard. If the researcher was presented as a PhD candidate, some of the staff might be overwhelmed and become guarded and uncertain. If the staff probed further on the nature of the study, they would be briefed in more detail. Towards the end of the observational period, most of the participants knew the title and the nature of the work well.

During the observations, which took place over several months, the researcher gained the trust of many of the participants, and they talked willingly about many issues. Since the researcher is familiar with the field of healthcare, the staff did not need to explain specific terminology, allowing for discussions and questions that seemed important to them. As the staff grew confident in the researcher and his ability to maintain confidentiality, situations arose where the staff member disclosed vulnerabilities. They talked about their relationship with their closest leader, they could complain about patients, and they could reveal their faults in practice. As this happened increasingly, the question of research-ethics naturally arose. Before commencing the study, an agreement was reached with the administrative and clinical leaders of the nursing homes that if any actions that could harm the patients were observed, the researcher would intervene.

In the current study, the theoretical framework functioned as a guideline during data collection and when writing up the field notes. Strategies to ensure that the observations were reported objectively included making notes during observation sessions using neutral language, and keeping the interval before final transcription of the field notes as short as possible. (Hammersley & Atkinson, 2007; Maxwell, 2008).

The observation guide (appendix 1) was based on the SEIPS-model, incorporating keywords from the five elements in the work system (Persons, tasks, tools & technology, organisation, physical environment), and was intended to function as both a framework and a cognitive reminder.

The guide was functional as a reminder of the overall complexity and interconnectivity in the work system. During the pilot study, it was challenging to operationalise the keywords listed in appendix 1. Some keywords such as knowledge or competence lacked clear definitions and were based on how the researcher perceived the staff members' ability to cope in different and challenging situations.

An example was that when staff members were performing an unfamiliar medication-related task, they would first try to find out how to do it. This could entail asking colleagues for help, searching for guidelines in folders, or searching online. Observation of this seemingly simple activity related to the different elements in the work system. This is exemplified in appendix 1, which shows how the SEIPS-model was instrumental as a framework during observations, helping the researcher to view activities from multiple perspectives.

3.7.2 Interviews

Halfway through the observation period, the staff working full time in both wards were interviewed. A time was scheduled in advance and the interviews, lasting from 30-80 minutes, took place in a separate room in

one of the wards. Half of the interviews were transcribed by the researcher, while a professional service transcribed the other half. Names of the participants were replaced with identifiers such as "Nurse 1 at Ward B".

During the interviews, an open approach was adopted, where the participants were encouraged to talk about different elements relating to medication administration in their daily work. An interview guide (Appendix 2) was used actively to steer conversations towards topics of interest. Examples of questions the researcher might ask if conversations drifted unintentionally away from the topic were given under keywords and headings related to the SEIPS-model. At the end of each interview, the participants were asked if there were any special situations they had experienced that they wanted to talk about. Due to the nature of conversations, not all the interviews progressed similarly, but the intended essence was captured throughout the process.

In advance of the individual interviews, certain points had emerged from the prior observations that led to some questions being formulated to clarify aspects of the medication administration process. For example: "Some days ago, I saw that you moved the medication trolley to the common dining area while you prepared medications. Could you elaborate on this?"

During the interviews, some participants seemed to create a narrative putting them in a favourable light, in contrast to prior observations. One interpretation could be that the participant wished to reflect positively on the ward and his/her colleagues. Patient safety is generally regarded as critical by all stakeholders, and it may be a sensitive topic with underlying tensions as the staff desire to uphold high standards at all times (Kangasniemi, Vaismoradi, Jasper, & Turunen, 2013). When queried on sensitive issues, participants may have felt vulnerable, creating uncomfortable situations that led them to embellish the truth. It may also be that the situations observed were misinterpreted by the

observer, as the staff's intentions are an invisible element. A third alternative is that the participants wanted to please the interviewer, or wanted to "win me over to their side" as described by Allmark et al. (2009). The presence of an observer will influence the participants' behaviour, often in such a way that they will put up a façade corresponding to what they believe is expected of them. The interviews could thus moderate this effect somewhat by triangulating with the findings from the observations (Lincoln & Guba, 1985).

3.8 Data analysis

The QUAL-data consisted of 120 pages of transcribed observation notes based on 140 hrs of observations equally distributed across Ward A and Ward B. The qual data came from 16 individual interviews, 10 from Ward A and 6 from Ward B.

Data from the QUAL-component, the observations, were used in all the published papers, while Papers II and III utilised the supplemental data (qual) from the interviews as well. Paper I and II utilise an inductive content analysis, while Paper III utilises a deductive content analysis. Paper III used data solely from Ward A.

The data analysis process took place in 11 stages outlined in Figure 2. Stages 1−5 and 10−11 are shared for both the inductive content analysis and the deductive content analysis while stages 6−9 differ. Integration of the QUAL-qual components took place in stage 7.

1) The transcribed observation notes and interviews were read with a focus on the manifest content multiple times by the research team to gain an overall impression.

2) The research group met to discuss prevalent themes and possible research questions.

3) Several topics of interest were scrutinised, but the complexity of the medication administration process, the recurrent interruptions the staff suffered, and the involved role of the nurses were most noticeable and critical for further investigation. Research questions to answer the overall aim of the study were discussed, and an analytical approach was decided.

4) The units of analysis were Ward A and Ward B.

5) Based on the specific aims and research questions in the three papers, relevant meaning units were identified. These ranged from one sentence to small paragraphs.

3.8.1 Inductive content analysis – Papers I and II

In this thesis an inductive content analysis was utilised for Papers I and Paper II, based on the method described by Elo and Kyngäs (2008). Numbers followed by an A indicate the steps in the inductive content analysis.

6.a) The first step in the inductive content analysis is the organisation of the data, including open coding, to enable the creation of subcategories and categories (Elo & Kyngäs, 2008). These codes changed under while to achievie appropriate significance in relevance to the content.

7.a) Based on the codes, a variety of subcategories were created. At this stage, data from the observations (QUAL) and the interviews (qual) were integrated (Paper II).

8.a) The codes were collapsed based on similarities, forming categories that were mutually exclusive. This was challenging as many elements overlapped, leading to an iterative process going back and forth and exchanging ideas in the research team to achieve the

most correct interpretation of the data. Categories were named by creating content-specific words conveying the meaning of the contained subcategories.

9.a) Abstraction of the identified categories involved formulating general descriptions and a continued iteration going through stages 7a − 9a several times.

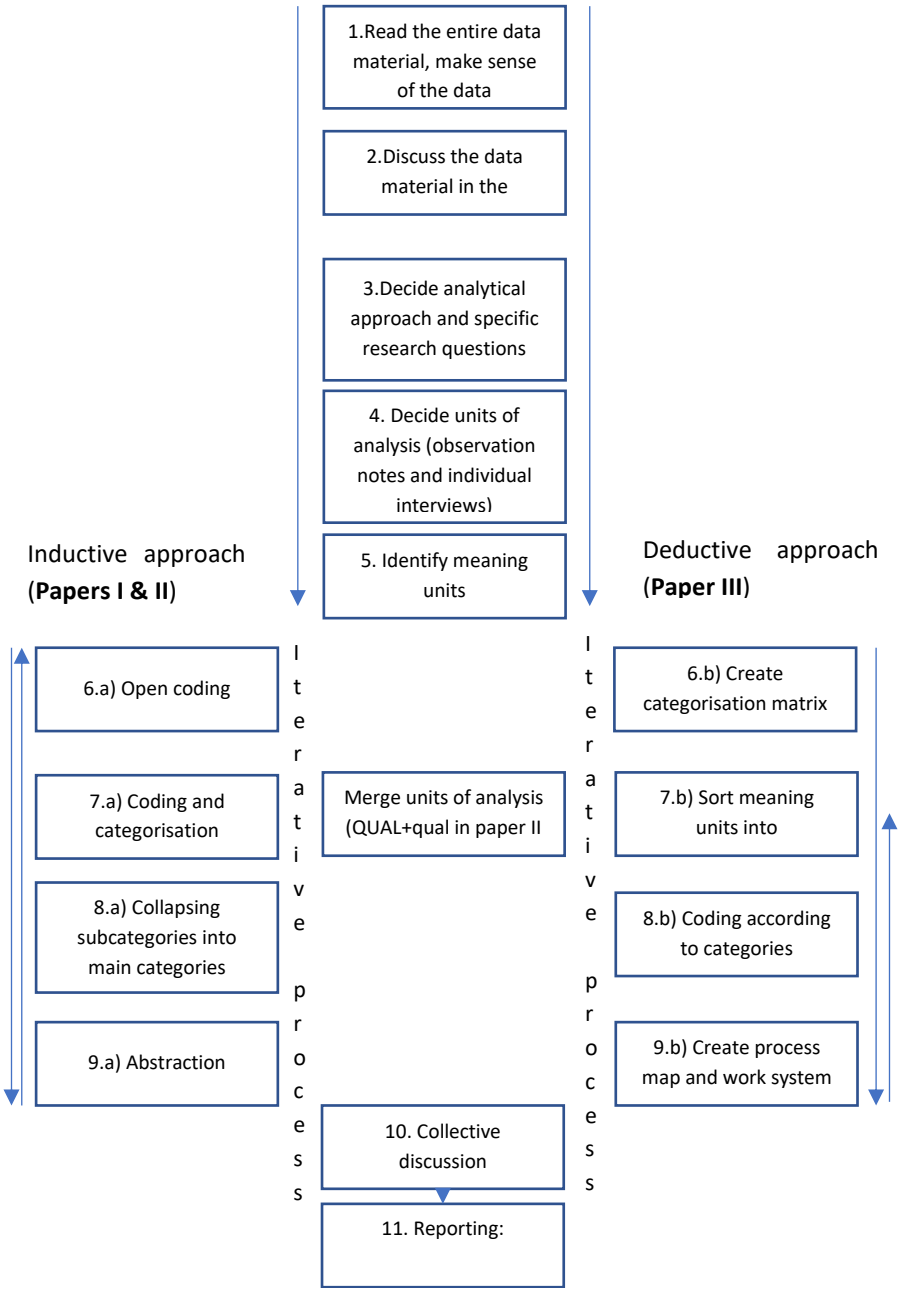

Figure 2: The data analysis process

3.8.2 Deductive content analysis- Paper III

Paper III differed from the first two in that it utilised a deductive content analysis. The deductive content analysis was based on the description given by Elo and Kyngäs (2008). Numbers followed by a B indicate the steps in the deductive content analysis.

6.b) First, all the meaning units were sorted into a categorisation matrix, creating a massive table. This matrix was based upon the six stages of the medication administration process (rows) and the five elements in the work system of the SEIPS-model (columns).

7.b) The meaning units were coded and then collapsed into the pre-existing categories, creating a much more compressed matrix with the potential to inform the investigation. After theory has guided the initial coding scheme or categories, the operationalisation of codes is a vital step. The operationalisation is determined by the underpinning theory and guides the researcher when analysing text data. All the categories in the matrix were reviewed several times until they corresponded with the bounds of the matrix.

8 - 9.b) The matrix was used to process map the medication administration process with an emphasis on the involved stakeholders. The work system analysis (Paper III) used the matrix (table 4) extensively to identify facilitators and barriers and to create a table analogous to the categorisation matrix to present the results.

Table 4: The data matrix used in the analysis, with examples in each category

	Tools & technology	Tasks	Physical environment	Organisation	Persons
Ordering	The doctor uses a separate module in the computer system, unavailable to the nurses.	The head nurse reads up on all the patients before the doctor arrives	The nurse station is too small when more than two persons attend.	They plan medication for the weekend, anticipating a worsening of the condition.	It feels good having colleagues you trust
Transcribing	The codes in the electronic administration record system take time to learn by heart.	The nurse prints out the documents the doctor has prepared	A long distance to use the fax	The medication record from the hospital is bewildering	You need intimate knowledge of the different drugs to transcribe efficiently
Dispensing	Only one nurse has access to the computer system used to order medications	Multidose may lead to errors if there are many changes	The medicine room is cramped, and locating the correct medication takes time	The medication is transferred to pill dispensers on certain weekdays.	Sometimes coincidences lead to awareness of lacking medications
Preparing	When checking against the electronic medication administration record, the nurses print out an extra copy	Double checking occurs when nurses remove medications from the pill dispenser.	Noisy in the nurse station, interruptions are normal	There is a lack of double control when preparing drugs on night shifts	It is easy to make a mistake when the workload is high
Administering	It would be beneficial to have a iPad to document while administering medications	We try to explain to the patients what medication we are giving.	The medication is administered in the common room, many people and high level of noise	Areas of responsibility are not always clear	The doctor trusts the nurses to make judgements
Observing	It can be hard to retrieve relevant documentation	There are many demands on documentation	There is a constant need to move around to keep oriented	A lack of personnel on night shifts leads to poor observations.	There are individual variations in how the staff document the effect of medications

10) In this stage, the research group met to discuss and review whether the findings answered the research questions adequately.

11) Properly reporting the findings included the final write-up of the papers in a way that ensured the trustworthiness of the analysis.

3.9 Researcher role

The PhD candidate is a male intensive care nurse with over ten years of experience from nursing homes, hospital wards, intensive care wards and four years as a lecturer in nursing studies at university level.

Such professional experience entails an intimate familiarity and inside knowledge of healthcare systems in general and medication administration specifically. This familiarity may have assisted the research progress as unusual conditions or functions were easy to identify. It may also be that familiarity with the field desensitised the researcher to regular work activity, and another researcher without healthcare background would have found different aspects on which to focus (Bourgeault et al., 2010). Measures to prevent the researcher role from dominating included reflexivity; an awareness of the researcher role, the interaction with the participants and of the possibility to influence or bias the surroundings and the data collected (O'Brien, Harris, Beckman, Reed, & Cook, 2014).

3.10 The research team

The research team consisted of the PhD candidate and the three supervisors with diverse backgrounds from nursing education, safety science and intensive care nursing. During the study, the team had regular meetings to evaluate (the preliminary findings) and plan the progress. Regular meetings became especially important during the data collection and the analysis to discuss and triangulate the findings.

3.11 Ethical issues

Descriptions of the fieldwork, the observational guide (Appendix 1) and the interview guide (Appendix 2) were sent to NSD along with an explicit statement that all research was conducted according to the Declaration of Helsinki (World Medical Association, 2013). No sensitive information on any patients or health care workers or any sensitive groups were involved, and NSD approved the study (No. 45389) (appendix 4). The approval of the ethics committee was not required.

All participants in the study were recruited voluntarily with the possibility to withdraw from the project at any point in time. Before the data collection, healthcare workers in the participating nursing homes were invited to an informal informational meeting. There the main points of the study were outlined, and the participants could ask questions. They were once again informed that all data would be handled with confidentiality and of the possibility to withdraw at any time. An informed consent form was distributed to all employees, but they were not required to sign it (Appendix 3[2]). If participants did not withdraw, that was deemed consent. No one chose to withdraw during the study. However, two participants that met the inclusion criteria did not wish to be interviewed.

A critical ethical issue was that if the researcher observed situations with the potential to harm patients, these should be reported. As a nurse and a researcher, there is an obligation to adhere to nurse ethics (Norsk Sykepleierforbund, 2011). These state that one cannot let harmful actions hurt patients, and that one is always obliged to offer help or assistance when needed. One example of this arose during the pilot study when witnessing a patient being given the wrong medications, with the

[2] The form was created in an early stage of the project and reflects a focus on teamwork during medication administration. Experiences from the first stage of observations resulted in a narrowed focus towards solely medication administration.

potential to harm. The researcher discreetly asked the involved nurse if she had double-checked the medication against the prescription. She proceeded to do so, realised the error and rectified it. By getting involved in the situation, researcher ethics may have been breached, but this was necessary according to nursing ethics. This is an example of a situation in which organisational, professional ethics are overriding according to Guillemin & Gillam (2004). Such behaviour can serve to gain the researcher respect from the participants, or it may serve to alienate. There were several examples in the interviews where staff members described activities challenging safe medication administration. During the observations in the main study, there were no occasions that arose necessitating intervention to stop adverse drug events. There were, however, several situations where staff members made medication administration errors, without direct consequences for the patients. Examples were how some documentation tasks were delayed, or how some nurses circumvented procedures to increase efficiency.

3.12 Research quality

The most common criteria to ascertain validity in qualitative research were developed by Lincoln & Guba (1985), who termed it trustworthiness. In their definition, trustworthiness aims at supporting the argument that the "inquiry's findings are worth paying attention to". In other words, trustworthiness is all about researchers reporting the research process as accurately as possible. Credibility, confirmability, dependability and transferability are extensions of the term trustworthiness. To ensure trustworthiness, all the steps in the research process are thoroughly described in this thesis.

To limit bias in the fieldwork and the impact on the research findings, the researcher was attentive to how the data were interpreted and was aware that the field had an impact on him and that he was affected by the study setting in turn (Bourgeault et al., 2010).

This thesis used Human Factors theory as a theoretical framework, and dependability and confirmability may, therefore, be strengthened, so that other researchers at other times will be able to use the same framework when doing similar studies. If the theoretical framework or research data is confirmed or soundly adapted to work in a specific setting, this can also improve arguments of transferability and generalisation (Lincoln & Guba, 1985).

3.12.1 Credibility and confirmability

Credibility is ensured by the accurate identification and description of those participating in the study. It also concerns how accurately the data and the analysis process address the overall aim of the study. These points have been well considered throughout the study by providing an explicit description of the entire research process so that external readers may assess the interpretations of the findings. Awareness of the researcher's reflexivity has also been made explicit, including awareness of the researcher role, preconceptions and personal background.

The selection of two different nursing home wards with participants having different backgrounds and experience increases the possibility of illuminating the research question from different angles and perspectives, thus contributing to a rich variety of descriptions of medication administration in nursing homes. Moreover, several methods of data collection, observations, conversations and interviews, elaborate on the variety and enable the researcher to answer the research questions credibly. To further support the credibility, Papers I and II contain multiple representative quotations from the transcribed text material. By introducing individual interviews of various central stakeholders at the mid-point of the data collection period, member checks of early interpretations of the observation data helped clarify and elaborate identified issues (Lincoln & Guba, 1985). Member-checking continued during the remaining observation period through conversations, questions and direct observations of the stakeholders. This facilitated the

moderation of the researcher's interpretations and an accurate description of the medication administration process. Objective research results are the hallmark of the term ‘confirmability’, and a criterion is if multiple observers agree on a phenomenon. In the current study, the observations were made by a single researcher, but by involving different researchers in analytical triangulation, joint interpretations and discussions throughout the research process, achieving confirmability was a high priority (Graneheim & Lundman, 2004).

3.12.2 Dependability

Dependability refers to the stability of the data over time and shifting conditions (Lincoln & Guba, 1985). The observations were made throughout six months, ensuring persistent observations. By using a theoretical framework in guiding the data collection, consistency over time was less of a problem since a single focus was easier to maintain. At the same time, the overall understanding and interpretation of the findings evolved, facilitating a narrower focus towards the end of the data collection period. The nursing home wards reported stable staff conditions and few external drivers enacting any significant changes in the period before or during the data collection period.

3.12.3 Transferability

Transferability refers to the potential for extrapolation, generalisation or transferability to other settings or groups (Lincoln & Guba, 1985). The descriptions of the nursing home wards in the study are context specific, but there are reasons to believe the main findings are still valid for a wide range of healthcare institutions. The main reason is the rich descriptions of the study setting and the variety the included wards provide in respect of a representative, general account of the medication administration process in nursing homes. The findings in the thesis reflect international literature on medication administration in nursing homes.

3.13 Methodological reflections

In retrospect, some issues could have been handled differently to enhance the overall study design and trustworthiness. Two nursing homes represent a small sample and present marginal opportunities to generalise the findings, but as stated in Chapter 3.5, this was a deliberate choice. The positive trade-off was the in-depth study of medication administration on a micro-level, which provided several insights that may otherwise have been missed.

The use of a single researcher during observations introduces limitations to inhibit biases. If two or more researchers with different backgrounds had observed, it would have allowed for a more extensive data collection, more possibilities for triangulation and would have limited bias. However, more researchers in the field would also have introduced other challenges. Staff members in the two wards might have experienced the researchers' presence as more intrusive, which would have influenced their behaviour to a greater extent.

There is a danger when initiating research with a theoretical framework or basis that the findings can be biased. In other words, you are more likely to produce data in support of the underlying theory than the opposite. It can also result in researchers overemphasising theory, blinding them to the contextual aspects of a phenomenon (Hsieh & Shannon, 2005). The flip side of this coin is that, by using a pre-existing theory, the researcher can identify aspects that would otherwise go unnoticed. Theory directing attention processes is probably more likely to affect observations. Both the research question and the theoretical framework will steer attention towards structures and phenomena of interest. Thus, the researcher will pay more attention when social interactions occur that can give insights into the medication administration process.

Another limitation is that during the observations, due to practical issues, mostly day-time shifts were covered. It is possible that more

observations during evening shifts, night shifts and weekends would have provided different or more comprehensive insights.

Since a part of the study revolves around describing both the specific and the generic medication administration process, it would have been a strength to use the staff members to member-check the findings at the analytical stage. Due to practical considerations, this was not possible. The use of central documents in the medication administration process was considered at a late stage in the research progress but lacked ethical approval. The study could have benefited from using strategic documents from the quality system and from management to compare with actual findings from interviews and observations.

There were several options available for the analytical methods. The reason for using content analysis as described by Elo and Kyngäs (2008) was their pragmatic and practical instructions on how to perform both inductive and deductive content analysis of qualitative data material. Alternative approaches that were considered are described by Graneheim & Lundman (2004) and Hsieh & Shannon (2005).

This study could also have been more comprehensive if it had contained data from the most important stakeholders of all – the patients. Patients were not the focal point, due to design choices focusing on the professional stakeholders. Patients are central in medication administration and the work system of nursing homes. Since the patients are central to understanding the medication administration process completely, they should be included in future studies.

The use of a Human Factors framework throughout the study is described in detail in previous chapters (Chapter 2.1), but it is conceivable that other perspectives could have gained other or more interesting insights into the medication administration process. It is also possible that the use of grounded theory could have introduced new information. However, since the aim was to explore the complexity of the medication

administration process, Human Factors stood out as an appropriate framework from the outset.

On several occasions, the management in both nursing homes were asked whether any statistical material on adverse events was available. The answer remained negative throughout the investigation. An interesting next stage in the study could have been the use of questionnaires to investigate patient safety culture and attitudes among staff to medication administration.

The interview guide was semi-structured. It is possible that a structured interview guide would have enhanced the possibility of comparing the individual interviews. This would also allow for a comparative study between the two nursing home wards. However, as the aim was to use a Human Factors approach to explore the medication administration process in nursing homes, a comparative study did not align with the paramount aim of the thesis.

4 Results

This chapter gives an overview of the findings in the three papers in the thesis and elaborates on the relationship between the papers and the overall aim of the thesis: To use a Human Factors approach to explore the complexity of the medication administration process in nursing homes, thereby contributing to preventing adverse drug events.

By using the SEIPS-model to provide an overarching view of the three papers, the main characteristics of the work system are presented in Table 5. These characteristics influence shifting configurations of the medication administration work system.

Table 5: An overview of the characteristics of the medication administration process distributed across the work system in the nursing home wards (Roman numerals refer to paper I, II and III)

Persons	**Physical environment**	**Tasks**	**Tools & technology**	**Organisation**
Roles vary according to situations (II) The competence varies (II) Shifting responsibility (II) Flexibility is a necessity (II) The nurse compensates for other staff members (II) Team structure is random (II)	Alarms and noise are prevalent (I+III) Passive and active Interruptions (I) Medicine room is distant (I+III) Mobile medication trolley (I+III) Small nurse station (I) Cluttered work	Non-linearity of the MAP (I+III) Great number of single tasks (I+III) Variation in how similar tasks are performed (I) Double documentation (III) Freedom of how to perform tasks (I+II) Multi-dosage poses challenges (I+III)	eMAR functionality is inadequate (I+III) The use of mobile applications varies (I+III) Technological interruptions (I) Second-rate technological solutions (I) Analogue solutions in parallel with digital	Continuity and staff stability are rated important by staff members (II+III) Familiarity with the system facilitates effectiveness (III) Workload impacts performance (II) Vulnerable shifts on nights, weekends and vacations (II+III)

Random task delegation (II) High nurse competence facilitates the MAP (III) Independent decision making (III)	environment (I+III)	Many different persons involved (III) Double-check is performed sporadically (I+III) Documentation is time-consuming(I+III)	solutions (I+III)	Management must be adaptive (II) Fluid leadership (II) Normalisation of deviant behaviour (I) Interprofessional collaboration varies (I+II+III) Training opportunities are sparse (II)

Conditions in the work system such as interruptions and cluttered work environment (physical environment), high workload (organisation), non-linearity (tasks), and second-rate technological solution (tools & technology) influence the persons (staff) in the centre and their ability to be flexible and adaptive. The surrounding elements in the work system are not static but are slowly evolving, while the centre element acts rapidly to shifting system configurations to balance the work system.

