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Laura-Maria Peltonen

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To my dear family

ABSTRACT

Laura-Maria Peltonen

INFORMATION NEEDS IN THE DAY-TO-DAY OPERATIONS MAGAGEMENT OF HOSPITAL UNITS

University of Turku, Faculty of Medicine, Nursing Science

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Day-to-day operations management of hospital units is complex due to several actors, changing situations and various information systems in use. Professionals responsible for the day-to-day operations management face challenges to obtain important information for managerial decision-making. The aim of this study was to model important information needed in the day-to-day operations management of hospital units. The study had an observational design. The professionals responsible are here referred to as 'shift leaders' and they included nurses and physicians in charge. Data were collected in 2012–2016.

First, a literature review was done to describe information systems developed for the day-to-day operations management of hospital units. Second, an instrument for exploring information needed in the day-to-day operations management of hospital units was developed and tested. Third, a national survey was done to model important information needed in the day-to-day operations management of hospital units. Thereafter, one information submodel was clinically tested.

The findings showed that numerous information systems have been developed for professionals responsible for the day-to-day operations management of hospital units, but these do not adequately support managerial decision-making. The instrument for exploring information needed in the day-to-day operations management of hospital units was valid and reliable, and the data collected with it showed that the needs differed between professionals, time of day and types of units. The largest difference was between professionals. Nurses' important information needs covered patients, personnel and materials, while physicians' needs focused on patient care. Categories of important information for the model were determined by factor analysis for these different user groups.

The final model of important information had ten information categories, all of which were needed by different user groups with a different set of individual items. This emphasizes the need for flexible and user tailored information systems. The model may be used to develop information processing in the day-to-day operations management of hospital units to support the safe, efficient and cost-effective care provision.

Keywords: day-to-day operations management, first-line management, hospital, information need, information processing, information system, shift leader

TIIVISTELMÄ

Laura-Maria Peltonen

TIEDON TARPEET SAIRAALAYKSIKÖN PÄIVITTÄISEN TOIMINNAN JOHTAMISESSA

Turun yliopisto, Lääketieteellinen tiedekunta, Hoitotiede

Annales Universitatis Turkuensis, Turku, 2018

Sairaalayksikön päivittäisen toiminnan johtamien on haastavaa usean toimijan, muuttuvien tilanteiden ja lukuisten käytössä olevien tietojärjestelmien vuoksi. Toiminnasta vastaavilla ammattilaisilla on vaikeuksia saada tärkeää tietoa päätöksenteon tueksi. Tutkimuksen tarkoitus oli mallintaa sairaalayksikön päivittäisen toiminnan johtamisessa tarvittavia tärkeitä tietoja. Tutkimusasetelma oli havainnoiva. Toiminnasta vastaavat ammattilaiset olivat sairaanhoitajia ja lääkäreitä. Aineistot kerättiin vuosina 2012–2016.

Aluksi kuvattiin sairaalayksikön päivittäisen toiminnan johtamiseen kehitettyjä tietojärjestelmiä kirjallisuuskatsauksella. Toiseksi, kehitettiin ja testattiin mittari, jolla voitiin tarkastella tiedon tarpeita sairaalayksikön päivittäisen toiminnan johtamisessa. Kolmanneksi, tehtiin kansallinen kysely, jonka perusteella sairaalayksiköiden päivittäisen toiminnan johtamisessa tarvittavia tärkeitä tietoja voitiin mallintaa. Lopuksi, yksi malli testattiin kliinisessä ympäristössä.

Päivittäisen toiminnan johtamiseen on tulosten perusteella kehitetty lukuisia tietojärjestelmiä, mutta ne tukevat johtamisen päätöksentekoa vain osin. Sairaalayksikön päivittäisen toiminnan johtamisen tiedontarpeiden selvittämiseen kehitetty mittari osoittautui validiksi ja reliaabeliksi. Mittarilla kerätty tieto osoitti, että tiedontarpeet eroavat ammattiryhmän, ajankohdan ja sairaalayksikön mukaan. Suurin ero oli ammattiryhmien välillä. Sairaanhoitajat tarvitsivat tietoa potilaista, henkilöstöstä ja materiaaleista kun taas lääkäreiden tarpeet keskittyivät potilashoitoon. Käyttäjäryhmien tärkeitä tietosisältöjä jäsenneltiin faktorianalyysin avulla.

Tärkeiden tietojen malli koostui yhteensä kymmenestä tietokategoriasta, jotka vaihtelivat käyttäjäryhmittäin. Myös kategorioiden sisällä olevat yksittäiset tiedon tarpeet vaihtelivat käyttäjäryhmillä. Tämä korostaa joustavien ja käyttäjälähtöisesti räätälöityjen tietojärjestelmien tarvetta. Mallia voidaan käyttää tietojen käsittelyn kehittämiseen sairaalayksiköiden päivittäisen toiminnan johtamisessa, jotta paremmin tuetaan turvallisia, vaikuttavia ja kustannustehokkaita palveluita.

Avainsanat: lähijohto, operatiivisen toiminnan johtaminen, sairaala, tiedon tarve, tietojen käsittely, vuorovastaava

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ABBREVIATIONS

AGFI	Adjusted goodness of fit index
ANA	American Nurses Association
ANOVA	Analysis of variance
CFI	Comparative fit index
CI	Confidence interval
CMIN/DF	Minimum discrepancy / degrees of freedom
df	Degrees of freedom
DIKW	Data-Information-Knowledge-Wisdom framework
EHR	Electronic health record
GDP	Gross domestic product
GFI	Goodness of fit index
ICU	Intensive care unit
IFI	Incremental Fit Index
KMO	Kaiser-Meyer-Olkin measure
M	Mean
NFI	Normed fit index
OECD	Organisation for Economic Co-operation and Development
RMR	Root mean square residual
RMSEA	Root mean square error of approximation
SD	Standard deviation
TLI	Tucker-Lewis Index
USA	United States of America
WHO	World Health Organization
WMA	World Medical Association
χ^2	Chi-squared

LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following publications.

1. Murtola L-M, Lundgrén-Laine H, Salanterä S. 2013. Information systems in hospitals: a review article from a nursing management perspective. *IJNVO* 13(1), 81–100.

2. Peltonen L-M, Lundgrén-Laine, H, Siirala E, Löyttyniemi E, Aantaa R, Salanterä S. 2018. Assessing managerial information needs: Modification and evaluation of the Hospital Shift Leaders' Information Needs Questionnaire. *J Nurs Manag* 26(2), 108–119.

3. Peltonen L-M, Lundgrén-Laine, Salanterä S. 2017. Towards improving shift leaders' information management in intensive care units: developing and testing a model for a management information system. *IJTMCP* 2(4), 343–361.

4. Peltonen L-M, Siirala E, Junttila K, Lundgrén-Laine, H, Löyttyniemi E, Vahlberg T, Aantaa R, Salanterä S. Information Needs in the Day-to-Day Operations Management in Hospital Units - A Cross-Sectional National Survey. [submitted].

1 INTRODUCTION

In 2016, the OECD nations (Organisation for Economic Co-operation and Development) spent from 4.3% in Turkey to 17.2% in the United States of America (USA) of their gross domestic product (GDP) on health, summing up to almost 890 €/capita in Turkey and 7,960 €/capita in the USA (OECD 2018). Finland was situated in the middle of the list with 9.3% of GDP and 3,800 €/capita and an annual budget of 18.9 billion € (National Institute for Health and Welfare 2017). Hospitals account for one-third of the national health expenditure, although, there are substantial variations in the costs of treatments in the hospital setting (Daidone & Street 2011). In the USA, hospital care accounted for 32% (Centers for Medicare and Medicaid Services 2017) and in Finland specialised health care accounted for 34.7% (6.9 billion €) of the national health care costs (National Institute for Health and Welfare 2017). Furthermore, about one-quarter of hospital budgets are used on the nursing and medical workforce (Patrick 2014). There is internationally a need to constrain the increasing health care costs. As the nursing and medical workforce accounts for a great deal of the costs, attention should be paid to the efficient use of these resources, which is a part of the day-to-day operations management, and further, contributes to the quality of care and safe care provision.

The day-to-day operations management of hospital units is difficult because of several professionals involved, constantly changing situations, a vast amount of information, and numerous information systems needed to support managerial decision-making. Running patient care in a hospital unit is the duty of designated nurses and physicians, namely shift leaders, who are responsible for allocating the right resources to meet patient care needs within the unit. Hospital units are normally run by unit managers during office hours. However, during evenings, nights and weekends, this responsibility is delegated to other members of the staff. The managerial decisions when running a hospital unit concern staffing, materials and patient care (Lundgrén-Laine et al. 2011, McCallin & Frankson 2010, Siirala et al. 2016). Paying attention to the day-to-day operations management is important, because poor organisation of hospital resources decreases the quality of care and employee satisfaction (Aiken et al. 2002, Johansson et al. 2010, Kane et al. 2007, Kinston 1983, Raup 2008) and may waste resources. Typically, the professionals responsible for the unit need to make decisions ad hoc without delay (Lundgrén-Laine et al. 2011, Siirala et al. 2016). However, the information used by them is scattered among several locations, such as information systems, slips of paper and memory (Kontio 2013, Lundgrén-Laine 2013) and currently they use much effort to find important information to support their decision-making (Andersson et al. 2003, Gurses et al. 2009, Kontio et al. 2013, Moss & Xiao 2004, Reddy et al. 2002).

To date, considerable resources are put on information systems in health care settings to manage the increasing amount of information (Berner et al. 2005, Simborg et al. 2013). For example, in Finland a regional unified healthcare and social services' information system for 29 hospitals, 37 health care centres and dozens of social care organisations, with a customer base of 1.6 million individuals, is estimated to cost 385 million €. In addition, the annual total costs are estimated to be 43 million € (Apotti 2018). Nonetheless, healthcare information systems are expected to increase the quality of care while lowering costs (Apotti 2018, Bailey et al. 2014, Harrison & Palacio 2006, Lee et al. 2013, Stabile & Cooper 2013), although two-thirds of information system implementation projects have difficulties reaching set goals (Kaplan & Harris-Salamone 2009). Reported barriers to an increase in quality and reduction in costs related for example to electronic health records (EHRs) are: poor usability and interfaces, lack of patient centredness, lack of interoperability, slow adoption of clinical decision support systems, market barriers, potentials for misuse, and a lack of clinical informaticians (Simborg et al. 2013).

Research on information processing and information needs in the day-to-day operations management of hospital units is internationally scarce, and the professionals responsible have reported that existing solutions do not support their decision-making adequately (Peltonen et al. 2018 a,b). Developing information systems based on users' needs is necessary to ease access to timely and accurate information. Therefore, the overall aim of this study is to model important information needed in the day-to-day operations management of hospital units. The findings of this may be used to develop and improve information processing in the day-to-day operations management of hospital units to support the safe, efficient and cost-effective provision of care.

2 LITERATURE REVIEW

This literature review describes existing knowledge about clinical management, professionals responsible for the day-to-day operations management, information needs, information processing and information systems developed to support the day-to-day operations management of hospital units. The literature review presents three main topics. These are clinical management structures, the day-to-day operations management, and the role of information in the day-to-day operations management of hospital units. The chapter ends with a summary of existing knowledge and identified knowledge gaps. The definitions of the central concepts are presented in Table1.

Table 1. Definitions of central concepts of the study

Central concept	Definition
Hospital unit	The World Health Organization (WHO 2017) defines hospitals as institutions with inpatient facilities with organised medical and other professional personnel that deliver a range of acute, convalescent and terminal care round-the-clock every day of the week. Hospitals have different units that provide different types of care to patients with different health problems, such as imaging, surgical and medical services.
Day-to-day operations management	Decision-making to ensure the functioning of a unit on a day-to-day basis conducted by the professionals responsible.
Shift leader	Nursing and medical professionals responsible for the functioning and care provision of a unit during a specific shift (see e.g. Lundgrén-Laine 2013). A nurse in charge is a registered nurse responsible for nursing care. The person working in this role varies between hospital units; during day time this is typically the nurse manager, while at night it may be a staff nurse. Correspondingly, a physician in charge is responsible for patient care within a unit during a specific shift. The person working in this role varies between hospital units; during day time this is typically the head of department, while at night it may the registrar on call.
Information need	Recognition of inadequate knowledge to satisfy a goal at a specific point in time (Ormandy 2011).

The literature search was targeted to six databases (MEDLINE, CINAHL, Medic, Scopus, Web of Science and the Cochrane library). The searches were based on the central concepts of the study as presented Figure 1. Details of the search and the search findings are described in Appendix 1. Reference lists of the articles of interest were screened manually for more relevant literature. Also, general search engines were used to seek relevant literature using the central concepts presented in Figure 1.

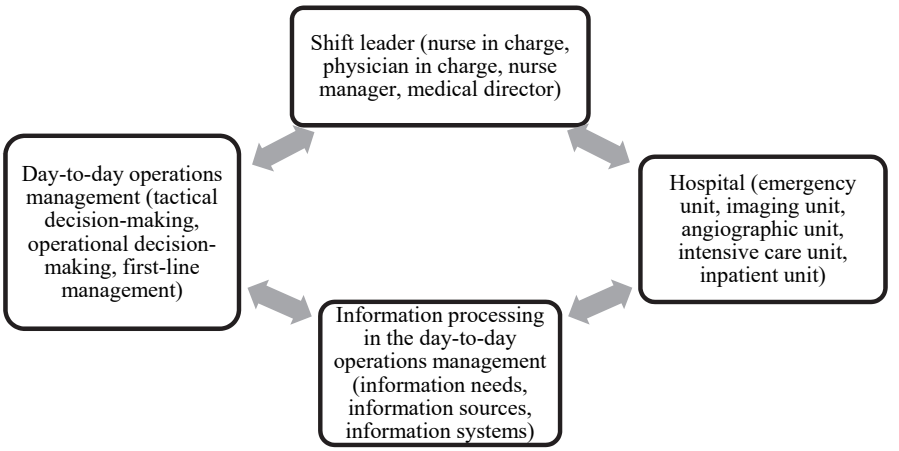

Figure 1. Central concepts used in the searches of the literature review.

Articles were included in the review when they covered research exploring the day-to-day operations management of hospital units and information processing related to this. Articles were excluded if they covered clinical care, clinical information systems, social services, dentistry, the selection of managers, the organisation of hospital units, consultation services, the evaluation of managers' work, leadership styles, succession planning, and hospital managers' longer-term planning related decisions, such as staff turnover, professional development, organ donation coordination, and practice development. Research on hospital organisation was limited to work published after 1980. Research on information processing in hospitals was limited to articles published after 2000. However, seminal work on decision-making and information processing was included without time limitations. After excluding the duplicates, abstracts were screened first on topic level, then on abstract level, and finally on full text level. A total of 146 studies were included in the literature review. A flow chart of the literature selection process is illustrated in Figure 2.

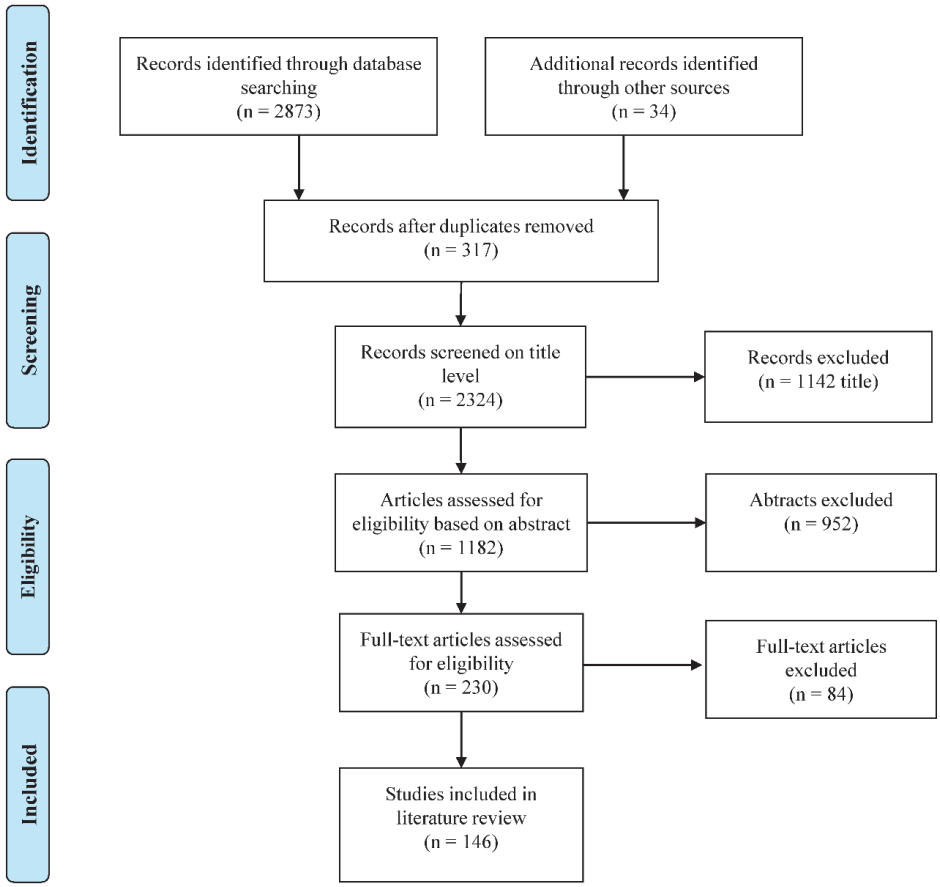

Figure 2. Flowchart of the literature selection process (adapted from Moher et al. 2009)

2.1 Clinical management structures in hospitals

Hospitals are governed in different ways depending on circumstances, histories, and cultures (Alexander et al. 2003, Ditzel et al. 2006). The governance can be considered as a process of top-level organisational leadership, policy making and decision-making (Ditzel et al. 2006), usually with system-wide governing boards, with or without advisory boards at the local level (Morlock & Alexander 1986). The main responsibilities of hospital boards include financial and effectivity performance (Culica & Prezio 2009). A correlation between effective boards and positive financial performance in hospitals has been found, although the performance of clinical care quality is associated with clinical expertise (McDonagh 2006) led by the clinical management.

Hospitals are traditionally divided into different clinical and functional units where professionals distinguish themselves based on clinical specialities (Nyssen 2007, Vera & Kunz 2007). The organisational structure of hospitals varies between settings and countries. Large hospitals often have a more complex structure when compared to smaller hospitals. Conventionally, hospitals have a hierarchal design (Nyssen 2007), but currently, process-based organisations are applied, where professionals organise themselves into functional teams around patient care pathways, due to the expected positive effects on efficiency (Vera & Kunz 2007).

Managerial decision-making in a hospital can generally be described through three hierarchal levels, namely, strategic, tactical and operational levels. The strategic decisions-making level concerns the organisation's long-term goals, mission and vision. This level is often associated with the top management, although the lower levels provide valuable input needed in strategic decision-making (Carney 2004). The tactical level concerns how the strategic plans are put into action, consisting of details related to specific functions or units. This is often the responsibility of middle management, while the operational level decisions cover the management of the day-to-day care delivery to meet patient care needs in different hospital units. The line between strategic, tactical and operational decision-making terminology, is however not as simple as that, as each manager, regardless of their level in the hospital hierarchy, may conduct decisions that concern the here and now, short-term or long-term goals of the area they are responsible for. For example, first-line managers have been reported to make both tactical and operational decisions during a normal day at work (Betson & Pedroja 1989, Siirala et al. 2016). Furthermore, the managerial decision-making levels are separated from clinical decision-making and activities related to direct patient care made by professionals, here referred to as clinical care. Overall, the purpose of all managerial activities in a hospital is to ensure the resources necessary for the provision of clinical care.