The persons in the centre of the SEIPS-model possess different characteristics. For instance, some are highly competent, flexible and creative and able to take up different roles according to shifting circumstances. On the other hand, other staff members seem to have inadequate competence and teamwork and task delegation is fluid and appears reactive rather than pro-active.

The physical environment affects how and where the staff perform tasks related to medication administration. Long distance to the medicine room, makes the use of mobile medication trolleys common.

Consequently, a considerable part of cognitively challenging tasks take place in cramped, busy environments characterised by different kinds of interruptions and a cluttered workspace.

The tasks involved in medication administration are perceived differently; nurses regard the tasks as complex and challenging, while the nurse assistants tend to view medication administration as more linear and rule bound. Medication administration involves multiple stages and many single tasks, and most of the identified facilitators and barriers seem to be found during ordering and transcribing.

The tools & technology often pose challenges to the staff of the nursing homes. Most prominent is the poor design of the electronic medication administration records. For example, to document the effect of on demand dosing, there is a separate module within the eMAR, not connected to the main medical records. This often leads to double documentation and creative workarounds, and in some instances delays or omissions of documentation.

The organisation is characterised by fluid leadership and inadequate guidelines and procedures relating to medication administration. There are periods with high workload and insufficient staffing that create vulnerable shifts, increasing the risk of medication administration errors. To overcome such high intensity, periods the staff create shortcuts and workarounds. Workarounds and the acceptance of inferior work-conditions become normalised. The staff highlight stability and continuity as vital to performing their tasks safely.

The attributes of the persons, physical environment, tasks, tools and technology and organisation do not exist as isolated cells of the work system, but they interact in often subtle ways and must, therefore, be seen

as a whole. For instance, distances, high workload or pragmatic planning result in the staff preparing medicines in the nurse station, in proximity to other care related activities and colleagues. Due to perceived time restraints and technological challenges, documentation may be postponed or performed in an alternative fashion. A lack of visible leadership, and inadequate guidelines, provide the nurse with a freedom and flexibility to coordinate and perform many medication-related activities at will. In some cases, the freedom and flexibility provide a safety net, while in other cases it creates vulnerabilities that may enable medication errors to occur.

4.1 Medication administration and interruptions (Paper I)

In this paper, medication administration in two nursing home wards was studied. The objectives were to describe the medication administration process, and to investigate how interruptions during medication administration may be described.

The medication administration process in nursing homes is complex, and has a high number of single tasks, a varying degree of linearity, different technological solutions, and involves continuous interprofessional collaboration. There are high demands regarding documentation, and the staff has apparent freedom as to how and where to perform medication-related activities. A process map depicts the medication administration process (see Figure 1 in Paper I).

Interruptions are normal and can be characterised as active, passive or technological. Active interruptions are instances where work on a primary medication task was disrupted. It could be due to staff asking direct questions, answering incoming calls or spontaneously engaging in conversations. Most often, the interruption of a primary task led to a

break before resuming. Sometimes it could lead to the staff member taking on a secondary task, while the primary task did not always resume after that. Active interruptions often took place in environments where the staff congregated, such as nursing stations and common rooms. Furthermore, active interruptions could lead to both negative and positive outcomes. The latter could be instances where informal conversations led to the staff discussing medical issues, resulting in changes in medication on treatment plans.

Passive interruptions are cognitive stimuli with the potential to affect concentration, but not necessarily breaking workflow. Most common passive interruptions included background noise and activity while staff members perform tasks in the proximity. On occasions where stimuli disrupted staff, the interruptions would transform into being active interruptions. Passive interruptions were quickly normalised as a common part of the daily medication work tasks.

Technological interruptions arise from the use of tools and technology rather than as an endpoint such as incoming calls or alarms. Three variations of technological interruption were prevalent. First, the use of electronic medication administration records was often perceived as overly complex and disrupting the workflow. There were often lengthy logins when individuals switched between software to document actions at a stage in the medication administration process. Second, the staff used paper documents in addition to the electronic medication administration record. This behaviour and the demands regarding documentation were perceived as disruptive to the workflow. The alternation between modes of documentation also led to challenges in the retrieval of information in a timely fashion. Third, the staff used mobile applications to assist them in various tasks. However, this depended on flawless wireless connections, which was not always the case.

To summarise, Paper I documents that most interruptions have adverse outcomes while some have positive outcomes. Complexity in the

medication administration process seems universal, and interruptions are normalised. Due to the inherent complexity of the work system, a deeper understanding of nursing homes is vital before implementing interventions to minimise medication administration errors and remedy adverse drug events associated with interruptions.

4.2 The nurse role during medication administration (Paper II)

In this paper, the objective was to describe the nurse role during medication administration in nursing homes. During the qualitative analysis, three categories emerged. The nurse role could be described as compensatory, flexible and adaptable. Each of these categories bears similarities but differs in the detailed description of the different aspects of the nurse role. Furthermore, there is a dynamic interaction of several contributory factors detailing how the nurse role is integral in medication administration.

On an individual micro-level, the nurse role is compensating. This entails first and foremost that the individual staff member is affected by the competencies of the surrounding staff. The nurse in charge is left to compensate for the degree of skills and competencies of their team members. This often manifested in a shifting responsibility, where nurses often took on tasks beyond their work descriptions to ensure all medication-related tasks were fulfilled. Furthermore, the patients were reported to have more complex diagnoses and more advanced medical treatment than before. This evolution has led to the nurses taking on more responsibilities and a perceived need to update their competence. The need for updated competence was set against a long-term situation in the wards with inadequate resources that inhibited competence development in the staff.

On a team level, the staff experienced flexibility in how they structured their workday and performed medication-related activities. Tasks in the

workgroup on specific shifts were delegated differently in line with shifting circumstances. This delegation of tasks also depended on skills and competencies, as well as the professions present on a given shift. Sometimes this led to a vulnerability in the ward if the team lacked skill redundancy to perform critical medication-related tasks. The lead nurse was often engaged in performing administrative tasks, shifting many of the medication-related tasks to the remaining staff.

On an organisational level, it proved crucial that the nurse continuously adapted to changing workloads during the various shifts. Furthermore, staff stability and vulnerable shifts were identified as critical to safe medication administration. Staff stability was reported as especially important in periods of high workload. Working together with colleagues they knew well, and whose competence and skills set they could depend on helped reduce the overall workload, and they felt less stressed.

The registered nurse has a central role in all the stages of medication administration, and this role goes beyond the job description. Varying workload, staff stability, the degree of leadership, available competence and dynamic events in the workday are compensated by the registered nurses in order to ensure fulfilment of all tasks related to medication administration. Performance variability in the work system aims to be proportional to the system complexity, but this is not always the case. The seeming resilient behaviour nurses exhibit may be brittleness, as they operate on the invisible borders of safe medication administration. Identifying normal operations and first-hand knowledge of the clinical setting is paramount before implementing any interventions.

4.3 A work system analysis of medication administration (Paper III)

In this paper, the objective was to map out barriers and facilitators to safe medication administration in nursing homes, by using SEIPS-based process modelling.

The major stakeholders in the medication administration process are registered nurses, medical doctors, other staff members, the pharmacist and the patients. Of them, only the registered nurse is involved in all the stages of the process; 1) ordering, 2) transcribing, 3) dispensing, 4) preparing, 5) administering, 6) observing and documenting.

In a SEIPS-based process modelling (Figure 2 in Paper III) and accompanying work system analysis (Table 1 in Paper III), over 60 barriers, dual traits and facilitators were identified and described. The SEIPS-based process map differs from the one described in Paper I (Figure 1, Paper I) in that it focuses on the relationship and interactions of the involved stakeholders throughout the medication administration process. At the same time, it shows a figurative representation of factors that may influence the medication administration process. These factors are described as facilitators, barriers and dual traits, and are elaborated on in the accompanying work system analysis, to make a holistic representation of the medication administration process.

There are relatively few facilitators and dual traits across the elements (persons, physical environment, tasks, tools and technology, organisation) of the work system, but a considerably higher number of barriers associated with the elements tools and tasks. One important facilitator is how the use of mobile devices with electronic medication administration record functionality would significantly enhance the medication administration process in both the ordering and preparing stages. Membership stability is identified as another facilitator, allowing the staff to prepare for vulnerable shifts, such as weekends.

Most of the barriers were associated with documentation tasks in the first two stages, ordering and transcribing of the medication administration process, and many of those were linked to the use of technology. Examples are lengthy login times, poor search functionality and separate modules for the registered nurse and the medical doctor in the electronic medication administration record. Indications are that the first stage of

the medication administration process is especially vulnerable to medication administration errors. Medication administration errors in the first stage of the medication administration process have the potential to cascade and cause sequential errors and adverse drug events at a later stage.

Dual traits are introduced as a novel element, describing activities that can act either as barriers or facilitators depending on the individuals and shifting circumstances. Dual traits to safe medication administration are tied to how individual staff member's knowledge, personality and competence vary and influence how they perform their tasks in different situations. Examples are how the workflow in the electronic medication administration record depends on the staff knowing certain codes by heart.

The process map and the accompanying work system analysis illuminates how and where measures might be taken to improve the quality of care, professional stakeholders' satisfaction, as well as patient safety issues related to medication administration. The paper also contributes to an innovative approach to how a SEIPS-based process modelling may assist in research and clinical improvement work.

4.4 Medication administration errors

The papers had a focus on understanding the medication administration process, and not on uncovering medication administration errors or specific outcomes such as potential adverse drug events. However, the empirical material in the three papers provides documentation on how characteristics of the work system may hinder or allow medication administration errors to occur. These characteristics, as shown in Table 5, are related to the different types of unsafe acts described in tier one of the HFACS (Diller et al., 2014). For example, fluid leadership is a characteristic in the work system element "organisation". and is

associated with a failure of leadership in tier three of the HFACS that may lead to decision-based errors.

Unsafe acts are classified as decision-based errors, skill-based errors, perception errors, routine violations and exceptional violations. The following examples are drawn from both wards, indicating that even though the wards differ in many ways, medication administration errors are common.

Decision-based errors may occur when staff members have inadequate knowledge or information to perform a certain medication-related task.

Inadequate competence is illustrated in a case described in an interview, where the nurse had little prior experience of a drug they were about to administer. Rather than waiting six hours between doses, as prescribed, the nurse gave it in 90-minute intervals throughout the shift. The failure was later pointed out by a colleague. This error occurred due to a lack of specific knowledge of the medication procedure and may relate to a lack of communication and inadequate training.

In the following excerpt from an interview, the nurse describes how they ended up administering the wrong dose to a patient:

If you do not have adequate knowledge of the drugs you are giving, you may make mistakes. Also, sometimes the medicine charts are ambiguous. In one case, a colleague of mine gave oral morphine wrongly. There was some uncertainty if it should be ml or mg and then…well the patient received 10 times the prescribed dosage. It turned out the nurse did not know the drug, so when the dosage was measured, the nurse did not react in any way.

Characteristics that may have contributed to this situation are variations in competence, lack of familiarity with the systems and sparse training opportunities.

Skill-based errors are often due to repetitive tasks that may induce slips in the concentration of the nurse, causing the error. Examples of associated characteristics in the work system are noise, interruptions, cluttered workspace and high workload. An example from the empirical data describes how a nurse forgets to administer painkillers to one of the patients during an entire shift. He/she later explains that it was due to many distractions, high workload and stress.

Perceptual errors may be caused by characteristics in the physical environment, such as inadequate lighting, noise, similar labels or unclear documentation but may also be due to personal sensory inadequacies such as degraded hearing, cognitive impairment or poor eyesight.

Staff members complained several times about how documentation was often ambiguous and open to interpretation. Sometimes this was due to information being stored in several places, while at other times it was due to illegible handwriting.

Routine violations are analogous to the normalisation of deviant behaviour. Sometimes, this may be related to fluid leadership and how the staff perceive current rules and guidelines as exemplified in this excerpt from an interview with a nurse:

It happens that you forget, I mean that you're late with medications or that you've forgotten to register some opiates….We know the rules but….and when it happens, we only get a reminder from the management, with a link to the current guidelines or routines.

Some routine violations seem to be due to practical concerns where the nurses recognise a workaround as beneficial, as described in this excerpt from an interview with a nurse:

Sometimes we administer morphine four times during a shift. You do not document the effect every time. If you understand that the patient still

needs more, you document that, so your colleague does not have to begin at the bottom rung of the ladder again.

The failure to document the effect in line with the procedure may also be due to a failure of leadership or be a symptom of the current organisational climate.

Exceptional violations were observed on a few occasions as illustrated in the following observation note:

During the doctor's visitation, they discuss a patient, described as somewhat difficult and challenging. The nurse informs the doctor that the patient does not like how morphine works. The nurse then says that it does not matter; we call it paracetamol and give it anyway.

In another example, two nurses are uncertain whether the drug they are about to administer is the right one. They argue that the drug has a striking similarity to another drug and check it against a register. Afterwards, they are still not certain but decide to administer it to the patient anyway. In this case, it was never determined whether the patient received the correct drug. These cases can be classified as exceptional violations since the act was wilful and against the rules. In the latter case resolving the issue would have simply entailed discarding the presumed correct medication and retrieving a new one from the original container.

Both wards represented in the study had a system for reporting adverse events to the management. Staff members said that they did not always use it since they did not always find a sound reason to do so. Moreover, staff members reported that they perceived that the management seldom learned from the incidents or made any targeted quality improvement efforts based on prior incidents. The staff were supposed to reflect on recent adverse events weekly, but this was seldom the case.

5 Discussion

This chapter discusses selected issues identified among the findings and is structured according to the elements of the medication administration work system of the nursing homes. The concluding section of the discussion discusses possible ways of preventing adverse drug events, reflecting on the identified characteristics of the medication administration work system in nursing homes.

5.1 The medication administration process

Paradoxically many of the staff members did not perceive the medication administration process as overly complicated, as they focused on the single task of handling the medicines for the patients. True awareness of what the medication administration process consisted of therefore varied greatly. Some focused on the six rights of safe medication administration (Yoost et al., 2015), and others focused pragmatically on the tasks at hand in the preparing and administering stage. Those with a complete view of the process were nurses in charge as team leaders and with administrative responsibility. They perceived all the extras of medication administration, as they had to relate to a range of factors within the work system: the medical doctor, the pharmacy, they had to take inventory in the medicine room, and they needed to know changes in planned medications. They needed a situational awareness that encompassed the entirety of the clinical activity within the ward to perform their tasks effectively. Part of this situational awareness was how the nurse, in preparation for the arrival of the medical doctor, conducts a series of activities before the first stage in the medication administration process. The pre-stage of the medication administration process has not been described in previous literature (Carayon, Wetterneck, Cartmill, et al., 2014; Huang & Gramopadhye, 2014; Qian et al., 2018) but demands considerable time and effort from the nurses. This often comes at the

expense of the other staff members who must **compensate** with increased activity in the ward to ensure that the daily tasks are done.

Since many barriers, such as double-documentation or active negative interruptions are associated with the initial stages of the medication administration process, it is conceivable that these may cause medication administration errors. One example from the current study may be how the nurse in charge makes notes in a separate book from the official electronic medication administration record, and later forgets to document this properly before the patient is due to receive the medicines. Circumventing correct documentation is per definition a medication administration error and may lead to sequential errors later in the medication administration chain (Carayon, Wetterneck, Cartmill, et al., 2014), either in the dispensing, preparing or administering stage. This is what Diller et al. (2014) term 'skill-based errors', and they are typical of healthcare personnel engaged in repetitive behaviour. It also ties in closely with the normalisation of deviance theory where the staff deviate from the norm but perceive it as beneficial in the short-term (May & Finch, 2009). In the Human Factors Analysis Classification system, this is described as routine violations (Diller et al., 2014).

According to Carayon, Wetterneck, Cartmill, et al. (2014), understanding the temporal complexity of the vulnerabilities of the medication administration process is important in devising solutions to improve patient safety. Moreover, the solutions must target multiple stages of the medication administration process to address both single, grouped and sequential errors. The following discussion reflects on the different issues related to the performance variability and complexity of the work system in accordance with the five elements of the work system.

5.1.1 Organisation

A hallmark of complex adaptive systems is horizontal structures and lack of a single point of control (Rouse, 2000). Most staff members reported

leadership to be distributed and fluid. The role of team-leader changed according to shifting conditions and became part of the self-organising complex system. According to Mukamel et al. (2006), horizontal structures are prevalent in nursing homes, thus creating ample opportunities for effectively balancing the work system.

This coincides with the findings in this thesis, where the staff members were **prepared to take on several roles** depending on circumstances. At its most extreme, some of the nurses that had responsibility for the pre-visitation downgraded the role of the medical doctor if they were uncertain about his/her capabilities. In doing so, the nurses took on tasks and responsibilities far beyond expectations, but they experienced this as necessary to safeguard the medication administration process. Since the nurses did not meet any resistance when taking on additional tasks from the medical doctor, this came naturally to them. Findings in Paper II, however, revealed that if several nurses with equal experience took part in a meeting where one nurse assumed leadership, the others would feel downgraded. It shows how the adaptive capabilities of the individuals may have both positive and negative influences on the overall adaptive capacity of the system. It further reflects how the agents in a complex system such as the nursing home wards in this study through adaptive behaviour results in both positive and negative consequences, depending on the viewpoint (Plsek & Greenhalgh, 2001; Rouse, 2008).

Another finding that ties in with the staff's ability to adapt and work in teams was how highly they regarded **membership stability of the workforce**. When the staff members know whom to trust and are sure of each other's competence, the delegation of tasks and communication comes naturally. Moreover, in cases where the staff had to work with colleagues with whom they were unfamiliar, they tended to take on more tasks themselves. Other studies from the nursing home setting regard membership stability in the workforce as being important to achieving effective teamwork (Buljac-Samardzic, van Woerkom, & Paauwe, 2012;

Feldman, Bridges, & Peng, 2007; Havig, Skogstad, Veenstra, & Romoren, 2013).

Assumptions are that high workload may lead to increased staff turnover and thus low membership stability in the workforce. Others claim that short periods of high workload may induce the staff to be more creative, enabling them to find effective workarounds (Feldman et al., 2007). Findings from the current study indicate that this is a double-edged sword. In the interviews, several staff members reported that working together when it was busy was like being part of well-oiled machinery. On the other hand, if something unforeseen happened, they were vulnerable since suddenly they were without extra resources to handle the new situation. During extreme conditions, the staff had to prioritise medication administration to those patients needing it most, while stable patients received less attention. Other tasks, like documentation and cleaning patient rooms, were deprioritised in order to administer medications.

Overall, fluid leadership stands out as important in understanding the medication administration process and the interactions with the elements of the work system. In a systematic review describing characteristics of healthcare organisations struggling to improve quality, disconnected leadership was highlighted as instrumental (Vaughn et al., 2019). Disconnected leadership was associated with poor organisational culture, poor leadership skills, unsupportive leaders and lack of transparency. A consequence of the complexity of the work system described in the thesis is how any change in a work system element interacts with and produces changes elsewhere in the work system. It may be that fluid or disconnected leadership erodes healthy adaptations in the work system. The task of leadership may be to act as a conduit, connecting the elements of the work system. The SEIPS-model may, therefore, have the potential to help leaders and managers realise the complexity of the work system, thus recognising the value of their role.

5.1.2 Tools and technology

The most crucial elements connected to tools and technology are related to the use of electronic medication administration records. One salient point revolves around the pragmatic use of computers, involving problems the staff experience concerning lengthy login times and similar issues.

There is a marked difference depending on whether computers are readily available to properly document and confirm changes in the medications. A lack of electronic medication administration record availability leads to analogue solutions and **double-documentation**, with subsequent problems in retrieving vital information in a timely fashion, laying the ground for sequential errors (Carayon, Wetterneck, Cartmill, et al., 2014). Sequential errors can include ambiguous documentation in the transcribing stage, leading to delayed medication administration.

Technological interruptions are identified as disruptive to the workflow in Paper I. Indications are that the utilisation of an electronic medication administration record instead of a paper-based record may serve to decrease the staff's perceived risk of committing medication administration errors (Alenius & Graf, 2016). Furthermore, several studies point out that the use of computer systems may improve workflow, and lead to fewer medication administration errors. This is contrary to findings in this thesis which suggest that the use of computer systems may introduce vulnerabilities to the work system.

Technological interruptions may be due to **second-rate technological solutions**, where the staff using the equipment have been omitted from the implementation processes of new systems. It may be that input from key stakeholders while implementing new computer systems, could have led to positive alterations capable of improving medication safety. There are also suggestions that employing Human Factors engineering experts to design computer systems in collaboration with the people using the

systems is beneficial in complex socio-technical systems (Dul et al., 2012).

One consequence of the second-rate technological solutions is how the staff members use a separate book to record various events from pre-visitations, important patient engagements, the ordering of drugs for upcoming meetings and diagnostic details on patients. The staff report this as an advantageous tool in addition to using electronic medication administration records and other official documentation devices, while observations in the current study indicate it may introduce vulnerabilities. Poor information technology services are identified across a broad spectre of healthcare organisations as detrimental to quality improvement (Vaughn et al., 2019).

5.1.3 Tasks

A major challenge in the medication administration process is the use of **multi-dosage medicines** whenever the prescription changes. The multi-dosage medicines come pre-packaged from the pharmacy based on the last prescription received. These packages are delivered in plastic containers, with enough medicines to last two weeks. When the doctor comes regularly once or twice each week, and often changes the prescriptions, this creates a lag where the multi-dosage medicines do not contain the correct type or amount according to the updated prescription. This creates extra work for the staff members in charge of medication administration, and some staff members described it as an unwelcome addition to their daily tasks that introduced unnecessary risks. Indications are that due to the extra work involved in changing prescriptions, patients with multi-dose may receive fewer changes in their prescription than patients with regular drug dispensing (Sjöberg, Ohlsson, & Wallerstedt, 2012). One study documents that the use of multi-dose may altogether decrease the quality of drug treatment among nursing home patients with polypharmacy (Sjöberg et al., 2011).In addition to creating extra work, it may also be that the use of multi-doses removes some of the vigilance

of the nurses while dispensing and preparing the drugs, making them less likely to uncover irregularities (Wekre, Melby, & Grimsmo, 2011). Closer collaboration with the pharmacy and shorter intervals between prescribing new multi-doses may relieve some challenges.

Double-checking is a procedure involving independent, simultaneous checking of medications by two competent persons before administration to the patient (Kellett & Gottwald, 2015). This may pose a problem when the nursing home wards lack enough nurses on a shift. Even though procedures to double-check potent medications are mandatory, some situations are challenging. There is one example of a nurse describing using the mobile phone to verify the administration of morphine. It points to both creativity and flexibility, but also an inherent weakness in the system. In some instances, the nurses described how they would have to call the home care services staff for help if they needed to double-check a critical medication on a night shift or a vulnerable shift. This was a workaround that involved time delays. Most times the nurses would rather skip double-checking altogether due to a lack of resources or wait for the next shift to arrive. Research suggests that medication errors still occur when double-checking and that the nurse's perception of the practice is mixed. Some prefer double-checking as a way of feeling safe, while others feel that it is unnecessary (Alsulami, Conroy, & Choonara, 2012). Indications are that there is minimal evidence for adopting mandatory double-checking for adult populations, considering it is a labour-intensive process (Lapkin et al., 2016).

5.1.4 The physical environment

In some instances, separating positive and negative consequences is challenging, as described in Paper I, since **active interruptions** may have **positive outcomes**. There is a rather complex chain of events responsible for some of the active positive interruptions. One example stems from the distances in the physical environment in the nursing home wards. Where the original intent was that stages three (dispensing) and four (preparing) in the medication administration process take place in a separate medicine room, the distances between the ward and the medicine room has led to the staff using mobile medication trolleys. These are often placed where the staff normally congregate, places such as common rooms and the nurse station – places where a range of activities often occur simultaneously. This leads to many people performing different activities in small physical areas, thus making them susceptible to interruptions. Working in such a disruptive environment does not seem to bother the staff members. When asked about it, they claimed that being constantly surrounded by colleagues and patients is an added insurance. This may reflect a need for constant coordination and communication to promote safe practices (Raban & Westbrook, 2014). If a staff member is challenged or interrupted while performing a medication-related task, it allows for reflection and re-evaluation, thus potentially preventing a medication administration error. The normalisation of interruptions, as described in Paper I, seems to be tied to the physical environment of the nursing homes with large spaces and distances that have led to mobility in the medication administration process. The mobility of medication administration in nursing homes has become central in the everyday practice through socialisation, institutionalisation and rationalisation (Ashforth & Anand, 2003). As such, interruptions are deeply embedded in the institutions, and rooting them out may lead to unintended consequences (Westbrook et al., 2017).

Using the SEIPS-model in mapping the medication administration process in the nursing homes may help reveal the interconnectedness of

the work system, and aid leaders and managers to deal with negative interruptions.

5.1.5 Persons

Agents capable of spontaneous self-organisation dominate complex adaptive systems (Rouse, 2008), and are represented by the individual staff members in this study. Since they are different individuals, they differ in training, competence, social skills and motivation. Moreover, complex adaptive systems are often embedded in other social complex systems, increasing the complexity as multiple professional stakeholders interact in a dynamic relationship (Plsek & Greenhalgh, 2001). This reflects how the staff in the nursing home wards must constantly relate to neighbouring wards, next of kin, the pharmacy and other external stakeholders. By working together over time, they learn how to adapt to each other, and patterns of behaviour evolve.

This thesis describes how the staff often work on the invisible borders of safe medication administration. To balance the work system, the individuals perform activities and workarounds outside regulations and how management imagine the work (Hollnagel, 2012). Many of these activities that circumvent norms and regulations become normalised over time through mechanisms such as socialisation, institutionalisation and rationalisation (Banja, 2010). The workarounds have both positive and negative aspects: in one respect they are partly responsible for all that goes right most of the time, but they also create vulnerabilities in the work system that allow errors to occur. The healthy outcomes are often hard to recognise as they are an integral part of the normal functioning workday, and thus what partly constitutes a resilient organisation (Hollnagel, 2014).

Following the introduction of the coordination reform in Norway, nursing homes have generally reported an increase in patients with multiple diagnoses and an increase in complex nursing-related tasks,

where the associated increase in training and competence is disproportional (Glette et al., 2018; Syse & Gautun, 2013). The change in workload and tasks related to medication administration is also reported in the current findings, where staff members sometimes feel overwhelmed by the new conditions. Staff members (Paper II) were concerned that their ward, whose original purpose was to house patients who have dementia, now housed patients with all kinds of additional diagnoses. The new workday may have eroded some of the staff's adaptive capabilities, making them less capable of handling new challenges.

A list of contributory factors that influence the nurse role during medication administration includes how the nurses seldom reflect on why they are continuously expected to create workarounds to solve problems or obstacles in their normal workday. They find that **being creative and solving problems is a normal** end expected part of their work-day (Smeulers et al., 2014).

The workarounds are also about more than finding practical or technical solutions to concrete challenges. They often revolve around resolving issues related to the available competence on a certain shift and the delegation of tasks based on what skill-sets are available and needed. Even though patients and tasks are pre-assigned, the staff often re-prioritised and changed their assignments in order to perform more effectively. This autonomous behaviour, typical of complex adaptive systems (Rouse, 2008), was normal for the staff members and seemed to give them a sense of importance. On the other hand, this flexibility also may have served to make leadership roles more fluid or disconnected.

5.2 Balancing the work system

According to Carayon, Wetterneck, Rivera-Rodriguez, et al. (2014), *any change in a work system element interacts with and produces changes elsewhere in the work system*. This thesis contains a broad array of

examples where actions, conditions or situations in one specific work system element leads to consequences elsewhere. In both Human Factors theory (Dul et al., 2012; Holden et al., 2013) and theory relating to complex adaptive systems (Rouse, 2008), a key element is the balancing of work systems.

The balancing of the nursing home work system may manifest differently. Examples range from how the staff adapt unconsciously and continually and exhibit problem-solving behaviour, creating workarounds, to how the physical environment enforces social clustering and certain behaviour during medication administration. Further examples are how fluid leadership influences team composition and task delegation and how lacklustre technological solutions inspire double-documentation.

Some of these balancing acts may lead to stable positive alterations to the work system, while other changes may introduce vulnerabilities. At a given time and situation, the work system is in a specific configuration, based on the current interactions and available resources. Over time, these configurations shift to accommodate changes and variations in the workday. Certain alignments of the work system elements might conspire to create work system configurations prone to failures, while some alignments are conducive to safe medication administration (Holden et al., 2013).

Two major challenges seem apparent to any potential quality improvement work in nursing homes. One is to identify the current configuration of the work system that mostly impacts the medication administration process. Second is to identify which interactions in the work system are involved in maintaining a healthy and balanced work system, and which interactions may have a negative impact.

The mostly invisible balancing of the work system may lead to situations with constant accumulation of deviations and small errors. All the small deviations and errors generally pass below the radar, but may conclude

in different types of adverse events at times when the systems performance variability is stretched thin. It may be that nursing homes are in a state of flux, where the balancing of the work system rests on faulty premises. If the vulnerabilities in the work system are not identified and measures are taken to achieve a healthy balance, it may be a question of time before adverse events occur.

5.3 A contribution to the prevention of adverse drug events in nursing homes

Nursing homes vary greatly in terms of demographics, patients, staff, regulations and norms. Improving the quality of the medication administration process is, therefore, challenging. Simple measures cannot reduce the complexity of medication administration in nursing homes as it seems ingrained in the characteristics of the work system and its patterns of interactions.

Furthermore, the thesis points out that medication administration in nursing homes is a precarious process that navigates on the borders of safe practice. Latent factors, shown as the characteristics outlined in Table 5, are abundant in the work system, influencing ongoing processes, such as medication administration. This thesis also documents that the earlier stages of the medication administration process present the largest numbers of barriers to safe medication administration. Existing interventions to safeguard medication administration only partly address the challenge of medication errors and in some cases, present new opportunities for errors to occur. Prior research recommends a strong theoretical focus to investigate the nature and complexity of the underlying causes of medication administration errors. (Keers, Williams, Cooke, & Ashcroft, 2013a).

The HFACS describes types of errors as theoretical constructs and discerning specific causes for each type of error depends on the available information and the subjective interpretation of the researcher. The

characteristics of medication administration in nursing homes, described in Table 5, potentially relate to several types of errors, and efforts to prevent a specific type of error may also be effective in preventing other types of errors. However, indications are that different actions should meet each of the error-types described by the HFACS to reduce rates of medication errors (Niemann et al., 2015).

Decision-based errors are associated with characteristics (Table 5) such as the staff members having a varying degree of competence and sparse opportunities to train. Inferior technological solutions may also affect the availability of information. Indirectly this is linked to organisational factors such as fluid leadership, and inadequate resources. In response to these factors, staff members are flexible and able to adapt to changing situations, but this often leads to random team composition and task delegation. The generic solution is that decision errors should be met with more training and education (Niemann et al., 2015).

Research suggests that nursing students' medication knowledge is unsatisfactory, and that the knowledge gap transfers to later clinical practice (Simonsen, 2016). Thus, efforts to increase nurses' medication knowledge, should begin with the education of nurses. For instance, it may be prudent to identify and customise teaching to students who struggle with drug dose calculation in order to increase their conceptual understanding of medication calculus (Simonsen, 2016; Sinnott et al., 2014). A recent project from the Norwegian University of Science and Technology aims at doing just that by introducing an interactive digital learning platform to increase nursing students' medication competence. A competence-profile results, providing a basis for further development and overview of individual skill-levels throughout the education (NTNU, 2019). However, prior studies into e-learning programs effectiveness in enhancing medication knowledge among nurse students are inconclusive (Simonsen, 2016).

A focus on medication knowledge and drug dose calculation should continue in clinical practice. One possible option could be mandatory annual or biannual recertification programmes for all relevant healthcare personnel. In one study, accreditation of healthcare personnel in medication management in hospitals led to a significant reduction of medication errors over a three-year period (Wang et al., 2015).

A recent review on the prevention of medication errors suggests that simulation may aid efforts to train staff to deal with both exceptional events, as well as more normal daily activities. Simulation is effective in preventing iatrogenic risks related to medication errors if human factors knowledge is successfully integrated and if the programme is well designed (Sarfati et al., 2019). Moreover, using a directed team training programme such as TeamSTEPPS (Agency for Healthcare Research and Quality 2020) during simulations, may enhance teamwork attitudes as well as improving performance (Motycka et al., 2018). Results from this thesis may, therefore, be of importance when considering future simulation designs. Altogether, there is evidence that simulation-based training and multifaceted approaches combining education and risk management are effective in reducing medication errors (Lapkin et al., 2016).

However, efforts such as accreditation, simulation and team training demand extensive organisational resources and management that consciously focus on patient safety.

Skill-based errors are failures to execute a planned action and typically occur when a staff member forgets something or acts wrongly due to distractions or slips of concentration due to repetitive tasks (Diller et al., 2014). Findings in the thesis indicate that nurse assistants find medication administration easier and less complex than do registered nurses. One consequence may therefore be, that nurse assistants have a higher risk of committing skill-based errors.

Findings in the thesis describe characteristics such as active and technological interruptions with a negative outcome, and the fact that the medication administration process is long and consists of many single steps may contribute to skill-based errors. The physical environment of medication administration is often cramped, with a cluttered workspace and several people working simultaneously. There are also inferior technological solutions that enforce workarounds, such as double documentation.

The literature describes a list of interventions to prevent interruptions during medication administration. Among these are the use of dedicated rooms for medication administration, yellow vests or tabards, no interrupt zones, ward signage, safety checklists and various technologies. These interventions have proven effective in reducing interruptions, but there is little evidence that they reduce medication errors (Lapkin et al., 2016; Raban & Westbrook, 2014).

Some interruptions are positive and may act as a safety net, preventing medication errors, while others are negative (Flanders & Clark, 2010; Flynn, Liang, Dickson, Xie, & Suh, 2012). An example of this in the thesis are random social congregations around the medication trolley, where potential medication errors are intercepted. Identifying positive interruptions should, therefore, be a priority before implementing single preventive measures (Lapkin et al., 2016; Raban & Westbrook, 2014). One measure may simply be for managers to ask the staff members what level of interruptions they find distracting during medication administration. This may be accomplished at a staff meeting or during appraisal interviews with staff members.

As is the case of decision-based errors, skill-based errors may also benefit from simulation and training. Research shows that nurse students with limited clinical experience may learn how to cope with interruptions in a safe, simulated environment. After taking part in simulations, nursing students reported positive learning experiences with a

heightened awareness of interruptions and how they impact the medication administration process. This also enabled the nursing students to learn techniques for managing interruptions, including enhanced clinical reasoning and judgement (Hayes, Power, Davidson, Daly, & Jackson, 2015). Directed training on how to handle interruptions should also be an effective measure for experienced personnel.

Making the medication administration process less complex is a daunting task, but some streamlining should be possible by means of updating procedures and highlighting current guidelines. The use of protocols and checklists to limit medication errors have shown a limited effect but may be effective in preventing interruptions. Double-check of medications before administering them to patients is mandatory but challenging to achieve in all cases. There is little evidence of the effectiveness of double-checking to reduce medication errors (Lapkin et al., 2016).

Research suggests that introducing electronic medication administration records may reduce the perceived risk of committing medication errors (Alenius & Graf, 2016), but among a host of new technologies, only bar-coding seems effective in reducing medication errors. Electronic bar-coding involves measures to control the correct medicines, dosages and patient identity in an effective way. However, this measure is inadequate if integrated into inferior medication administration records or if kept as a separate module (Shah, Lo, Babich, Tsao, & Bansback, 2016). Staff members from both wards suggested that using mobile devices with electronic medication administration record functionality would significantly ease medication management. This may be effective if the use is restricted, so as not to introduce the same type of problems as with the use of mobile medication trolleys.

Perceptual errors, tied to cognitive traits and impaired sensory organs, are linked to the physical environment of the nursing homes and the ergonomics of the workplace. Characteristics in the thesis linked to perceptual errors are, for instance, passive interruptions and cluttered

work environment as well as similar-looking medicines and poorly designed workspaces. Human factors ergonomics aim to improve such factors, and consulting experts on human factors ergonomics may assist in the redesign of the work environment and labels, and provide expert advice to both staff and management (Carayon, Wetterneck, Rivera-Rodriguez, et al., 2014; Dul et al., 2012). Managers can also use the SEIPS-model in appraisal interviews with the staff members to structure and map out potential vulnerabilities in the work system. It may also present the opportunity to ask staff members whether they have any special needs such as hearing aids or special glasses.

Violations are deliberate deviations from standard procedure and seem to be common and integrated with how nursing homes adapt to constraints in the work system and changing circumstances. From routine violations, there is a fine line to exceptional violations, considered a risk to patient safety. Violations may relate to the organisational climate described in tier four of the HFACS.

Characteristics identified in this thesis as associated with violations are high workload and vulnerable shifts, how the individual compensates to meet the needs of the patients, the need to be flexible in collaborative work, the adaptive behaviour on an organisational level and the fluid leadership.

One study shows that a common cause of medication administration errors is staff tiredness and increased workload (Gorgich, Barfroshan, Ghoreishi, & Yaghoobi, 2016). The staff violate procedures and take shortcuts to increase their effectiveness, but violations may also be markers of high levels of safety (Amalberti, Vincent, Auroy, & de Saint Maurice, 2006). The positive aspects of routine violations are that they may increase system performance and the individual satisfaction of the personnel if the violations are within the limits of safe practice. Identifying whether the adaptations are within those limits is a key issue that demands investigation in the context of each nursing home. The

features of normalisation of deviance (chapter 2.3) underline the inherent risk that routine violations, may spiral into unsafe territory and cause adverse events.

A Suggestion on how to manage violations in nursing homes may be to establish ways for the staff members to communicate difficulties and discuss possible solutions. To do so facilitates opportunities to learn and adjust plans so violations may be avoided. By analysing existing violations, it may be possible to understand why they occurred. The SEIPS-model facilitates a system approach and may help staff members and management in identifying key issues across the work system to address medication safety.

Overall, interventions or measures to improve medication safety should be multifaceted and they demand healthy management and strong leadership provided with adequate resources. The characteristics in Table 5 relate to factors in all four tiers of the HFACS, from the frontline workers to the highest organisational level. There is a constant trade-off between efficiency and thoroughness which is a core challenge in administering medications safely in nursing homes (Hollnagel, 2009).

5.4 Reflections on the Human Factors approach

Utilising a Human Factors approach in this thesis allowed for a holistic view of the medication administration process, enabling a focus on elements, interactions and activities of importance in the work-system based on the empirical findings. There is a need for models and maps making complex systems available, structured and understandable. Human Factors and the SEIPS-model facilitate this structuring of human interactions in complex environments. Process mapping and work system analysis (Paper I and Paper III) proved a potent tool, allowing for modelling and illustrating the complexity in the socio-technical system of nursing homes. Thus, combining Human Factors and process mapping gave a roadmap for medication administration in nursing homes with

potential benefits for various stakeholders aiming to focus on either long-term outcomes or short-term outcomes. An apparent weakness of the SEIPS-model is the vagueness of how it deals with adaptations as a whole. To be useful, such concepts should be operationalised to a greater degree. This thesis partly accomplishes this by describing actions, conditions and situations where the adaptive behaviour of the work systems is exemplified. Also, characteristics of the work system are linked to specific types of errors and show some of the hierarchical associations between factors such as economy, supervision, management, physical and technological environment, resources and individual attributes. Further operationalisation of the elements in the work system and the interactions and adaptions may lead to a more refined SEIPS-model.

SEIPS-based process modelling, therefore, seems to be an appropriate tool to investigate not only the medication administration process but other processes in diverse healthcare settings as well.

6 Conclusion

The complexity of medication administration in nursing homes is formed by healthcare personnel, patients and the surrounding work system elements. The personnel and the work system elements have positive and negative characteristics and interact and adapt according to shifting circumstances. There are six stages in the medication administration process with over 60 associated facilitators and barriers.

Main characteristics in the work system are **active, passive and technological interruptions,** making medication errors more likely. A few interruptions may have positive outcomes, functioning as a safety net against adverse drug events. **Leadership is fluid**, and the **role** of the team leader is interchangeable. This is often due to **variations in competence** and an uneven skill-mix within the team. The normalisation of deviance may explain why staff members accept **second-rate technological solutions** and **high workload**, invent workarounds and creative solutions, bending the rules and guidelines. In most cases, it is with good intentions and healthy outcomes, but it also creates vulnerabilities in the nursing home work system where medication administration errors and potential adverse drug events occur.

By using the SEIPS-model portraying and operationalising the complexity of medication administration in nursing homes, the knowledge may become a source for improving the work system and preventing adverse drug events. The SEIPS-model may also help leaders and managers realise the complexity of the work system and make them more conscious of their role as leaders. There are many different interventions and technological solutions that may improve medication safety. Multifaceted approaches targeting specific types of errors have shown the best effect in preventing adverse drug events in nursing homes.

6.1 Implications for practice and research

The use of a SEIPS-based process modelling to map out practices and identify strong and weak points in relevant work processes such as medication administration is a potent tool that researchers, staff and management may adapt and employ for their use.

Implications for staff and management:

- Simulation is effective in learning to cope with interruptions during medication administration. Simulation is also an effective method in training nursing students and the staff in medication administration knowledge and medical calculus. A two-fold recommendation is that individual nursing homes request simulation training from the nearest educational institution, and for educational institutions to reach out and offer simulation training for nearby nursing homes.
- To avoid unnecessary distractions, there should be restrictions on which rooms the mobile medication trolley may be in. Separate rooms for documentation should be considered.
- Regular accreditation of personnel administering medications should be considered. This may be achieved through collaboration with a local educational institution.
- Flowcharts in Paper I and Paper III provide specific information on workflow, facilitators and barriers in the medication administration process that may contribute to revising checklists or protocols.
- Doctors should only prescribe multi-dose for stable long-term patients with few alterations to their medications. Shorter dispensing intervals should be planned in collaboration with the pharmacy.
- Electronic bar systems may be considered as they have shown a positive effect on reducing medication errors, if well integrated into an electronic medication administration record system.

- In appraisal interviews with staff members, the manager may structure the discussion on the elements of the SEIPS-model to provide new insights on the working conditions. Managers may use this opportunity to map out violations and which interruptions staff members find distracting.
- High workload is associated with medication errors, and the management should prioritise resources to prevent vulnerable shifts by retaining a stable staff. Incentives might include providing a flexible watch plan and opportunities for all regular staff members to attend courses or seminars.

Recommendations for future research:

Future research in medication safety in nursing homes may entail to:

- Develop a short-version tool akin to SEIPS process modelling described in Paper III to enable researchers, staff or management to process map practices before introducing new technologies, practices, guidelines or interventions.
- Design longitudinal studies that combine micro-, meso- and macro-levels to further increase the understanding of the interactions in the medication administration work system of nursing homes.
- Combine process mapping with supplemental qualitative and quantitative approaches. Associated objectives could be to identify positive interruptions and healthy routine violations, as well as to investigate the cognitive processes of staff members during medication administration.

7 Literature

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Appendices

Appendix 1 – The observation guide

SEIPS-based observation guide (Carayon et al., 2006)

Work system					Work process
Person(s)	**Tasks**	**Tools / technology**	**Organisation**	**Physical environment**	Professional work
Knowledge, skills, attitudes, leadership style, competence, training Roles, status	Difficulty Complexity Variety Workload, ambiguity, routines, time pressure, documentation practice	Usability Familiarity Functionality Accessibility, level of automation, the design of equipment	Training Guidelines, Procedures Quality systems, culture, size, management style, economy, resources	Layout Distances Dispensers Temperature, lighting, air condition, state of facilities	*Medication administration* Ordering, transcribing, dispensing, preparing, administering, observing
Examples of observational findings structured according to the SEIPS-model					
The person seemingly lacks knowledge of where to retrieve relevant information.	To obtain correct information, the staff member needs to perform a long chain of single tasks.	The computer system offers poor search functionality for the kind of information he/she wishes to retrieve.	Guidelines are not current, and the staff lack training in that kind of procedures.	The nurse station is cluttered with paper and retrieval of specific information can be difficult.	

Appendix 2 – The interview guide

Introduction

Could you say something about the activities during a normal workday?

In what way are you involved with medication administration?

Use keywords from the SEIPS-model to pinpoint and specify during the interview.

- Ask the informant to describe what they do at work
    - Talk about their experiences with medication administration
- Communication
    - How is vital information shared among the staff when you are at work?
- Teamwork and collaboration
    - Could you describe how you work together?
- Medication administration
    - How would you proceed if a patient was in urgent need of some strong pain killers?
    - Documentation
    - How do you perceive medication administration as part of the regular workday?
        - How do you experience documentation tasks in relation to medication administration?
- Training and competence
    - What opportunities are there to maintain your competence at work?
- Physical structures
    - How do you feel the facilities are in relation to the work you do?
    - Distances, noise
- Computer systems and technological solutions

  - How do you experience the computer systems in relation to documentation and other tasks?
  - How about training on these systems?
- Guidelines / rules / regulations
  - How do you proceed if you are not sure what to do or need confirmation?
- Tasks / complexity
  - How difficult would you rate the difficulty of medication administration?
- Workload
  - Delegation
- Time management
  - How do you perceive the time you have assigned for different tasks?
- Management
  - How would you describe the management at your ward?
- Special experiences
  - Have you experienced anything out of the ordinary that you would like to share?

Appendix 3 – Information and consent

Forespørsel om deltakelse i forskningsprosjektet **"Teamarbeid i primærhelsetjenesten»**

Bakgrunn og formål

Formålet med dette doktorgradsstudiet er å få mer kunnskap om hvordan teamarbeid i primærhelsetjenesten fungerer. Studien vil utforske og beskrive teamstrukturer og teamledelse ved å bruke et human factors rammeverk.

Forskningsspørsmålene er som følger:

1. Hva karakteriserer teamarbeid i sykehjem og i hjemmebaserte tjenester?
2. Hvordan relaterer teamstruktur og teamledelse til administrering av medikamenter i sykehjem og i hjemmebaserte tjenester?

Studien utføres av doktorgradsstipendiat Kristian Odberg, fra Høgskolen i Gjøvik, i samarbeid med Universitetet i Stavanger.

Hva innebærer deltakelse i studien?

Dette vil samles data ved hjelp av observasjoner og intervjuer. Forsker / doktorgradsstipendiat vil være synlig på institusjonen og følge ansatte gjennom vakter. Enkelte ansatte vil bli spurt om å være informanter i intervjuer, disse vil ta ca. 45 minutter hver. Forsker kan også stille spørsmål eller snakke med ansatte / informanter under observasjoner, såkalte feltsamtaler. Under observasjoner vil opplysninger noteres underveis. Ingen personlige data vil bli notert. Intervjuer vil tas opp på digital lydopptaker. Kjønn, alder, erfaring og profesjon vil bli notert. Dette er bakgrunnsopplysninger som vil anonymiseres. Ingen identifiserbare personopplysninger vil publiseres. Spørsmålene vil

omhandle hvordan informanter beskriver sitt arbeide, og hvordan de beskriver sitt samarbeid med kollegaer.

Hva skjer med informasjonen om deg?

Alle personopplysninger vil bli behandlet konfidensielt.

Kun doktorgradsstipendiat Kristian Odberg og veiledere vil ha tilgang til disse dataene. De vil lagres på sikret datasystem, og alle data anonymiseres etter prosjektslutt.

Ingen deltakere vil kunne gjenkjennes i publikasjoner fra prosjektet.

Prosjektet avsluttes **20-12-2017**. Digitale opptak vil etter prosjektslutt slettes, og alle lagrede data anonymiseres.

Frivillig deltakelse
Det er frivillig å delta i studien, og du kan når som helst trekke ditt samtykke uten å oppgi noen grunn. Dersom du trekker deg, vil alle opplysninger om deg bli slettet.

Dersom du / dere ønsker å delta eller har spørsmål til studien, ta kontakt med doktorgradsstipendiat Kristian Odberg ved Høgskolen i Gjøvik, tlf: 90793384/61135399. Mail: Kristian.odberg2@hig.no. Studien er meldt til Personvernombudet for forskning, Norsk samfunnsvitenskapelig datatjeneste AS.

Samtykke til deltakelse i studien

Jeg har mottatt informasjon om studien, og er villig til å delta.
Jeg samtykker til å delta i intervjuer JA /NEI (stryk det som ikke passer)
Jeg samtykker til at forsker kan følge meg på vakt JA / NEI (stryk det som ikke passer)

(Signert av prosjektdeltaker, dato)

Appendix 4 – NSD-approval

Norsk samfunnsvitenskapelig datatjeneste AS
NORWEGIAN SOCIAL SCIENCE DATA SERVICES

Harald Hårfagres gate 29
N-5007 Bergen
Norway
Tel: +47-55 58 21 17
Fax: +47-55 58 96 50
nsd@nsd.uib.no
www.nsd.uib.no
Org.nr: 985 321 884

Kristian Odberg
Senter for sykepleie Høgskolen i Gjøvik
Teknologivegen 22
2815 GJØVIK

Vår dato: 02.11.2015 Vår ref: 45389 / 3 / LT Deres dato: Deres ref:

TILBAKEMELDING PÅ MELDING OM BEHANDLING AV PERSONOPPLYSNINGER

Vi viser til melding om behandling av personopplysninger, mottatt 28.10.2015. Meldingen gjelder prosjektet:

45389 A human factors approach to teamwork in primary health care

Behandlingsansvarlig Høgskolen i Gjøvik, ved institusjonens øverste leder
Daglig ansvarlig Kristian Odberg

Personvernombudet har vurdert prosjektet og finner at behandlingen av personopplysninger er meldepliktig i henhold til personopplysningsloven § 31. Behandlingen tilfredsstiller kravene i personopplysningsloven.

Personvernombudets vurdering forutsetter at prosjektet gjennomføres i tråd med opplysningene gitt i meldeskjemaet, korrespondanse med ombudet, ombudets kommentarer samt personopplysningsloven og helseregisterloven med forskrifter. Behandlingen av personopplysninger kan settes i gang.