The clinical management of hospitals has traditionally been a hierarchal structure of nursing and medical professions. The division of labour between the nursing and medical management personnel is usually straightforward. Nurses take care of nursing affairs while physicians attend to physicians' issues, where each specialty's professional is responsible for his or her own area of activity (Virtanen 2014). The nursing and medical professionals' managerial titles vary between settings and countries (Kirkpatrick et al. 2012). In general, on the executive level, the chief nursing officer and chief medical officer have strategic responsibilities to standardise, advance and guarantee the appropriate provision of evidence-based care within the organisation (Patton & Pawar 2012). On the middle level, the directing managers may be defined as those professionals who report to the chef executives (Carney 2004, Floyd & Wooldridge 1992). The nurse directors oversee nursing services within a specific division within their organisation (Carney 2004),

and the medical directors are responsible for medical supervision and general regulation of all medical aspects associated with care provision (Kossaify et al. 2013). Finally, the first-line nursing managers provide tactical and operational management for nursing activities (Asamani et al. 2013, Carney 2004, Siirala et al. 2016, Virtanen 2014,) and first-line medical managers for medical activities correspondingly (Asamani et al. 2013, Haffner et al. 2000, Virtanen 2014). First-line nursing managers are referred to in the literature with different terminology depending on the context. They may be termed head nurse (Admi & Eilon-Moshe 2016, Fast 2016, Gunawan & Aungsuroch 2017, Sullivan 2018), charge nurse (Lundgrén-Laine et al. 2013a,b, Marquis & Huston 2017, Moss et al. 2001), charge nurse manager (McCallin & Frankson 2010), assistant nurse manager (Admi & Eilon-Moshe 2016, Sullivan 2018), clinical nurse manager, front-line nurse leader, front-line nurse manager, first-line nurse manager (Admi & Eilon-Moshe 2016), nurse manager (Admi & Eilon-Moshe 2016, Sullivan 2018), team leader (Marquis & Huston 2017), nurse administrative manager (Parand et al. 2014), nursing unit manager, unit leader, unit manager (Admi & Eilon-Moshe 2016, Gunawan & Aungsuroch 2017), unit sister (Gunawan & Aungsuroch 2017), nursing supervisor (Weiss & Tappen 2015), and in the ambulatory and home care settings – coordinator (Sullivan 2018) and primary nurses (Marquis & Huston 2017). Also the first-line medical managers are referred to by many names in the literature, such as head of department (Haffner et al. 2000, Virtanen 2014), chief physician, medical manager (Parand et al. 2014) and clinical department manager (von Knorring et al. 2016). Managerial decision-making levels and roles on different levels in the hospital are exemplified in Figure 3.

Clear definitions of managerial roles at the unit level do not exist, and there is a tendency to confuse the unit manager role with the shift leader role, even though they have different degrees of authority and responsibilities. The unit manager is responsible for translating strategic and tactical goals into practice and is accountable for the unit round-the-clock (Admi & Eilon-Moshe 2016, Asamani et al. 2013, Gunawan & Aungsuroch 2017, McCallin & Frankson 2010, Sullivan 2018), while the shift leader accounts for the unit only during a specific shift (Admi & Eilon-Moshe 2016, Sullivan 2018). Regarding the nursing profession, bigger units may have a group of charge nurses, who are responsible for the immediate functioning of the unit during a specific shift (Admi & Eilon-Moshe 2016, Carter 2011). The nursing shift leaders may for example be referred to as shift charge nurses and team leaders (Admi & Eilon-Moshe 2016). The charge nurse role is quite established in the acute care setting, as they have been part of the organisation of care for more than 30 years (Admi & Eilon-Moshe 2016, Krugman & Smith 2003). The provision of medical care in a unit is often the responsibility of senior medical staff during normal office hours, but the responsibility may be assigned to a registrar

beyond normal office hours (Craig & Dowling 2013). Here, we refer to the professionals responsible as shift leaders, nurses in charge and physicians in charge.

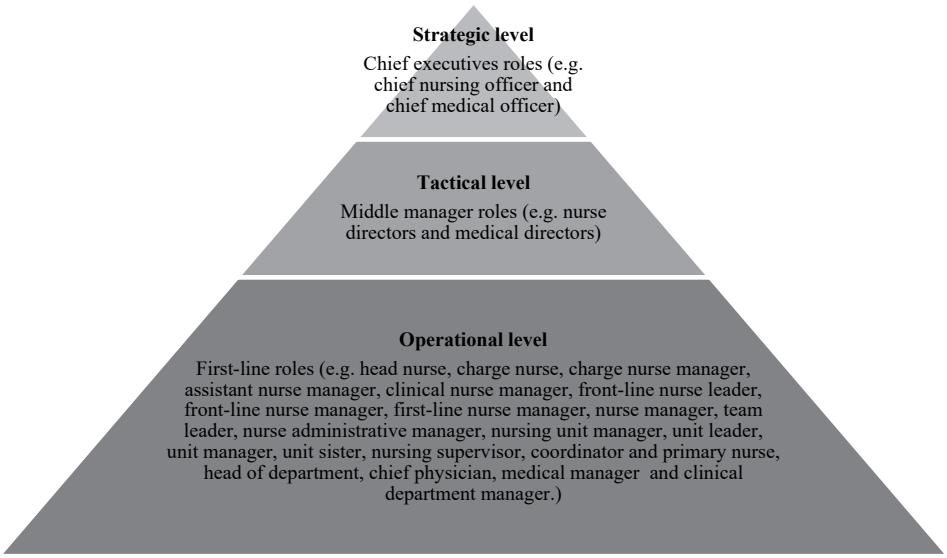

Figure 3. Managerial decision-making levels and roles on different levels in the hospital

2.2 The day-to-day operations management of hospital units

2.2.1 Operations management

Management is a process of directing through the arrangement and use of resources; this is separated from leadership – a broader term – that aims to influence the behaviour of others (Marquis & Huston 2017, Weiss & Tappen 2015). The managerial process can be seen to include planning, organisation, command, control (Betson & Pedroja 1989, Kim & Kim 2016, Marquis & Huston 2017, McCallin & Frankson 2010, Weiss & Tappen 2015), human resource management (Betson & Pedroja 1989, Kim & Kim 2016, Marquis & Huston 2017, McCallin & Frankson 2010,), and coordination (McCallin & Frankson 2010, Weiss & Tappen 2015). The term operations management has long been studied in organisation and management studies, and it may be defined as '*the activity of managing the resources which produce and deliver products and services'* (Slack et al. 2010, p.4). On the operational level in the hospital, management is about running the day-to-day functions, that is, all activities needed to provide necessary care to patients in the unit,

based on their needs. In the health disciplines, the use of the term operations management is somewhat difficult as the term often is associated with clinical management or surgical procedures. Therefore, the term *day-to-day operations management* was chosen for use here.

There are many theories about decision-making. Research in nursing has often adopted analytical or intuitive approaches (Cader et al. 2005, Lauri et al. 2001, Lauri & Salanterä 1998). One often-used approach is Hammond's cognitive continuum theory, which has shown to add to the understanding of phenomena in the field of nursing (Cader et al. 2005). This theory, originating from the field of psychology, shows the association between judgement and cognition on a continuum that ranges from intuitive to analytical decision-making, with judgement tasks from well- to ill-structured, where well- structured tasks induce analytical decision-making and ill-structured tasks induce intuition (Hammond 1986, 1996). Interestingly, in those situations where fast decision-making is needed, nurses more often resort to intuitive decision-making than to analytical decision-making (Lauri et al. 2001, Lauri & Salanterä 1998).

However, there is also individual variation in managerial decision-making, and research has shown that gender, values, life experience, individual preference and thinking styles influence decision-making (Marquis & Huston 2017). Furthermore, demographic, professional and cultural factors have been associated with levels of stress experienced by decision-makers (Admi & Eilon-Moshe 2016) and the decision-making models they use (Lauri et al. 2001). Novice nurse managers are reported to resort to linear decision-making processes, while those working longer in the role use their experience to be more effective in decision-making (McCallin & Frankson 2010), even if this might not be the case in all settings (Asamani et al. 2013).

The decisions in the day-to-day operations management of hospital units include issues related to the organisation and management of resources and work in the unit, such as decisions related to staffing, materials and patient care (Andersson et al. 2003, Asamani et al. 2013, Bateman 2012, Betson & Pedroja 1989, Lundgrén-Laine et al. 2011, McCallin & Frankson 2010, Moss & Xiao 2004, Moss et al. 2001, Siirala, et al. 2016, Schleppers & Bender 2003) as well as issues that are related to the quality and safety of patient care, teaching, counselling and administration (Admi & Eilon-Moshe 2016, Asamani et al. 2013, Betson & Pedroja 1989, McCallin & Frankson 2010). Nurse managers make decisions that are both tactical and operational in nature (Asamani et al. 2013, Marquis & Huston 2017, Siirala et al. 2016). For example, research in the perioperative environment (Siirala et al. 2016) has shown that their decisions concern an immediate instant, the near

future and the long-term future. The immediate decisions covered staffing and material resources, rescheduling of procedures, and monitoring the day-to-day activities in the unit. The near future decisions covered the planning of procedures and material resources, and staff allocation; and the long-term decisions covered human resources, nursing development, material resources, and finances. However, the day-to-day operations management in hospitals is typically characterised by immediate decisions (Lundgrén-Laine et al. 2011, Siirala et al. 2016).

The day-to-day operations management of hospital units is also a multidisciplinary collaborative effort between different actors (Andersson et al. 2003, Haffner et al. 2000, Lundgrén-Laine 2011, Marjamaa & Kirvelä 2007). The complexity of this is well-exemplified through a bundle of decisions at patient admission to the intensive care unit, where the physician in charge decides to admit a critically ill patient to the unit. Thereafter, the charge nurse is faced with many decisions related to where the patient should be placed; what nurse should care for the patient based on available nurses, knowledge and skills; when the patient may be admitted; and what equipment is needed (Lundgrén-Laine et al. 2011).

The influence of the day-to-day operations management has received attention, and poor organisation of hospital resources decreases both the quality of care and employee satisfaction (Aiken et al. 2002, Johansson et al. 2010, Kane et al. 2007, Kinston 1983, Raup 2008). Inadequate staffing levels have been shown to increase patient mortality (Aiken et al. 2014, Junttila et al. 2016, Kane et al. 2007, Needleman et al. 2011), decrease the quality of care (Aiken et al. 2002, Kane et al. 2007) and reduce managing with work amongst staff (Aiken et al. 2002, Cummings et al. 2010). The work of the first-line nurse managers is further associated with nurses' performance, nurse and patient outcomes, nurses' intention to stay, staff and patient satisfaction (Cummings et al. 2010, Gunawan & Aungsuroch 2017), safety (Agnew & Flin 2014, Cummings et al. 2010), use of research evidence (Gifford et al. 2007) and effectiveness (Cummings et al. 2010).

2.2.2 Shift leaders

Shift leaders may be first-line managers or other members of staff in charge of a shift. The first-line nurse managers are registered nurses who plan, organise, deliver, and evaluate nursing and interdisciplinary care and organise all necessary human and material resources needed in the provision of care (Gunawan & Aungsuroch 2017). The current and desired roles of first-line managers vary (Skytt et al. 2008), and their work is described as challenging (Asamani et al. 2013, McCallin & Frankson 2010) and characterised by constant interruptions (Bjerregård-Madsen et al. 2016, Moss & Xiao 2004, Siirala et al. 2016). The first-line

medical managers use their time both for administration and clinical activities, and the bigger the unit is the more time is used for administration when compared to clinical activities (Haffner et al. 2000). However, nurse managers are not expected to participate in clinical nursing as before (Bjerregård Madsen et al. 2016). A recent review on nursing managerial activities showed that there is a great variation between activities among managers, with the most common activities being human resource management, supporting staff, resource allocation, interaction with staff and other stakeholders, clinical activities (advising staff, managing quality and patient contact), financial management, developmental activities, and strategic planning (Bjerregård Madsen et al. 2016).

Unit managers typically run the unit during normal office hours from Monday to Friday (Surakka 2008), but at other times such as evenings, nights and weekends, designated nursing and medical staff members take over (Admi & Eilon-Moshe 2016, Craig & Dowling 2013, Weaver & Lindgren 2016). This management responsibility is also termed off-shift, out of hours (Weaver & Lindgren 2017, Weaver & Lindgren 2016), and non-dayshift management (Weaver et al. 2017) and it covers three-quarters of the week. The hospital unit shift leader is separated from the administrative supervisor role, who is the hospital level shift leader working beyond normal office hours (Weaver et al. 2017, Weaver & Lindgren 2017, Weaver & Lindgren 2016). Here, all professionals responsible for the day-to-day operations management of hospital units during specific shifts are referred to as shift leaders.

In the nursing profession, charge nurses who have expanded staff nurse roles are accountable to unit managers and work on a shift-by-shift basis coordinating resources to meet patient care needs within a unit, and this is separated from the unit manager's role who has round-the-clock accountability and responsibility for the unit (Sullivan 2018). There is less literature regarding the medical manager. The head of the department is responsible for the medical care around the clock (Haffner et al. 2000, Virtanen 2014), and normally the attending physician supervises the inpatient services, along with clinical work and resident education (Wingo et al. 2016). However, registrars may be in charge of shifts beyond office hours (Craig & Dowling 2013). A shift leader is in a difficult position on a day-to-day basis, and charge nurses have reported moderate stress levels due to their work (Admi & Eilon-Moshe 2016). Charge nurses have described the essence of their job as responsibility that moves between positions of full control and entrusting responsibility with others simultaneously, as the role lacks established authority and has the temporal dimension of a shift (Goldblatt et al. 2008). Furthermore, mentoring novice leaders is important, as it is associated with increased patient and staff satisfaction as well as improved quality of care (English et al. 2013).

There are demanding requirements on the competencies needed for those responsible for hospital units. A systematic literature review (Pihlainen et al. 2016) on competencies necessary in hospital management included health-care context-related, operational and general competencies. First, the health-care context-related competences included social (e.g. norms and roles), organisational (e.g. task and responsibilities), business (e.g. processes and development) and financial aspects (e.g. budgets and their management). Second, the operational management included competencies related to processes (e.g. quality improvement), operations (resource allocation and delegation), clinical work (knowledge and skills) and development (e.g. staff development). Finally, the general competencies included time management, interpersonal skills (e.g. communication), strategic mindset (e.g. analytical thinking), thinking application (e.g. multitask and prioritising) and human resource management. Noticeably, the educational needs in management skills of nurse managers (Bjerregård Madsen et al. 2016, Gould et al. 2001, Parry 2012, Watkins et al. 2014), charge nurses (Jasper et al. 2010, Platt & Foster 2008, Porter et al. 2006) and heads of departments have also been recognised (Clyne et al. 2015, Craig & Dowling 2013,), but also educational needs for registrars are reported, as they too may be in charge of shifts beyond office hours (Craig & Dowling 2013).

2.3 The role of information in the day-to-day operations management of hospital units

2.3.1 Information needs

An information need can be defined as the recognition of insufficient knowledge to satisfy a goal at a specific instance (Ormandy 2011) or as an item that an individual requires in order to solve a problem (Timmins 2006). Understandably, the information needs in the day-to-day operations management are related to the managerial processes and tasks. However, the information needs of first-line managers may differ from those of shift leaders who only work beyond office hours and have a staff member position, as the responsibilities and accountabilities of the positions differ. Nonetheless, for the day-to-day operations management, real-time information seems important, as managerial decisions typically are made ad hoc in constantly changing situations in a hospital (Lundgrén-Laine et al. 2011, Siirala et al. 2016).

Shift leaders' information needs have previously been explored in the emergency setting (Norri-Sederholm et al. 2015), intensive care units (Lundgrén-Laine et al.

2013a,b, Peltonen et al. 2016), the cardiac patient care process in hospitals (Kontio et al. 2013), and functional units in hospitals (Andersson et al. 2004, Junttila et al. 2007, Ruland 2001, Shand & Callen 2003). Research and detailed information needs in these settings are presented in Table 2.

Previous research has shown that the information needs differ between professions, as nurses in charge information needs covered staffing, material and patient information when compared to physicians, whose information needs mostly focused on patients and their care (Lundgrén-Laine et al. 2013a). Information needs also seemed similar between units, as needs often included information about patients, staffing and materials (Andersson et al. 2003, 2004, Kontio et al. 2013, Lundgrén-Laine et al. 2013a,b, Norri-Sederholm et al. 2015). Interestingly, information needs were further associated with the size of the unit and the experience of the nurse in charge (Lundgrén-Laine et al. 2013a). Research exploring ad hoc decision-making in day-to-day operations management emphasizes the need for real-time information (Hu et al. 2006, Kontio et al. 2013, Lundgrén-Laine et al. 2013a,b) when compared to more tactical decisions aiming at the near-future or beyond, i.e. tactical decisions.

Another thing emphasized in previous research related to the day-to-day operations management and the information needed in different surroundings is situational awareness (Kontio et al. 2013, Lundgrén-Laine et al. 2013a,b, Norri-Sederholm et al. 2015); that is, the shift leader must be aware of what is happening, must understand what this means, and project how this may influence the future, which only may be accomplished through timely and accurate information (Endsley 2000).

Table 2. Research on information needed in the day-to-day operations management

Author, year	Setting	Design	Methods	Participants	Information needs
Andersson et al. 2004	County hospital in Sweden	Case study	Archives Interviews Participatory observation Focus group	Health care managers from clinics and units, nurses and physicians (n = not reported)	Patient information Patient satisfaction Resource allocation Resource expenditure Staff satisfaction Unit level clinical activities
Andersson et al. 2003	Swedish hospital, paediatric unit	Case study	Archives Interviews Participatory observation Focus group	Unit managers, nurses and physicians (n = 8)	Costs Patient information Resource use Staff satisfaction
Junttila et al. 2007	Nine units of a Finnish hospital	Implementation of Nursing Management Information System	Expert group Survey Interview	Nurse directors, head nurses and nurse experts (n = 20)	69 individual indicators related to clinical processes, finance, patients and their needs, and staffing.
Kontio et al. 2013	Finnish university hospital, cardiac patients care process	Observational study	Interview	First-line and middle managers, nurses and physicians (n = 14)	Equipment location on the unit Finance and budget Forecasting options Guidelines Materials Patients and patient flow Real-time staff resources on the unit Real-time workload on the unit Staff knowledge, skills and competence Unit resources and available beds

Author, year	Setting	Design	Methods	Participants	Information needs
Lundgrén-Laine et al. 2013a	17 intensive care units in Finnish hospitals	Cross-sectional national survey	Survey	Charge nurses and intensivists (n = 353)	57 crucial individual information need items related to patient admission, management of work, staff allocation, material resources, special treatments, and patient discharge were reported. 22 of these were shared by both professions.
Lundgrén-Laine et al. 2013b	17 Intensive care units in Finland and 16 in Greece	Cross-sectional national survey	Survey	Charge nurses (n = 307)	20 crucial individual information need items related to patient admission, management of work, staff allocation, material resources, and special treatments were reported. Most of these were related to management of work. Differences existed between information at discharge.
Norri-Sederholm et al. 2015	Four Finnish rescue units	Observational study	Interview	Paramedic field supervisors (n = 10)	Crucial information includes background data of the situation at hand, staffing and material resources on site and their sufficiency, available and used resources in the surroundings, safety aspects and operating procedures.
Ruland 2001	Norwegian hospital	Case study	Focus group Prototyping	Nurse managers (n = not reported)	Patient information, care needs and patient flow Finance and budgets Staff sufficiency and adequacy per shift Quality of nursing Forecasting
Shand & Callen 2003	Australian hospital	Observational study	Interview	Clinical managers, nurses, physicians and data managers (n = 20)	Information about patients Cost weights Clinical indicators Top diagnostic related groups Procedures done to patients Details per medical speciality or equivalent

2.3.2 Information processing

Vast amounts of information are needed in hospitals every day, and therefore processing information plays a central role in the organisation and provision of care. Information may be defined as a fact or detail about something (Oxford Advanced Learner's Dictionary), and there are several levels to it. One common way of understanding these levels is the Data-Information-Knowledge-Wisdom (DIKW) framework. The origin of this framework is a bit unclear, but it was presented by Blum in 1986 and then introduced to the field of nursing by Graves and Corcoran in the same year. The framework has three levels: data, information, and knowledge. Later a fourth level was added into this hierarchy, namely wisdom, to better serve evidence-based practice and decision support in the field of nursing (Bickford 2009). In this framework, data are '*discrete entities that are described objectively without interpretation*,' information as '*data that have been interpreted, organised, or structured*,' knowledge as '*information that is synthesised so that relationships are identified and formalised*', (Graves and Corcoran 1989, p. 227) and wisdom as '*the appropriate use of knowledge to manage and solve human problems'* (ANA, p. 3).

Studies on how humans process information originate from the 1950s from the field of psychology, and numerous models have been developed on the topic. In general, this approach views professionals as information-processing systems that interpret information from the surroundings, processes obtained information, stores and recovers information from memory, and acts based on the information (Proctor & Vu 2012, Reed 2012). One theory used in nursing is the information processing theory (Banning 2008, Lauri & Salanterä 1998, Lauri et al. 1997, Thompson et al. 2017). According to this theory, a decision is reached through earlier knowledge, collecting information, generating alternatives, forming hypotheses, and testing the hypotheses (Newell 1989, Newell & Simon 1972, Simon 1978).

The coordination of professionals' activities and other available resources to meet with patient care needs and the need for information processing to achieve this can be viewed from three perspectives: vertical, lateral and longitudinal (Nyssen 2007). Firstly, the vertical view includes the distribution of decision-making responsibility between the different levels of the organisation and the need for information to be available both top-down and bottom-up. Secondly, the lateral view includes activities and information needs on the same managerial decision-making level within an organisation, such as between experts from different domains and the exchange of information related to this. Finally, the longitudinal view includes continuously updating information related to patient care. This can also be viewed through the managerial decision-making levels, as illustrated in Figure 4.

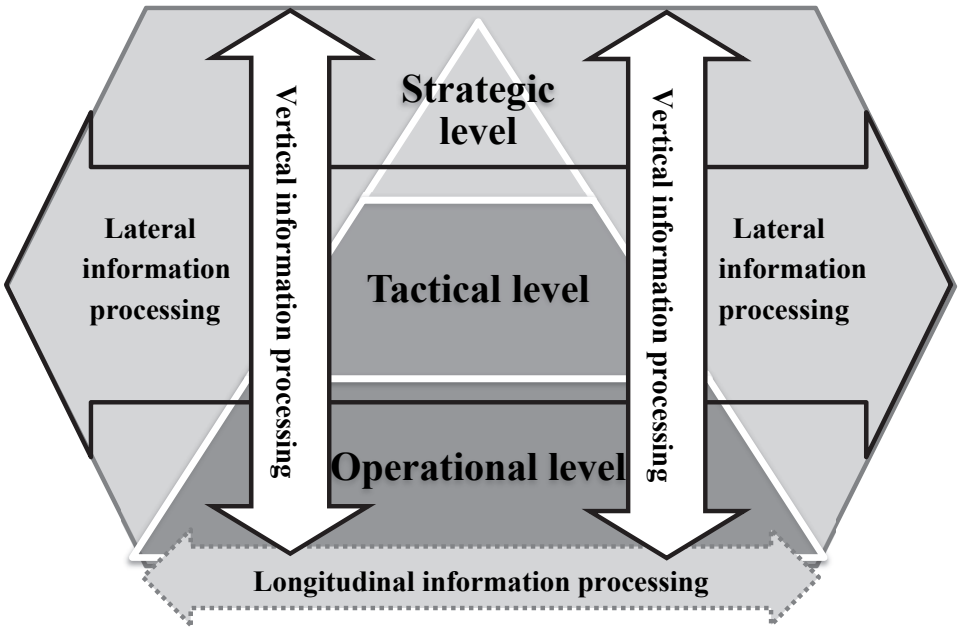

Figure 4. Organisational levels and information processing (adapted from Murtola et al. 2012)

However, accessing information in the day-to-day operations management in a simple and fast way is not self-evident in the hospital setting. Shift leaders use a considerable amount of time and effort to obtain important information to support their decision-making, as information is spread out in different places and information may be delayed, insufficient and out-of-date (Kontio et al. 2011, Kontio et al. 2013). Furthermore, sources are numerous and both human, paper-based and electronic sources are used (Andersson et al. 2003, Kontio et al. 2013, Moss & Xiao 2004, Peltonen et al. 2016, Reddy et al. 2002). For example, in a 1100 m^2 intensive care unit, a shift leader may walk up to 3.5 kilometres during one shift seeking information (Lundgrén-Laine et al. 2013a). Correspondingly, a charge nurse may use almost 50 minutes of a shift to assemble and update paper-based information tools, where they gather information collected from different sources (Gurses et al. 2009). Handovers between shift leaders have shown variation with a lack of relevant patient information (Spooner et al. 2016). Although nowadays, electronic whiteboards are widely used to display information about specific patients and their care status to support the dissemination of information between clinicians in care coordination (Gjære & Lillebo 2014, Hertzum 2012, Hertzum & Simonsen 2016, Randell et al. 2015), little research exists about information systems developed to assemble and display relevant information for shift leaders in hospitals.

In general, information systems acquire, store and present information (Reichertz 2006). Numerous different information systems are used in hospitals for different purposes. These may be divided into two groups: administrative and clinical. On one hand, clinical systems refer to those that are directly linked to patient care, such as electronic health records, order entry systems, dietary systems, pharmacy systems and laboratory systems. On the other hand, administrative systems refer to information systems that support all other activities that are conducted to support clinical care, such human resource systems, quality improvement systems, scheduling systems, employee record systems, financial systems, and billing systems (McHaney 2006, Marquis & Huston 2017, Wagler et al. 2017, Zytkowski et al. 2018). Although information from clinical systems is important in running a hospital unit, the focus in this review is on the administrative information systems, as the phenomenon of interest is the day-to-day operations management. Administrative systems can further be organised into systems that provide information for decision-making i.e. management information systems, and systems that are used to communicate decisions further, i.e. office automation systems (Clément 2015).

Many reasons lie beyond the developments of information systems in the health care setting. Important issues include the digitalisation of paper-based systems, the enormous increase in data, an intention towards organisational wide systems, secondary use of clinical data, consumers as users of systems, need for change management, growing amounts of graphic information, and the rapid development of technologies (Haux 2006). However, management information systems have traditionally not been among the highest investment priorities when compared to clinical information systems (Locatelli et al. 2010), even though an association between information culture and patient safety is reported in information processing, related to losing information at a change of shift and patient transfer, information delay, and documentation errors (Jylhä 2017).

Information systems used to support the day-to-day operations management are often developed only to serve one purpose, such as scheduling, patient classification, workload management and allocation (see e.g. Choi et al. 2014, Clément et al. 2015, Dexter et al. 2000, Fasoli & Haddock 2010, Gale & Noga 2013, Kerfoot & Smith 2015, McHaney 2006, Rainio & Ohinmaa 2005, Rauhala & Fagerström 2004, Wagner et al. 2005), patient care management systems (Choi 2014, McHaney 2006), cost accounting systems (Choi et al.2014, Clément et al. 2015), human resource management systems (Clément et al. 2015, Fitzpatrick & Brooks 2010, McHaney 2006, Pulido et al. 2014), material resource management systems, fiscal resource systems (Clément et al. 2015), and quality surveillance and improvement systems (Clément et al. 2015, Jeffs et al. 2014, Kinnunen-Luovi et al. 2014, McHaney 2006, Ruuhilehto et al. 2011, Zane et al. 2004). However, a

data warehouse approach has been suggested to integrate information from several systems such as clinical information and rostering information (Junttila et al. 2007).

Information systems that integrate information and provide a snapshot of a unit's situation for nurse managers and nurse directors have also emerged (Jeffs et al. 2014, Krugman & Sanders 2016, Ruland & Ravn 2003, Shand & Callen 2003). As with most of the current information systems and business intelligence systems, these also provide the information retrospectively. But even in the most advanced hospitals, comprehensive information systems that integrate important information to support the day-to-day operations management are lacking (see e.g. Yoo et al. 2016). Only a few real-time information systems have been reported related to scheduling (Tuominen et al. 2016), automated paging (Etchells et al. 2010), reaching radiologists (Rumball-Smith & MacDonald 2011), predicting care time (Sorge 2001, Sun et al. 2012, Tiwari et al. 2014) and assessing the occupancy status in operating rooms (Hu et al. 2006, Xiao et al. 2008). Although several reviews evaluating health information systems exist (see e.g. Nguyen et al. 2014, Sligo et al. 2017), only one review evaluating management information systems was found. This review showed that scheduling programs, nursing cost-related programs, and patient care management programs were effective in time-saving and beneficial in nursing care, although there is a lack of quality in the evidence (Choi et al. 2014).

Despite rapid advancements in technology and the development of information systems for use in hospitals, the professionals responsible for the day-to-day operations management in hospitals are still dissatisfied with current information systems (Kivinen & Lammintakanen 2013, Kontio et al. 2013, Lammintakanen et al. 2010, Marjamaa & Kirvelä 2007, Murtola et al. 2012, Peltonen et al. 2018a,b, Ruland 2001, Shand & Callen 2003). Currently, real-time information is infrequently available, and decisions are made based on insufficient information (Frith et al. 2010, Kontio et al. 2013, Siirala et al. 2016).

2.4 Summary of and gaps in contemporary knowledge

The day-to-day operations management in hospitals is demanding, as situations rapidly may change and managerial decisions need to be made ad hoc without delay. Shift leaders need situational awareness, which only can be based on timely and correct information to make high quality decisions (Kontio et al. 2013, Lundgrén-Laine et al. 2013a,b, Norri-Sederholm et al. 2015). However, currently shift leaders use a considerable amount of work to access important information at the point of decision-making (Gurses et al. 2009, Lundgrén-Laine 2013, Siirala et

al. 2016), and sometimes their decision-making is limited by a lack of important information (Frith et al. 2010, Kontio et al. 2013, Siirala et al. 2016). Whatever the task or problem to solve faced by the shift leader, information is needed to support decision-making. The quality of shift leaders' decisions are influenced by the information at hand at the point of decision-making. The association between shift leaders information access and quality of managerial decisions is presented in Figure 5.

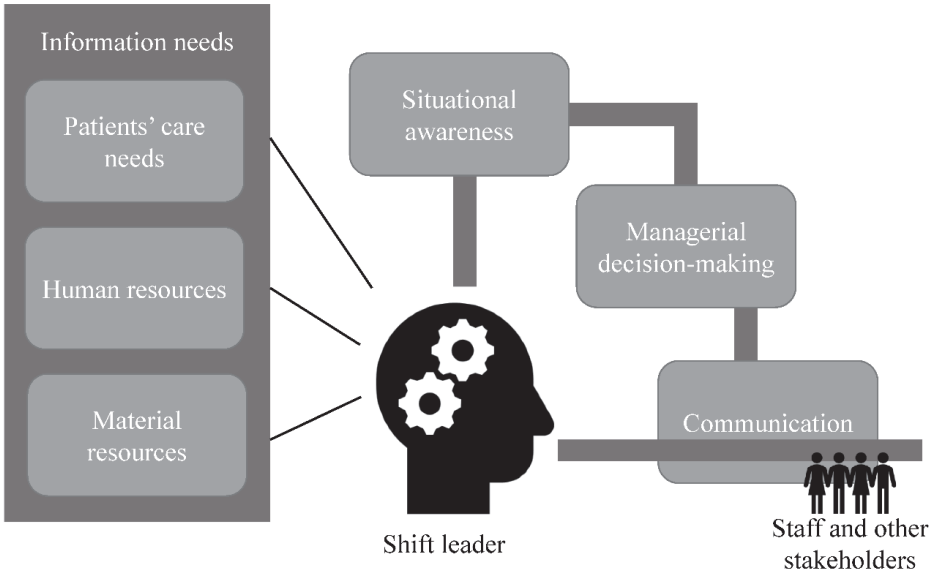

Figure 5. Shift leaders' information needs and managerial activities

In short, contemporary research covers hospital managerial responsibilities, decision-making and tools developed to support specific managerial tasks. However, research has often focused on unit managers when compared to those responsible for the day-to-day management during evenings, nights and weekends, even if the managers are present on the unit only about one-fourth of the whole week. Furthermore, there is more research reported on managers from the nursing profession when compared to physicians.

Shift leaders have reported dissatisfaction with the content and number of currently needed information systems (Kivinen & Lammintakanen 2013, Lammintakanen et al. 2010, Peltonen et al. 2018a,b, Ruland 2001), which often are developed for only one specific managerial task. However, improved information access could be organised through a reduction in needed information systems by integrating important information into one source based on user-specific needs, as accountabilities and responsibilities differ between the professionals responsible for the day-to-day operations management of hospital units, depending on their profession, position and setting. To date, we do not know what information is important to

whom and how information should be displayed to support the different users responsible for the day-to-day management of hospital units. Nor do we know how information systems support the day-to-day operations management. These gaps are illustrated in Figure 6.

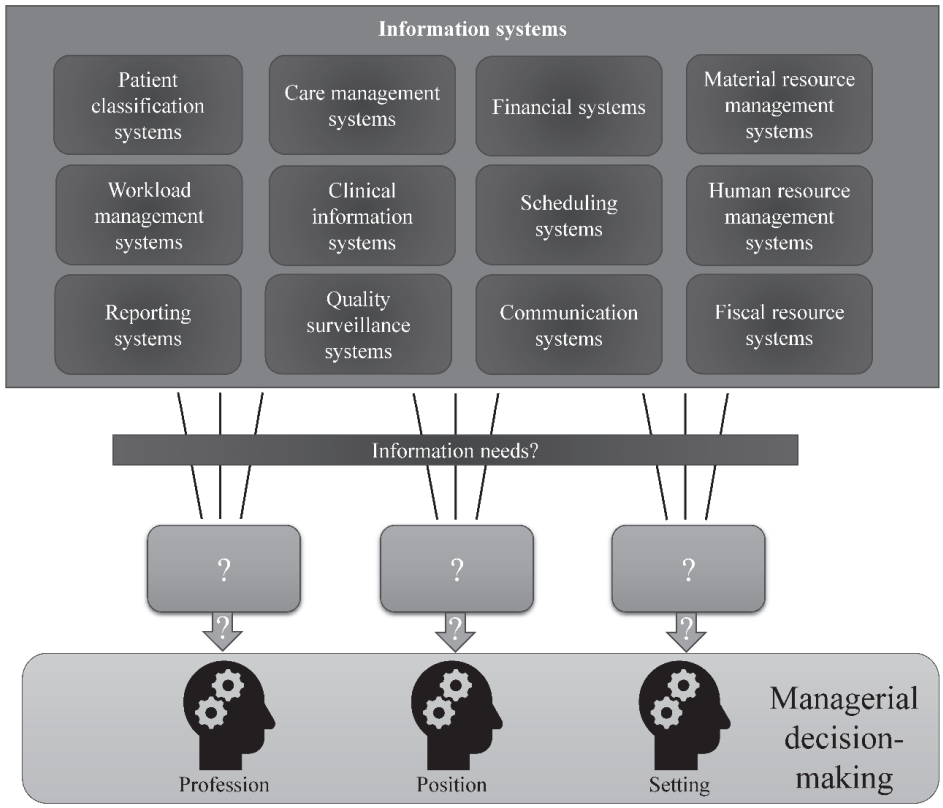

Figure 6. Gaps in literature about information needs in the day-to-day operations management of hospital units

Another problem emerging from the literature is the lack of real-time information. Current information systems rarely provide real-time information, as data is assembled retrospectively and hence better supports tactical decision-making. Therefore, research is needed to improve information systems in the day-to-day operations management of hospital units. Modelling important information needed in the day-to-day operations management enables the development of user-centred solutions that could improve access to important information and support situational awareness and better decisions. This is a prerequisite for safe and efficient care provision as well as a means to improve patient and staff satisfaction. How-

ever, limited research exists about the information needs of shift leaders in different hospital units. Furthermore, a multiprofessional approach is needed, as the managerial decision-making is interconnected between the nursing and medical professionals.

3 AIMS OF THE STUDY

The overall aim of this study is to model important information needed in the day-to-day operations management of hospital units. The findings of this may be used to develop and improve information processing in the day-to-day operations management of hospital units to support the safe, efficient and cost-effective provision of care. The study was conducted in three phases consisting of four sub-studies (Papers I to IV).

Phase 1: Information systems developed for the day-to-day operations management (Papers I to III)

The aim of this phase was to describe information systems developed to support the day-to-day operations management of hospital units. The research questions were:

- What information systems have been developed to support the day-to-day operations management of hospital units?
- How satisfied are hospitals shift leaders with current information systems?

Phase 2: Instrument development (Paper II)

The aim of this phase was to develop and test an instrument for exploring information needed in the day-to-day operations management of hospital units. The stated research questions were:

- What changes are necessary to the *ICU Information Needs Questionnaire* to make it suitable for use in a broader hospital setting?
- Is the modified version of the questionnaire, that is, the *Hospital Shift Leaders' Information Needs Questionnaire* valid and reliable?

Phase 3: Modelling information needs (Papers III to IV)

The aim of this phase was to describe and compare important information needed by different users in the day-to-day operations management of hospital units. The stated research questions were:

- What information is important in the day-to-day operations management of hospital units according to different users?
- How can important information be assembled for shift leaders in the day-to-day operations management of hospital units?

4 MATERIALS AND METHODS

This chapter describes settings, populations, samplings, data collection methods and data analysis methods used in the study. An overview of the four sub-studies and designs, settings, sampling, samples, methods, and expected outcomes are found in Table 3.

4.1 Settings

Data were collected in public teaching hospitals in two countries, Finland and New Zealand. In Finland, the data were collected in regional (n = 2), central (n = 6) and university hospitals (n = 4) in ten hospital districts out of the twenty-one districts in the country. In New Zealand, the data were collected in central (n = 1) and university hospitals (n = 4) in four district health boards from the twenty district health boards in the country. New Zealand was chosen for data collection to see if information needs are alike in western countries across the world. The intensive care settings was chosen because critical care is fairly well guided by international guidelines and organised in a similar way. In Finland, adult patients care processes were targeted throughout the hospitals. More specifically, neurologic and neurosurgical, cardiac, acute stomach and trauma patients were of interest. Hospital units included were emergency, imaging, angiographic, high dependency, and inpatient units. These units excluded social care and psychiatric care. In New Zealand, data were collected in level-three mixed intensive care units. Detailed descriptions of the targeted hospital units are as follows:

- Emergency units include hospital units that provide both inpatient and outpatient emergency services around the clock. These units may be organised as part of the primary services, specialised care or by both. These units care for patients with a sudden illness, injury or worsening of a chronic condition by instant assessment and care.

- Radiology units include hospital units that provide radiology services around the clock. The services may for example include x-ray, magnetic resonance imaging and ultrasound.

- Procedure units include here a variety of hospital units that provide services to other units in the hospital, such as angiotherapy, high dependency care and smaller medical procedures.

- Intensive care units are here limited to mixed level three units that provide care to critically ill adult patients. Level three units are defined as units with enough

resources to provide the most complex care for the critically ill around the clock (Valentin et al. 2011). These units also needed to have a full-time physician and a senior nurse responsible for staff and quality of care.

- Inpatient units include hospital units that specialise in care provision of specific patient groups. Here, these are limited to units that provide care for adult patients.