Dokumentet er elektronisk produsert og godkjent ved NSDs rutiner for elektronisk godkjenning.

Avdelingskontorer / *District Offices:*
OSLO: NSD. Universitetet i Oslo, Postboks 1055 Blindern, 0316 Oslo. Tel: +47-22 85 52 11. nsd@uio.no
TRONDHEIM: NSD. Norges teknisk-naturvitenskapelige universitet, 7491 Trondheim. Tel: +47-73 59 19 07. kyrre.svarva@svt.ntnu.no
TROMSØ: NSD. SVF, Universitetet i Tromsø, 9037 Tromsø. Tel: +47-77 64 43 36. nsdmaa@sv.uit.no

Det gjøres oppmerksom på at det skal gis ny melding dersom behandlingen endres i forhold til de opplysninger som ligger til grunn for personvernombudets vurdering. Endringsmeldinger gis via et eget skjema, http://www.nsd.uib.no/personvern/meldeplikt/skjema.html. Det skal også gis melding etter tre år dersom prosjektet fortsatt pågår. Meldinger skal skje skriftlig til ombudet.

Personvernombudet har lagt ut opplysninger om prosjektet i en offentlig database, http://pvo.nsd.no/prosjekt.

Personvernombudet vil ved prosjektets avslutning, 20.12.2017, rette en henvendelse angående status for behandlingen av personopplysninger.

Vennlig hilsen

Katrine Utaaker Segadal

Lis Tenold

Kontaktperson: Lis Tenold tlf: 55 58 33 77

Vedlegg: Prosjektvurdering

Personvernombudet for forskning

Prosjektvurdering - Kommentar

Prosjektnr: 45389

Utvalget informeres skriftlig og muntlig om prosjektet og samtykker til deltakelse. Informasjonsskrivet er godt utformet.

Personvernombudet legger til grunn at forsker etterfølger Høgskolen i Gjøvik sine interne rutiner for datasikkerhet.

Forventet prosjektslutt er 20.12.2017. Ifølge prosjektmeldingen skal innsamlede opplysninger da anonymiseres. Anonymisering innebærer å bearbeide datamaterialet slik at ingen enkeltpersoner kan gjenkjennes. Det gjøres ved å:

- slette direkte personopplysninger (som navn/koblingsnøkkel)
- slette/omskrive indirekte personopplysninger (identifiserende sammenstilling av bakgrunnsopplysninger somf.eks. bosted/arbeidssted, alder og kjønn)
- slette digitale lydopptak

Personvernombudet registrerer at prosjektleder skal følge ansatt/ansatte på vakt. Personvernombudet legger til grunn at det er klarert med aktuell institusjon at taushetsplikten ikke er til hinder for at prosjektleder kan følge ansatt/ansatte på jobb. Videre legges det til grunn at det ikke registreres opplysninger om tredjepersoner, her ment pasienter, basert på prosjektleders tilstedeværelse.

Part 2 – The papers

Paper I: Medication administration and interruptions in nursing homes: a qualitative observational study

> Odberg, K. R., Hansen, B., Aase, K., & Wangensteen, S. (2017). Medication administration and interruptions in nursing homes: A qualitative observational study. *Journal of Clinical Nursing*. doi:10.1111/jocn.14138

Paper II: A qualitative study of the nurse role during medication administration

> Odberg, K. R., Hansen, B. S., & Wangensteen, S. (2019). Medication administration in nursing homes: A qualitative study of the nurse role. *Nursing Open, 6*(2), 384-392.

Paper III: A work system analysis of the medication administration process in a Norwegian nursing home

> Odberg, K. R, Aase, K., Hansen, B.S., & Wangensteen S. (2019). A work system analysis of the medication administration process in a Norwegian nursing home. *Applied Ergonomics* (revised)

Paper I

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ORIGINAL ARTICLE

WILEY Journal of Clinical Nursing

Medication administration and interruptions in nursing homes: A qualitative observational study

Kristian Ringsby Odberg RN, MSN, PhD Candidate[1] | **Britt Sætre Hansen PHD, RN, Professor**[2,3] | **Karina Aase PhD, Professor, Centre Director**[2,3] | **Sigrid Wangensteen PhD, MSN, RN, Associate Professor**[1]

[1]Department of Health Sciences, Norwegian University of Science and Technology (NTNU), Gjøvik, Norway

[2]Faculty of Health Studies, University of Stavanger, Stavanger, Norway

[3]SHARE – Centre for Resilience in Healthcare, University of Stavanger, Stavanger, Norway

Correspondence
Kristian Ringsby Odberg, Department of Health Sciences, Norwegian University of Science and Technology (NTNU), Gjøvik, Norway.
Email: Kristian.odberg2@ntnu.no

Aims and objectives: To contribute in-depth knowledge of the characteristics of medication administration and interruptions in nursing homes. The following research questions guided the study: *How can the medication administration process in nursing homes be described? How can interruptions during the medication administration process in nursing homes be characterized?*

Background: Medication administration is a vital process across healthcare settings, and earlier research in nursing homes is sparse. The medication administration process is prone to interruptions that may lead to adverse drug events. On the other hand, interruptions may also have positive effects on patient safety.

Design: A qualitative observational study design was applied.

Methods: Data were collected using partial participant observations. An inductive content analysis was performed.

Results: Factors that contributed to the observed complexity of medication administration in nursing homes were the high number of single tasks, varying degree of linearity, the variability of technological solutions, demands regarding documentation and staff's apparent freedom as to how and where to perform medication-related activities. Interruptions during medication administration are prevalent and can be characterised as passive (e.g., alarm and background noises), active (e.g., discussions) or technological interruptions (e.g., use of mobile applications). Most interruptions have negative outcomes, while some have positive outcomes.

Conclusions: A process of normalisation has taken place whereby staff put up with second-rate technological solutions, noise and interruptions when they are performing medication-related tasks. Before seeking to minimise interruptions during the medication administration process, it is important to understand the interconnectivity of the elements using a systems approach.

Relevance to clinical practice: Staff and management need to be aware of the normalisation of interruptions. Knowledge of the complexity of medication administration may raise awareness and highlight the importance of maintaining and enhancing staff competence.

KEYWORDS
complexity, interruptions, medication administration, nursing homes, patient safety, primary care

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1 | INTRODUCTION

Alongside a growing elderly population, there are demands for increased collaboration between primary care and specialist healthcare (Cardoso, Oliveira, Barbosa-Póvoa, & Nickel, 2012; Monkerud & Tjerbo, 2016). This has led to nursing homes caring for patients who often have multiple and complex diagnoses and a high prevalence of polypharmacy (Herr et al., 2017). This is also the case in Norwegian nursing homes where increased collaboration with the specialist healthcare service has led to nursing homes being required to receive patients from hospitals as soon as they are ready for discharge, and incurring punitive economic sanctions if failing to meet those demands. This has led to increased pressure for nursing homes to receive patients with ongoing medical treatment and complex diagnoses (Syse & Gautun, 2013).

The most common types of adverse events in primary care are those related to diagnosis and medication (Makeham, Dovey, Runciman, & Larizgoitia, 2008; Marchon & Mendes, 2014). The World Health Organization (WHO) (2014, 2016) supports this, designating medication administration as a major source of adverse events.

Medication administration is a complex process, consisting of different stages depending on workflow and workplace conditions. Six stages are often described in the literature: (1) ordering, (2) transcribing, (3) preparing, (4) dispensing, (5) administering and (6) monitoring and reporting (Carayon, Wetterneck, Cartmill et al., 2014). It has been estimated that healthcare personnel perform a total of 50–200 tasks, from the doctor prescribing a drug to the drug being administered, and possible effects observed and documented (Kliger, Blegen, Gootee, & O'Neil, 2009; Moyen, Camiré, & Stelfox, 2008).

The medication administration process is prone to different kinds of interruptions. Estimates document that nurses are interrupted at a rate of 0.4–14 times an hour when performing tasks related to medication administration (Alvarez & Coiera, 2005; Biron, Loiselle, & Lavoie-Tremblay, 2009; Lee, Tiu, Charm, & Wong, 2015; Monteiro, Avelar, & Pedreira, 2015). The risk of adverse events may increase by 60% if nurses are disrupted in their workflow during the preparation stage (Biron, Loiselle et al., 2009). Others have found that both the dosing and administering of medications are particularly vulnerable stages at which adverse events are more likely to occur (Kunac & Reith, 2008; Leape et al., 1995).

Medication administration is an interwoven process inseparable from other nursing activities, and some researchers claim that to investigate it properly, there must be greater understanding of the underlying process and the work system in which it takes place (Hopkinson & Jennings, 2013; Jennings, Sandelowski, & Mark, 2011; Tucker & Spear, 2006).

The WHO (2017) recommends using a Human Factors approach and has set a worldwide target of reducing severe, avoidable medication-related adverse events by 50% over the next five years. The Human Factors literature mentions interruptions as a vital contributing factor to adverse drug events, linking it to underlying factors in the physical environment such as noise and layout, and attributes associated with tasks such as cognitive load and workload. Central in Human Factors literature is the work system in which a person or persons perform tasks in a physical environment using different tools and technology under certain organisational conditions. These factors in the work system interact and affect processes being performed (Carayon et al., 2006).

What does this paper contribute to the wider global clinical community?

- The study presents an original description and categorisation of interruptions that occur in daily practice at nursing homes.
- It expands the knowledge of medication administration in nursing homes, demonstrating that complexity in the medication administration process seems universal and that interruptions are normalised and may have both positive and negative outcomes.
- It highlights that a deeper understanding of the underlying work system is important before implementing interventions to remedy adverse drug events associated with interruptions.

Due to the complexity of medication administration and the acknowledgement of interruptions as a potential source of adverse medication events, the objective of this study was to expand our knowledge of the medication administration process in the context of nursing homes.

2 | BACKGROUND

Overall, research suggests that interruptions are a vital contributor to unsafe clinical practices and may lead to adverse drug events (Biron, Lavoie-Tremblay, & Loiselle, 2009; Bower, Jackson, & Manning, 2015; WHO, 2016). At the same time, some researchers argue that interruptions may have positive effects on patient safety and are a necessary part of conducting safe clinical practices (Anthony, Wiencek, Bauer, Daly, & Anthony, 2010; Hopkinson & Jennings, 2013; Rivera & Karsh, 2010).

The research literature uses terms like interruptions, distractions and disruptions interchangeably and with varying definitions. The use of different terms has led to some ambiguity when comparing numbers and results (Hopkinson & Jennings, 2013). This study defines interruptions as a halt or break in a primary work task, alternatively engaging in a secondary task that takes attention away from and stops interaction with the primary task (Biron, Loiselle et al., 2009; Li, Magrabi, & Coiera, 2012).

Several reviews on interruptions during medication administration have focused on acute medical care and hospital settings (Biron, Loiselle et al., 2009; Grundgeiger & Sanderson, 2009; Hopkinson &

Jennings, 2013; Keers, Williams, Cooke, & Ashcroft, 2013; Li et al., 2012; Monteiro et al., 2015; Moyen et al., 2008; Raban & Westbrook, 2014; Rivera & Karsh, 2010). Knowledge of what characterises the medication administration process in nursing homes is sparse. Al-Jumaili and Doucette (2017) indicate that work system factors such as patient characteristics, nursing staff knowledge of medication administration, staff/patient ratio and technology in use may affect medication safety. Lee et al. (2015) explicitly examined interruptions during medication administration in nursing homes and found suboptimal conditions. They reported four to five such interruptions an hour, mostly from patients. Interventions to reduce interruptions document varying results depending on the context in which they are implemented (Dall'Oglio et al., 2017; Lapkin, Levett-Jones, Chenoweth, & Johnson, 2016; Westbrook et al., 2017). A review of the current literature indicates a knowledge gap related to medication administration and interruptions in the nursing home context.

The aim of this study was therefore to contribute in-depth knowledge of the characteristics of medication administration and interruptions in nursing homes. The following research questions guided the study:

How can the medication administration process in nursing homes be described?

How can interruptions during the medication administration process in nursing homes be characterized?

3 | METHODS

3.1 | Design

The study had a qualitative observational design (Maxwell, 2008) and was carried out in two nursing homes in Eastern Norway in 2016. This was the most appropriate design due to the lack of in-depth studies on medication administration and interruptions in the nursing home setting, and a lack of observational studies to systematically map the surrounding work system.

3.2 | Study setting, recruitment and participating wards

As in many other countries, Norwegian nursing homes differ in style of management, size and patient types. They are managed independently in each municipality, and a common task for Norwegian nursing homes is active treatment in addition to ensuring that the basic needs of the residents are satisfied (Malmedal, 2014).

When recruiting nursing homes, the goal was to acquire variation through purposeful sampling. Therefore, two different nursing homes in two different municipalities in Eastern Norway were approached (Maxwell, 2008). In one nursing home, an urban-based palliative care-centred nursing ward (Ward A) was included. In the other nursing home, a rural-based nursing ward with patients primarily suffering from dementia (Ward B) was included.

Initial contact with the nursing homes was made by telephone during December 2015. Senior managers at both nursing homes were briefly informed of the intent and form of the study, whereupon they agreed to participate and contacted the wards they deemed appropriate for inclusion. The first author then contacted the local management of the two wards and briefed them in person. They agreed to participate in the study, and the first author arranged a preparatory meeting with the staff at the wards. The meetings took place at the respective wards, and staff were informed of the study and given the opportunity to ask questions.

Common for both participating wards is that medicine rooms are distant from the rest of the ward, the nurses' station and common rooms. Both wards therefore employ medication trolleys, placed in the nurses' stations, for the everyday administration of medications. Nurses' stations and common rooms are physical environments with a high level of activity and background noise. Stationary computers for documentation tasks are available at the nurses' station, as well as procedures, journals, paper documentation, guidelines and papers and equipment relevant for day-to-day clinical practices.

Ward A conducts previsitations in the nurses' station. Ward B conducts previsitations in a dedicated office, largely secluded from the rest of the ward, with less interference from other activity and background noise. Wireless network access is good in Ward A and intermittent in Ward B. Key characteristics of Ward A and Ward B are listed in Table 1.

3.3 | Data collection

The first author, a male registered nurse, conducted fieldwork through partial participant observations (Hammersley & Atkinson, 2007). A guide for observations in line with Human Factors theory was based on the following keywords: "Tools & technology," "Tasks," "Organization," "Physical environment" and "Persons" (Carayon et al., 2006). Using this guide helped the researcher to focus on the different elements of the work system in which the process of medication administration takes place. A pilot study was performed in January 2016 in a nursing home ward different from the included wards but in a comparable contextual setting to test data collection methods and the observation guide. This led to a more detailed observation guide. Data from the pilot study were not used in the analysis of this study.

Observations took place twice a week, 2–6 hr a day totalling 140 hr from April–November 2016. Most observations took place in the daytime shift, and a few on the evening shift and initial hours of the night shift. Data collection was centred on scheduled critical aspects of medication administration, for example, previsitation (ordering and transcribing), and activities in the medicine room (dispensing). Staff members were observed during the entire medication administration process. The researcher did not actively partake in clinical work but was dressed in work attire like the rest of the staff. Awareness of the importance of reflexivity during the research process was ever present to minimise researcher influence (Maxwell, 2008). The researcher wrote field notes and transcribed them

TABLE 1 Characteristics of Ward A and Ward B

	Ward A	Ward B
Type of patients	Palliative care, cancer care, complex illnesses. High degree of pain management and nutritional management	Light to severe degree of dementia and varying degree of disabilities and chronic diseases
Number of patients	6	10
Total number of staff	25 healthcare workers, a mix of RNs, specialist nurses (SRN), NAs and other professions covering two wards	29 health healthcare workers, a mix of registered nurses (RN), nurse assistants (NA), and unlicensed nurse assistants (UNA) covering two wards
Dayshift staff	3–4 (mostly SRNs)	3 (mix of RNs and NAs)
Evening shift staff	2 (at least one RN)	2 (not always a RN)
Night shift staff	1 (always a RN)	½ (not always a RN)
Team structure	Primary-based. All patients are allocated among staff, and each staff member has medication responsibility for their patient	Group-based. One staff member per shift in charge of medications for all patients
Number of observations	16	15
Hours of observations	70	70

immediately afterwards. When necessary, conversations with staff to clarify aspects of medication administration and to explore the process were conducted. These were not digitally recorded, but citations and excerpts from conversations were noted verbatim during observations.

3.4 | Analysis

Shortly after the data collection had been finalised, the co-authors convened and discussed transcribed observational notes after a thorough read-through to ascertain a common understanding of the data. The analysis was performed in two parts. In the first part, information from the six stages of the medication administration process was obtained from analysis of the observational notes and the researchers' field experience. The process was documented as a chronological narrative, presented as a functional flow chart depicting the commonalities and key differences in the two wards. In the second part, the qualitative inductive content analysis in line with Elo and Kyngäs (2008) was performed in three phases. The preparation phase involved rereading the material several times and selecting the individual wards as units of analysis. An important step was making sense of the data as a whole. After that followed an organisation phase with open coding in the margin of transcribed notes, and grouping by similarities and subsequent categorisation. Altogether, 248 units of meaning were grouped in 10 descriptive subcategories based on content similarities. Examples of subcategories are "incoming calls" and "use of mobile applications." The subcategories were abstracted to three categories, for example, "technological interruptions," that were classified under one main category. An excerpt from the analysis exemplifies how units of meaning were categorised as shown in Table 2.

Grouping, categorisation and abstraction were carried out in NVIVO version 11. Analytical triangulation with co-authors led to the organisation phase being repeated several times before reaching a conceptual model in the reporting phase (Elo & Kyngäs, 2008). Excerpts from observational notes were chosen to illustrate the categories and reported in italics throughout the results section. The paper has been prepared according to the SRQR guidelines (O'Brien, Harris, Beckman, Reed, & Cook, 2014).

3.5 | Ethics

The Norwegian Social Science Data Service (NSD) (No. 45389) approved the study. A form was distributed for participants to give

TABLE 2 Example of analysis

Unit of meaning	Subcategory	Category	Main category
While the nurse is preparing the medications at the medication trolley, a colleague passes by, and they engage in informal conversation, updating each other on the status of the patients they are taking care of.	Discussions	Active interruptions	Complexity and interruptions made normal
During previsitation, the door opens on five occasions, and staff enter to copy some papers.	Using office equipment	Passive interruptions	
Two nurses are in front of the stationary computers, there has been a software update, and they are unable to log in. Documentation has to be postponed.	Use of Electronic Medication Administration Records (eMAR)	Technological interruptions	

their informed consent. Participants were informed of data confidentiality and of the opportunity to withdraw at any time. No one chose to withdraw during or after data collection. The study did not require approval from the Norwegian Regional Committees for Medical and Health Research Ethics as no patients or patients' information was involved.

The first author performed all observations, and management of both nursing homes was informed that professional ethics overrode researcher neutrality (Guillemin & Gillam, 2004). This entailed more specifically that if the observer identified situations with the potentiality for unwanted incidents, staff would be alerted. No such incidents occurred.

4 | RESULTS

4.1 | Common medication administration processes

The study documented medication administration in the current nursing homes as complex processes, involving continuous interprofessional collaboration. Contributing factors to the observed complexity were the high number of single tasks, varying degree of linearity, the variability of technological solutions, demands regarding documentation and staff's apparent freedom as to how and where to perform medication-related activities. There were many commonalities in the two wards and observations of practice were used to construct a simplified flow chart on the basis of the six stages of medication administration as depicted in Figure 1.

The standard medication administration process begins with the ordering (1) of specific drugs to patients during previsitation; this takes place in the nurses' station (Ward A) or a dedicated office (Ward B). Doctor and nurse examine patient charts and discuss changes of prescription. Where computers and documentation software are readily available (Ward A), the doctor or nurse directly transcribes (2) changes to the Electronic Medication Administration Records (eMAR). If not (Ward B), changes are noted on paper for later alteration in documentation software (eMAR). For long-term patients using multidosage medications, the doctor needs to fill in a prescription, which is later faxed to the pharmacy by the nurse. Updated multidosage medications arrive within one or two weeks. An updated medicine chart is then printed and placed in an indexed folder in the medication trolley serving as paper MAR. Short-term changes are effectuated by altering the content of pill organisers (See Figure 1: 3 Dispensing) in the medicine room or near the medication trolley if the necessary drugs are available there. If change entails removing medications from multidosage packages, these plastic bags are opened and their content transferred to pillboxes.

Preparing (4) medications entails removing drugs from pill organisers to medicine cups, while double-checking content against printed MAR. This takes place around the medication trolley placed in the nurses' station or a common room. Ward A employs primary patient care and a RN or NA prepares and administers medicines only to one or two patients under their care. Ward B uses a group-based patient care system, where a RN or a NA prepares and administers drugs to all patients on the ward. Some drugs are crushed, and injections or liquid medicines for oral ingestion are prepared on top of the medication trolley. Medicine cups and eventual additional medications are administered (5) to patients in situ in common rooms, corridors or patient rooms. Most patients in Ward A receive their medications in their room, while patients in Ward B often receive the medications in the common rooms. The staff are to oversee patients ingesting administered drugs. When drugs have been administered, this is documented in MAR and eMAR. The last step in the medication process is to observe the effects of administered drugs and document this in eMAR (6).

4.2 | Complexity and interruptions made normal

The data analysis revealed 10 subcategories, three categories and one main category: complexity and interruptions made normal, as documented in Figure 2.

The study findings indicate that interruptions are normal and give rise to both positive and negative outcomes. Interruptions with different characteristics occur during all stages of the medication administration process and are categorised as "active interruptions," "passive interruptions" and "technological interruptions."

4.2.1 | Active interruptions

Active interruptions were instances where work on a primary medication task was disrupted. These were interruptions caused by staff asking direct questions, staff answering incoming calls or when staff spontaneously engaged in conversations. Most frequently, disruption of the primary task would lead to a break before resuming. On a few occasions, a break in the primary task would lead to taking on a secondary task. The primary task did not always resume thereafter. One could observe active interruptions taking place in environments where staff congregated, such as nurses' stations and common rooms. Active interruptions had two outcomes for the person who was interrupted: A) those with a negative impact, leading to a halt in the primary work task, and B) those facilitating work tasks, manifested, for example, as interruptions in the form of spontaneous informal conversations where staff discussed medical issues, leading to changes in medication or treatment plans. An excerpt from the observation notes illustrates an active interruption with a positive outcome:

> *Nurse and doctor are interrupted during pre-visitation by another nurse, asking if the patient in room X should still get medicine Y. This led to a change in a prescription that would probably otherwise not have taken place.*

Excerpt from observational notes illustrating active interruptions with negative outcomes:

> *During pre-visitation, the nurse is interrupted three times, being asked different questions. Each time the*

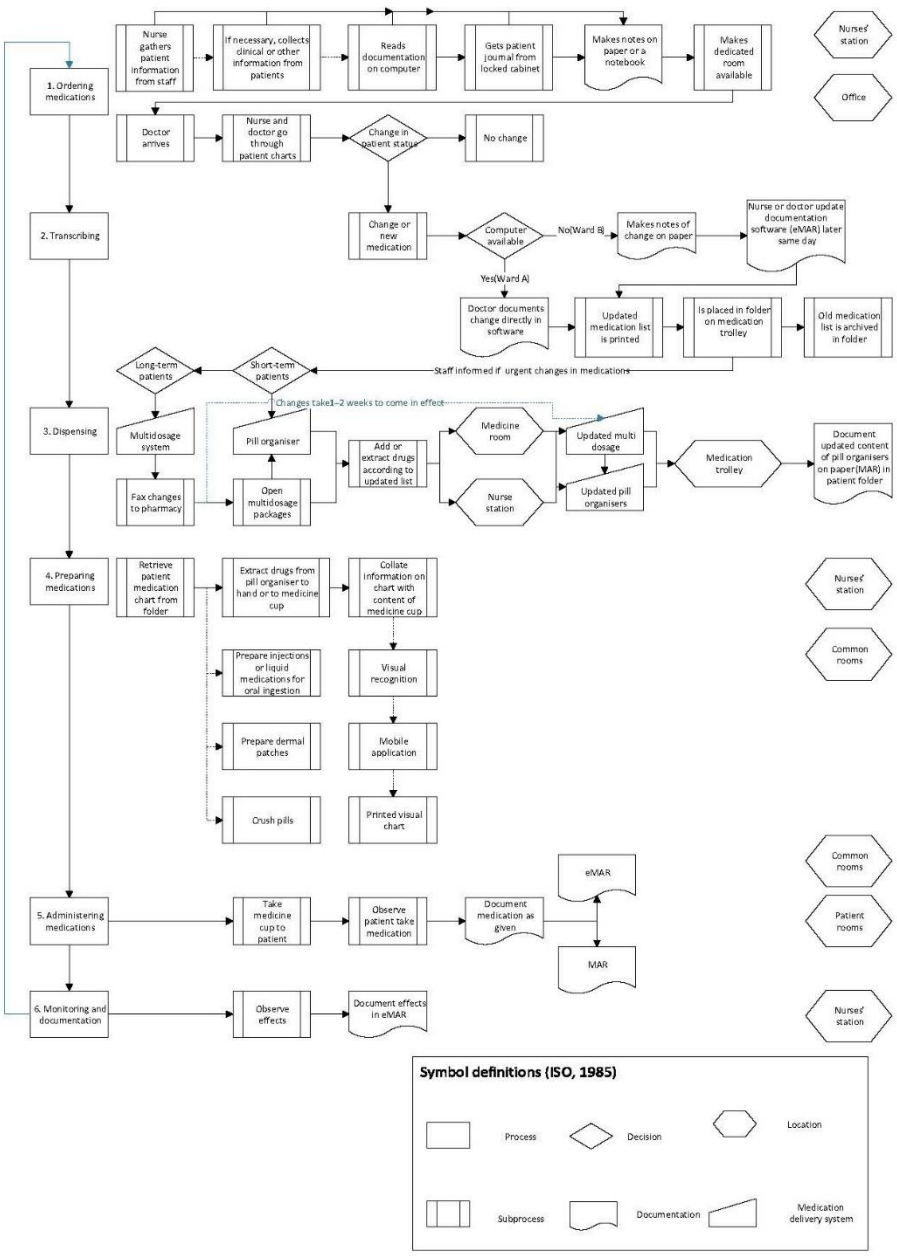

FIGURE 1 Flow chart of the medication process in Ward A and Ward B [Colour figure can be viewed at wileyonlinelibrary.com]

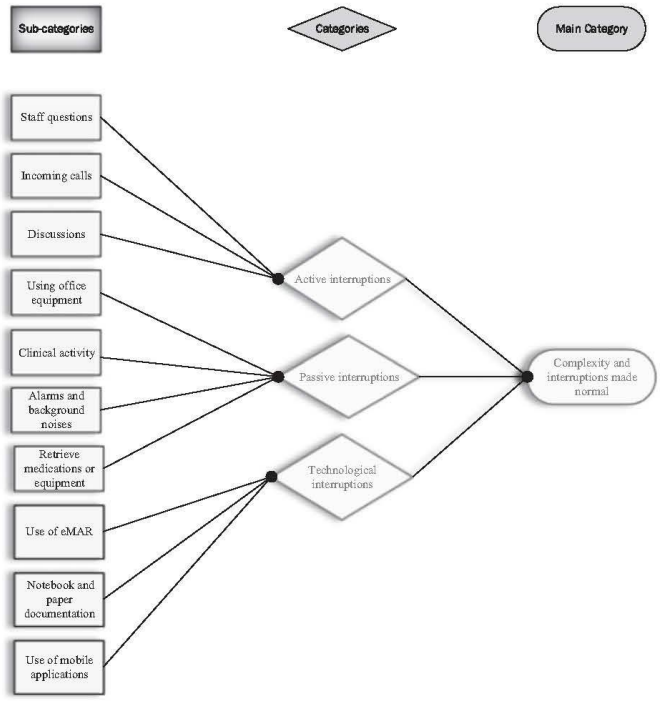

FIGURE 2 Overview of subcategories, categories and main category

nurse and doctor have to recapitulate before commencing discussion.