Table 3. An overview of the sub-studies

Sub-study	Period	Design	Setting	Sampling and sample	Methods	Expected outcomes
1	2012–2013	Scoping literature review	CINAHL, PubMed (MEDLINE), ABI/INFORM Global, IEEE Xplore and Cochrane Database of Systematic Review	Total sample (n = 25). All articles adhering with the inclusion and exclusion criteria were included in the review.	Systematic search Deductive thematic content analysis of data extracted from articles	- Research on information systems developed for nurse managers in hospitals
2	2014–2015	Instrument modification study	University hospital (n = 1) and regional hospitals (n = 2) in Finland	Purposive sampling Shift leaders (n = 67) who worked in emergency, radiology, angiographic, intensive care and inpatient units.	Data collection: - Structured observations - Interviews including a) open questions b) expert evaluation Data analysis: - Deductive thematic content analysis - Content validity index - Inductive thematic content analysis	- Managerial activities in the day-to-day operations management - Questionnaire to be used for exploring information needs in the day-to-day operations management of hospital units
3	2012–2016	International cross-sectional survey and interviews. Usability testing.	Level three intensive care units in New Zealand (n = 5) and in Finland (n = 1)	Purposive sampling Shift leaders working in level-three intensive care units - Survey (n = 20) - Interviews (n = 15) - Model testing (n = 6)	Data collection: - Structured survey - Structured interviews - Model testing Data analysis: - Frequencies - Medians - Inductive thematic content analysis - Deductive thematic content analysis of data extracted from articles	- Important information needs of intensive care shift leaders - Sources of important information - Model of management information system

Sub-study	Period	Design	Setting	Sampling and sample	Methods	Expected outcomes
4	2015–2016	Cross-sectional national survey	Central (n = 6) and university hospitals (n = 3) in Finland	Stratified random sampling Charge nurses (n = 469) and physicians in charge (n = 111) who worked in emergency, radiology, angiographic, intensive care and inpatient units.	Data collection: - Structured survey Data analysis: - Descriptive statistics (frequencies, means, medians, standard deviations) - Analyses of variance, Spearman's correlation coefficient - Model development (exploratory factor analysis) - Questionnaire validity and reliability (Cronbach's α, item to total correlations, confirmatory factor analysis)	- Important information needs of shift leaders in emergency, radiology, angiographic, intensive care and inpatient units - Validity and reliability of developed instrument
Outcome: Model of important information needed in the day-to-day operations management of hospital units						

4.2 Populations and samplings

The population was nursing and medical professionals who were responsible for the day-to-day operations management of hospital units during a specific shift. Both nurses and physicians were of relevance, as the day-to-day operations management is an interconnected process involving both professions (Lundgrén-Laine et al. 2011, Lundgrén-Laine 2013). The roles and responsibilities of the persons responsible varied between organisations and units. Conventionally, each unit has one nursing and one medical unit manager, who are on the unit during normal office hours (from 8 a.m. to 4 p.m.) but beyond normal office hours, i.e. in the evening, at night and during weekends when the managers were away, the responsibility was delegated to other members of staff, such as senior nurses or consultants. Bigger units could also have assistant managers in charge of the day-to-day operations management while the unit managers focused more on tactical decisions.

The sample in the literature review included all possible articles describing, comparing and evaluating information systems available for nurse managers in hospitals to support their day-to-day operations management. Systems not used for the day-to-day operations management were excluded. A total of 25 articles were included in the review. More details are found in Paper I (pages 86–88).

The sampling technique was purposive when recruiting participants for the development of the *Hospital Shift Leaders' Information Needs Questionnaire*. Interviews (n = 24) and observations (n = 20 hours) were conducted in a university hospital, and testing of the questionnaire under development was done in two regional hospitals (n = 67) in Finland. Emergency, procedure, radiology and inpatient units were targeted. Shift leaders from all hospital units of interest were identified by their superiors and recruited for the study. More details are found in Paper II (pages 2–3).

The sampling technique was purposive when exploring information needed in the day-to-day operations management in intensive care units in New Zealand and when testing the developed model in one intensive care unit in Finland. Each level-three intensive care unit in the country recognised by the Intensive Care Nurses Association in New Zealand was approached. Only five units from five hospitals were eligible and willing to participate out of the 29 approached units. Two level-three units declined to participate. Shift leaders were recruited by their superiors, as they needed to have experience in running the day-to-day operations in the unit. A total of twenty shift leaders responded to the survey, and fifteen of these were

also interviewed. For testing the developed management information system model, shift leaders (n = 6) were recruited from Finland. More details are found in Paper III (pages 346–347).

Stratified random sampling was used to reach respondents for the national survey in Finland. The required sample size was 570, as each item in the questionnaire required a minimum of five respondents (Bryman & Cramer 1997). Hospitals were geographically divided into three groups including the north, the middle and the south. From each group, one university hospital and one central hospital was randomly chosen for the study. In addition, three central hospitals, one from each geographical group, were randomised into a back-up group, as a 60% response rate could be expected (Phillips et al. 2017). After collecting data in the six hospitals with a response rate close to 60%, data collection was continued in the remaining three hospitals on the list to reach the wanted sample size. Each hospital had a local coordinator and 100 paper-based questionnaires to distribute evenly between respondents from different units. Hence, a total of 900 shift leaders were targeted from nine hospitals. The coordinator contacted the units, and individual respondents were identified by their superiors. The coordinator manually distributed the surveys in each unit and collected them after a designated response time, which usually lasted two weeks. More details are found in Paper IV (pages 158–159).

4.3 Data collection

4.3.1 Scoping review (Paper I)

Information systems developed to support nurse managers in hospitals were explored through a scoping review. This method is suitable to explore existing knowledge and identify knowledge gaps (Grant & Booth 2009, Peters et al. 2015, Tricco et al. 2016). Five databases were searched. These included ABI/INFORM Global, CINAHL, Cochrane Database of Systematic Reviews, IEEE Xplore and PubMed (MEDLINE). Combinations of ‘management information systems’, ‘hospital’, ‘coordination’, ‘technology’, ‘nurse manager’ and ‘nursing’ were used in the searches. Database-specific terminology such as medical subject headings (MeSH) were used when possible. Manual searches were also made based on references found in the database searches. Inclusion criteria were academic journal publications concerning information systems used by nurse managers. Included articles were study reports or reviews by experts in the field. Articles that were not about information systems developed to support nurse managers were excluded.

Data were collected in 2012. The process followed methodical guidance for scoping reviews (Peters et al. 2015, Tricco et al. 2016). More details about the article selection are found in Paper I (pages 86–88).

4.3.2 Observations (Paper II)

The observation method was used when developing the *Hospital Shift Leaders' Information Needs Questionnaire* (Paper II, pages 3–4). Observations may be descriptive, focused or selective in nature (Spradley 1980). The observations made were selective in nature, as specific events and professionals were of interest. The observations were structured. The structure of an observation was guided by its purpose and pre-defined categories (Wilson & Streatfield 1981). As the interest lay on the information-processing of shift leaders in the day-to-day operations management, the following categories were defined: time of decision, event to start information-seeking, type of managerial decision, and information needed to make a decision. These were documented. The observations were done in one university hospitals' emergency unit. Structured observations are particularly suitable when little information exists about the phenomena of interest (Bowling 2002, Mulhall 2003). The observer did not participate in the events of interest. The purpose of the observations was to develop an overview of the information management process in the day-to-day operations management. A total of eight nurses in charge were followed. Data were collected during all days of the week and during morning, evening and night shifts. One observation session lasted from two to four hours. The observations were structured; managerial activities and information needs related to these were documented in a notebook.

4.3.3 Interviews (Papers II–III)

The interview method was used twice. First, when exploring the sources of important information needed in the day-to-day operations management in intensive care units in New Zealand, and second, in the process of developing the *Hospital Shift Leaders' Information Needs Questionnaire.*

In New Zealand, the sources of important information needed in the day-to-day operations management in intensive care units were explored through interviews. These were structured and completed online with software allowing communication through voice, video and text (e.g. Skype®, Connect Pro® and email). This enabled interviewing regardless of the distance between interviewer and interviewee in a time- and resource-effective way (Janghorban et al. 2014). Structured

interviews are often connected to quantitative data, as participants are asked closed questions (Holloway & Galvin 2016, Mitchell 2015). The interviews were preceded by a survey exploring important information needed in the day-to-day operations management in intensive care units in New Zealand. The interviewees were recruited through the survey, where they were asked at the end of the survey for their email address if they agreed to participate in an interview. The interviews included demographic questions about the informant, their unit, and shift leaders' responsibilities and accountabilities on their unit. Then, the interview continued with a structure based on the results from the previously made information needs survey. The informants were nurses (n = 7) and physicians (n = 2) who worked in a shift leader's role in level-three intensive care units in New Zealand. The interviews were different for nurses and physicians, as the information needs of these professions differed. The interview guide was pilot-tested with six shift leaders to assure functionality. These included one physician and five nurses. The live interviews lasted 30 minutes to 2.5 hours. Webropol® questionnaires were also built to support email communication for informants who were unable or reluctant to take part of an online 'live' interview. These questionnaire were also pilot-tested by one nurse and one physician. The pilot tests led to slight changes connected to the instructions. Data were collected in 2012. More details are found in Paper III (pages 347–348).

Interviews were also used in the development of the *Hospital Shift Leaders' Information Needs Questionnaire* in Finland. Informants were recruited through their superiors in one 800-bed university hospital in Finland. During the interviews, informants were first asked two open-ended questions. These were to describe their managerial activities and the information needed for these. Then, informants were asked to judge how relevant each of the 122 items in the *ICU Information Need Questionnaire* were for the day-to-day operations management in their unit. More details are found in Paper II (pages 2–5).

4.3.4 Surveys (Papers II–IV)

The survey method was used in three sub-studies. First, in the pilot test of the *Hospital Shift Leaders' Information Needs Questionnaire*; second, when collecting data with the *ICU Information Needs Questionnaire* in New Zealand; and third, in a national survey in Finland.

The pilot of the *Hospital Shift Leaders' Information Needs Questionnaire* was done in 2014 (Paper II). The instrument was tested in two regional hospitals with approximately 100 beds each. The design was a cross-sectional online survey. The testing provided information about the function, feasibility and response rate of the

survey. The questionnaire was distributed electronically using email addresses (n = 258) provided by the superiors of the participating units. Two reminders were used to increase the response rate. Data were collected between June and October in 2014. More details are presented in Paper II (pages 2–5).

Validated tools should be used to ensure research quality (Kimberlin & Winterstein 2008). The *ICU Information Needs Questionnaire* was an existing validated instrument used to explore important information needed in the day-to-day operations management of intensive care units in New Zealand from five Hospitals (Paper III). Data were collected in a cross-sectional online survey with Webropol® in 2012. The survey was distributed to a total of 95 shift leaders in intensive care units, including nurses in charge (N = 61) and physicians in charge (N = 34). Details are found in Paper III (pages 346–348).

Information needed in the day-to-day operations management was explored with a cross-sectional national survey in Finland (Paper IV). Data were collected in nine hospitals, including six central hospitals and three university hospitals. The sizes of the hospitals varied, with patient beds from 300 to 2,000 and personnel from 1,600 to 12,000. More details are found in Paper IV (pages 158–159). Data were collected with the *Hospital Shift Leaders' Information Needs Questionnaire*. The instrument development process is described in Paper II and the results section 5.2.

4.3.5 Instruments (Papers II–IV)

The ICU information needs questionnaire

The *ICU information needs questionnaire* was used for collecting data in the intensive care units in New Zealand. This validated instrument has previously been used in Finland and Greece (Lundgrén-Laine et al. 2013a,b). The questionnaire was developed based on a study where the think-aloud technique and protocol analysis were used to identify shift leaders' ad hoc decisions in intensive care units. The questionnaire consisted of two parts. These were related to respondent demographics and characteristics of the unit, and 122 items divided into six dimensions. Items in the questionnaire were identified by connecting each identified ad hoc decision to an information need. The dimensions were: patient admission (21 items, organisation and management of work (60 items), allocation of staff (18 items), material resources (7 items), special treatments (5 items), and patient discharge (11 items). Each item was stated in a similar way: 'immediate information about the patient's diagnosis is…' The importance of the information needed was assessed on a rating scale from 0 (completely unnecessary) to 10 (absolutely necessary). Responding was estimated to take about 20 minutes.

The Hospital Shift Leaders' Information Needs Questionnaire

A modification of the *ICU information needs questionnaire* was needed to explore information needs in the broader hospital setting because information needs in intensive care units may differ from other units in a hospital due to the specialised care needs and treatments of critically ill patients. Any validated method can be chosen for the modification of a questionnaire as there is a lack of evidence of the best method for this (Epstein et al. 2015).

The original *ICU Information Need Questionnaire* was modified for the broader hospital environment through observations of the day-to-day management in hospital units and interviews with experts and proposed respondents in the field. Using experts and proposed respondent is one way to increase the content validity of the instrument under development (Rattray & Jones 2007). The modified questionnaire was tested with 10 purposefully chosen experts (managers and staff members from the nursing and medical professions and nurse scientists), who examined the content, instructions, and face validity of the questionnaire (Sousa & Rojjanasrirat 2010). Then, the modified questionnaire was tested in two regional hospitals. The questionnaire was distributed electronically (Webropol 2016) to the respondents (N = 258) using email addresses provided by their superiors. The modification process was done in 2014. Here, the experts and proposed respondents were from emergency, radiology, procedure and inpatient units. These units included patients from both surgical and medical specialties, including cardiac, trauma, acute gastrological, acute gastrosurgical, neurological, and neurosurgical patients. The instrument development process is described in Paper II and the results in section 5.2.

4.3.6 Model testing (Paper III)

Intensive care unit shift leaders' important information needs and sources for obtaining information were used to design a management information system model. Important information was determined based on findings from the data collected in New Zealand and previous research exploring intensive care shift leaders' information needs in Finland and Greece (Lundgrén-Laine et al. 2013a,b). Literature (Lundgrén-Laine et al. 2013a) and manual information sheets used by intensive care shift leaders were used for the structure of the model. In the final version to be tested, information needs were grouped into six sheets: real-time overview of unit, dashboard for planning an upcoming shift, patients on the unit, material resources, staffing resources, and communication and guidelines. The model was digitalised in mock-up software (http://www.mybalsamic.com). The mock-up was then used to collect shift leaders' (n = 6) perceptions of the model from a large 24-

bed level-three intensive care unit in Finland. Developing such a system is an iterative process, and five participants usually give enough insights to capture the biggest issues for development where after things start to repeat themselves (Nielsen 1994). During the test, informants were shown a demo of the information system mock-up. Thereafter, they were asked to think aloud while examining the model. This method may be used when exploring informants' thoughts (Fonteyn et al. 1993, van Someren et al. 1994). The sessions recorded for analysis and each session took from 30 to 45 minutes. More details are provided in Paper III pages 346–349).

4.4 Data analyses

4.4.1 Scoping review (Paper I)

A total of 25 articles were included in the review. The findings were deductively categorised using the model of decision-making levels and information management in hospitals presented in Figure 1, based on the descriptions of the information systems in the articles. Data was extracted based on the research question about the type of studies and information systems presented. The findings are represented as a narrative synthesis, as a meta-analysis or meta-summary was not possible due to the types of studies found (Grant & Booth 2009). The quality of the reported studies was not assessed with a validated instrument.

4.4.2 Observation (Paper II)

Data collected was analysed line-by-line from the structured notes from the observation. This information was gathered into process descriptions about decision-making processes, and individual information items needed for reaching a decision were extracted. For example, at 9:45 a.m. after a phone call from one of the staff nurses, who informed about an absence due to sickness, a decision related to the need for calling more nurses on duty was needed. Hence, information about the number and competence of the nurses on duty as well as the number and care needs of the patient was needed. Discovered information need items were compared with items on the original *ICU information needs questionnaire*. Data analysis was done simultaneously with the data collection.

4.4.3 Thematic content analysis (Papers II and III)

Interview data was analysed with thematic content analysis. Content analysis focuses on more than merely calculating, as it reflects meanings and contexts (Burns & Grove 2009). A concept map was used to assist in understanding shift leaders information processing. Data collected from nurses were analysed separately from the data collected from physicians when developing the questionnaire. However, the findings are presented composed due to the slight sample size (Paper II, page 4).

Graneheim and Lundman's (2004) work guided the analyses (Papers II and II). Data was first read and thereafter similar expressions were combined into subcategories. Hereafter, upper categories were shaped of similar items, and finally main categories were made. For example, in the analysis of the data from testing the management information system an expression was '*is there a possibility to scroll back in history to see the allocation of nurses for the last 3 to 4 days*?'. This expression was put together with other similar expressions to form the sub-category '*allocation history needed*'. These were put together with similar issues under the upper category '*functionality of system*' and these formed the main category "*improvement needs'*. When analysing further, the suggested improvements – for the management information system model features that were labelled useful and features needing improvements – were collected. These were grouped based on their similarities and differences under the six information sheets. The clinical testing of the model was done in December of 2016. The analyses are reported in Papers II (pages 2–4) and III (page 348).

4.4.4 Content validity index (Paper II)

Interview data on the relevance of items in the *ICU Information Need Questionnaire* were analysed using the CVI approach with a 4-point rating scale (DeVon et al. 2007, Polit and Beck 2006). The content validity index (CVI) approach was used on item level to rate relevant items (DeVon et al. 2007, Polit & Beck 2006). Items were rated not relevant, somewhat relevant, quite relevant, and highly relevant. Items rated not relevant were excluded. Items rated somewhat relevant were modified based on comments from the informants so that they better suited the broader hospital setting. And items rated somewhat and highly relevant were included in the modified questionnaire. A value of 0.78 was deemed to be the lower limit for CVI on item level regarding agreement between participants, as suggested by Lynn (1986). After the questionnaire modification process, a new CVI number

for individual items were not calculated. More details on the questionnaire modification process are found in Paper II on pages 2–4.

4.4.5 Statistical analyses (Papers II–IV)

When analysing the data from the pilot test (Paper II) and the national survey (Paper IV), a 70% cut-off point was used to extract important information, that is, an information need was considered important when 70% of the respondents rated an item nine or ten on the scale ranging from zero (completely unnecessary) to ten (absolutely necessary). This limit has been used before in similar studies in the intensive care setting (Lundgrén-Laine et al. 2013a,b). In both sub-studies (Paper II and IV), means were used to calculate sum variables for the six dimensions for the *Hospital Shift Leaders' Information Needs Questionnaire*. The dimensions were as follows: the admission of a new patient into the unit (items 1–20); the organisation and management of work (items 21–52); special treatments, examinations, and procedures (items 53–61); the allocation of material resources (items 62–71); the allocation of staffing resources (72–100); and patient discharge (items 101–114). Responses were considered missing and excluded from the analysis if more than 25% lacking.

Data were analysed using SAS version 9.4 for Windows in the questionnaire development study. Differences between managers' and staff members' managerial activities were explored using Fisher's exact test, and differences in information needs were explored using Wilcoxon's rank sum tests. The respondents' characteristics (position and profession) and the question '*Do you think you are the right person to respond to this questionnaire?'* were compared using Fisher's exact test. Medians were calculated for the items exploring shift leaders' satisfaction with current information systems. Item–total correlations were calculated for both individual items and the six dimensions. Values above 0.3 were used to identify items that added to the explanatory power of the questionnaire (Rattray & Jones, 2007). A split-half analysis was done using the Spearman-Brown coefficient for each dimension. Cronbach's α values were calculated, and a missing item led to its exclusion from the analysis. The possibility of conducting a factor analysis was assessed with the Kaiser-Meyer-Olkin (KMO) measure and the Bartlett test for sphericity. P-values below 0.05 were considered statistically significant.

Data collected in New Zealand with the *ICU information needs questionnaire* was analysed using SPSS 22 for Windows (IBM, USA). Medians were used when exploring important information needs of respondents. This sample was too small for inferential statistics. There were few physician respondents (n = 5), and hence a larger dispersal between the information needs occurred when compared to the

nurses in charge. The most important needs were deemed to have a high median for nurses in charge (median 9–10) and an even higher median for physicians in charge (median 10) to ensure that the information was absolutely necessary. The detailed results from this analysis are reported in Peltonen et al. 2016.

In the national survey, sum variables were calculated for all information need items (n = 114) in addition to the six information need dimensions (n = 6). These sum variables were calculated by summing up responses to items and dividing the number with the total number of responded items. Associations with participant characteristics on the sum variables for information needs and information need dimensions were explored with analysis of variance (ANOVA). Tukey's test was used for pairwise comparisons when findings were significant. Associations of respondents' characteristics with managerial activity items were explored with ordinal logistic regression. Correlations between work experience, managerial activities and information needs were evaluated with the Spearman's correlation coefficient. P-values <0.05 were considered significant. The questionnaires' psychometric properties were assessed with item-to-total correlations for each item and the six dimensions. Further, a split-half analysis using the Spearman-Brown coefficient for each dimension, and Cronbach's α values for the managerial activity scale and the six dimensions were calculated. A missing item led to exclusion from the analysis.