Dispensing, preparing and administering medications were stages in the medication process in which many people were involved simultaneously in Ward A, due to their primary patient approach to care. Often two or more healthcare workers were engaged in conversations around the medication trolley while dispensing or preparing medications. Staff mostly administered medications in private in patients' rooms. Ward B had a single RN or AN preparing and administering medicines for the entire ward and that person was more often left alone in the nurses' station when preparing medications. On the other hand, when staff from Ward B administered medicines to the patients, it was often in the common rooms, typically with a high level of activity, background noises and inquisitive patients. Active interruptions from both patients and colleagues during the administering of medications were thus more prevalent in Ward B.

Incoming calls from stationary phones or handheld phones led to interruptions when the nurses chose to answer. The RN with responsibility for medication administration in Ward B was obliged to carry a mobile phone and had to answer all calls. Otherwise, when phones were far away from staff, calls were not answered and became background noise or passive interruptions. On several occasions, incoming calls caused interruptions during all stages of the medication administration process. This could lead to a break in the primary task while answering the phone as a secondary task, before recommencing the primary task. If an incoming call occurred during preparation or dispensing of medications, the primary task sometimes continued while the nurse talked on the phone.

4.2.2 | Passive interruptions

Passive interruptions are cognitive stimuli with the potential to reduce concentration or affect cognitive faculties, but not necessarily breaking workflow. Another term for passive interruptions could simply be distractions or "background noise and activity". Examples of passive interruptions include staff retrieving medical equipment or medicines, performing clinical tasks in the proximity, using office equipment, nearby conversations or alarms. On occasions when these stimuli obviously disrupted staff, the interruptions would transform into being active interruptions. Passive interruptions were either technological or human in nature. Technological passive interruptions could be alarms or phones in the background, while human passive interruptions were voices, conversations and commotion caused by staff clinical activity.

Most passive interruptions seemed to be caused by colleagues. In both wards, despite its mobility the medication trolley was most often placed inside the nurses' station. Members of staff entered the nurses' station during previsitations or while other tasks related to medication administration were being performed such as retrieval of equipment, medicines, guidelines, post, requisitions or other documents. Some staff members entered the nurses' station to use the printer, stationary computers or the phones. Discussions and use of office equipment sometimes led to high levels of perceived background activity for those performing primary tasks related to medication administration. Sometimes staff took the medication trolley out of the nurses' station, and typically placed it in a common room with patients and colleagues present, and thus in an environment with a similarly high level of activity. An excerpt from the observational notes documents the normalisation of passive interruptions as a common part of the daily medication work task:

> *I asked the nurse how she experienced performing complex tasks while in the nurses' station. The nurse answered that sometimes it was hectic and there was a lot going on, but this was how it was and one just had to learn to cope with it as best one could.*

This behaviour seemed symptomatic in that staff very seldom asked for quiet or sought conditions where they could perform medication administration in peace.

4.2.3 | Technological interruptions

Technological interruptions are different from passive interruptions of a technological nature in that they arise from the use of tools and technology rather than as an endpoint such as incoming calls or buzzing alarms.

The use of technology was observed as a disrupting element at several stages of the medication administration process. Three different variations on the use of technology seemed disruptive to the workflow.

First, the use of documentation software (eMAR) was often perceived as overly complex and disrupting the workflow as this excerpt from the observational notes documents:

> *A nurse at PC documenting actions. She says to the researcher "You need to click a lot to do what you want to do, but things go reasonably well once you know how. Not everything is directly user-friendly. To write some type of reports, you need to access a Word document, and then cut and paste into the documentation software. This is cumbersome."*

Personal competence in the use of eMAR seemed to affect how effective staff perceived it to be. At the same time, a few said, "You just have to do your best. It is not always possible to do things the way you want. Then you have to find other ways to get around it."

Staff said that the eMAR was not designed according to how they were supposed to document medication administration, and using alternative solutions stole time. One example was that if patients needed additional medications, staff had to open a new window and document this in free text.

Another element disrupting workflow was caused by lengthy logins when staff were switching between software. This was apparent in situations where personnel came into the nurses' station to document actions at a stage in the medication administration process. Sometimes a staff member had forgotten to log out of the stationary computer, and login time became extended because of that. Login time and switching between software could cause up to several minutes of resumption lag. Some nurses explained that they preferred to wait until the end of their shift, and then document everything. In the meantime, they kept notes on scraps of paper in their uniform pockets.

Second, nurses used paper documents and notebooks in addition to eMAR throughout all stages of the medication administration process. Some of these documents were formal, and some of them were informal. Formal documents were patient charts and medication charts printed directly from eMAR, serving as an analog backup to document the dispensing, preparing and administration of medications. Some staff members documented medications as ingested while they prepared the medications, to avoid this task later. Others came back after patients had ingested their medicines and documented this action on the paper chart. Afterwards, they also documented the medications given in eMAR and noted any effects or side effects. Some staff members mentioned that these demands regarding documentation felt disruptive to their workflow.

The staff used informal notes as mnemonic devices for meetings and social activity as well as clinical activity in the ward. Some notes were scraps of papers kept in their uniform pockets, and sometimes the staff used a joint notebook kept in the nurses' station. This notebook contained information on various aspects of clinical activity such as planned alteration of medications, appointments to remember or points to bring up on previsitation. Information on patients and medications was documented multiple places, and some stated that it was difficult to know exactly where to find information. The use of a notebook in which everyday clinical activity was recorded seemed to supplement the use of documentation software. This alteration between modes of documentation caused interruptions in workflow.

Third, the staff used mobile applications to assist them in various tasks. When these applications worked flawlessly, they could be beneficial, but most applications are dependent on a wireless connection that is not always available. In parts of both Ward A and Ward B, connectivity dropped so much that the use of mobile applications was nearly impossible.

For example, when adjusting drug dosages or changing medications, the doctors used an online medical encyclopaedia, which was dependent on a wireless connection as seen in this excerpt:

The doctor looks down at the phone, searching for the correct dosage. . .the internet connection is too slow and the doctor looks up after a while, saying he will adjust dosages later instead.

The staff always used their private phones when consulting mobile applications and individual variations may have factored in, influencing the frequency of use, type of applications and fluency of interface.

5 | DISCUSSION

The aim of this study was to contribute in-depth knowledge of the characteristics of medication administration and interruptions in nursing homes. The main findings indicate that medication administration is a complex process consisting of many separate tasks (see Figure 1) and that colleagues often interrupt work tasks related to medication administration, either actively or passively. Many of the interruptions are caused by factors in the physical environment and/or the technology.

5.1 | Interruptions are normalised

The study points to the normalisation of active, passive and technological interruptions during the workday by all the staff involved in medication administration. More concretely, this entails that the staff put up with working in noisy, often cramped environments, where they are likely to be interrupted. They also accept that the technological solutions they employ are not tailored to meet their needs, forcing them to constantly adapt solutions and workarounds to facilitate medication administration. Due to the complexity of the medication administration process, it may be the case that interruptions are ingrained in the work system, making it difficult for the staff to recognise them as such. This conforms with normalisation process theory in that sustainment of unfavourable practices may become normalised within complex work systems over time (Banja, 2010; May & Finch, 2009).

5.2 | Human interaction

The study shows that human interaction with colleagues was the most likely cause of active interruptions and this is supported in the literature (Hall et al., 2010; Hedberg & Larsson, 2004; Lyons, Brown, & Wears, 2007). Moreover, active interruptions may also affect communication and teamwork, having detrimental effects on decision-making processes (Jett & George, 2003). As medication administration seems an interwoven part of nursing activities (Jennings et al., 2011), this implies that interruptions may have unforeseen consequences for a wide range of clinical and administrative activities. This study found instances where interruptions had positive outcomes, resulting in, for example, a change in treatment benefitting patients. One may argue that this is an indication of the need for constant communication and coordination to promote safe practices. Removing all sources of active interruption in the clinical environment may therefore be unwise, a finding confirmed by Rivera and Karsh (2010). However, most of the time the active interruptions had only negative effects by halting the primary task being performed. Active negative interruptions may cause staff to lack focus, increase feelings of stress and frustration and impact memory. This can lead to cognitive impairment and staff forgetting other tasks or committing failures of omission (Bower et al., 2015).

There are further distinctions in active interruptions. If interruptions are goal-oriented, the closer the interruptions are in nature to the primary task being interrupted, the less resumption lag one can expect. On the other hand, similarity between the interruption and the primary task may also cause cognitive confusion when resuming the primary task and thus increase the likelihood of making mistakes (Li et al., 2012). Observations often showed that during the preparation stage, staff members congregated around the medication trolley and active negative interruptions were frequent. These interruptions could be questions related to medication administration, and thus be similar in nature to the primary task being performed. These interruptions had a clear goal for the person interrupting and often proved helpful for them in completing their current task. So, the person interrupting benefits, while the person being interrupted experiences a negative outcome.

Furthermore, the findings of this study suggest that one member of the staff will be viewed as more competent by other staff members. The person with more experience and competence will have more responsibility and perform more complex tasks with higher cognitive demands. This may result in the person with more responsibility receiving more attention and questions than the others, and thus being more susceptible to being interrupted. Evidence from the literature further suggests that interruptions that are not goal-oriented should be weeded out using appropriate interventions (Rivera & Karsh, 2010). This is especially true for interruptions occurring during complex tasks with high memory demands (Li et al., 2012). This complexity suggests that a deeper understanding of the underlying work system is vital before elaborate interventions are implemented (Carayon, Wetterneck, Rivera-Rodriguez et al., 2014; Raban & Westbrook, 2014).

5.3 | The physical environment

What appears most significant in the physical environment is the use of the medicine room when distant from the rest of the ward and clinical and administrative activity. Some nursing homes share internal resources, and multiple wards often share a single medicine room. This has led to some wards employing medication trolleys and consequently moving some stages of the medication administration process closer to where the patient-related clinical activity takes place. This may have increased the chance of adverse events due to a higher level of passive and active interruptions. This mobility is not one-sidedly negative; being closer to the patients means more time

for observation and care-related activity and may prove beneficial in other areas.

Another aspect related to the physical conditions in the work system was the general use of nurses' stations. Most stationary computers used for documentation were located there. This also led to printers, copy machines and phones being in proximity of the computers, as well as printouts of guidelines, protocols, order sheets, etc. The nurses' station was thus the hub in which administrative activity and several stages of the medication administration process took place. This concentration of activity may have led to nurses' stations being aggregators of latent factors, with the inherent potential of becoming active threats. This contrasts somewhat with the finding of Biron et al. (2009) that the medicine room was the location with most frequent interruptions. On the other hand, nursing also seems to be about social interaction; the staff talk to each other, share work-related information or get tips when needed. These informal meeting places during the staff's workday may therefore be essential for the necessary communication and teamwork needed to conduct safe practices (Anthony et al., 2010; Hopkinson & Jennings, 2013; Rivera & Karsh, 2010).

5.4 | The tools and technology

Technological interruptions were mostly related to the active use of different technology, and how it affected the workflow of the staff when they performed tasks related to medication administration. Biron, Loiselle et al. (2009) use the term technical sources of interruptions, including alarms or operational failure due to missing or malfunctioning equipment. In this study however, these types of interruptions were termed passive interruptions. Others define passive interruptions as distractions that can be ignored or processed simultaneously with the primary task (Biron, Lavoie-Tremblay, et al., 2009). Most strikingly in this study was how the staff perceived eMAR as both an effective tool and a tool that gave rise to glitches in that some functions were missing or cumbersome. This may have led staff to find workarounds, using paper documentation instead. Alenius and Graf (2016) suggest that the use of eMAR may reduce the perceived risk of committing errors related to medication administration if it exclusively replaces the use of paper documentation. Others indicate that eMAR does not necessarily contribute to documentation efficiency, but can increase staff documentation compliance (Qian, Yu, & Hailey, 2015). Our findings indicate that eMAR should be tailored to meet the needs of the staff, to prevent unnecessary breaks or workarounds and thus avoid double documentation and perceived interruption of workflow.

During the ordering, transcription and dispensing stages of medication administration, staff often used mobile applications to verify pillbox content or to check correct dosages of medications. Sometimes a lack of wireless connection led to a complete break in the task being performed. This suggests a vulnerability in the work system whereby the staff are dependent on unstable technical solutions, and may contribute to the fact that paper documentation was prevalent despite the availability of digital solutions.

5.5 | Limitations

Limitations in this study are the use of a sole observer throughout the research process, introducing potential bias. This was countered using a research team consisting of three nurses and one engineer, allowing for different viewpoints and analytical triangulation throughout the research process. The first author is a registered nurse and observations may therefore be biased because of preconditioning in a similar field. On the other hand, familiarity in the field (nursing) allows insights to be gained more quickly. A sample including only two nursing homes is small, but a purposeful sampling was chosen aiming for variation allowing for in-depth investigation of the medication administration process. Some conditions observed may be special for the two wards selected, yet medication administration is a universal process, and the findings and insights are easily transferable across settings.

6 | CONCLUSION

Medication administration and interruptions are interwoven elements in the complex work system of nursing homes. Interruptions seem to have different characteristics and may play a significant role in the process of medication administration. Findings indicate that there are three main categories of interruptions: active, passive and technological. A process of normalisation seems to have taken place, where staff put up with second-rate technological solutions, noise and disruptions when they are performing medication-related tasks, without complaint. Interruptions are not always negative and can have both unforeseen and positive consequences. Before seeking to minimise interruptions during the medication administration process, it is therefore important to understand the interconnectivity of the elements within the medication administration work system. Using a Human Factors approach in further studies seems a reasonable way of encompassing this complexity, and finding or developing and employing appropriate interventions to reduce the risk of adverse medication events caused by negative interruptions.

7 | RELEVANCE TO CLINICAL PRACTICE

Staff and management need to be aware of the normalisation of interruptions. Knowledge of the complexity of medication administration may raise awareness and highlight the importance of maintaining and enhancing staff competence.

CONTRIBUTIONS

Study design: KRO, BSH, KA, SW; data collection and analysis: KRO, BSH, KA, SW and manuscript preparation: KRO, BSH, KA, SW.

CONFLICT OF INTEREST

None.

ORCID

Kristian Ringsby Odberg http://orcid.org/0000-0003-3456-9740

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RESEARCH ARTICLE

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Medication administration in nursing homes: A qualitative study of the nurse role

Kristian Ringsby Odberg[1] | **Britt Sætre Hansen**[2] | **Sigrid Wangensteen**[1]

[1]Department of Health Sciences, Norwegian University of Science and Technology (NTNU), Gjøvik, Norway

[2]Faculty of Health sciences, SHARE—Centre for Resilience in Healthcare, University of Stavanger, Stavanger, Norway

Correspondence
Kristian Ringsby Odberg, Department of Health Sciences, Norwegian University of Science and Technology (NTNU), Gjøvik, Norway.
Email: Kristian.odberg2@ntnu.no

Abstract

Aims: The objective of this study was to expand the knowledge of the nurse role during medication administration in the context of nursing homes. The following research question guided the study: *How can the nurse role during medication administration in nursing homes be described?*

Design: A QUAL–qual mixed study design was applied.

Methods: Data were collected using partial participant observations and semi-structured interviews of all staff members involved in medication administration. An inductive content analysis was performed.

Results: Medication administration is a pervasive process ingrained in the day-to-day activities of providing care to the patients. The nurse role is compensating, flexible and adaptable. There is a dynamic interaction between several contributory factors, those being shifting responsibility, a need for competence, invisible leadership, varying available competence, staff stability and vulnerable shifts.

KEYWORDS
medication, nurses, nursing, nursing homes, older people

1 | INTRODUCTION

Patient safety issues in primary health care are mainly related to diagnosis and medication. It is generally acknowledged that adverse events related to medication administration account for a significant threat to overall patient safety (Kohn, Corrigan, & Donaldson, 2000; Makeham, Dovey, Runciman, & Larizgoitia, 2008; Marchon & Mendes, 2014; Vogelsmeier, 2014). Medication administration involves an intricate mixture of various tasks and demands that temporally structure the nurse's workday (Carayon et al., 2014; Grigg, Garrett, & Craig, 2011; Jennings, Sandelowski, & Mark, 2011; Moyen, Camiré, & Stelfox, 2008; Odberg, Sætre Hansen, Aase, & Wangensteen, 2017).

Primary health care in the Western World reaches out to a broad segment of the population and is the facet of the healthcare system with which most people interface. Each municipality independently governs Norwegian nursing homes, and there are local and regional variations in size, patient types and the style of management. However, the basic principles of active treatment and ensuring the basic needs of the residents are universal (Malmedal, 2014). Recent reforms have led to increased collaboration between primary care and specialist health care. Nursing homes experience increased pressure to receive more patients needing more complex active medical treatment, compared with a few years back (Syse & Gautun, 2013).

2 | BACKGROUND

The medication administration process consists of six stages: ordering and prescription; transcribing; dispensing; preparing; administering; and finally observing and documenting effects and side effects (Carayon et al., 2014). Medication administration errors (MAE) may occur anywhere

All authors contributed equally.

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along this chain and cause an adverse drug event (ADE; Carayon et al., 2014; Choo, Hutchinson, & Bucknall, 2010; Odberg et al., 2017; Smeulers, Onderwater, Zwieten, & Vermeulen, 2014). According to WHO (2016), MAE's are preventable at different levels.

Overall research acknowledges the importance of the nurse role in maintaining and improving medication safety in health care (Choo et al., 2010; Grigg et al., 2011; Kowalski & Anthony, 2017; Smeulers et al., 2014). Many factors influence safe medication management. Some argue that nurses (RN) may have insufficient knowledge and skills to perform safe medication management (Andersson, Frank, Willman, Sandman, & Hansebo, 2018; Simonsen, 2016); others point to normalization of risk-inducing behaviour and interruptions (Odberg et al., 2017), or use of technology, design flaws, time constraints, poor communication, lack of leadership, as well as outdated policies and guidelines (Al-Jumaili & Doucette, 2017; Carayon et al., 2014; Keers, Williams, Cooke, & Ashcroft, 2013; Lapkin, Levett-Jones, Chenoweth, & Johnson, 2016; Marasinghe, 2015). There is an apparent lack of studies investigating the nurse role during medication administration in nursing homes.

Due to the complexity of medication administration, the acknowledgement of MAE's in primary care and the essential role of the RN, the objective of this study was to expand knowledge of the nurse role during medication administration in the context of nursing homes. The following research question guided the study: How can the nurse role during medication administration in nursing homes be described?

3 | METHOD

3.1 | Design

The study applied a qual-qual mixed method design (Morse, 2016) using partly participant observations (Hammersley & Atkinson, 2007) supplemented by semi-structured interviews for data collection. The first author collected all the data in two nursing home wards in Eastern Norway.

3.2 | Study setting and recruitment

The senior managers of the participating nursing homes were contacted by telephone in December 2015. They were informed of the objective and content of the study and agreed to participate. Shortly after, the first author briefed the entire staff on both wards during regular staff meetings and asked whether they would consider participating in interviews. One nursing home ward with ten patients was rurally based and catered mostly to patients suffering from dementia and minor disabilities. The other nursing home ward, with six patients, was in a neighbouring urban municipality, with patients having multiple complex medical diagnoses and in need of palliative care.

3.3 | Data collection methods

A pilot study was conducted in a nursing home ward providing a similar contextual setting as the current study to test the data collection methods. Experiences and findings from the pilot study resulted in a more detailed observation guide and interview guide. No data from the pilot study were used in the current study.

The data collection took place in 2016, consisting of 140 hr of observations supplemented by 16 semi-structured interviews of staff members. Most observations took place in the daytime shift and a few on the evening shift and opening hours of the night shift. The first author, dressed in work attire, followed staff members around conducting partly participating observations during medication administration-related tasks (Hammersley & Atkinson, 2007). A semi-structured observation guide based on the elements in the work system of Human Factors theory (persons, tasks, physical environment, tools and technology, organization) guided the researcher when observing the different stages of medication administration (Carayon et al., 2006). Examples are, observations of pre-visitation, transcribing medicines or staff preparing medicines before administering them. Situations observed were noted between sessions, while excerpts from relevant conversations between staff members were written down verbatim immediately. After each observational session, all notes were transcribed and expanded on while the memory of the events was clear in the mind.

Participants working more than a 50% position for more than a year were interviewed. There were eight staff nurses, three nurse assistants, two nurse managers and two doctors. The majority were women (12). The reason for including professions apart from the nurses was observations showing a strong dynamic interaction between all staff members during medication administration. The interviews were digitally recorded and lasted from 30 min - 1 hr. The interview guide was constructed in line with observational findings and from elements in the work system in Human Factors theory (Carayon et al., 2006).

3.4 | Analysis

Shortly after finalizing the data collection, the authors read all the material multiple times to reach a common understanding of the data as a whole. The first author then coded openly in the margins of the transcribed material, extracting meaning units pertaining to the research question. These meaning units were condensed, coded and grouped based on similarities, forming subcategories and main categories in line with principles in inductive content analysis (Elo & Kyngäs, 2008). Data from the observations and interviews were handled and coded separately and integrated in the final stage of the categorization process (Morse, 2016). Analytical discussions and reflections with the co-authors led to several iterations before arriving at a conceptual model. Observational data formed the core for describing the day-to-day care and the structure of medication administration. Excerpts from the interviews and observation notes were chosen to illustrate the different main categories and subcategories. They are reported in italics throughout the Results section and coded to differentiate the position (second and third letter) and the individuals (final letter):

TABLE 1 Analysis exemplified with one of three main categories and subsequent subcategories

Main category	Sub-category	Condensed meaning	Examples of meaning units
Compensating	Need for competence	Differences in individual competencies. Keeping up to date is an individual responsibility	IRN-D Yeah…internal education, we have some of that. The previous doctor used to spend some time with us, refreshing competencies and skill—not anymore though—and sometimes we arrange some educational stints
	Shifting responsibility	The nurse is regarded as pivotal for the running of day-to-day business	IRN-E It may be slow at times if the doctor is uncertain. He does not take hasty or quick decisions and may sow doubt by the way he acts. Then you feel more responsible as a nurse, because you have to lead the way somehow, and that is not how it should be

IRN-A = Interview Registered Nurse A
INA-A = Interview Nurse Assistant A
INM-A = Interview Nurse Manager A
IMD-A = Interview Medical Doctor A

An example of analysis is shown in Table 1.

3.5 | Ethics

The Norwegian Social Science Data Service (NSD; No. 45389) approved the study. Since there was no involvement of patients or use of patient information, the study did not require approval from the Norwegian Regional Committee for Medical Health Research Ethics.

The first author is a male registered intensive care nurse with no prior familiarity with or knowledge of any of the wards or the participants in the study. All participants gave their informed consent and were informed of data confidentiality and of the opportunity to withdraw at any time. No one chose to withdraw during or after data collection.

Before observations, the researcher informed all participants that professional ethics overrode researcher neutrality, meaning that the staff would be alerted if the researcher identified situations where patient harm could be averted (Guillemin & Gillam, 2004). The researcher encountered no such situations.

The paper was prepared according to SRQR guidelines (O'Brien, Harris, Beckman, Reed, & Cook, 2014).

4 | RESULTS

When aiming to describe the nurse role in medication administration, three main categories emerged: compensating, flexible and adaptable. Each of these main categories contains subcategories describing different aspects of the nurse role and the collaboration needed to perform medication administration. The results reflect a dynamic interaction of several contributory factors and how the nurse role is integral in medication administration as shown in Table 2:

4.1 | Compensating

The roles of the individual staff members are affected by the competencies of the surrounding staff. The most striking finding is how

TABLE 2 Contributory factors influencing the nurse role during medication administration on different levels

Individual level **Compensating** Need for competence Shifting responsibility	Team level **Flexible** Leadership Available competence	Organizational level **Adaptable** Staff stability The vulnerable shifts
• Varying competence Need for updated competence • Medication administration perceived as complex by RN's • Takes on more responsibility than necessary • Administrative tasks take precedence • The RN's are natural leaders • Do more tasks than obliged • Inadequate resources	• Leadership is distributed and invisible • Nurse managers are in a tight position • Delegation of tasks Available competence Vulnerable Random • Informal leadership • Random team composition • RN's prioritize administrative tasks	• Shifting workload • Cannot plan for everything • Staff stability important Experience and personality • Staff composition important • Workarounds are normal • Prepare in advance • Contingency plans • Continuity of care

the nurse in charge is left to compensate for the degree of skills and competencies of their team members.

4.1.1 | Shifting responsibility

NA's perceive medication administration as an easy task, describing it as only preparing and administering medicines. The nurses have a fuller picture encompassing all six stages of the medication administration process, and they also consider it a much more complex process as documented in the following interview excerpts with a nurse:

> IRN-A I started out as an NA, which I appreciate. It gave me a lot of the basic skills necessary, but of course, there is a lot more responsibility as a nurse. You do more of the same, but you have more responsibility and more tasks as a nurse.

The NA's see themselves in the light of the nurses and perceive their duty to assist the nurses. Consequently, they consider the nurses to be their superior in all settings, referring to them if questions or problems arise. Some nurses thrive on this, making them feel competent and taking the role as leaders. This invisible role designation led to a hierarchical structure, especially evident on shifts with a single nurse. On shifts with several nurses, seniority seems to fall to the nurse with most experience as illustrated in this observational excerpt:

> There are three nurses in the nurse station, allocating tasks at the start of the morning shift. It is hard to identify who is the leader, but after a while, the nurse with seniority becomes the centre of attention and makes final decisions on which patients they will have responsibility for.

The nurses have a considerable responsibility, and they tend to take on tasks belonging to the other staff members as well as their own. Observations document that the nurses often regard themselves as being "the spoke of the wheel" and often define specific medication administration tasks as more important than other tasks. A substantial number of the tasks related to medication administration were delegated from the MD and could not be delegated to nurse assistants.

The nurses adjust dosages to patients with varying needs, for example, when administering drugs for diabetes or pain management. Most often, they have a sheet of paper with pre-authorization from the doctor on various drugs. At other times, the nurses make changes or adjustments themselves, based on observations and patient needs and inform the doctor on a later occasion. Excerpt from observational notes:

> During pre-visitation the nurse informs the doctor that "we have made the following changes in some medication prescriptions. The nurse then asks the doctor if he may formalise the changes, which means to transcribe them in the electronic medication administration record. Then the nurse rationalises the decision and the doctor agrees.

The MD generally accepts this as normal routine provided the RN's are able to substantiate the drug alterations. An excerpt from an interview with an MD follows:

> IMD-A I know how experienced the nurses on this ward are when it comes to administering morphine, so I probably often note the indication and give the nurses space to be flexible. There is seldom a right or wrong, but the nurses have to substantiate their opinions or when they make alterations.

Observations documented that when the doctor was uncertain, the nurses experienced more responsibility together with a feeling of uneasiness. In cases where the doctor had strong opinions and openly discussed the patients with the nurses, they were included and empowered. This duality gave rise to the nurses compensating for how the doctor behaved. If they considered the doctor to be "weak," they compensated by taking on tasks that were not theirs initially. If they considered the doctor "strong," they let the doctor handle things as they stood. Examples of additional tasks could be how the nurse offered to take on documentation tasks belonging to the doctor (transcribing), merely to ensure that this was done.

4.1.2 | Need for competence

The staff often noted that patients have more diagnoses and are in need of more advanced medication administration than before; they had to take responsibility for patients before they were adequately treated or diagnosed and in turn more complex tasks related to medication administration. This has led to more responsibility and a need for updated competence.

There is limited funding to send staff to courses and conferences and maintaining competence largely depends on personal initiative. The staff complain that if they need more advanced competence, they have to use their spare time, receiving no financial reimbursements or incentives. At the same time, all staff members acknowledge that complex healthcare environments and nursing sciences are in constant flux due to advances both medically and procedurally.

The managers seemed aware of the inadequate resources that inhibit competence development in the staff, placing them between a rock and a hard place. One nurse manager described it in an interview as:

> INM-A We continuously receive new guidelines relating to medications, with new demands on documentation. At the same time, we need to keep tabs on everything; it always comes down to the economy, who pays for what. Everything has consequences if we are not thorough in following up. We have more tasks and demands than ever.

4.2 | Flexible

Flexibility mirrors the freedom staff members experience in structuring their workday and performing medication-related activities. Tasks in the workgroup on specific shifts are delegated differently in line with changing circumstances. The nurse also compensates for the other team members' strengths and weaknesses. If a nurse spots a weakness in a colleague or does not trust him or her to do a specific task, they do it themselves instead. When they did, it was not explicitly stated and was viewed by the others as expected behaviour.

4.2.1 | Available competence

The team on a specific shift have a shared world of experience and skill where the staff works. Available skills and competencies on a given shift are demarcated partly by the professions in the team.

Some shifts may experience staff lacking the competencies to administer certain medications. At other times, only one person, usually a nurse, has the necessary skills to perform specific activities vital to a patient. This may lead to vulnerability as the team may experience a lack of skill redundancy. Such vulnerability may lead to adverse events under adverse circumstances, for example, staff shortage, or unexpected events in the ward. Some shifts have only one nurse, and most administrative and medication-related tasks will fall on that nurse. Many tasks during a shift are indirectly care-related or related to medication administration; these are perceived as administrative tasks. Administrative tasks are often considered a nurse prerogative, and nurses may find themselves swamped because of their inherent task flexibility, being able to undertake a variety of roles. If there are NA's present, they are most often engaged in clinical work, close to the patient, reporting verbally to the nurse on the team. The NA's acknowledge the nurses' workload:

> INA-A If you have the evening shift alongside a nurse, they have a higher workload, because a majority of the activity on this ward demands a nurse, because of competence and such.

4.2.2 | Leadership

The nurse managers were in charge of the team composition on the individual shifts, distributing staff across the various shifts, weeks in advance. The teams were formed so that professions complemented each other with the aim of always having a nurse on all shifts.

Although the staff are supposed to update on the patients on their own by reading from the electronic medical record, they also had an informal roundtable discussion before commencing each shift. This discussion served to vent frustration, to reflect on recent events, but also to discuss and delegate patients and specific tasks among the staff members. The task-allocation often took into account the wishes of the staff members and was in contrast to the manager's prior assignments:

> INA-A "Patients and tasks are in fact assigned in advance, but we sit there during the time of the report and distribute tasks and patients among ourselves as well. It depends on the workload, if our wishes are granted, we have to ensure that no one gets too much to do, that we assign fairly. If we have a nurse on that shift, she will have the final say. Otherwise, it's like the toss of the dice."

The skills and competencies available on a particular shift result from the managers' pre-planning but get randomized as circumstances change; staff may become ill, forcing changes. The flexibility of task assignment is therefore dependent on the skills and competencies needed in the various tasks related to medication administration. Not all staff members can set up an intravenous line or administer all type of medicines.

4.3 | Adaptable

The main category "adaptable" contains two related categories: *Staff stability* and *Vulnerable shifts*. In short, adaptability is about how the staff adapt to changing workloads during the various shifts and how they perceive the relationship with their co-workers as a critical factor in collaborating and performing medication administration safely. An alteration in work tasks and workload is sometimes predictable, but most often not. Consequently, some shifts end up being vulnerable.

4.3.1 | Staff stability

Staff stability is critical to achieving optimal care for the patients, underlining the importance of knowing your co-workers when working in a demanding and complex environment. Working well together depends on personality, and there are individual differences influencing cooperation. The freedom to ask colleagues for help during medication administration is reported as crucial by most staff members and depends on a shared understanding of the situation and that all staff members report on their location at all times. Also, sharing experiences together seems vital, allowing the staff to form bonds that would not otherwise have formed. The relationship with co-workers is illustrated in the following excerpt from an interview with a nurse assistant:

> INA-B "We experience a lot together, stressful and taxing situations…for the most part we are good at talking to each other, but there are variations, it depends on who you're working with; it's all about personal chemistry."

Having good personal chemistry with colleagues was necessary for the staff to thrive. When the staff know each other, they are less

vulnerable if something unpredictable happens. The quality of the care depends on the stability of the staff and when staff members know each other, there seems to be less need for direct communication and delegation of tasks. A stable staff also know the patients and can work more efficiently and may provide better care. The opposite happens if there are many substitute nurses; the continuity of care may be disrupted and a proportionally higher fraction of the total workload is taken on by the regular staff members.

4.3.2 | The vulnerable shifts

In periods of high workload, the staff seems to work with great efficiency and they describe the work as going smoothly. Like one nurse said: *IRN-B* "When it's busy we are like well-oiled machinery." Another nurse stated that it is a balancing act. "If it's too hectic, we do not work so well together". Such high workloads may have positive professional outcomes, as the staff claim to work more smoothly. It may also lead to adverse patient outcomes in that the healthiest patients receive less attention and care. One nurse (IRN-C) said during observations that "when it is busy we prioritise medication to the patients most needing it." At the same time, several stated that they like working when it is busy since it gives them a feeling of higher self-worth.

Both nursing home wards reported staff levels to be adequate during the day shifts on weekdays. Evening shifts, night shifts and weekends were often reported as vulnerable depending on workload and status of the current patients. This vulnerability was directly linked to the professions and competencies of the staff at work. Working vulnerable shifts seemed to invoke negative emotions in the staff and an excerpt from an interview with a nurse describes it as follows:

> IRN-D "This is the way it is. I feel very alone during my weekend shifts, being a single nurse and the only regular staff member. That is not okay. I feel that I lose control and when Monday finally arrives, I send a silent thanks that everything went well.".

Some night shifts had no nurse on duty, and all medications had to be prepared in advance. The staff were aware of the vulnerable shifts in advance and did their best to plan accordingly, as shown in this observation note:

> The nurse in charge realises that there are no nurse set up on the next shift and that they have a patient suffering from pains hard to relieve. They decide to prepare a dose of morphine in advance, doing the double-checking now.

This proactive engagement seems to be due partly to the unpredictable nature of working in a complex healthcare system; the staff expected the unexpected.

Because the vulnerable shifts could be particularly unpredictable, the staff prepared medications in advance or sent notice to the staff on the neighbouring wards that they might need assistance. In coping with the provision of medicines around the clock, the staff knowingly bent guidelines and procedures to fit the reality of their work environment. An excerpt from an interview with a nurse elaborates on how she would handle a potential situation on a vulnerable shift:

> IRN-E If I needed to administer morphine and was alone on my shift, I might have taken a photo with my cell phone and sent it to a colleague for confirmation. I would have done something like that if the situation demanded it.

5 | DISCUSSION

The main findings indicate that the RN has a central role at all the stages of medication administration and that this role goes beyond the job description. Varying workload, staff stability, the degree of leadership, available competence and dynamic events in the workday are compensated by the RN's to ensure fulfilment of all tasks related to medication administration at all times.

5.1 | Resilience

Medication administration in nursing homes is a complex process taking place in a complex system with inherent vulnerabilities, placing high demands on the sociotechnical work system and the staff (Carayon et al., 2014; Choo et al., 2010; Grigg et al., 2011; Odberg et al., 2017). Findings in the current study document this complexity and elaborate on how the staff and particularly the RN's adjust to shifting circumstances in their work environment. Human Factors focus on the interaction of the elements in the sociotechnical work system and how people perform processes in this system (Carayon et al., 2006). Workarounds and adaptations are often described as "filling in the gaps" to cover for design flaws or internal or external pressure and complexity (Rankin, Lundberg, Woltjer, Rollenhagen, & Hollnagel, 2014). The main categories in the current study describe role compensation, flexibility and adaptability as crucial when describing the nurse role in medication administration. These categories reflect an intrinsic ability to confront and adjust to a dynamic and challenging workday.

If one adopts a resilience engineering perspective, work processes in complex systems are recognized by variations, driving people to change and adapt behaviour to meet the fluctuations both long-term and short-term (Hoffman & Woods, 2011). Everyday adaptations to cope with dynamic events can be described as performance variability, encompassing individual adaptations and how the surroundings react to them (Hollnagel, 2009, 2014). The nurse role is highly regulated, but the unpredictable nature of healthcare

systems often forces RN's to improvise, to find workarounds and adapts to the conditions offered by the current situation (Lindblad, Flink, & Ekstedt, 2017). Sometimes these adaptations may lead to unsafe situations, but most often they will have a successful outcome (Hollnagel, 2009).

Performance variability in a system should aim to be proportional to the system complexity, meaning that the staff of the nursing homes should have appropriate skills, resources and flexibility at hand to meet any unforeseen events (Braithwaite, Wears, & Hollnagel, 2016; Grigg et al., 2011). The current study identified six areas (subcategories) necessitating adaptive behaviour to ensure safe medication administration. These areas are on an individual level (Need for Competence and Shifting Responsibility), team level (Leadership and Available Competence) and organizational level (Staff Stability and The Vulnerable Shifts). Figure 1 illustrates the balancing act of safe medication administration documented in the study.

5.2 | The nurses are compensating

Individual adaptive behaviour manifested itself in the degree of flexibility nurses exhibited about the medication administration responsibility and how they compensated for the other staff members. This flexibility depended on the capabilities of the workgroup on a specific shift, as well as their training and competence. Other attributes usually associated with nurses' performance are motivation, fatigue and stress (Al-Jumaili & Doucette, 2017; Carayon et al., 2006; Grigg et al., 2011). Furthermore, the training and skill maintenance in medication administration-related tasks are to some degree random in that it is voluntary to participate. Consequently, the staff members may have different skill sets and competencies. Over time, this may contribute to lowering the overall competence of the staff.

Individual characteristics of the staff, therefore, vary significantly from shift to shift, having a impact on performance variability and degrading the ability to prepare for unexpected conditions. Changing circumstances meant that the staff had to improvise and prioritize. At the same time, the staff were obliged to undertake a variety of tasks, not all of them clinically related. These findings seem universal as RN's often are required to undertake multiple tasks simultaneously in stress-inducing physical environments, making them more prone to making errors (Carayon et al., 2014; Monroe & Graham, 2005; Odberg et al., 2017). Under high workload, administrative tasks related to medication administration took precedence for the RN's, thus delegating the remaining workload to the other staff members. In effect, administration of drugs and the subsequent observations were delegated to RN's or NA's without first-hand knowledge of the patients. A lack of task redundancy often resulted in task vulnerability, and medications or treatments sometimes had to be postponed or were interrupted. Breaks in the medication administration chain may increase the risk of committing MAE's and potential ADE's (Carayon et al., 2014).

5.3 | The nurses are flexible

An important finding was how the leadership was distributed and invisible, leading to flexibility when delegating tasks and responsibilities. Nurse managers had indirect control of staff allocation and task delegation in that the staff often made their own decisions and planned contrary to prior assignments. The leadership and style of management seem to affect how the staff perform and delegate tasks. A clear leader with a hands-on approach may impose more direct control and strictures in relation to the myriad of regulations and guidelines on medication administration, while a more distant leader lets the staff regulate more independently. In terms of resilience, this resembles the terms work-as-done (WAD) and work-as-imagined (WAI; Braithwaite et al., 2016). Human Factors theory often uses the analogues "blunt end" and "sharp end" to encapsulate much of the same meaning (Rankin et al., 2014; Reason, 2000). In the current

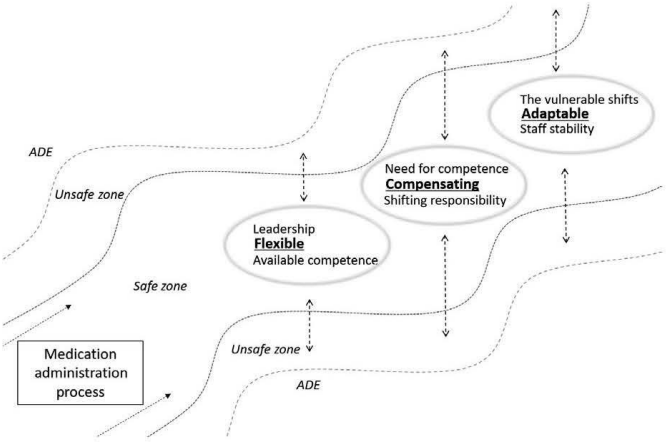

FIGURE 1 The balancing act of safe medication administration

study, the nurse managers of both nursing homes "imagined" how the wards should be run (WAI), something that not always translated to how it was actually done (WAD). This discrepancy underlines the importance of communication across levels and management capable of addressing the needs of the staff (Backman, Sjögren, Lövheim, & Edvardsson, 2017; Hollnagel, 2012). Examples in the current study indicate that even though managers endeavour to structure the workday of the staff, they simultaneously encourage flexible behaviour without giving clear indications of where this delineation ought to be. The staff may perceive this as distant management and thus use considerable internal resources to structure their workday. This entails the staff forming ad hoc teams with a random team-structure and performing many of the tasks of the regular nurse manager.

5.4 | The nurses are adaptable

The vulnerable shifts are to some degree predictable, but still pose challenges to the staff. Staff shortage, lack of competence and scarce resources may impede the staff's ability to be adaptive and find workarounds (Hollnagel, 2009). Over time, this behaviour may evolve to be a part of normal operations, stretching the boundaries of safe medication administration. As a consequence, the staff may be balancing precariously close to unsafe medication administration in their daily routines without knowing. If something unpredictable happens during a vulnerable shift, the border may be crossed and ADE's occur. Some staff members expressed gratitude when they finished a so-called vulnerable shift and opined that sometimes it was due to luck or coincidence that no ADE's occurred.

Staff stability and shared mental models are often recognized as a key factor to ensure safe care in healthcare environments (Salas & Frush, 2013). When the staff know each other's skills and competencies and trust each other, there is less need for communication to coordinate medication administration tasks. They describe it as working in silent agreement. It may lead to increased freedom and flexibility when performing tasks, but may also lead to less structure, less use of guidelines, checks and regulations. The law of requisite variety states that WAI should be as complex or varied as WAD, meaning that one should strive to increase the knowledge and competence of the staff to enable them to cope with unforeseen activities. Another approach is to seek to minimize unforeseen events through rules, regulations, standardizations and guidelines (Braithwaite et al., 2016). To balance the complexity of the WAD and WAI, one needs an in-depth understanding of the organization. Without it, medication administration may spiral into an unregulated activity, having both positive and negative effects—the positive effects being apparently increased resilience when facing unexpected events, the negative effects being the erasing of borders between safe and unsafe acts. Erasing the borders may continue and eventually breach the bounds of safe medication administration without the staff knowing. This may be exemplified by the RN who in a potential situation would consider using the mobile phone to message an image to a colleague rather than asking the manager to double-check a medication to be a reasonable solution.

6 | LIMITATIONS

Data collection was performed by a single researcher with a nursing background, which may introduce bias. This was countered by a research team, discussing and reflecting on the data throughout the research process. Having a nursing background may influence preconceptions, but also allows for rapidly gaining insights that might otherwise be missed. The researcher was aware of the potential Hawthorne effect throughout the observations. The two nursing home wards included were intentionally different, to provide a broad picture of the nurse role in medication management.

7 | CONCLUSION

Medication administration is ingrained in normal clinical activities, and isolated work processes may be challenging to define. Work system factors such as competence, leadership and staffing may influence the ability to perform safe medication administration. To counter this, nurses exhibit role compensation and flexibility and are highly adaptable during all the stages of administering medicines. The seeming resilience nurses exhibit, may be brittleness, extending the boundaries of day-to-day clinical activities close to the borders of safe medication administration.

By identifying normal operations, one may learn, adapt and develop appropriate safety measures in the future. The study underscores the importance of first-hand knowledge of the clinical setting before implementing interventions or enforcing any organizational changes.

CONFLICT OF INTEREST

There are no conflict of interests.

ORCID

Kristian Ringsby Odberg http://orcid.org/0000-0003-3456-9740

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Paper III

A work system analysis of the medication administration process in a Norwegian nursing home ward

Abstract

Nursing home patients often have multiple diagnoses and a high prevalence of polypharmacy and are at risk of experiencing adverse drug events. The study aims to explore the dynamic interactions of stakeholders and work system elements in the medication administration process in a nursing home ward. Data were collected using observations and interviews. A deductive content analysis led to a SEIPS-based process map and an accompanying work system analysis. The study expands on the knowledge of the complexity of the medication administration process by portraying the dynamic interactions between the major stakeholders in the work system, and the temporal flow of the activities involved. Secondly, it identifies facilitators and barriers in the work system linked to the medication administration process. Most barriers and facilitators are associated with the work system elements tools & technology, organisation and tasks and occur early in the medication administration process.

Keywords: Medication administration, Patient safety, Human factors

Highlights:

- Nurses are the only professional stakeholder involved in all the stages of the MAP.
- Most barriers are associated with the first stage of the MAP.
- A novel description of the MAP by using SEIPS as a conceptual model is introduced.

Contents

1.0 Introduction

Medication administration causes a significant number of healthcare-related adverse events in primary care (Andersson, Frank, Willman, Sandman, & Hansebo, 2018; Ferrah, Lovell, & Ibrahim, 2017; Marchon & Mendes Jr, 2014) and in recognition of this, the World Health Organization (WHO) has promoted a worldwide effort to reduce medically related harm by 50% over the period 2017–2021 (WHO, 2017). Nursing home patients often have multiple diagnoses and a high prevalence of polypharmacy and are therefore at risk of being subjected to adverse drug events (ADE) (Herr et al., 2017). Variability is prevalent among nursing homes and units within and across facilities, indicating challenges when seeking to standardise rules and guidelines for medication management. This variability may manifest itself in the elements of the sociotechnical work system (Carayon et al., 2006; Holden et al., 2013): physical environment, persons, tools & technology, organisation and processes. (Al-Jumaili & Doucette, 2017; Carayon et al., 2006; Huang & Gramopadhye, 2014).

A human factors systems approach seeks to grasp the complexity of the interconnected socio-technological system of the medication administration process. The System Engineering Initiative for Patient Safety (SEIPS) (Carayon et al., 2006) is a human factors approach to patient safety that has been applied to a variety of healthcare research, education and practice (Carayon et al., 2006; Carayon, Wetterneck, Cartmill, et al., 2014; Gurses et al., 2010; Karsh et al., 2005; Pronovost et al., 2009; Shekelle et al., 2013; Sittig & Singh, 2009). The current study uses an adapted version of the original SEIPS model (figure 1) (Carayon et al., 2006).

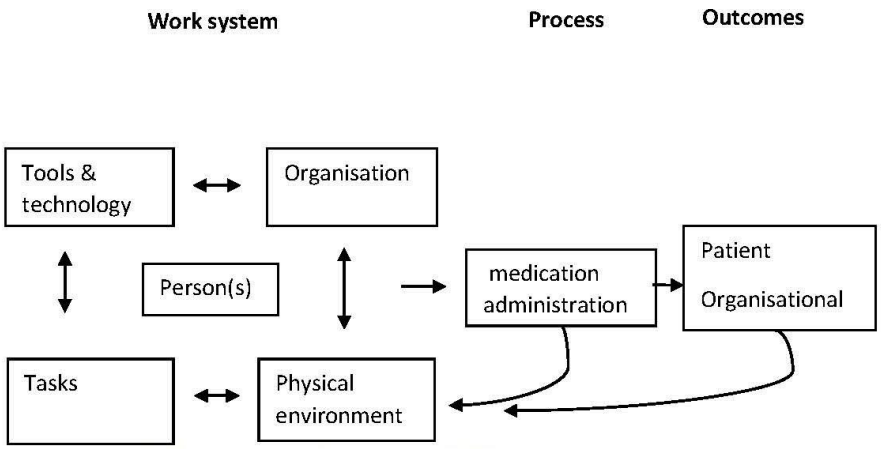

Figure 1: An adapted SEIPS model based on Carayon et al., (2006).