When designing the model, exploratory factor analysis was used to explore how important information needed by the shift leaders could be grouped together. Recommendations made by Gaskin and Happell (2014) guided the factor analysis. Based on these recommendations, the following choices were made. The sample was determined to be sufficient in size (n = 570), as five respondents per item are considered to be a minimum for factor analysis (Kline 1994), and high communalities were expected, as these and a larger set of items per factor reduce the needed sample size (Gaskin & Happell 2014). The sample adequacy was also tested with the KMO measure and the Bartlett test for sphericity. A parallel analysis with the Monte Carlo Simulation was used to guide the number of factors to be extracted. However, if the number of factors suggested by the parallel analysis resulted in an overestimation of the factors with only a few items, the scree test was used, where the number of factors to be extracted was determined by examining the slope of higher and lower Eigenvalues (Kline 1994). If this did not result in more than three items per factor, the number of factors was reduced to see if these items loaded on the resulting factors, a method suggested by Watson and Thompson (2006). Data were extracted with the maximum likelihood method, as this is the appropriate method for interval data and it has been demonstrated to be superior to principal axis factoring and ordinary least squares when the normality assumption is violated (Gaskin & Happell 2014), as in the data collected in the national survey in Finland.

Factors were rotated to support the interpretation of the results. Oblimin rotation was used, as it is suitable when items are expected to correlate (Gaskin & Happell 2014). When presenting the findings, small coefficients (<0.20) were suppressed. SPSS 24 for Windows (IBM Corp., Armonk, N.Y., USA) was used to analyse the data. The exploratory factor analyses done for developing the model of important information needs are reported in the results section 5.3.1.

A confirmatory factor analysis was done to determine the structure of the questionnaire with structural equation modelling using AMOS version 23 for Windows (IBM Corp., Armonk, N.Y., USA). This method may be used when there is a strong conceptual basis for the factor model (Brown 2014). This is reported in Paper IV (pages 165–166) and section 5.2.

4.5 Ethical considerations

Research must provide more good than possible harm. This research focused on how to improve health services by better supporting professionals responsible for the day-to-day operations management in hospital units. The population of interest was healthy individuals, that is, professionals in the health care setting. The study was by nature observational, without interventions, and therefore there was no risk of putting participants in unequal positions from that perspective. Further, the topic is not sensitive in a way that could be expected to pose stress for the study participants, as the focus is on information management. International and national ethical guidelines (WMA 2013, the Finnish advisory board on research integrity 2012) guided the research process, and appropriate detailed research plans were made for each phase of the study. The detailed plans supported the process and helped to identify possible risks in different stages of the process. Participating organisations and the participants' will and reluctance to participate were respected.

Ensuring informed consent was important. Each study phase was prepared with informing about the study in person orally and in documented form in each participating unit in each hospital. These sessions and information sheets were prepared based on national guidelines (The National Committee on Medical Research Ethics 2017). Data collection never started immediately after an information session and hence participants had some time to consider if they were willing to participate in the study or not. A questionnaire was always distributed together with information about the study and how the collected data will be handled. The surveys were distributed in the pilot phase electronically to emails using an online survey system (Webropol®). A maximum of three reminders were automatically sent to those who had not responded. More reminders were considered offensive. In the

national survey, the data was collected with paper-based questionnaires. These were distributed and collected by a research coordinator at each specific hospital. All coordinators worked in the organisations where the data were collected. The participating organisations were monetarily compensated in the national survey for the hours of work used by the coordinators to reduce the expenses for participating organisations. Returning a questionnaire was considered informed consent in the survey studies. This was communicated when informing about the studies.

Ensuring participant anonymity was important. In the surveys, the researcher did not obtain personal information about professionals participating in sub-studies II and IV, as local coordinators in each hospital were responsible for distributing the surveys. Respondents were not identified on a personal level. Possible respondents were identified by supervisors, and their identity was never communicated from the superiors to the researcher in the national survey made in Finland and the survey made in New Zealand. The identity of respondents when testing the developed questionnaire in two regional hospitals in Finland could have been revealed to the researcher through email addresses. These were not collected anywhere else than in the online survey program (Webropol®), and they were not available for outsiders. All findings are reported so that no specific individual or unit can be recognised. Findings are also disseminated through international and national journals and seminars intended for researchers, professionals and community to reach a broad audience.

This research did increase the amount of work of the participants. For example, responding to a survey took about 10–20 minutes per respondent. The interviews on the other hand took much longer, but these were an essential part of the questionnaire development process. Possible ways of keeping the excess workload to a minimum were considered, and the smallest reasonable sample sizes were chosen to cause as little extra work as possible to participants and participating organisations in each study phase. A validated instrument was chosen when possible. However, such an instrument only existed for intensive care units (Lundgrén-Laine et al. 2013a); therefore a new instrument was needed for exploring information needs beyond the intensive care unit in the hospital. The development process was thorough, including different steps and data collection methods, and piloting was done to ensure its suitability and function before the national data collection. Collected data were always stored so that only authorised persons had access, data analysis was made with care, and research findings were published accurately.

More ethical consideration was needed for data collected with the observation method. A professional may become stressed about a researcher following the work. Therefore, the informants were properly informed about the aim of the ob-

servations and what specific issues in the situations were of interest. Each professional willing to participate was approached by email after the general information situation at the unit. This topic was not focusing on the professionals' characteristics or way of working, but on information needs and sources used in the day-to-day operations management, and this was clearly communicated to the participants. Data were collected with a structured form visible to the participants. Therefore, no participant should have felt being watched in a stressful way. The observer did not observe direct patient care. Hence the patents' integrity was not threatened. The observer was not to interfere with the work on the unit. One important aspect during the planning stage was to think in advance about how to react during an observation if something unexpected and ethically contradictory were to happen.

This study extends the theoretical basis about knowledge-based management in the day-to-day operations management of hospitals. This emerging topic is still scarcely explored, even though the need for improvements has been stated in several studies (Kivinen & Lammintakanen 2013, Kontio et al. 2013, Lammintakanen et al. 2010, Marjamaa & Kirvelä 2007, Peltonen et al. 2018a,b, Ruland 2001, Shand & Callen 2003). The findings directly inform the development of information systems to better support shift leaders' work to adopt excising technology for easier and faster access to important information at the point of decision-making. This may reduce their perceived stress and improve the quality of the decisions they make. This may indirectly also improve patient care and increase staff satisfaction through better resource allocation.

Ethical statements were obtained from the Ethics Committee of the University of Turku for the instrument development study conducted and the national survey made in Finland (18/2014, 16/2015). The national coordinator of ethics committees at the Ministry of Health in New Zealand assessed the need for ethical approval for data collected on intensive care units in New Zealand. Further review was not needed by the national ethics committee as the study was observational and posed minimal risk to participants (National Ethics Advisory Committee 2012). Administrative approvals were obtained from all hospitals participating in the sub studies. Permission to use and modify the *ICU Information Need Questionnaire* was obtained from the owner of the instrument.

5 RESULTS

The results of the study are presented under five topics, including characteristics of respondents, development of the *Hospital shift leaders' information needs questionnaire*, information needs in the day-to-day operations management, information sources and systems developed for the day-to-day operations management, and a model of important information in the day-to-day operations management. The chapter ends with a summary of the main findings.

5.1 Characteristics of respondents (Papers II–IV)

The pilot of the *Hospital Shift Leaders' Information Needs Questionnaire* survey had a response rate of 26% (n = 67). Most respondents were nurses in charge (89.6%, n = 60) and the remaining few were physicians in charge (10.4%, n = 7). Their mean age was 43 years, ranging from 26 to 65 years, and their mean work experience was 19 years, ranging from 0.5 to 38 years. Many who worked in a shift leader's role held a staff member position (82%, n = 55), while the minority held a managerial position (18%, n = 12). Most respondents worked on inpatient (50.8%, n = 34) and emergency units (37.3%, n = 25), while a minority of respondents were from imaging units (11.9%, n = 8). More information can be found in Paper II (page 5).

The response rate to the information needs survey collected in intensive care units in New Zealand was 21.1% (n = 20). This number included fifteen nurses in charge (response rate 25%) and five physicians in charge (response rate 15%). All intensive care units were mixed units. This means that they had patients with both medical and surgical care needs. The mean age of the survey participants was 47 years. Fourteen participants were women and six were men. Their mean work experience was 18 years (from 7 to 30 years). Seventeen were shift leaders more than three times per week. One participant was shift leader once a week, and the remaining two worked as shift leader from two to three times per month. Nine of these shift leaders, including nurses in charge (n = 7) and physicians in charge (n = 2) from all five intensive care units participating in the study in New Zealand, agreed to an interview about sources of important information. In addition, nurses in charge (n = 6) from Finland were interviewed on the same topic. These nurses in charge (n = 6) were from one level-three intensive care unit in Finland and they participated in testing the developed model for a management information system. The participants were all nurses and female. They had a mean age of 51 years, a mean work experience of 26 years and a mean work experience in shift leader position of 11

years. They worked as shift leader from 0.7 to three times a week. More details are described in Paper III (page 349).

Based on the pilot study, an online survey would result in a low response rate. Therefore, data were collected with a paper-based version of the questionnaire in the national survey, which reached a response rate of 65% (n = 570). Most of the respondents were nurses in charge (80.3%, n = 453) and women (80.7%, n = 419), and the rest were physicians in charge (19.7%, n = 111) and men (19.3%, n = 100). Their mean age was 45.1 years (SD 10.2, n = 560), and the mean for how long they had worked in the health care setting was 19.8 years (SD 10.4, n = 512). The mean for their managerial experience was 8.5 years (SD 7.2, n = 237). More than half of the respondents (58.6%, n = 334) were from university hospitals and the remaining 41.4% (n = 236) from central hospitals. Respondents represented emergency (22.1%, n = 122), imaging (12.3%, n = 68), procedure (12.0%, n = 66) and inpatient units (53.6%, n = 296). Unit sizes were diverse: Emergency units treated between 23 and 250 patients a day (M 166.7, SD 99.5, n = 77), imaging units between 12 and 315 patients (M 147.2, SD 73.9, n = 48), procedure units reported patients treated per day between 3 and 100 (M 23.4, SD 21.7, n = 23) or number of patient beds between 2 and 60 (M 18.5, SD 14.8, n = 44), and inpatient units reported beds between 7 and 52 (M 24.3, SD 6.9, n = 290). More details are found in Paper IV (page 160).

5.2 Development and validation of the Hospital Shift Leaders' Information Needs Questionnaire (Papers II and IV)

The *Hospital Shift Leaders' Information Needs Questionnaire* was developed and tested. After 20 hours of observations, all information need items were overlapping the information needs in the original *ICU information needs questionnaire*. As no new items were discovered, this data collection method was discontinued. A total of 24 professionals, including nurses (n = 17) and physicians (n = 7) in charge of the day-to-day operations management, were interviewed in the development of the *Hospital Shift Leaders' Information Needs Questionnaire*. Interviews lasted 1.5–2 hours. Based on the observations and interviews, 17 items of the original *ICU information needs questionnaire* were left unaltered, as they were assessed quite relevant or highly relevant by at least 19 of the professionals. A total of 46 items were deleted, as they did not fit any units other than the intensive care unit and were assessed not relevant. A number of 59 items were modified to better fit a broader hospital setting as they were assessed somewhat relevant, and 42 new items were added based on suggestions by the interviewees. The final version of the newly developed instrument had 114 items, and it was named the '*Hospital*

Shift Leaders' Information Needs Questionnaire'. It consisted of demographic questions, six items regarding managerial activities, and 114 information need items. For the pilot test, two additional questions were added: one to ensure appropriateness of the chosen respondents and the other one to assess the functionality of the questionnaire. These are presented in Paper II (page 4).

The demographic questions included profession, age, gender, work experience, unit, the patient groups cared for in the respondent's unit (i.e. cardiac, neurological/neurosurgical, trauma, acute gastrological or gastro-surgical and other patients), the number of patient beds or the number of patients treated per day, and the time of day when the respondent was responsible for the unit. The first part of the questionnaire explored the frequency of the shift leader's managerial activities. These activities included 1) decisions related to patient flow, 2) decisions related to the placement of patients, 3) decisions related to the number of personnel, 4) decisions related to the placement of personnel, 5) decisions related to material resources, 6) negotiations with stakeholders to coordinate care, and 7) redressing of grievances and guidance of others. The response alternatives in the pilot were every shift, every week, every month, every second month, less often than every second month, and never. After the pilot test, these were changed to: every shift, every week, every month, less often than every month, and never. The next part of the questionnaire measured information needs. There were 114 information need items organised into six dimensions: (1) patient admission (items 1–20), (2) organisation of work (items 21–52), (3) special treatments, examinations and procedures (items 53–61), (4) allocation of material resources (items 62–71), (5) allocation of staffing resources (72–100), and (6) patient discharge (items 101–114). All information need items were presented in the same way, e.g., '*Information about the number of patients on the unit is …*'. These items were rated on a scale ranging from zero (completely unnecessary) to ten (absolutely necessary). The structure of the questionnaire is described in Paper II (page 4).

In the pilot, respondents were further asked to rate their satisfaction with current information systems with six items on a Likert-type scale ranging from one (strongly disagree) to five (strongly agree). The items were: '*information systems support my decision-making*', '*information systems improve ease of access to information*', '*information systems improve speed of access to information*', '*information systems are developed to serve me*', '*several information systems are needed to support my decision-making*', and '*I prefer to use one system that provides me with all necessary information*.' Respondents were further asked to rate whether the questionnaire was difficult, annoying, too long, or important on a Likert scale ranging from strongly agree to strongly disagree. They were additionally asked: '*Do you think you are the right person to respond to this questionnaire*?' The response options were yes and no. The final question of the questionnaire was

open-ended for additional items that the informant assumed were important in the day-to-day operations management of the unit. More details about the questionnaire development process are found in Paper II (pages 4–6).

The testing of the questionnaire showed a good Cronbach's α value (α = 0.79) for the whole questionnaire, and correspondingly, the α values for individual dimensions varied between 0.85 and 0.96. The Spearman-Brown coefficients between dimensions varied from 0.89 to 0.98. More variability was noted in the item-total correlations, as values between dimensions varied from 0.34 to 0.75. Here, the dimension regarding material resources stood out with the lowest value. The item-total correlations between individual items were good, as 110 out of the 114 items had a value above 0.3. More details related to the testing of the instrument are presented in Paper II (pages 5–6).

The national survey further validated the *Hospital Shift Leaders' Information Needs Questionnaire*. The Cronbach's α for the whole questionnaire was excellent (α = 0.85), the α values for individual dimensions varied between 0.93 and 0.96. Deleting any dimension would have decreased the α to values between 0.80 and 0.84. Also, here the split half analyses showed excellent results, as Spearman-Brown coefficients varied from 0.94 to 0.98. The item-total correlations between dimensions varied from 0.54 to 0.78. The item-total correlations of individual items were good, and all items added to the questionnaires' explanatory power, as all items exceeded a value of 0.3. There were however ten items that had values above 0.8, and these were checked for possible overlap with other items. No items were omitted, as they measured different details of the same phenomena. The confirmatory factor analysis resulted in significant regression estimates for all items on each dimension; however, the goodness-of-fit values were not optimal. The goodness-of-fit values were: $x2 = 27121.70$, df = 6201, $p < 0.001$, GFI = 0.43, AGFI = 0.40, NFI = 0.56, IFI = 0.62, TLI = 0.62, CFI = 0.62, RMR = 0.52, RMSEA = 0.08, and CMIN/DF = 4.37. More details about validation of the *Hospital Shift Leaders' Information Needs Questionnaire* are found in Paper IV (pages 163–165).

5.3 Information needs in day-to-day operations management of hospital units (Papers II–IV)

Information needs of shift leaders, including nurses and physicians, in emergency, radiology, procedure, intensive care and inpatient units were collected with cross-sectional surveys. Based on the findings (Papers II pages 9–10, III page 350, and IV pages 161–162), the user groups had different information needs. These needs

differed by profession, the unit where the respondent worked and the time of day when the respondent was responsible for the unit.

Important information needed in the day-to-day operations management of emergency, radiology, procedure and inpatient units were organised by factor analysis, as the number of individual information needs varied between different user groups from 14 to 39 (profession, unit and time of day), as described in Paper IV (pages 161–162). This analysis resulted in nine submodels, one for each user group. However, the data collected on intensive care units was too small (n = 20) for a factor analysis and hence previous literature was used to model important information needed in the day-to-day operations management of intensive care units as described in Paper III (pages 346–349).

The information needs submodels are here presented by profession, unit and time of day. Thereafter, associations of respondents' characteristics with information needs are presented.

5.3.1 Information needs by profession, unit and time of day (Papers II –IV)

Data about important information needed in the day-to-day operations management of intensive care units were collected in five hospitals in New Zealand with an online survey (Paper III). Important information could be categorised into a real-time overview of the situation on the unit, planning the upcoming shift, patients on the unit, staffing resources, material resources, communication and guides. More details about the information needs are presented in Paper III (pages 349–356) and in Peltonen et al. 2016.

Based on the findings in the questionnaire development study (Paper III), all shift leaders' important information needs covered patient admission and discharge, organisation of work, and allocation of staff and material resources. Shift leaders in a staff member position additionally needed information about special treatments, examinations and procedures. Those shift leaders who held a staff member position also reported about one-third (63.6%) more individual important information need items when compared to those who held a managerial position (22 items for managers and 36 items for staff members). This indicates a more dispersed set of information needed by those with a staff member position. More details about information needs between shift leaders with managerial and staff member roles are presented in Paper II (pages 6–10).

The national survey (Paper IV) confirmed findings from the questionnaire development study (Paper II). Important information needs differed by profession, unit,

time of day and type of hospital. All respondents shared important information needs at patient admission regardless of profession, unit, time of day and type of hospital. These shared needs included personal data (name and identity code) and health information (reason for admission, health history, vital functions and need for precaution against infection). Nurses in charge had a more dispersed set of important information needs (35 items) when compared to physicians in charge (14 items). The nurses in charge had information needs related to patient care, personnel and materials, while the physicians in charge had important information needs related to patient care. The inpatient unit respondents' important information needs were more dispersed than those in the emergency, imaging and procedure units. More details about the reported information needs of shift leaders by time of day and position held by the respondent are presented in Papers II (pages 8–14) and IV (pages 161–162).

Based on the data from the national survey (Paper IV, pages 161–162), the nurses in charge (n = 453) had 35 (30.7%) important information needs out of the total 114 items. These were organised into four information categories (factors), including patient care needs and special issues on unit (6 items), staffing resources and sufficiency (14 items), patient admission (11 items) and patient discharge (4 items). The KMO measure, Bartlett's test for sphericity and cumulative *Extraction Sums of Squared Loadings* were good and they are presented in Table 11. The factors and loadings of important information needs for nurses in charge are presented in Table 4.

Table 4. Factor loadings of important information for nurses in charge (n=453)

Item	**Factor 1** Patient discharge	**Factor 2** Staffing suffi-ciency	**Factor 3** Patient admis-sion	**Factor 4** Patient care needs and special is-sues on unit
Item 103. Receiving ward	**0.942**			
Item 104. Means of patient transfer	**0.923**			
Item 110. Receiving ward is informed about the patient transfer	**0.780**			
Item 106. A transfer cancellation	**0.738**	0.202		
Item 73. Number of staff on duty		**0.934**		
Item 71. Up-to-date roster		**0.840**		
Item 75. Real-time placement of staff		**0.819**		
Item 85. Normal number of staff per shift		**0.804**		
Item 74. Professions of staff on duty		**0.790**		
Item 90. Sufficiency of the staff on duty		**0.785**		
Item 82. Absence of staff (e.g., due to sickness)		**0.773**		
Item 72. Names of the staff on duty		**0.664**		
Item 83. Realization of the planned shifts		**0.580**		
Item 76. Nurse in charge of a unit		**0.558**		
Item 49. Special situations that have oc-curred during the ongoing shift		**0.421**		0.354
Item 22. Number of patients on the unit		**0.335**		0.252
Item 77. Physician in charge of the unit		**0.327**		0.252
Item 64. Situation regarding medication on the unit	0.243	**0.249**		0.218
Item 3. Reason for the patient's admission			**0.874**	
Item 2. Patient history			**0.844**	
Item 6. Need for precaution against infection			**0.751**	
Item 1. Patient's name and personal identity code			**0.739**	
Item 10. Special information regarding the patient			**0.677**	
Item 7. Patient's vital functions			**0.674**	
Item 8. Special needs of the patient		0.209	**0.583**	
Item 15. Care needs that impact on the prep-aration for a patient's arrival			**0.565**	
Item 4. State of urgency of the patient			**0.520**	
Item 18. Special needs of the patient			**0.408**	0.302
Item 20. Terminal care decision	0.283		**0.365**	
Item 25. Patients on the unit with abnormal vital functions				**0.574**
Item 26. Patients on the unit with a need for intensive monitoring	0.250			**0.550**
Item 42. A significant change in a patient's condition during the ongoing shift	0.347			**0.518**
Item 41. A patient's death	0.294			**0.502**
Item 50. Guidelines for action under special circumstances		0.310		**0.389**
Item 69. Any treatment- / examination- / medical device-related problems		0.247		**0.259**

The physicians in charge (n = 111) had a lower number of important information needs when compared to the nurses in charge (35 items for nurses in charge vs. 14 items for physicians in charge) based on the findings (Paper IV, pages 161–162). Altogether, 14 (12.3%) out of the 114 items were important to physicians in charge. These were organised into three information categories (factors) including patient admission (7 items), patient medical care needs on the unit (4 items), and exceptions in planned care (3 items) as shown in Table 5. Here, patient prioritisation had the most information need items. The KMO, Bartlett's Test of Sphericity and cumulative *Extraction Sums of Squared Loadings* were good. They are presented in Table 11. The factors and loadings of important information needs for physicians in charge are presented in Table 5.

Table 5. Factor loadings of important information for physicians in charge (n=111)

Item	**Factor 1** Exceptions in planned care	**Factor 2** Patient admission	**Factor 3** Patient medical care needs
Item 43. A patient's abnormal lab values or treatment / examination/ procedure findings	**1.020**		
Item 45. Complications arisen during treatment / an examination/ a procedure	**0.664**		
Item 57. Patients whose special treatment / examination / procedure should be prioritized	**0.251**	0.209	
Item 3. Reason for the patient's admission		**0.850**	
Item 2. Patient history		**0.840**	
Item 1. Patient's name and personal identity code		**0.723**	
Item 6 Need for precaution against infection		**0.670**	
Item 10. Special information regarding the patient		**0.651**	
Item 7. Patient's vital functions		**0.638**	0.279
Item 4 State of urgency of the patient		**0.457**	
Item 26. Patients on the unit with a need for intensive monitoring			**0.834**
Item 25. Patients on the unit with abnormal vital functions			**0.745**
Item 24. Medical care needs of patients on the unit			**0.661**
Item 42. A significant change in a patient's condition during the ongoing shift	0.410		**0.413**

Shift leaders in emergency units (n = 122) had 27 (23.7%) important information needs out of the 114 items, based on the findings (Paper IV, pages 161–162). The most important information were organised into four information categories (factors). These were patient care needs (5 items), staffing resources (10 items), patient admission (9 items), and special events (3 items). The KMO, Bartlett's Test of Sphericity and cumulative *Extraction Sums of Squared Loadings* were good. They are presented in Table 11. Loadings of items on the extracted factors of important information for professionals in emergency units are listed in Table 6.

Table 6. Factor loadings of important information for professionals in emergency units (n = 122)

Item	**Factor 1** Staffing resources	**Factor 2** Patient admission	**Factor 3** Patient care needs	**Factor 4** Special events
Item 73. Number of staff on duty	**0.927**			
Item 71. Up-to-date roster	**0.829**			
Item 82. Absence of staff	**0.802**			
Item 85. Normal number of staff per shift	**0.764**			
Item 90. Sufficiency of the staff on duty	**0.762**			
Item 75. Real-time placement of staff	**0.761**			
Item 74. Professions of staff on duty	**0.738**			
Item 72. Names of the staff on duty	**0.583**			
Item 76. Nurse in charge of the unit	**0.506**		-0.276	
Item 22. Number of patients on the unit	**0.296**		-0.283	
Item 3. Reason for the patient's admission		**0.868**		-0.251
Item 2. Patient history		**0.841**		
Item 1. Patient's name and personal identity code		**0.705**		
Item 6. Need for precaution against infection		**0.681**		
Item 10. Special information regarding the patient		**0.679**		
Item 7. Patient's vital functions		**0.634**		
Item 15. Care needs that impact on the preparation for a patient's arrival		**0.524**		
Item 4. State of urgency of the patient		**0.479**		
Item 20. Terminal care decision		**0.369**	-0.366	
Item 110. Receiving ward is informed about the patient transfer			**-0.868**	
Item 103. Receiving ward			**-0.857**	-0.236
Item 42. A significant change in a patient's condition during the ongoing shift			**-0.640**	0.203
Item 26. Patients on the unit with a need for intensive monitoring			**-0.581**	0.295
Item 25. Patients on the unit with abnormal vital functions	-0.202		**-0.480**	0.297
Item 50. Guidelines for action under special circumstances				**0.583**
Item 49. Special situations that have occurred during the ongoing shift	0.286			**0.512**
Item 77. Physician in charge of the unit	0.212			**0.359**

Shift leaders in imaging and procedure units (n = 134) had 32 (28.1 %) important information needs out of the total 114 items, based on the findings (Paper IV, pages 161–162). These were organised into four information categories (factors), including patient admission (11 items), staffing sufficiency (8 items), material resources (5 items), and patient care needs (8 items). The KMO, Bartlett's Test of Sphericity and *Extraction Sums of Squared Loadings* are presented in Table 11. The loadings of items on the four factors of important information for professionals working in imaging and procedure units are presented in Table 7.

Table 7. Factor loadings of important information for professionals in imaging and procedure units (n = 134)

Item	**Factor 1** Patient admission	**Factor 2** Staffing sufficiency	**Factor 3** Material resources	**Factor 4** Patient care needs
Item 3. Reason for the patient's admission	**0.867**			
Item 2. Patient history	**0.844**			
Item 1. Patient's name and personal identity code	**0.752**			
Item 6. Need for precaution against infection	**0.746**			
Item 10. Special information regarding the patient (e.g., pacemaker, allergies)	**0.652**			
Item 7. Patient's vital functions	**0.628**			0.253
Item 8. Special needs of the patient (e.g., interpreter, guard)	**0.607**	-0.233		
Item 14. Location of the patient at the time of notification	**0.560**			
Item 15. Care needs that impact on the preparation for a patient's arrival	**0.557**			
Item 13. Special treatments/examinations/procedures that are planned to be conducted on the patient	**0.534**			0.250
Item 4. State of urgency of the patient	**0.509**			
Item 73. Number of staff on duty		**-0.934**		
Item 71. Up-to-date roster		**-0.847**		
Item 82. Absence of staff (e.g., due to sickness)		**-0.763**		
Item 90. Sufficiency of the staff on duty		**-0.747**		
Item 72. Names of the staff on duty		**-0.642**		
Item 49. Special situations that have occurred during the ongoing shift (e.g., a violent situation, hardware failure, an information system malfunction)		**-0.410**	-0.258	
Item 50. Guidelines for action under special circumstances (e.g. catastrophe, violent situation, accident, adverse event)		**-0.296**	-0.279	
Item 77. Physician in charge of the unit		**-0.262**		
Item 70. Examination, procedure and care equipment replacement			**-0.901**	
Item 69. Any treatment- / examination- / medical device-related problems			**-0.849**	
Item 63. Availability and fitness of operating and procedure rooms / patient bed spaces			**-0.558**	
Item 57. Patients whose special treatment / examination / procedure should be prioritised			**-0.300**	0.275
Item 53. Patients with an urgent need for treatment / an examination / a procedure	0.223		**-0.262**	0.229
Item 25. Patients on the unit with abnormal vital functions				**0.784**

Item	**Factor 1** Patient admission	**Factor 2** Staffing sufficiency	**Factor 3** Material resources	**Factor 4** Patient care needs
Item 24. Medical care needs of patients on the unit				**0.742**
Item 42. A significant change in a patient's condition during the ongoing shift				**0.735**
Item 26. Patients on the unit with a need for intensive monitoring				**0.722**
Item 41. A patient's death				**0.644**
Item 33. Patient's reason for being on the unit				**0.605**
Item 110. Receiving ward is informed about the patient transfer				**0.480**
Item 45. Complications arisen during treatment / an examination/ a procedure			-0.306	**0.447**

The professionals on inpatient units (n = 296) had 39 (34.2%) important information needs out of the 114 items (Paper IV, pages 161–162). These were organised into four information categories (factors). These were staffing and sufficiency (10), patient care needs (10), patient admission (12 items), and patient discharge (7 items). The KMO, Bartlett's Test of Sphericity and cumulative *Extraction Sums of Squared Loadings* were good as presented in Table 11. Loadings for items on the four factors of important information for professionals working on inpatient units are presented in Table 8.

Table 8. Factor loadings of important information for professionals in inpatient units (n = 296)

Item	**Factor 1** Patient discharge	**Factor 2** Staffing sufficiency	**Factor 3** Patient admission	**Factor 4** Patient care needs
Item 103. Receiving ward	**0.942**			
Item 104. Means of patient transfer	**0.918**			
Item 101. Patient's hometown	**0.803**			
Item 110. Receiving ward is informed about the patient transfer	**0.789**			
Item 102. Planned time of transfer	**0.743**			
Item 106. A transfer cancellation	**0.701**			
Item 112. Relatives are informed about the patient's transfer	**0.666**			0.216
Item 73. Number of staff on duty		**0.926**		
Item 82. Absence of staff		**0.816**		
Item 71. Up-to-date roster		**0.806**		
Item 90. Sufficiency of the staff on duty		**0.786**		
Item 85. Normal number of staff per shift		**0.774**		
Item 75. Real-time placement of staff		**0.755**		
Item 74. Professions of staff on duty		**0.727**		
Item 76. Nurse in charge of the unit	0.205	**0.521**		

Item	Factor 1 Patient discharge	Factor 2 Staffing sufficiency	Factor 3 Patient admission	Factor 4 Patient care needs
Item 49. Special situations that have occurred during the ongoing shift		**0.411**		0.309
Item 64. Situation regarding medication on the unit	0.263	**0.268**		
Item 3. Reason for the patient's admission			**0.866**	
Item 2. Patient history			**0.862**	
Item 1. Patient's name and personal identity code			**0.735**	
Item 6. Need for precaution against infection			**0.717**	
Item 10. Special information regarding the patient			**0.710**	
Item 7. Patient's vital functions			**0.653**	
Item 13. Special treatments/examinations/procedures that are planned to be conducted on the patient			**0.578**	0.206
Item 8. Special needs of the patient		0.214	**0.574**	
Item 15. Care needs that impact on the preparation for a patient's arrival			**0.558**	
Item 5. Patient's diagnosis			**0.473**	
Item 20. Terminal care decision	0.218		**0.423**	
Item 18. Equipment needed during transportation to the unit			**0.416**	0.238
Item 24. Medical care needs of patients on the unit				**0.764**
Item 25. Patients on the unit with abnormal vital functions		-0.227		**0.684**
Item 26. Patients on the unit with a need for intensive monitoring				**0.667**
Item 23. Care acuity of patients on the unit		0.209		**0.617**
Item 30. A cancellation of an isolation of a patient				**0.558**
Item 29. Number of isolated patients due to precautions against infection on unit		0.211		**0.555**
Item 22. Number of patients on the unit		0.271		**0.503**
Item 42. A significant change in a patient's condition during the ongoing shift	0.356			**0.448**
Item 41. A patient's death	0.279			**0.443**
Item 50. Guidelines for action under special circumstances		0.278		**0.304**

Shift leaders working during office hours (n = 203) had altogether 16 (14.0%) important information needs out of the 114 items (Paper IV, pages 161–162). The most important information needed were organised into four information categories. These included patient care needs (6 items), staffing resources (7 items), patient admission (10 items) and special events (3 items). The KMO, Bartlett's Test of Sphericity and cumulative *Extraction Sums of Squared Loadings* were good as shown in Table 11. Loadings for items on the four factors of important information for professionals working during office hours are presented in Table 9.

Table 9. Factor loadings of important information for professionals working during office hours (n = 203)

Item	**Factor 1** Patient admission	**Factor 2** Staffing resources	**Factor 3** Patient care needs	**Factor 4** Special events
Item 1. Patient's name and personal identity code	**0.742**			
Item 2. Patient history	**0.858**			
Item 3. Reason for the patient's admission	**0.877**			-0.273
Item 4. State of urgency of the patient	**0.536**			
Item 6. Need for precaution against infection	**0.726**			
Item 7. Patient's vital functions	**0.690**			
Item 8. Special needs of the patient	**0.558**			
Item 10. Special information regarding the patient	**0.724**			
Item 1.5 Care needs that impact on the preparation for a patient's arrival	**0.561**			
Item 18. Equipment needed during transportation to the unit	**0.429**		-0.247	
Item 22. Number of patients on the unit		0.256	**-0.275**	0.239
Item 25. Patients on the unit with abnormal vital functions		-0.209	**-0.417**	0.286
Item 26. Patients on the unit with a need for intensive monitoring			**-0.481**	0.309
Item 49. Special situations that have occurred during the ongoing shift				**0.670**
Item 50. Guidelines for action under special circumstances				**0.678**
Item 71. Up-to-date roster		**0.827**		
Item 73. Number of staff on duty		**0.924**		
Item 74. Professions of staff on duty		**0.740**		
Item 75. Real-time placement of staff		**0.768**		
Item 77. Physician in charge of the unit				**0.324**
Item 82. Absence of staff		**0.776**		
Item 85. Normal number of staff per shift		**0.732**		
Item 90. Sufficiency of the staff on duty		**0.707**		
Item 103. Receiving ward			**-0.904**	
Item 106. A transfer cancellation			**-0.811**	
Item 110. Receiving ward is informed about the patient transfer			**-0.871**	

Professionals working beyond office hours (n = 249) had 28 (24.6%) important information needs out of the 114 items (Paper IV, pages 161–162). These most important information were organised into four information categories including patient care needs and special issues on the unit (5 items), staffing resources (10 items), patient admission (10 items), and patient discharge (3 items). The KMO, Bartlett's Test of Sphericity and cumulative *Extraction Sums of Squared Loadings* were good as shown in Table 11. Loadings for items on the factors of important information for professionals working beyond office hours are presented in Table 10.

Table 10. Factor loadings of important information for professionals working beyond office hours (n = 249)

Item	**Factor 1** Patient discharge	**Factor 2** Staffing resources	**Factor 3** Patient admission	**Factor 4** Patient care needs and special issues on the unit
Item 1. Patient's name and personal identity code			**0.689**	
Item 2. Patient history			**0.828**	
Item 3. Reason for the patient's admission			**0.911**	-0.205
Item 4. State of urgency of the patient			**0.469**	
Item 6. Need for precaution against infection			**0.734**	
Item 7. Patient's vital functions			**0.640**	
Item 8. Special needs of the patient			**0.556**	
Item 15. Care needs that impact on the preparation for a patient's arrival			**0.533**	
Item 18. Equipment needed during transportation to the unit			**0.399**	0.250
Item 20. Terminal care decision	0.294		**0.415**	
Item 25. Patients on the unit with abnormal vital functions	0.220	0.205		**0.595**
Item 26. Patients on the unit with a need for intensive monitoring	0.298			**0.619**
Item 42. A significant change in a patient's condition during the ongoing shift	0.441			**0.422**
Item 49. Special situations that have occurred during the ongoing shift		-0.376		**0.384**
Item 50. Guidelines for action under special circumstances		-0.249		**0.430**
Item 64. Situation regarding medication on the unit	0.253	**-0.264**		
Item 71. Up-to-date roster		**-0.819**		
Item 72. Names of the staff on duty		**-0.614**		
Item 73. Number of staff on duty		**-0.928**		
Item 74. Professions of staff on duty		**-0.744**		
Item 75. Real-time placement of staff		**-0.767**		
Item 76. Nurse in charge of the unit	0.253	**-0.534**		
Item 82. Absence of staff		**-0.797**		
Item 85. Normal number of staff per shift		**-0.778**		
Item 90. Sufficiency of the staff on duty		**-0.769**		
Item 103. Receiving ward	**0.884**			
Item 106. A transfer cancellation	**0.758**			
Item 110. Receiving ward is informed about the patient transfer	**0.857**			

Table 11. Statistics of factor analysis models

	Nurses in charge (n = 453)	Physicians in charge (n = 111)	Emergency unit (n = 122)	Imaging and procedure units (n = 134)	Inpatient units (n = 296)	Normal office hours (n = 203)	Beyond normal office hours (n = 249)	All respondent (paper IV) (n = 564)
KMO	0.90	0.85	0.89	0.89	0.92	0.89	0.91	0.95
Bartlett's Test of Sphericity	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Extraction Sums of Squared Loadings	52.1%	55.9%	53.1%	49.4%	56.1%	55.6%	54.2%	51.52%

5.3.2 Association of characteristics with information needs (Papers II and IV)

Based on the pilot study (Paper II), shift leaders in managerial position rated their information needs higher than those with a staff member position for the patient admission dimension (mean difference 0.55, 95% CI 1.03–0.06, p = 0.019) and for the patient discharge dimension (mean difference 0.70, 95% CI 1.43–0.04, p = 0.032). No differences were observed for respondents in different units. However, the findings from the national survey (Paper IV) showed a difference in information needs between profession (p = 0.008). Here, nurses rated their needs higher when compared to physicians (mean difference 0.49, 95% CI 0.12 to 0.85). Differences were also found in gender (p = 0.021), as females rated their information needs higher when compared to male respondents (mean difference 0.41, 95% CI 0.06 to 0.75). Differences were additionally observed between shift leaders from different units (p < 0.001). Further tests showed that shift leaders in imaging units reported their information needs lower than those from inpatient units (mean difference -1.00, 95% CI -1.52 to -0.48, p < 0.001) and procedure units (mean difference -0.93, 95% CI -1.57 to -0.28, p = 0.001). However, time of day (p = 0.114), the type of hospital (p = 0.109) and work experience (p = 0.317) were not significant. The model explained 14.5% of the variability in the information needs. More details about the associations between information needs and shift leaders characteristics are presented in Paper II on pages 5–6 and in Paper IV on pages 160–163.

5.4 Information sources and systems developed for the day-to-day operations management of hospital units (Papers I and III)

Based on the data collected in New Zealand (Paper III, page 350, study findings are also partly reported in Peltonen et al. 2016, page 10), shift leaders needed to obtain information from many sources to support their managerial activities. Nurses in charge reported using manual information tools, often designed based on the unit's physical structure. Important information about patients, staffing and other resources was collected on this sheet and updated several times during an ongoing shift. Several issues about information quality emerged. These included inaccurate, wrongly documented, missing, forgotten and misplaced information as well as information overload and issues related to information and communication technologies. They had a need for higher quality information and improvements in information processing practices. Based on the findings, shift leaders obtained important information from four types of sources including digital, human and manual sources as well as real-time events. The information sources were located both within the unit and beyond, but some information only existed in the shift leader's

mind as knowledge. Important information sources are exemplified in Table 12. More details are presented in Paper III (page 349).