The basis for the SEIPS model lies in the structure-process-outcome approach to healthcare quality proposed by Donabedian (1978). The sociotechnical work system represents the structure. The work system produces work processes that shape outcomes. The person/team is at the centre of the work system, i.e. the nurse, medical doctor, patients or a group of individuals (e.g. team, organisational unit). The individual or team can exhibit cognitive, physical and psychosocial characteristics influenced by the internal/physical and external environment, tools and technology, tasks and organisation (Carayon et al., 2006; Holden et al., 2013). This reflects an underlying principle of systems orientation where the person/team is an embedded component of a sociotechnical system (Dul et al., 2012).

Prior studies on medication administration have focused on different aspects. 13−31% of the residents in nursing homes experienced medication administration errors (MAE), however incidence of serious ADE's was low and this may have been due to underreporting rather than a low frequency of serious outcomes (Ferrah et al., 2017). Several work system factors influencing medication safety in nursing homes are identified, such as the use of technology,

inadequate medication knowledge and training, interprofessional collaboration, access to physician and pharmacist, staff/resident ratio, workload and time pressure, and interruptions (Al-Jumaili & Doucette, 2017).

The introduction and use of electronic medication administration records (eMAR) may reduce concerns about committing errors and reduce staffs vigilance. At the same time, the introduction of new technology may lead to workarounds through first-order problem solving (Vogelsmeier, Halbesleben, & Scott-Cawiezell, 2008). The use of automated medication systems merits further studies to evaluate possible effects on MAE's and patient safety (Alenius & Graf, 2016; Fuller, Guirguis, Sadowski, & Makowsky, 2018; Risør, Lisby, & Sørensen, 2017; B. W. Risør, Lisby, & Sørensen, 2015). Nurses' experiences with the medication administration process (MAP) indicate a need to possess sound clinical reasoning and sufficient knowledge to assess the risks of medication administration in a relevant context. Furthermore, nurses need to operate in a relevant context with a learning climate and professional environment allowing for the development of nursing skills and knowledge (Andersson, Frank, Willman, Sandman, & Hansebo, 2018; Odberg, Hansen, & Wangensteen, 2019; Parry, Barriball, & While, 2015; Pirinen et al., 2015; Rohde & Domm, 2018). Interruptions during medication administration are associated with clinical errors, but more studies are needed to comprehend the phenomenon and the effects on clinical practice (Bower, Coad, Manning, & Pengelly, 2018; Hayes, Jackson, Davidson, & Power, 2015; Odberg, Hansen, Aase, & Wangensteen, 2017; Westbrook, Woods, Rob, Dunsmuir, & Day, 2010). Interventions to reduce interruptions have a limited effect on reducing MAE's (Raban & Westbrook, 2014). There also seems to be a low adherence to guidelines on medication administration (Lapkin, Levett-Jones, Chenoweth, & Johnson, 2016). The introduction of

safety checklists to evaluate nursing practice and to improve the MAP is recommended (Qian, Yu, Hailey, Wang, & Bhattacherjee, 2018).

In all, this describes a complexity in medication administration and a need to visualise the dynamic interactions of the stakeholders in the MAP (Al-Jumaili & Doucette, 2017; Carayon, Wetterneck, Cartmill, et al., 2014; Jun, Ward, Morris, & Clarkson, 2009; Reason, 2000). A process, such as medication administration, may be perceived as a series of tasks performed by the persons in a sociotechnical system. The process is, therefore, an integral part of the work system. Attributes of the persons may affect how they perform different tasks and how they relate to organisational rules and guidelines. The use of tools and technology may affect how tasks are performed, and the physical environment, such as poor air quality or a noisy environment, may affect their work. Altogether, in any given process, several dynamic interactions may affect each other in both predictable and unpredictable ways. Process modelling is one way to comprehend better how persons, technology, physical environment, organisational factors and care processes interact and work (Jun et al., 2009). It differs from more traditional flowcharts by including the stakeholders as separate headings in the top row, thereby portraying the persons performing different tasks in the MAP. According to Wooldridge, Carayon, Hundt, and Hoonakker (2017), a SEIPS based process modelling technique may provide a powerful tool in identifying barriers and facilitators in healthcare work processes. No prior studies have integrated the SEIPS-model in modelling the complete MAP in nursing homes.

The study aims to explore the dynamic interactions of stakeholders and work system elements in the MAP in a nursing home ward. The following research question has guided the study: How can SEIPS based process modelling visualise barriers and facilitators in the medication administration work system of a nursing home ward?

1.1 The medication administration process

The MAP can be represented in six stages, from ordering, transcribing, dispensing, preparing, administering and observing (Carayon, Wetterneck, Cartmill, et al., 2014; Odberg et al., 2017). It involves different stakeholders performing different tasks using technologies such as eMAR while relating to organisational conditions, rules and guidelines within a physical environment. The major stakeholders in the current study are registered nurses (RN), medical doctors (MD), nurse assistants (NA), the patients and the pharmacists. The pharmacists were not a focus in the study, as they perform their role externally to the nursing homes in the current context, the only communication being via electronic or other correspondence. MAE's may occur anywhere along the MAP, and errors committed in the first stages may permeate the consecutive stages to cause potential ADE's such as the patient falling critically ill due to receiving the wrong dosage or drug. Examples of other MAE's may be failures of omission, mistaken patient identity or wrong route of administration. Urgent measures to prevent MAE's are double-checking, checklists, good medication knowledge, interprofessional teamwork and communication (Al-Jumaili & Doucette, 2017; A. Andersson et al., 2018; Carayon, Wetterneck, Cartmill, et al., 2014; Dilles, Elseviers, Van Rompaey, Van Bortel, & Stichele, 2011). There are many reasons why MAE's occur; some contributing factors are interruptions, poorly designed eMAR, lack of guidelines, poor interprofessional cooperation, lack of leadership and inadequate competence among staff (Al-Jumaili & Doucette, 2017; Andersson et al., 2018; Carayon, Wetterneck, Rivera-Rodriguez, et al., 2014; Dilles et al., 2011; Odberg et al., 2017). Facilitators and barriers can be proximal or distal to the endpoint of any process, meaning that an effect is only visible at the administering or observing stage of the MAP. Distal latent factors are influencing processes such as political decisions, and can be challenging to identify, while proximal active factors such as a health

care provider administering the wrong dosage or drug, are often more visible (Reason, 2000; Wooldridge et al., 2017).

1.2 Process modelling

There is general acknowledgement in the human factors literature that to increase overall understanding of the health care system, one needs to focus on processes within the work system rather than tasks (Wooldridge et al., 2017). Care processes can be wound treatment, patient transport or medication administration. Other processes taking place simultaneously in the work system can be the introduction of new software, the change of guidelines or workers renovating the patient bathrooms. There are also cognitive processes of the persons involved, that may explain or describe why and how some act in a certain way. These processes take place within the work system simultaneously. They interact and are part of what makes healthcare systems complex. There are numerous ways of modelling processes in healthcare, but some have proven more influential than others. Jun et al. (2009) found that flowchart and swimlane diagrams [1]were most commonly used, while flowchart diagrams were more accessible. Likewise, system diagrams of a similar type have proven useful when engaging in identifying risks in healthcare processes (Simsekler, Ward, & Clarkson, 2018). Using the SEIPS model is appropriate when engaging in complex systems and processes such as the medication administration process. By integrating the work system into the process map, the resulting diagram presents a holistic representation of the activities involved in the process while also retaining a general overview of the dynamic interactions of the involved system elements.

[1] Cross-functional process map to illustrate workflow and interrelated activities, which visually distinguishes job sharing and responsibilities (Damelio, 2016).

The process modelling in this study is based on Wooldridge et al. (2017) and is reminiscent of a swimlane diagram while retaining the dynamic temporality embedded in more traditional flowcharts. It is directly based upon the work system elements in the SEIPS model, systematically visualising the MAP. The process map (Figure 2,) is accompanied by a comprehensive work system analysis (Table 1) containing identified facilitators and barriers to safe medication administration.

2.0 Methodology

2.1 Design

The study used a qualitative design and data were collected using observations and interviews.

2.2 Setting

The study took place in a Norwegian nursing home ward with palliative patients in need of multifaceted medical treatment. The palliative ward had six patient rooms, mostly occupied for the duration of the study. Length of stay varied as some patients needed only short-term assistance (2-5 days); if their condition improved, they were discharged; if it worsened, they were transferred to other facilities. Other patients stayed for weeks or months. Most patients had extensive medical regimes including administration of oral medications, infusions, and patches at four regular intervals each day. The staff consisted of 25 members, six of whom were full-time registered nurses (RN), two nurse assistants (NA) and an associated medical doctor (MD) in a 50% position residing in the nursing home building with two regular visitations per week. The remaining staff members had either short-term engagements or held less than 50% positions at the ward.

2.3 Recruitment

The nursing home ward is part of a network of development centres in Eastern Norway and was chosen due to the leaders expressing an intention to participate in relevant research. The main author contacted the manager of the nursing home in January 2016, and the manager of a palliative ward agreed to participate. All the staff members were briefed in a joint meeting and asked to take part in the study, to which they agreed. The staff members were informed that they might be asked to participate in interviews at a later stage.

The inclusion criteria set for the interviews were that the participants had a regular position working 50% or more and that they had a role during the medication administration process. After three months of observations, the staff members fulfilling the inclusion criteria were asked to participate in the interviews. In all, 9 staff members, ranging from [2]nurses with post-graduate education in palliative care, RN's, a nurse manager, a MD, and NA's were asked. All agreed to be interviewed, and they were again informed of confidentiality and of the possibility to withdraw.

2.4 Data collection

The main author performed partial participant observations (Bourgeault, Dingwall, & De Vries, 2010) throughout six months from April to October 2016. All staff having tasks related to medication management in the ward were observed during daytime shifts and evening shifts on weekdays. A few observations took place during night shifts. Most observations took place during daytime shifts, this was deliberate to capture periods of high activity related to patient care and medication administration. While staff members performed tasks related to medication administration, the researcher took notes and paid attention to the various work

[2] Both registered nurses and nurses with post-graduate education are described as RN's in the study

system elements, such as the use of technology or how noise and interruptions affected their work. After each day of observations, the notes were transcribed by the researcher.

Halfway through the observation period, the staff members who met the inclusion criteria were interviewed. All observations (70 hours) (See appendix 1: Observation guide) and interviews followed guides based on the five elements of the SEIPS model, persons, physical environment, tasks, tools & technology and organisation. The interviews were semi-structured, lasting from 30 to 60 minutes, and were performed in a separate room in the nursing home facility (See appendix 2: Interview guide). The goal of the interviews was to explore how the staff related to and experienced the medication administration process. The interviews were audio-recorded and transcribed partly by the researcher and by a professional transcription service.

After the interviews were conducted, the remaining period (July to October) of observation narrowed in its focus, seeking to refine specific elements in the MAP pinpointed in the interviews.

2.5 Trustworthiness

The use of a sole observer, an intensive care nurse by training, may cause bias, such as prior conditioning (Bourgeault et al., 2010). At the same time, familiarity with the setting and the medication administration process may lead to insights otherwise missed. The researcher was aware that the interaction with the participants could influence or bias the surroundings and the data collected (O'Brien, Harris, Beckman, Reed, & Cook, 2014). To limit bias, special attention was given to how data was interpreted. By introducing individual interviews of the stakeholders at the mid-point of the data collection period, member checks of early interpretations of the observation data helped clarify and elaborate identified issues. The remaining observation period facilitated the moderation of the researcher's interpretations and

an accurate description of the medication administration process. The research team, consisting of three professional researchers with a diverse background in nursing and engineering, had regular meetings during the data collection and analysis, discussing issues and performing iterative analytical reflections to ensure reflexivity and trustworthiness of the findings. To ensure the dependability of the data, the observations were made by the same researcher throughout six months, using a observation guide. Over time, the staff members grew used to a researcher being present and probably took less notice (Lincoln & Guba, 1985). Excerpts from the interviews and observation notes are included in the results section to increase the transferability of the findings.

2.5 Analysis and process map development

The transcribed observation notes and interviews were analysed using deductive content analysis (Elo & Kyngäs, 2008). A categorisation matrix based on the five elements of the SEIPS model (columns) and the six stages of the MAP (rows) formed the categories. The delineation between the different stages was mainly based on observations, together with descriptions of the MAP (Carayon, Wetterneck, Cartmill, et al., 2014). As activities in the ward seldom were linear, the building of the process model involved interpreting where certain activities belonged. For example, activities in stage one (ordering) and stage two (transcribing) often took place simultaneously.

The first part of the deductive content analysis involved the entire research team individually reading the entire data material to make sense of the data. Relevant parts of the material were marked, and the data was discussed to form an analytical approach to answer the research question. To identify relevant meaning units, the focus was on the marked parts containing information that could assist in building an accurate description of the MAP, while also giving insights into possible facilitators and barriers that seemed relevant. 274 meaning units that all the members of the research team agreed on were identified in the text material and

placed in the matrix. One example was how "several interruptions during doctor pre-visitation" was placed in the nexus of "ordering" (stage one) and the "physical environment". Then, the meaning units were condensed into broader codes and provisionally identified by the main researcher either as a barrier or a facilitator.

A facilitator is defined as a trait or activity related to a specific work system element that promotes safe medication administration, while a barrier hinders safe medication administration. Hoonakker, Carayon, and Cartmill (2017) acknowledge that certain traits or activities can be perceived both as facilitators or barriers and use the term dimensions to encompass both. This was also the case in the current study, but as some activities were clearly identified as either a barrier or a facilitator, the term dual trait is introduced to encompass those activities that can act as both. In three subsequent meetings, all the researchers went through the material and discussed the forming of and the placement of the individual codes in the process map. Some codes were difficult to identify either as a facilitator or a barrier. Data from interviews and observations sometimes differed on the same subject, some of these instances were coded as dual traits. Placing the different codes under a specific work system element could also pose challenges. Examples are barriers placed under tools & and technology, such as the use of pen and paper, may fit under the work system element tasks. A consensus on how to define facilitators or barriers was reached through discussions and analytical triangulation in the final conceptual stage of the process map (figure 2) and the accompanying work system analysis (table 1).

2.6 Ethics

Participation was voluntary, and all involved staff members received oral and written information about the study, including data confidentiality and the possibility to withdraw at

any time. No one chose to withdraw. A form was distributed for participants to give their informed consent.

No patient sensitive information was documented or used in the analysis of the data, The Regional Committee for Medical and Health Research Ethics concluded that approval from the Norwegian Social Science Data Service (NSD) sufficed (No. 45389).

3.0 Results

3.1 The process map of the medication administration process

The results are presented as a process map (figure 2) and a work system analysis (table 1). The major stakeholders in the medication administration process (columns in figure 2) are registered nurses (RN), medical doctors (MD), other staff members, patients and the pharmacist. Of them, the RN with medication responsibility is involved in all stages of the process. The MD is involved in the ordering stage and the transcribing stage, in close collaboration with the RN and the patient. Other staff consist of RN's and nurse assistants and are peripherally involved in ordering and transcribing depending on need and circumstances. In addition, they are crucial in gathering clinical information and relaying this to the RN in charge of medication administration. They are also involved in delegated medication administration tasks such as delivering medicines to patients. The patients at the centre of the entire medication administration process are mostly active at the receiving end of the administering stage, while also playing a crucial part in imparting their clinical information to the staff in the first two stages. The pharmacist is only involved in the process when patients use multi-dosage orders. Symbols used in notes and computers indicate that some form of documentation occurs in all the stages of the MAP, predominantly in the ordering stage. The computer symbol (key in figure 2) indicates that staff members use

eMAR to retrieve information or to document. The note/paper symbol (key in figure 2) indicates that staff members use analogue forms of documentation, often in the form of small notebooks, paper slips or forms.

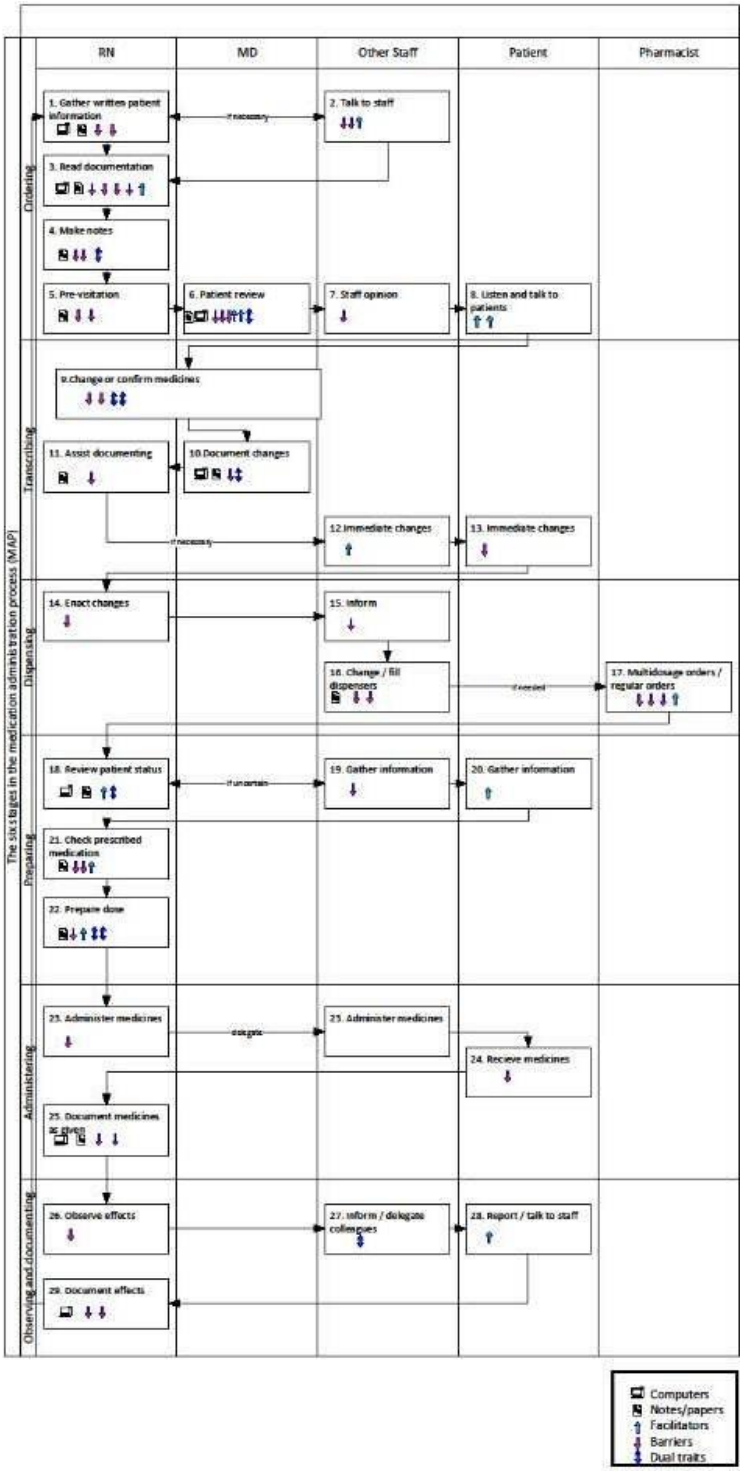
RN
MD
Other Staff
Patient
Pharmacist
The six stages in the medication administration process (MAP)
Ordering
Transcribing
Dispensing
Preparing
Administering
Observing and documenting
1. Gather written patient information
2. Talk to staff
3. Read documentation
4. Make notes
5. Pre-visitation
6. Patient review
7. Staff opinion
8. Listen and talk to patients
9.change or confirm medicines
10.Document changes
11. Assist documenting
12.Immediate changes
13. Immediate changes
14. Enact changes
15. Inform
16. Change / fill dispensers
17. Multidosage orders / regular orders
18. Review patient status
19. Gather information
20. Gather information
21. Check prescribed medication
22. Prepare done
23. Administer medicines
25. Administer medicines
24. Recieve medicines
25. Document medicines
26. Observe effects
27. Inform / delegate collegues
28. Report / talk to staff
29. Document effects
Computers
Notes/papers
Facilitators
Barriers
Dual traits

Figure 2: SEIPS-based process map of the medication administration process.

The medication administration process commences with the RN gathering patient information from written documentation and talking to colleagues (activities 1–3, Figure 2). While gathering information, he/she makes notes in a notebook or on a slip of paper (activity 4). When the MD arrives, they discuss each patient, talk to staff members and consult the patients (activities 5–8). Afterwards, they make actual changes in the documentation (activities 9–11), and patients may receive new medicines if needed (activities 12–13). The RN then makes the actual changes by checking the documentation and removing or adding medicines in the medicine dispensers (activities 14-16). If patients use multi-dosage medicines, new prescriptions are sent to the local pharmacy (activity 17). Before medicines are administered to the patients, the RN reviews patient clinical charts, talks to colleagues and assesses the patients (activities 18–20). Then the prescribed medications are checked against the medicine list and content of pill dispensers before being transferred to a suitable dispenser. In the cases where patients receive intravenous medicines, they are usually prepared in advance in the nurse station and double-checked before administered (activities 21–22). The RN brings the medicines to the patients and supervises while they ingest them, and documents the event afterwards (activities 23–25). All staff members are involved in observing and documenting the effects on the patients (activities 26–29).

3.2 Work system analysis

The study identified 60 work-system facilitators, barriers or dual traits across the five elements of the MA work system model (table 1). Each of these is noted in the table according to their source data: *italic* font from observations, **bold** font from interviews and normal font when data derives from both sources.

Table 1: Work system analysis of the medication administration process in a palliative nursing home ward.

			Work system elements					
	Activity	Activity description	Physical environment	Tools & Technology	Tasks	Person(s)	Organisation	
1	Gather written patient information	Finding clinical information from various sources, paper journals, patient folders.	*Relevant documents are located in different places distant to each other.*				*No guidelines exist on what to prepare for ward round.*	
2	Talk to staff	The nurse locates staff with updated knowledge of the patients and asks questions about the current clinical status.			*Time-consuming.*	Not always available.	**The staff feel appreciated, empowered.**	
3	Read documentation	Briefly reads highlights from last week. Thereafter looks up most recent notes and relevant documents in eMAR.	[3]Nurse station is small, noisy with several interruptions. *Information is located in different places.*	Poor or lacking documentation. Lengthy login to computer and eMAR. *2 computers are available at the nurse station*				
4	Make notes	Plans most salient issues to bring up when the doctor arrives and notes them in a notebook or on a slip of paper.		**Poor search function in eMAR** *Pen and paper easy to use. Uses a "black book" in addition.* *No formal archiving of plans.*				
5.	Pre-visitation	The doctor arrives and greets the staff. Informal talk. The nurse has a quick recap of last week's events and the status of patients.				*Staff member not always available, or busy.*	*No set time for arrival or preplanned schedule*	
6.	Patient review	Login to eMAR. Nurse and doctor systematically go through patient charts, discuss, and review medicines for each patient. They plan for eventualities until next visit is due.		*Slow login.* **Separate module for nurses and doctors in eMAR slows down the process.**	*MD documents in eMAR. Takes time.* (may be due to lack of familiarity with the process)	The *nurse has extensive knowledge of all patients. Depends on the individual nurse. Depends on the nurse 's overview. Individual differences regarding knowledge and competence..*	Usually, the same persons doing ward rounds. Ensures continuity. Prepares for eventualities on weekends or vulnerable shifts, by considering hiring extra staff and ensure adequate stock of medications. Staff consistency facilitates smooth collaboration.	
7.	Staff opinion	Staff members responsible for individual patients may be asked for the current patient status and their opinion.			*Time-consuming.*			
8.	Listen and talk to patients	Ward round. The nurse and MD may talk to some patients to get a better impression of clinical status before prescribing medicines.		**Mobile devices with eMAR would greatly enhance this activity**		*Patients partake in decisions.*		
			Barriers=3	Barriers=6 Facilitators=2 Dual traits=1	Barriers=3	Barriers=2 Facilitators=1 Dual traits=1	Barriers=2 Facilitators=3	

Barriers=16 Facilitators=6 Dual traits=2

[3] Interruptions and noise are recurrent throughout the MAP.