The scoping review (Paper I) about information and communication technologies that are developed to support first-line nurses in hospitals resulted in a narrative synthesis of 25 studies published between 1987 and 2011. Most of these (72%, n = 18) were from the USA, and a few were from the United Kingdom (12%, n = 3), Finland (2%, n = 2), Denmark (4%, n = 1) and Canada (4%, n = 1). Most articles (60%, n = 15) were reports on developmental projects or other expertise; less than half (40%, n = 10) reported information system implementation, and only some (24%, n = 6) evaluated adopted information systems. The findings (Paper I, pages 88–92) showed that most information systems (80%, n = 20) were developed to support several managerial decision-making levels. The majority (44%, n = 24) of the information systems were developed to support tactical decision-making, while strategic (31%, n = 17) and operational decision-making (24%, n = 13) received less support. Identified information systems were categorised into:

- planning and performance evaluation systems
- workload measurement and resource allocation systems
- shift management systems, and
- communication systems.

The findings in Paper II (page 6) showed that shift leaders were dissatisfied with current information systems. They reported that these systems supported managerial decision-making (median 4, 95% CI 3.44–3.94, n = 54) and improved the ease of access to information (median 4, 95% CI 3.06–3.59, n = 54) to some extent. But they were less satisfied with how information systems improved speed of access to information (median 3, 95% CI 2.85–3.43, n = 54) and how systems were developed to serve them (median 3, 95% CI 2.54–3.05, n = 54). They further reported that several information systems were required to support their decision-making (median 4, 95% CI (3.61–4.11), n = 53). Finally, shift leaders would have wanted one information system that would assemble all important information for display to support their decision-making (median 4, 95% CI 3.96–4.46, n = 53).

Table 12. Information sources used by shift leaders in intensive care units (Paper III and Peltonen et al. 2016)

Main information source	Information system	Examples
Digital sources	Clinical information systems	Clinical alert systems, electronic health records, patient management systems, picture archiving and communication systems
	Communication systems	Forms, emails, email bookings, Internet, intranet, shared drives
	Material resource systems	Bed management systems
	Human resource systems	Patient acuity systems, rosters, workload measurement tools
Humans	Individuals	Family members, patients, nurses, physicians, other professionals
	Groups	Infection group meetings, care planning meetings, staff meetings
Manual sources	Shared boards	Charts, pin boards, whiteboards
	Shared records	Admission records, staff allocation lists, calendars, list of staff competencies
	Guides	Shift leaders' manuals, clinical guidelines, material manuals, incident manuals, standards
	Notes	Shift leaders' shared notes, shift reporting sheet, own notes
	Patient records	Charts, records, prescriptions, bracelets, care plans
Real-time events	Observations	Alarms, bells, visual detection
	Rounds	Nursing rounds, coordinator rounds, medical rounds

5.5 Model of important information for the day-to-day operations management of hospital units (Papers II–IV)

Based on the findings (Papers II to IV), shift leaders need user-tailored information solutions, as only a limited number of information needs are shared between all professionals responsible for the day-to-day operations management of hospital units. Here, a model for important information was built based on the results of the factor analyses presented in section 5.3.1. First a general model for the professionals responsible for the day-to-day operations management is presented. Thereafter, the testing of one out of eight submodels with intensive care nurses in charge is reported.

5.5.1 Model of important information for shift leaders in hospital units (Paper IV)

Based on the exploratory factor analysis of the national survey data, important information could be organised into ten categories, including exceptions in planned care, material resources, patient admission, patient care needs, patient care needs and special issues, patient discharge, patient medical needs, special events, staffing resources, and staffing sufficiency. These can further be divided into needs related to patients and their care, available staffing resources, and available material resources. Specific information need items of different users are reported in Papers II (pages 9–10), III (page 350), and IV (pages 161–162). The overall model of categories of important information for users by profession, unit, and time of day are illustrated in Figure 7. Each user group does however have different individual information needs within an information category, as presented in section 5.3.1.

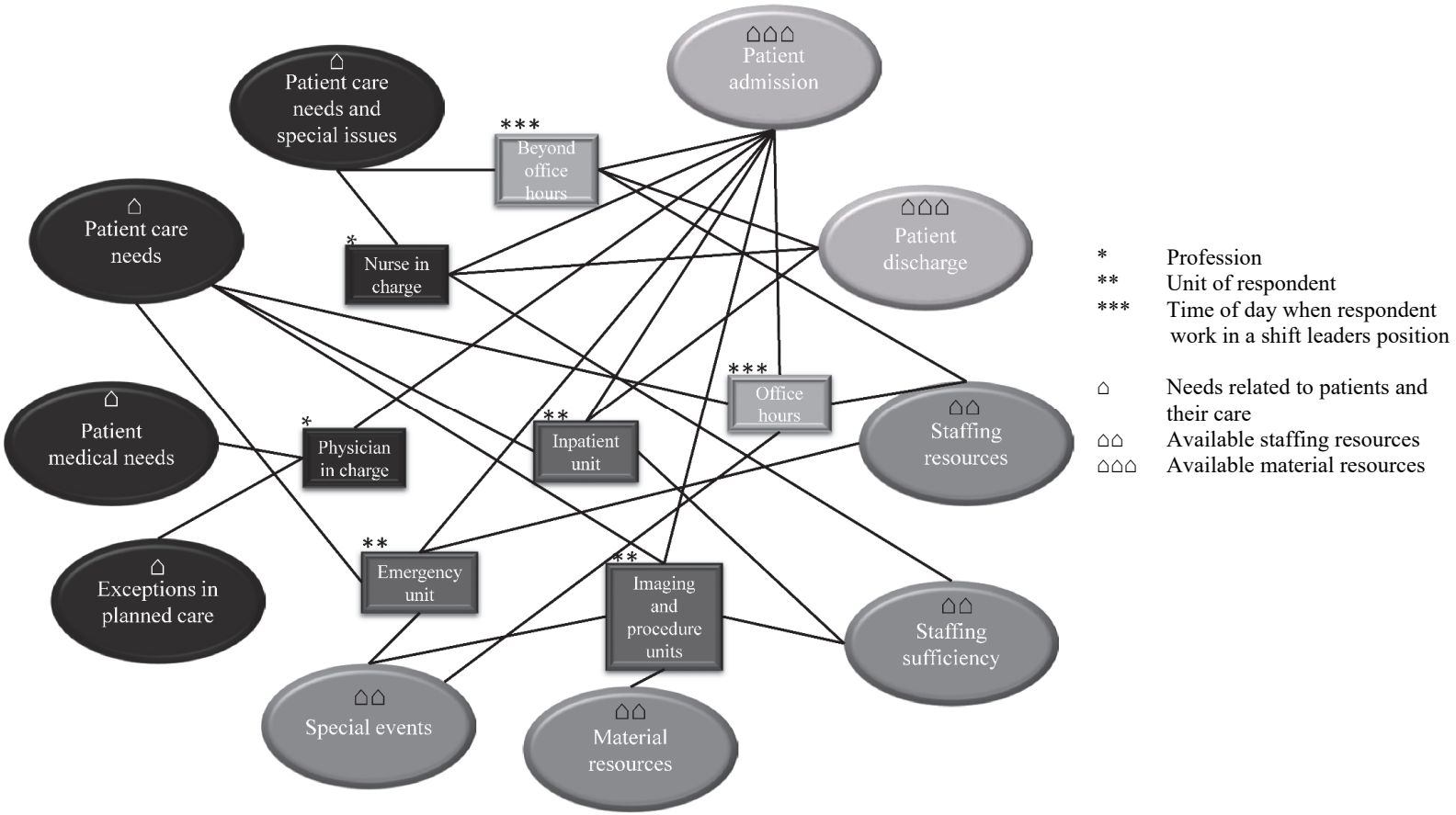

Figure 7. Model of important information needed in day-to-day operations management by profession, unit, and time of day

5.5.2 Testing of a submodel of important information with shift leaders in intensive care units (Paper III)

A model for a management information system was developed, digitalised and tested with nurses in charge from one intensive care unit. The model included six categories of important information needed by the shift leaders in an intensive care unit. The development of the model and specific information items are presented in Paper III (pages 349–356). The categories and number of items per category were:

- real-time overview of the situation on the unit (37 items),
- a dashboard for planning the next shift (34 items),
- details about patients on the unit (23 items),
- details of staffing resources (6 items),
- details of material resources (1 item), and
- communication means and procedural guides (4 items).

The nurses in charge thought that the designed management information system mock-up was good, and they had many improvements for it. The improvements were related to the usability of the system, the content in the system, and the functionality of the system. The nurses in charge found improvements to all six categories displayed on the mock-up. They also brought up general concerns related to the implementation of such a system in the hospital setting. The most important features perceived by the nurses in charge were:

- real-time information,
- automatic information transfer with information systems (e.g. human resource systems, electronic health records),
- a dashboard for planning,
- an option for manual updating of information,
- time and date, and
- contact details for key persons on duty.

Details concerning the findings from the testing are presented in Paper III (pages 349–356).

5.6 Summary of main findings

The main findings of this study are summarized in Figure 8.

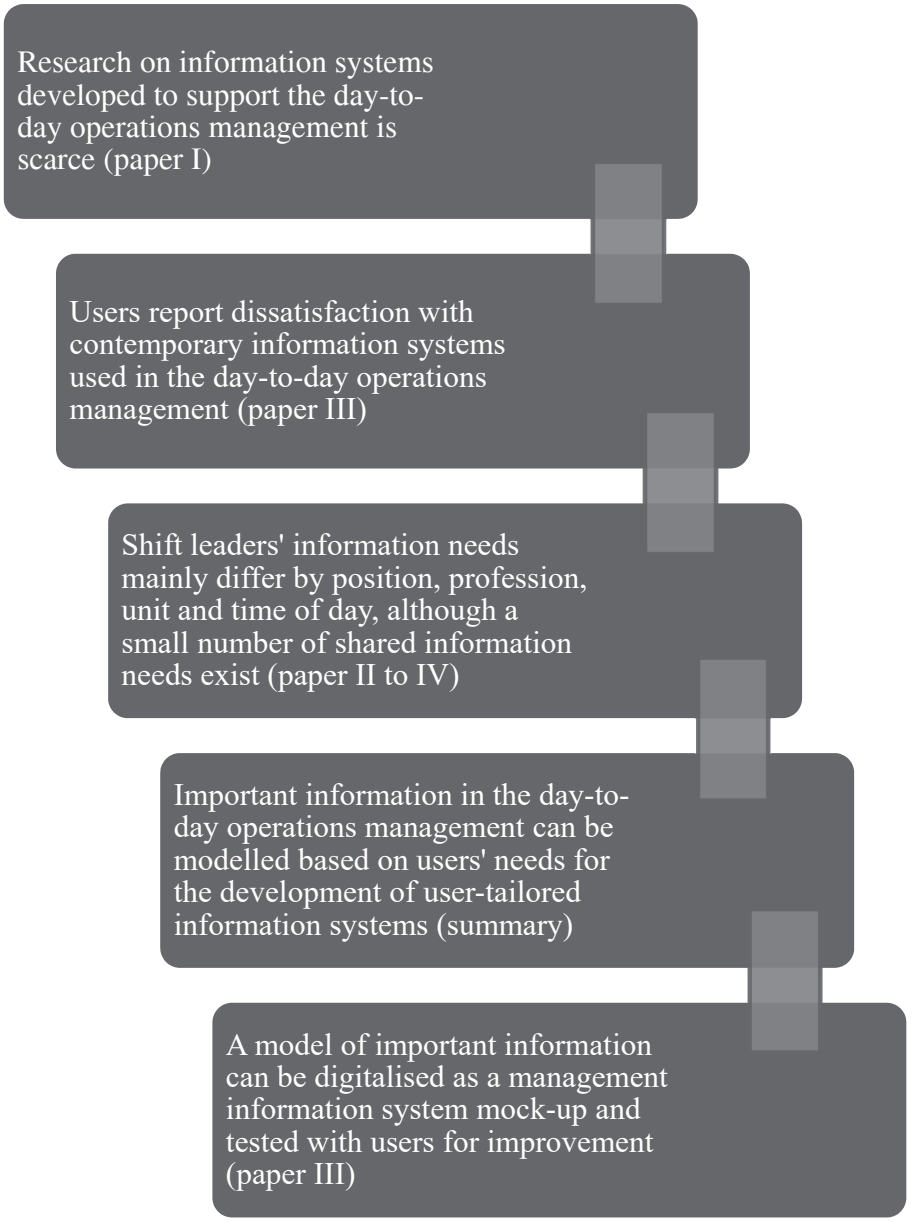

Figure 8. Summary of main findings

6 DISCUSSION

The discussion section is divided into three topics: discussion of the results, rigor of the study, and implications of the findings. The results are discussed from the points of view of the (1) potential of *the Hospital Shift Leaders' Information Needs Questionnaire*, (2) development needs of information systems in the day-to-day operations management of hospital units, (3) important information needs and sources used in the day-to-day operations management of hospital units, and (4) model of important information for information system development in the day-to-day operations management of hospital units.

6.1 Discussion of the results

6.1.1 Potential of the Hospital Shift Leaders' Information Needs Questionnaire

Overall, the *Hospital Shift Leaders' Information Needs Questionnaire* showed to be a valid and reliable instrument for the assessment of information needed in the day-to-day operations management of hospital units, although further testing to assess the psychometric properties is still needed. This instrument may be used when developing information processing to get a deeper understanding of information needed by different professionals responsible for the day-to-day operations management in different hospital units.

The content validity of the questionnaire was improved by the expert panel used in the development process. However, rating the content validity of the final version of the developed instrument is still needed (DeVon et al. 2007). The internal consistency of the developed instrument was good, based on the item-to-total correlations, the split-half analyses and Cronbach's α values (Paper II page 6, Paper IV page 165). However, the confirmatory factor analyses did not show a good model fit for the theory-based six dimensions, as χ^2, df, p, CMIN/DF, RMR, GFI, AGFI, NFI, IFI, TLI, CFI and RMSEA values were beyond the recommended boundaries (Hu & Bentler 1999, Jackson et al. 2009) (Paper IV, page 165). This is probably due to strong correlations between items, and therefore the minimum of five respondents per item, as suggested in the literature (Bryman & Cramer 1997), seems to be insufficient here. Increasing the size of the data or decreasing the number of items could be ways to improve the goodness-of-fit.

The details of the data collection are important to acknowledge in the planning phase of the study, and the pilot test was important in testing, not only the content of the questionnaire but also in finding the right respondents and means of distribution. For example in the pilot test, an electronic distribution was chosen, as it is a low-cost and practical option to collect and analyse survey data (McPeake et al. 2014). However, the electronic survey resulted in a low response rate (26%, n = 67) (Paper II page 5) even though reminders were used. Reminders are one way to increase the response rate of a survey (McPeake et al. 2014). Therefore, the national survey was done with a paper-based version. The results with the paper-based data collection were clearly better (65%, n = 570) when compared to electronic data collection (Paper IV, page 159). However, other means to improve the response rate were also used, such as face-to-face distribution of the questionnaires. Hence, when using the questionnaire, strategies to improve the success of the data collection need to be thoroughly considered (McPeake et al. 2014, Phillips et al. 2017).

6.1.2 Development needs of information systems in the day-to-day operations management of hospital units

Numerous information systems have been developed for professionals responsible for the day-to-day operations management. However, these systems do not sufficiently support the day-to-day operations management (Paper I, pages 91–92). Based on the findings in this study, much more information is needed in the day-to-day operations management than current systems provide (Papers II pages 9–10, III page 350, and IV pages 161–162). This is probably the reason behind shift leaders' dissatisfaction with the information systems in use related to the access to information, design and usability of systems, and the number of systems needed to support decision-making (Paper II, page 6). Furthermore, research about the effectiveness of the information systems in use to support the day-to-day operations management in hospitals are still scarce (Paper I, page 88), although the professionals responsible for running hospital units have reported dissatisfaction with current information systems and a need for a reduction in the numerous information systems needed to support managerial tasks (Peltonen et al. 2018 a,b).

These results indicate that a system which would assemble important information into one place has its place in the current information system architecture of hospitals to better support the day-to-day operations management of hospital units. This is also in line with current ways of improving care while reducing costs, such as the Six Sigma approach (Ahmed et al. 2013, Amaratunga & Dobranowski 2016, Glasgow et al. 2010, Nicolay et al. 2012) and the Lean approach (Antierens et al.

2018, Amaratunga & Dobranowski 2016, Blijleven et al. 2017, Casey et al. 2009, Glasgow et al. 2010, Joosten et al. 2009, Nicolay et al. 2012), where attention is put on adding value and important functions throughout the organisation to eliminate unnecessary functions. This is also in line with the shift leader's desire to have one information system to assemble important information (Paper II, page 6).

One information system that assembles important information in one place could increase the quality and timeliness of information and improve managerial decision-making. For example, integrated information systems have been shown to be three times faster to use by nurses when compared to unintegrated systems (Meyer & Lovis 2011). Furthermore, data processed by such a system would leave evidence of managerial decision-making, while current paper-based information tools become obsolete after one shift (Gurses et al. 2009, Peltonen et al. 2016) and leave no evidence of the quality and appropriateness of decisions made. A system that integrates important information has the potential to support better resource allocation and improve quality of care as well as indirectly increase satisfaction through better managerial decisions. Access to information is an important part of information processing (Newell 1989, Newell & Simon 1972, Simon 1978), hence important information should be easily available at the point of decision-making. Supporting managerial decision-makers with timely and accurate information may support analytical decision-making, as nurses tend to resort to intuitive decision-making when rapid decision-making is necessary (Lauri et al. 2001, Lauri & Salanterä 1998).

6.1.3 Important information needs and sources used in the day-to-day operations management of hospital units

The day-to-day operations management in hospitals is complex, and it is steered by multiple professionals from different disciplines in different positions with differing accountabilities and responsibilities. This was reflected in the information needs of different decision-makers in the day-to-day operations management (Paper II pages 9–10, Paper III page 350, and Paper IV pages 161–162). The information needs differed between professions, positions, time of day and units, and few information needs were shared by all (Paper IV pages 161–162). The only shared information needs were related to patient admission. This information included a patient's name and identity code, health history, cause for admission, vital functions, and any possible infection that needed precautions. These shared items seem to be a prerequisite for smooth care processes and should therefore be easily accessible.

The different groups had a varying number of important information needs. The physicians in charge (14/114 items) and those working during office hours (16/114) had the smallest number of important information needs, while shift leaders on inpatient units (39/114), nurses in charge (35/114), and those working during office hours and beyond (32/114) had the largest number of important information needs and twice as many information needs as the physicians in charge and those working during normal office hours. This indicates that the shift leaders on inpatient wards, nurses in charge, and those working during normal office hours and beyond have a broader variability in the managerial activities when compared to physicians and those who only work during normal office hours, such as unit managers (Surakka 2008). Another thing standing out in the results regarding information needs was real-time information, which seems to be a particularly important part of situational awareness in the day-to-day operations management (Endsley 2000). Interestingly, most contemporary information systems only provide information retrospectively, such as patient classification systems and many business intelligence systems.

It is now evident that the information needs of different users differ, as their responsibilities and accountabilities differ (Lundgrén-Laine et al. 2011, Peltonen et al. 2016, Surakka 2008). Current information systems may support physicians better when compared to nurses, as their information needs mostly focused on patient care, as was also the case in previous studies (Lundgrén-Laine et al. 2011, 2013a). Patient information is available in health records. But, the nurses in charge additionally needed information about materials and human resources (Paper II pages 9–10, Paper III page 350, and Paper IV pages 161–162), as was the case in previous research (Kivinen & Lammintakanen 2013, Lammintakanen et al. 2010, Lundgrén-Laine et al. 2013a,b). Therefore, an investment in nursing management information systems seems to be particularly important. This was supported by the difference in means in reported information needs between professions and units (Paper IV, page 164). This indicates that we can best support the day to-day operations management by tailoring information systems with user group specific displays. Important information need findings in this study are in line with previous research in the critical care setting (Lundgrén- Laine et al. 2013a,b).