9.	Change or confirm medicines	The RN and MD agree on the change after an individual review of the patient.		**Often confusing medicine prescriptions from the hospital.**	*Some changes are made in advance and need confirmation or signature from MD.*	*Relies on the knowledge and competence of the staff members. Individual variations.*	**Sometimes a lack of communication with other institutions may lead to mistakes.**	Barriers=5 Facilitators=1 Dual traits=3
10.	Document changes	The MD changes prescriptions in the eMAR and prints an updated medication list for each patient.		**Codes in eMAR make adjustments easy if you know the codes by heart.**	*Time-consuming.* Double-documentation.			
11.	Assist in documenting	RN takes over the printed medication lists and replaces the old ones in folders with the new ones.			*Redundant to save paper copies of all medicine charts.*			
12.	Immediate changes	If there are changes the other staff members should know immediately, they are informed.		*Would benefit from an effective calling system.*				
13.	Immediate changes	If there are medicines the patients need urgently, they are administered.			May cause interruptions to other tasks.			
				Barriers=1 Facilitators=1 Dual traits=1	Barriers=3 Dual traits=1	Dual traits=1	Barriers=1	
14.	Enact changes	RN checks that MD signature is on all printed lists. Replaces old lists with new ones.			Double documentation and time-consuming.			Barriers=6 Facilitators=1 Dual traits=0
15.	Inform	Staff members responsible for individual patients are updated at change shift by a lead nurse.					*No system to how remaining staff members are informed of the changes made.*	
16.	Change/fill dispensers	Pill dispensers are refilled according to updated medicine charts.	*The medicine room is distant from the rest of the ward.*		*This is done manually, and is dependent on visual recognition to identify correct medications..*			
17.	Multidose orders	If patients use multi-dosage, an updated medicine chart is sent to the pharmacy. Existing multi-dosage packages are opened and changed according to the new prescription.	*The fax is located on another floor.*	**Uses fax to send signed medicine chart to the pharmacist. Then the nurse has to phone the pharmacist to verify the prescription.**	**There is a 1-2 week delay before updated multidoses arrive.** **Easy to use multidose if they are up to date.**			
			Barriers=2	Barriers=1	Barriers=2 Facilitators=1		Barriers =1	

18.	Review patient status	Patient responsible nurse reviews clinical status and medicines given last 24 hours. Uses both eMAR and paper charts.		**Would benefit from a mobile device with integrated eMAR and medicine charts.**		**Dependent on first-hand patient knowledge of the patients and relevant competence.**		Barriers=4 Facilitators=4 Dual traits=3
19.	Gather information	Other staff members are conferred with if documentation is lacking or patient status is rapidly evolving.			*Time-consuming and may interrupt other tasks.*			
20.	Observe and talk to patients	Clinical status of patients is reviewed before administration. Strong painkillers may, for instance, have hemodynamic effects. Patients may be asked how they feel.				***The patients partake in decisions.***		
21.	Check prescribed medication	Checks content of pill dispenser against medicine chart.	*All medicines are readily available in a mobile medication trolley.*	*Uses printed medicine chart, with no information on current patient clinical status.*	*Complex task dependent on visual recognition of all tablets to ensure double control.*			
22.	Prepare dose	Tablets are transferred to a pill cup. Intravenous, patches or oral liquid medicines prepared.	*Medication trolley is mobile and allows for flexibility.*	*Medical calculations using whatever means available. Some have a calculator, some use a mobile device, some do calculations in their head or on a slip of paper.*	**Unchanged multi dosages are easy to use.**		**Double checks of on-demand medications are sporadic, dependent on adequate staffing and workload.**	
			Facilitators=1 Dual traits=1	Barriers=1 Facilitators=1 Dual traits=1	Barriers=2 Facilitators=1	Facilitators=1 Dual traits=1	Barriers=1	
23.	Administer medicines	Takes medicines to patients and confirms identity. Delegate to other staff members if necessary.	*Patients may be roaming about and can be time-consuming to locate.*					Barriers=4 Facilitators=0 Dual traits=0
24.	Receive medicines	Patients ingest medicines while supervised/observed by a staff member. Some patients may self-administer some medicines.					*Not all staff oversee the patients ingesting the medicines due to high workload or negligence of guidelines.*	
25.	Document medicines as given	Staff member documents medicines as taken in eMAR and on the printed medicine chart.		Login is lengthy, and some prefer to wait until the end of the shift with documentation tasks.	*Double documentation.*			
			Barriers=1	Barriers=1	Barriers=1		Barriers=1	

26.	Observe effects	Whenever staff are in contact with patients, they continuously review clinical status regarding what medications they have received.					*No systematic observation tools or documentation in use.*	Barriers=3 Facilitators=1 Dual traits=1
27.	Inform/delegate to colleagues	Delegate or ask colleagues to observe patients for potential effects.				*Dependent on personnel's competence and knowledge of what to observe and pass on.*		
28.	Inform staff	Patients are informed of the potential effects and encouraged to report any changes to the staff.				Often valuable contributions to how various treatments affect patients.		
29.	Document effects	Effects of medications are documented in eMAR.		**eMAR provides a poor interface for documenting the effects of medicines.** Lengthy login process.				
				Barriers=2		Facilitators=1 Dual traits=1	Barriers=1	
			Total Barriers=6 Facilitators=1 Dual traits=1	**Total** Barriers=12 Facilitators=4 Dual traits=3	**Total** Barriers=11 Facilitators=2 Dual traits=1	**Total** Barriers=2 Facilitators=3 Dual traits=4	**Total** Barriers=7 Facilitators=3 Dual traits=0	

There is a preponderance of identified barriers (38) in contrast to relatively few facilitators (13). Some activities show dual traits (9). Figure 3 shows how facilitators gravitate towards tools & technology and tasks, while facilitators revolve more around tools & technology, organisation and persons. The dual traits tend towards tools & technology and person(s).

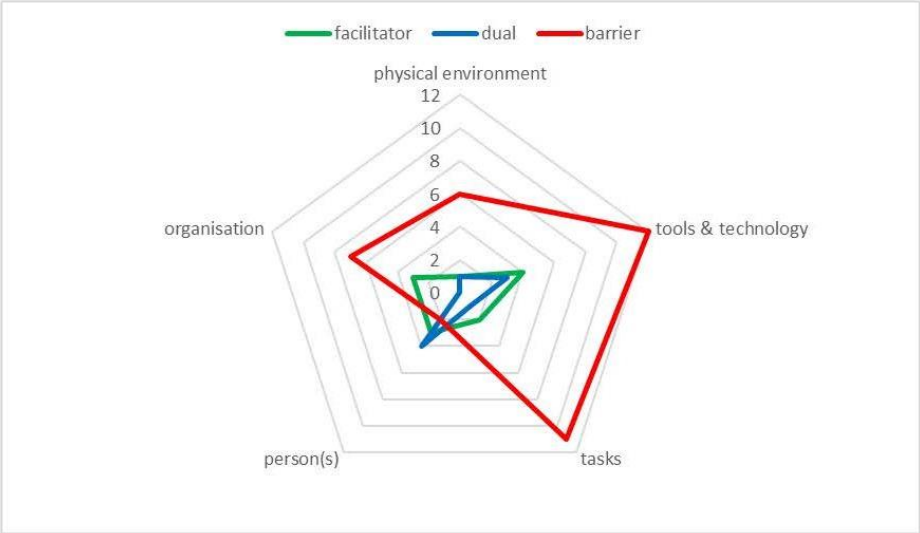

Figure 3: Overview of the distribution of facilitators, barriers and dual traits across the work system

A majority of the barriers occur in the first stage (ordering) of the MAP, while there are most facilitators in stage 1(ordering) and stage 4 (preparing). All the stages, absent stage 5 (administering), contain a few dual traits (figure 4).

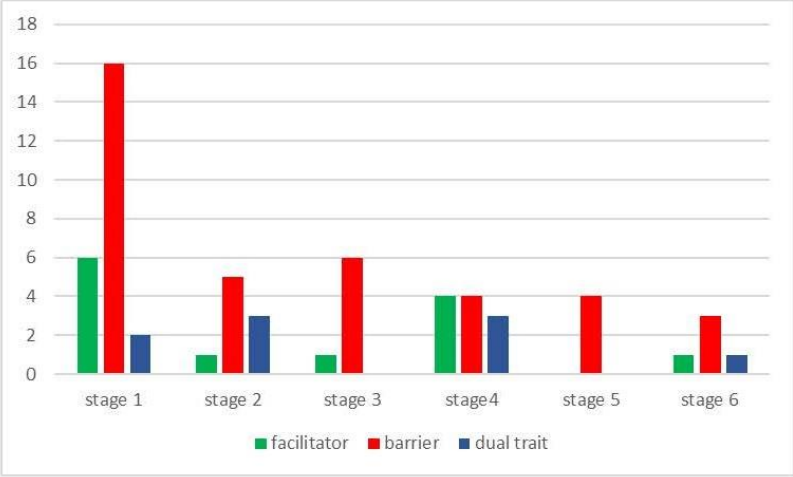

Figure 4: Overview of the distribution of facilitators, barriers and dual traits across the stages of the MAP

3.3 Facilitators for safe medication administration

In the opinion of staff members, the use of mobile devices with eMAR functionality would significantly enhance the MAP in both the ordering and preparing stages and be a major facilitator (activities 8, 18). An example of a discussion on documentation of medicines is described in the following excerpt from an observation note:

"The nurse enters the nurse station and addresses the other nurse present, expressing how easier things could have been, if they had access to an iPad to document their activities consecutively."

From an organisational point of view, staff consistency seems to be an overall decisive factor, allowing the staff to prepare for vulnerable shifts such as weekends (activity 6). This is exemplified in the following excerpt from an interview with a RN:

"We know each other well, and we also cooperate well as we know what the other knows and are capable to…. So we understand when a vulnerable shift approaches and are able to plan accordingly."

The staff also appreciate when their opinions are considered in medication-related decisions (activity 2). The nurse's competence and knowledge of patients and staff members is identified as a facilitator when reviewing patient status during the ordering and preparing stage (activities 6, 18). Excerpt from observation notes:

"The nurse is about to meet with the doctor and takes a good time to prepare. He/She uses the notes in the electronic journal, as well as the cardex at his/her side and makes notes in a book before him/her. He/She has been working dayshifts all week and are well acquainted with all the patients now at the end of the week….Whenever the doctor asks a question, he/she has a ready answer, and they often discuss how to proceed with the medications."

During the transcribing stage, all involved stakeholders would benefit from an effective calling system, ensuring staff availability when immediate medication changes are to be effectuated (activity 12). Finally, patient involvement may be a significant facilitator regarding how a patient's knowledge and self-observations positively affect the medication administration (activity 28).

3.4 Barriers to safe medication administration

Many of the barriers are related to the ordering stage of the MAP and are associated with the work system elements physical environment, tools and technology and tasks. Most prominent is how noise and interruptions, tied to the physical location, affect the entire MAP. An example of this is illustrated in the following observation note:

"During the meeting with the doctor, taking place in the nursing station, the door opens 15 times. Five persons enter at different times to use the xerox-machine, six enter to retrieve different medications, four enter to get some papers from their mailbox. The telephone sounds two times, and the nurse is interrupted several times to answer questions."

Problems associated with the electronic medication administration record (eMAR) are tied to tools and technology and tasks, exemplified by lengthy login times (activities 3, 6, 25, 29), poor search functionality (activity 4) and separate MD and RN modules (activity 6) prohibiting sharing of specific information. This is exemplified in the following interview excerpt with the MD:

"I am not happy about the eMAR we use! It has an exceptionally poor module for the doctors, and any tasks are laborious. If I need answers from blood tests, they come in the regular mail from the hospital… . There is no natural interaction between the different

modules, and it makes it harder for me to perform efficiently. It is also a challenge regarding patient safety that all the information is not available to me when I need it."

These problems seem to spur the use of additional paper documentation (activities 4, 10, 14, 21, 25), increasing time consumption (activities 6, 10, 14) and difficulties retrieving relevant patient information in a timely fashion (activity 3).

3.5 Dual traits in respect of safe medication administration

These are concentrated around the work system elements technology & tools, tasks and person(s). Examples are how the individual staff member's knowledge, personality and competence vary and influence how they perform their tasks in different situations.

Examples of dual traits are how the use of eMAR is tied to the staff's competence and training (activity 9). If staff know the codes by heart, the doctor finds it easy to document medication changes. If not, it can be taxing, since an index search must be done in advance (activity 10). Due to the barriers identified in the use of eMAR, all the staff members engage in auxiliary analogue documentation (activity 4). The staff perceive this as a helpful tool, while observations suggest this activity leads to double documentation and subsequent problems in retrieving essential patient information. An excerpt from an observation note exemplifies this:

"During the ward round, the doctor documents all the changes in the eMAR, while the nurse uses an informal black book, in addition to several notes he/she puts in his/her pocket. Occasionally the nurse also makes brief notes in the patient cardex."

Another example is how the staff make medication changes before conferring with the MD (activity 9). This may improve workflow but can also constitute a risk to medication

administration as the MD is not involved in the decision process. Excerpt from an interview with a nurse:

"Regarding insulin, for example, we do the measurements and administer. We have a patient experiencing varying blood glucose levels for the past few days now. Last night it was low because he/she refused to eat, and we halved the dose. The the blood glucose levels normalised, and we gave the regular dose. Then his/her blood glucose levels suddenly had dropped again when we checked, and we had to make sure he/she ate something."

The use of a mobile medication trolley is another example. While providing mobility and flexibility; it is often stationed in busy environments such as the nurse station, which is prone to noise and interruptions (activity 22).

3.6 Dynamic interactions

Several barriers and facilitators interact across the elements of the work system. One example is how the distances in the ward (physical environment) and how information is stored at different places, leads the staff members to use a book (tools and technology) to record and keep track of vital information, resulting in challenges to retrieve and document patient information properly. These challenges may follow indirectly from the lack of guidelines on what to prepare before ward rounds and uncertainty about when the doctor arrives (organisation). Subsequently, staff members may be unavailable when called upon for updates (person(s)). If the nurse is experienced (person(s)), it facilitates an efficient ward round. The availability of experienced nurses and staff consistency helps facilitating a smooth workflow in the ward (organisation). If all the staff members are familiar with each other and the conditions of the patients, they are to some degree able to predict future vulnerable shifts and act in a preventive way.

The eMAR is documented as cumbersome to use and with lengthy login times (tools & technology). Regulations state that all staff member must log off when they are finished with a session. In periods with high activity in the ward, this often resulted in that the staff members document on paper notes (tasks), and postpone proper documentation in the eMAR until the end of their shift. In some cases, this may lead to poor or lacking documentation (physical environment), which again poses challenges in the next ward round.

4.0 Discussion

The current study expands the knowledge of the complexity of the MAP in a nursing home setting by portraying the dynamic interactions between the major stakeholders in the work system, and the temporal flow of the activities involved. Secondly, it identifies facilitators, barriers and dual traits in the work system linked to the six stages of the MAP.

Most barriers and facilitators occur in the first few stages of the MAP, indicating a vulnerability. These barriers and facilitators are closely tied to documentation activities and the retrieval of critical information at the right time. MAE's at this stage could cause potential cascade effects leading to ADE's. MAE's committed in the first few stages may, therefore, be crucial for patient outcomes and depend on the nurses' vigilance in rectifying those errors before reaching the patient. A study on intensive care units also found the first two stages of the MAP to be particularly vulnerable (Carayon, Wetterneck, Cartmill, et al., 2014), indicating commonalities across healthcare settings.

By systematically considering all work system elements when analysing the medication administration process, the work system analysis informs us how the system may respond to

inherent variations. Since multiple simultaneous configurations of the dynamic work system are possible, it is crucial to prioritise which possible interactions are relevant (Holden et al., 2013). The findings suggest that several activities in different work system elements interact and reinforce each other. Barriers in tools & technology, such as poorly designed eMAR, may alter the behaviour of the stakeholders prompting workarounds or ad-hoc solutions that affect other work system elements. The work system analysis (table 1) documents a wide range of factors that may inhibit or strengthen the MAP at different points. Current research on factors contributing to adverse events in nursing homes, list various elements such as lack of competence, poor documentation, teamwork failures, inadequate communication and failure to follow procedures as critical (Andersson et al., 2018). McLeod, Barber, and Franklin (2015) found that many subtle variations in available resources seemed to affect how nurses interact and behave, with both positive and negative unintentional consequences on medication safety. Furthermore, they suggest that efforts to reduce MAE's should focus on better medication systems, management of interruptions, and reinforcement of patient involvement where appropriate.

4.1 Facilitators, barriers and dual traits in the work system analysis

The literature often describes the prescription of medicines as the sole domain of the MD (Carayon, Wetterneck, Cartmill, et al., 2014; Qian, Yu, Hailey, Wang, & Bhattacherjee, 2018). This study documents how the RN performs a series of activities before the MD conducts her/his activities arrives. One could, therefore, argue that an additional "pre-ordering stage" in the medication administration process exists where the RN in charge uses considerable time and resources preparing for the MD activities. Also, when the MD conducts her/his activities, there is a close collaboration before any decisions or changes are made. As the MD is present only at specific times during the week, the RNs operate rather

autonomously within pre-set limits. Some RNs adhere more strictly than others to guidelines, while others make medicinal decisions ordinarily made by the MD and await later approval and confirmation. This independent behaviour depends on the skills, training and competence of the RN. It is therefore crucial that a bond of trust exists between the MD and RN, allowing this flexibility. This is also confirmed by Vogelsmeier (2014).

A silent agreement seems to exist between all staff members that certain shifts are vulnerable, and that they prepare in advance. Such shifts may be night shifts or during weekends. The vulnerable shifts may entail unexpected events, stretching the limits of their resources. The deciding factors for how they cope with such situations are tied to the degree of competence and relevant training. Smeulers, Onderwater, Zwieten, and Vermeulen (2014) support this view and further indicate that given sufficient knowledge, nurses are in a pre-eminent position to enable safe medication administration. Also, staff consistency emerges as important when doing ward rounds. Having staff members familiar with the current routines, guidelines and patients facilitates interprofessional collaboration and ensures a smooth workflow.

Interruptions are identified as negative in the current study, disrupting workflow and causing hindrances in work processes even though research suggests that interruptions can be categorised differently and that some interruptions are positive in the overall perspective (Anthony, Wiencek, Bauer, Daly, & Anthony, 2010; Hopkinson & Jennings, 2013; Odberg et al., 2017; Rivera & Karsh, 2010). An example of dynamic interactions in the current study is apparent in the preparing stage, as the staff used a mobile medication trolley. The staff members often placed the trolley in areas of high activity, and as such, it became a hub of social activity where different activities, both social and professional, were discussed. In

some cases, the activity around the medication trolley thus facilitated important information sharing even though the staff members were vulnerable to interruptions.

4.2 Issues with documentation

The process map illuminates how eMAR acts as a barrier in several stages of the MAP. Poor interface, slow login, lack of user-friendliness and poor access to relevant information are the most pertinent elements, slowing down the overall workflow. Several studies have reported on similar findings, calling for more streamlined eMAR to facilitate care processes (Alenius & Graf, 2016; Baril, Gascon, St-Pierre, & Lagace, 2014; Beuscart-Zéphir, Pelayo, & Bernonville, 2010; Choo, Hutchinson, & Bucknall, 2010). Issues related to eMAR are often accompanied by the staff engaging in double documentation, creating layers of information on top of the original intent. Double documentation may be perceived as beneficial for the staff members but can create vulnerabilities during the ordering and transcribing stages of the MAP. Some RN's wanted to use mobile devices to streamline medication administration. Navas et al. (2015) found that the use of mobile devices during preparing and administering medications could decrease the likelihood of medication administration errors.

4.3 Implications

Implications of the current study that may enhance the work system, are that eMAR should be tailored to fit the needs of the involved stakeholders and that proper education should be given in advance. The introduction of mobile devices to document medication administration may result in increased flexibility and less double-documentation. Also, the physical environment in which medication administration takes place seems to interact with other work system elements such as tasks & tools and technology. Indications are that the first stages in the MAP are vulnerable to MAE's. Attention should, therefore, be directed towards creating proper work environments to lessen noise and interruptions during the first two

stages of the MAP. Efforts should also be made to increase the staff's competence in medication administration via regular on-site courses, while rules and guidelines should be updated and made visible. Staff consistency over time is reported as important, and management should invest resources in maintaining a stable staff.

4.4 Methodological process modelling issues

Changes beyond the original SEIPS process modelling described by Wooldridge et al. (2017) are partly methodological and partly about the visual layout. The data material was analysed employing a deductive content analysis with a categorisation matrix (Elo & Kyngäs, 2008) containing the six steps of the medication administration process and the work system elements. A categorisation matrix was valuable when constructing the process map, allowing for independent placement of the meaning units and subsequent collective agreement within the research group. Using a similar categorisation matrix during analysis may be beneficial for other researchers with comparable challenges. The layout of the process map (figure 2) is the same as in Wooldridge et al. (2017) except the symbols for facilitators and barriers, now represented as coloured arrows instead of coloured dots. Utilising dual traits (dual arrows) allows for elements that can represent both facilitators and barriers depending on circumstances, thus introducing more flexibility.

Another change from Wooldridge et al. (2017) is the work system analysis (table 1), by listing the elements of the work system in columns to show where the facilitators and the barriers may belong. Coding the different data sources (interviews and observations) allows for further interpretation of the results. What some informants may describe as a facilitator in interviews was found to be interpreted as a barrier in the observations. Thus there are

multiple perspectives that need consideration when identifying facilitators and barriers in the work system of the MAP.

One may argue that facilitators or barriers stemming from both data sources have a higher degree of confidence. Some data from the interviews and the observations on the same subject contrast, showing how important the data interpretation aspect is. By utilising observations and interviews, it is easier to identify proximal factors such as how staff document administration of morphine, rather than distal factors such as administrative leadership's allocation of funds to train staff (Wooldridge et al., 2017). This may be perceived as a weakness, as most of the activity documented in the study relates closely to clinical activity. Future research needs to take into account the linking of the proximal and distal factors at different levels (Holden et al., 2013). Possible solutions could involve an analysis of strategic documents and structured interviews with administrative stakeholders.

4.5 Strengths and limitations

The study is innovative in being the first one to map the entire medication administration process in a nursing home ward, using SEIPS as a conceptual model. The study also points to potential ways of enhancing the work system to provide a safer environment for medication administration in nursing homes.

The process map is based on observations and interviews from one ward, and the results are not necessarily generalisable. Efforts have been made to increase the trustworthiness of the findings, and the results should be transferable to other similar settings.

5.0 Conclusion:

A SEIPS based process modelling technique is an appropriate tool when identifying facilitators and barriers to safe medication administration in nursing homes. There are a large number of identified barriers to safe medication administration in the work system. The

barriers are found in all work system elements but are prevalent in the categories tools & technology and tasks, during the first few stages of the medication administration process. Potential medication administration errors introduced initially in the medication administration process may cascade and cause adverse drug events.

The use of dual traits and separate data source coding allows for interpretational flexibility and elaborates on the dynamic interactions of all the stakeholders involved. The prominent role of the RN is evident in all the stages of the MAP.

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Appendix 1 – The observation guide

SEIPS-based observation guide (Carayon et al., 2006)

Work system					Work process
Person(s)	**Tasks**	**Tools / technology**	**Organisation**	**Physical environment**	**Professional work**
Knowledge, skills, attitudes, leadership style, competence, training Roles, status	Difficulty Complexity Variety Workload, ambiguity, routines, time pressure, documentation practice	Usability Familiarity Functionality Accessibility, level of automation, the design of equipment	Training Guidelines, Procedures Quality systems, culture, size, management style, economy, resources	Layout Distances Dispensers Temperature, lighting, air condition, state of facilities	*Medication administration* Ordering, transcribing, dispensing, preparing, administering, observing
Examples of observational findings structured according to the SEIPS-model					
The person seemingly lacks knowledge of where to retrieve relevant information.	To obtain correct information, the staff member needs to perform a long chain of single tasks.	The computer system offers poor search functionality for the kind of information he/she wishes to retrieve.	Guidelines are not current, and the staff lack training in that kind of procedures.	The nurse station is cluttered with paper and retrieval of specific information can be difficult.	

Appendix 2 – The interview guide

Introduction

Could you say something about the activities during a normal workday?

In what way are you involved with medication administration?

Use keywords from the SEIPS-model to pinpoint and specify during the interview.

- Ask the informant to describe what they do at work
    - Talk about their experiences with medication administration
- Communication
    - How is vital information shared among the staff when you are at work?
- Teamwork and collaboration
    - Could you describe how you work together?
- Medication administration
    - How would you proceed if a patient was in urgent need of some strong pain killers?
    - Documentation
    - How do you perceive medication administration as part of the regular workday?
        - How do you experience documentation tasks in relation to medication administration?
- Training and competence
    - What opportunities are there to maintain your competence at work?
- Physical structures
    - How do you feel the facilities are in relation to the work you do?
    - Distances, noise
- Computer systems and technological solutions
    - How do you experience the computer systems in relation to documentation and other tasks?
    - How about training on these systems?
- Guidelines / rules / regulations
    - How do you proceed if you are not sure what to do or need confirmation?
- Tasks / complexity
    - How difficult would you rate the difficulty of medication administration?
- Workload
    - Delegation
- Time management
    - How do you perceive the time you have assigned for different tasks?
- Management
    - How would you describe the management at your ward?
- Special experiences
    - Have you experienced anything out of the ordinary that you would like to share?