A hospital-wide management information system developed based on users' needs could support a shared situational awareness between professionals responsible in different units, as some shared information needs were overlapping and related to other units, for example at patient discharge, as acknowledged before (Abraham & Reddy 2010). A shared situational awareness has the potential to reduce patient transfer delays between hospital units (Peltonen et al. 2015). However, one thing complicating the development of such a management information system is the general interoperability issues between systems (Brooks & Avera 2010, Edunits et

al. 2010, Vest 2012, Simborg et al. 2013). But, as observed, much information is still in manual form, and hence the digitalisation of this information could be directly done to support information exchange between systems on the local level.

The ANOVA (Paper IV, page 164) showed a differences in information needs (sum variables) between profession ($p = 0.008$), gender ($p = 0.021$) and units ($p < 0.001$) of respondents, although the mean differences between profession and gender were quite small (< 0.5). However, differences between units were close to one, which starts to be clinically relevant and should be considered when developing information processing in hospitals. Whereas, the time of day ($p = 0.114$), the type of hospital ($p = 0.109$) and work experience ($p = 0.317$) were not significant characteristics.

6.1.4 Model of important information for information system development in the day-to-day operations management of hospital units

The developed model of important information needed in the day-to-day operations management in hospitals emphasizes the differences in information needs between professions, positions, time of day and units. The overall model contained ten categories of important information including exceptions in planned care, material resources, patient admission, patient care needs, patient care needs and special issues, patient discharge, patient medical needs, special events, staffing resources, and staffing sufficiency. These information categories are partly overlapping, but so are the information needs of the different user groups. These ten categories can be seen through three perspectives from a higher abstraction level, namely, needs related to patients and their care, available staffing resources, and available material resources. This division is typically seen in the management literature (Andersson et al. 2003, Asamani et al. 2013, Bateman 2012, Betson & Pedroja 1989, Lundgrén-Laine et al. 2011, McCallin & Frankson 2010, Moss & Xiao 2004, Moss et al. 2001, Schleppers & Bender 2003, Siirala, et al. 2016). However, the main focus in this study is to find the specific needs of the users in order to develop user-tailored information systems.

Based on the differences in information needs, submodels were created for each user group, and the number and content (i.e. individual items) of information categories differed between these groups. This again mirrors the differences in activities by the different shift leaders, as their responsibilities and accountabilities differ (Lundgrén-Laine et al. 2011, Peltonen et al. 2016, Surakka 2008). As presented in the results section, the most important information was organised into four categories for six out of the seven user groups (submodels). Only physicians in charge had their important information organised into three information categories. One

likely reason for this was that the number of information need items was less for physicians when compared to the others. The most common categories of important information were related to patient admission and discharge, staffing issues, and care needs of patients, although each user group had a different set of specific information needs within these categories. This reflects the complexity of the managerial decision-making and different dimensions in information needs, such as a need for situational awareness and the patient process perspective. Two of the least common categories, namely, medical needs of patients and exceptions in planned care only concerned physicians in charge. While the third least common information category, material resources, only concerned imaging and procedure units. The fact that the physicians' information need categories, and individual information need items only were related to patients reflects their main responsibility, which is related to medical care (Haffner et al. 2000, Wingo et al. 2016). The information category of special events stood similarly out for emergency, imaging and procedure units as well as shift leaders working during office hours. However, other submodels may have contained similar items but in different compositions and within other factors.

Testing the digitalised management information system model confirmed the information needs related to timely information as intensive care nurses in charge wanted an information system that provided an overview of the units' situation real-time (Paper III, page 350). Furthermore, they needed an electronic dashboard for planning, resource allocation and communication. Obviously the content of an information system is important and should be developed based on users' needs. However, paying attention to the function and usability of the system is also important, as a poor system design and a bad user interface impede clinical work and may result in ineffective work and misleading information (Abraham & Reddy 2010, Kadry et al. 2010).

Developing a model of important information for the day-to-day operations management in hospital units needs to be an iterative process. The statistical analyses from the surveys gave a good theoretical basis for how to best organise and assemble important information for the professionals responsible for the day-to-day operations management of hospital units. However, testing the model in the clinical setting showed the importance of involving the users in all phases of the process, as numerous improvements were suggested to the model by the shift leaders. Furthermore, the survey findings only provided information about important items, while other aspects remained unattained. For example, the statistical analyses did not provide information about a need for an interactive planning tool, which was a result of developing the model for the intensive care units through interviews and existing information tools. Nor did they show the need for communication means, reported by the shift leaders during the clinical testing.

The exploratory factor analyses showed good results for factor loadings and the cumulative *Extraction Sums of Squared Loadings* varied between 52.1% and 56.1% for six of the seven analysed submodels. This means that the structure of the information categories were supported and that they explained the total variance quite well. But the factors in the seventh model accounted for only 49.4% of the variation. Here, a larger number of factors would have increased this number, but this would also have resulted in fewer items per factor, which again would not be a good solution from the practical point of view of a management information system, as information would be dispersed in that way.

Currently, national guidelines such as the '*eHealth and eSocial Strategy 2020'* by the Ministry of Social Affairs and Health in Finland, '*the Health Information Security Framework'* by the Ministry of Health in New Zealand, and the '*Support tool to assess health information systems and develop and strengthen health information strategies*' by the WHO strongly focus on improving information management for individuals and professionals on the clinical and strategic levels. However, more attention should be paid to information processing in the day-to-day operations management in health care organisations for safe, efficient and cost-effective care provision. The model of important information may be used in the development of management information systems to better support managerial decision-making in the day-to-day operations management of hospital units.

6.2 Rigor of the study

The rigor of the study should be discussed from the perspective of the whole research process (Cypress 2017, Lincoln & Cuba 1986, 2002). Commonly, the terms rigor and trustworthiness are used in qualitative studies, and validity and reliability are used in quantitative studies (Cypress 2017). The terminology for reporting rigor in studies varies, and authors disagree on what the right terminology should be (Cypress 2017, Morse 2015). Here, the rigor of the study is discussed through trustworthiness including credibility (i.e. internal validity), transferability (i.e. external validity), dependability (i.e. reliability) and confirmability (i.e. objectivity), which are often used in qualitative literature (Cypress 2017, Lincoln & Cuba 1985, 1986, Morse 2015), and validity and reliability including means of reducing bias and confounding, which are commonly used in quantitative literature (Hoppe et al. 2009, Lu 2009, Yang et al. 2012). However, the means for increasing rigor often relate to both qualitative and quantitative aspects.

To start with, the choice of study design is always made based on the aim of the study. Here the overall aim was to model important information needed in the day-to-day operations management of hospital units. A cross-sectional observational

approach was chosen, as there was no intervention with impact to assess or change in time to be measured. Well-designed observational studies provide valuable information in such situations (Concato 2004, Hoppe et al. 2009, Lu 2009), and cross-sectional designs are suitable when the occurrence is of interest rather than change in the phenomenon of interest (Lu 2009, Yang et al. 2012). From the perspective of confirmability, the means to improve confirmability during the whole research process included an external group of academics who followed up and commented on each step of the research throughout the process. And from the perspective of credibility, regular meetings with the research team that included statisticians were held to plan, reflect and discuss the research.

In the first sub-study, that is, the scoping review (Paper I) one limitation was that only one person made the article selection. However, all uncertain cases were discussed by the whole research team. Having two people involved in the selection process would increase the rigor of the study (Grant & Booth 2009, Peters et al. 2015, Tricco et al. 2016). Another weakness of the scoping review was that the quality of the studies was not assessed. This is a common problem in the literature, where less than a quarter of scoping reviews have quality assessment reported (Pham et al. 2014). Nonetheless, to ensure the strength of the evidence, quality evaluation is important (Grant & Booth 2009, Peters et al. 2015, Pham et al. 2014, Tricco et al. 2016). The transferability of the findings from the scoping review are limited by the search terms used. A broader variability and expanded terminology could have increased the findings. However, no limitations on language were used that could potentially increase a risk of bias in the findings, and a systematic process with defined inclusion and exclusion criteria were followed. These also increase the rigor of the research (Yang et al. 2012).

When content analysis was used in sub-studies 2 and 3, credibility and dependability were supported by involving the research team in all phases of the processes, from designing the study to interpreting the results. Interviews were recorded to minimise the risk of misinterpretation. The strength in having a team is being able to discuss similarities and differences of opinion and through consensus improve the entire group's understanding of how to move forward. Another important issue when reporting content analysis findings is to show the logic beyond categories and themes, and the connection to the aim (Graneheim et al. 2017). This could have further improved the trustworthiness of the studies, but the word limit for the articles unfortunately did not allow this.

The aim of the pilot was to develop and test the questionnaire content and functionality, but also to confirm the participants. Therefore, the respondents were asked about their managerial activities, and the results confirmed that the respond-

ents made managerial decisions. However, participation in research must be voluntary, and a self-selection bias is always a risk (Yang et al. 2012). This means that volunteers who participate may differ from those not willing to participate. An analysis of non-respondents was not possible. However, with this topic, no self-evident reason exists to assume that those willing to participate in the study would process information differently than those who do not. The pilot study also showed that the electronic survey response rate was poor, regardless of reminders. Therefore, face-to-face recruitment and a paper-based survey was used in the national survey.

Inaccurate measurement may also lead to misleading results (Kimberlin & Winterstein 2008, Yang et al. 2012). Here, the instruments used were shown to be valid and reliable. However, the CVI for the developed questionnaire was not reassessed after the modifications made. Computing the CVI for the final version of the questionnaire would have provided valuable information about the validity of the final version of the questionnaire. The internal consistency of the instruments used was good. Instruments with high Cronbach's alpha values have smaller measurement errors (Heo et al. 2015). The *ICU Information Needs Questionnaire* had Cronbach's α values ranging from 0.87 to 0.97 between the six dimensions and results from a confirmatory factor analysis that supported the structure of the questionnaire (Lundgrén-Laine et al. 2013a). Cronbach's α values for the *Hospital Shift Leaders' Information Needs Questionnaire* varied in the pilot study from 0.85 to 0.96 and in the national survey from 0.80 to 0.94 between the six dimensions. Although acceptable α values range from 0.7 to 0.95, values above 0.90 are often considered too high (Tavakol & Dennick 2011). However, a large number of items will increase the value (Kimberlin & Winterstein 2008, Tavakol & Dennick 2011), and the number of items in the instruments used were many (114 and 122). Also, the split half analyses were good for the Hospital Shift Leaders' Questionnaire, as Spearman-Brown coefficients varied between 0.89 and 0.98 in the pilot study and 0.54 and 0.94 in the national survey.

An instruments construct validity can be supported with robust item-total correlations that are above 0.30, inter-item correlations ranging from 0.30 to 0.70 and factor loadings above 0.40 (DeVon et al. 2007). Based on these boundaries, the *Hospital Shift Leaders' Information Needs Questionnaire* showed good construct validity as item-total correlations varied between 0.34 and 0.75 in the pilot study and between 0.54 and 0.78 in the national survey. Only four inter-item correlations were below 0.3 in the pilot and none in the national survey. Unfortunately, the sample in the pilot study was insufficient for a factor analysis based on the KMO and Bartlett's test of sphericity.

To improve transferability of the findings, as much detail as possible has been given about settings, samples, participants and methods in each sub-study. The transferability of the findings in the instrument development study are limited by the sample and sample size. Therefore, the findings related to the information needs of shift leaders is not generalizable. The study did however bring valuable information about the validity and reliability of the developed instrument.

The transferability of the information needs data collected in New Zealand was also limited to a small number of participants, although these were five different intensive care units across the country. Therefore, they only represent the needs of a selected number of professionals who agreed to participate in the study. Also the findings related to the management information system model are limited by the six participants, who were all nurses in charge from one university hospital's intensive care unit. The issue is not so much the number of nurses in charge involved, as five participants will provide 85% of the issues (Nielsen 1994) and developing an information system is an iterative process (Barnum 2011). However, including physicians and professionals from different units could have provided more insights into the study.

In the national survey, stratified random sampling was used to increase validity. Linear models were used to explore associations between respondent characteristics and information needs. In addition to randomisation, this was one more way to see possible confounding factors (Yang et al. 2012). The findings are however limited by the smaller number of physicians and professionals from radiology and procedure units when compared to nurses and other units. Furthermore, regarding the confirmatory factor analyses reported in in paper IV, model fit numbers were not optimal, as p-values were significant and χ^2, df, CMIN/DF, RMR, GFI, AGFI, NFI, IFI, TLI, CFI, and RMSEA values were outside recommended boundaries (Hu & Bentler 1999, Jackson et al. 2009). This indicates that the statistical model of the theory-derived structure for the questionnaire was not perfectly supported, even if regression estimates were significant. This is probably due to high correlations between items. In the future, the statistical model could be improved through a greater sample size or a smaller number of items.

6.3 Implications of the findings

The findings emphasize the need to better acknowledge the opportunities and challenges of information processing and the systems used in the day-to-day operations management of hospital units. Investments in the development of this information management may bring cost savings in many ways through better decision-making, smoother care processes and improved satisfaction. Organisations should

evaluate their current information processing practices to see how well information systems currently support the day-to-day operations management. This should also be taken into account when designing and developing information system architecture. The findings of this study may be used in the development of information systems in practice that better support the day-to-day operations management of hospital units. Information processing in the day-to-day operations management is an important part of managerial decision-making, and hence it is important to include this in the education of leaders in the health care setting. Specific emphasis should be put on the role and means of information processing and ways to assess and develop the access to and quality of important information needed to support managerial decisions.

The findings reinforce current knowledge related to information needs in the day-to-day operations management of hospital units. Future research is needed to:

1. Ascertain information needs in the day-to-day operations management beyond hospitals

   Determining important information needed in the day-to-day operations management beyond the hospital setting is needed to develop and improve information processing across the health care setting within organisations but also when the responsibility of the care of a patient is changed from one organisation to another.

2. Develop and improve information systems to better support the day-to-day operations management

   The findings of this study report what information is important in the day-to-day operations management of hospital units. The next step is to test the developed models in the clinical setting and iteratively develop user centred information systems to better support the day-to-day operations management. This emphasizes the need for user involvement during all phases of the development process. Furthermore, when evidence of important information exists in other settings, this research should expand accordingly.

3. Evaluate the impact of information processing and information systems on the day-to-day operations management and provision of care

   The professionals responsible for the day-to-day operations management use much effort to obtain necessary information to support their decision-making. Evidence of the best means to support decision-makers for efficient

and cost-effective care is needed. Therefore, the impact of information processing and information systems on the day-to-day operations management is necessary.

4. Validate further the *Hospital Shift Leaders' Information Needs Questionnaire*

   The *Hospital Shift Leaders' Information Needs Questionnaire* showed to be valid and reliable based on the measures taken in this study. However, more research is needed to further validate the instrument.

7 CONCLUSIONS

Numerous information systems have been developed for the professionals responsible for the day-to-day operations management of hospital units, but these systems mostly focus on one specific managerial task. Furthermore, professionals responsible for running hospital units have reported dissatisfaction with the content and number of currently used information systems. Therefore, an information system that assembles important information from different sources into one place could better support the day-to-day operations management of hospital units by increasing the quality and timeliness of information.

Important information needed in the day-to-day operations management of hospital units differed between professionals, positions, time of day and types of units. These differences concerned information needs and how important information was categorised. Therefore, information systems should be flexible to support different users' needs. Involving users in all development phases is important when developing information processing. Supporting managerial decision-making with easy access to important information has the potential to increase safety, efficiency, and cost-effectiveness of care as well as improve employee satisfaction.

The need for real-time information in the day-to-day operations management was evident. This is a weakness in contemporary information systems, which currently better support tactical management. The developed model of important information has ten information categories, all of which are needed by different user groups, and each user group has a different set of individual items within an information category. The findings reported may be used in the development of user-tailored information systems for the professionals responsible for the day-to-day operations management of hospital units.

The *Hospital Shift Leaders Information Needs Questionnaire* was successfully modified for use in the larger hospital setting. Based on the measures taken, it proved to be a valid and reliable for exploring information needed in the day-to-day operations management of hospital units. However, more research is needed to further validate the instrument.

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APPENDICES

Appendix 1. Description of systematic database searches and search findings

Database	Terms used	Findings
Pubmed	"Nurse Administrators"[Mesh] AND "day-to-day" OR operational OR "first-line" OR "front-line" OR operational OR tactical OR unit OR department Limitations: title	241
	"day-to-day" OR operational OR "first-line" OR "front-line" OR tactical OR unit OR department AND managerial OR manager* OR coordination OR coordinator* OR organisation Limitations: title	443
	"shift leader*" OR "nurse manager*" OR "nursing management" OR "unit manager*" OR "charge nurse" OR "in charge" OR "head of department" OR "attending physician*" AND "Hospitals"[Mesh] OR "Hospital Units"[Mesh] OR "Hospital Departments"[Mesh] Limitations: title	365
	"hospitalist*" OR "fellow*" OR specialist* OR consultant* OR resident* OR "Medical Staff, Hospital"[Mesh] AND managerial OR manager* OR coordination OR coordinator* OR organisation AND "Hospitals"[Mesh] OR "Hospital Units"[Mesh] OR "Hospital Departments"[Mesh] Limitations: title	166
	"shift leader*" OR "nurse manager*" OR "nursing management" OR "unit manager*" OR "charge nurse" OR "in charge" OR "head of department" OR "attending physician*"	50

	AND "Information Systems"[Mesh] OR "Hospital Information Systems"[Mesh] OR "Management Information Systems"[Mesh] Limitations: title	
	"hospitalist*" OR "fellow*" OR specialist* OR consultant* OR resident* AND "Hospital Information Systems"[Mesh] OR "Management Information Systems"[Mesh] Limitations: title	195
	"shift leader*" OR "nurse manager*" OR "nursing management" OR "unit manager*" OR "charge nurse" OR "in charge" OR "head of department" OR "attending physician*" AND information	13
	Duplicates within database searches	157
	TOTAL	**1316**
CINAHL (522)	"day-to-day" OR operational OR "first-line" OR "front-line" OR operations OR tactical OR unit OR department AND managerial OR manager* OR coordination OR coordinator* OR organisation Limitations: Peer reviewed, Research article, title	105
	(MH "Hospitals+") OR (MH "Hospital Units+") OR (MH "Health Facility Departments+") AND (MH "Nursing Management") OR (MH "Nurse Managers") OR (MH "Nurse Administrators") OR "nurse manager" OR (MH "Charge Nurses") OR (MH "Nursing Leaders") OR (MH "Leaders+") OR "shift leader" OR "head of department" OR "attending physician" OR "unit manager" OR "in charge" OR hospitalist* OR fellow* OR specialist* OR consultant* OR resident*	196

	AND "day-to-day" OR operational OR "first-line" OR "front-line" OR operations OR operational OR tactical OR unit OR department Limitations: Peer reviewed, Research article, title	
	(MH "Information Systems") OR MH "Decision Support Systems, Management") OR (MH "Management Information Systems") OR (MH "Operating Room Information Systems") OR (MH "Appointment and Scheduling Information Systems") OR (MH "Practice Management Information Systems" AND (MH "Hospitals+") OR (MH "Hospital Units+") OR (MH "Health Facility Departments+") AND (MH "Nursing Management") OR (MH "Nurse Managers") OR (MH "Nurse Administrators") OR "nurse manager" OR (MH "Charge Nurses") OR (MH "Nursing Leaders") OR (MH "Leaders+") OR "shift leader" OR "head of department" OR "attending physician" OR "unit manager" OR "in charge" Limitations: Peer reviewed, Research article, title	225
	AND (MH "Nursing Management") OR (MH "Nurse Managers") OR (MH "Nurse Administrators") OR "nurse manager" OR (MH "Charge Nurses") OR (MH "Nursing Leaders") OR (MH "Leaders+") OR "shift leader" OR "head of department" OR "attending physician" OR "unit manager" OR "in charge" AND information	26
	Duplicates within database searches	46
	TOTAL	**506**

Cochrane (27)	There is 1 result from 9841 records for your search on "'shift leader*" OR "nurse manager*" OR "nursing management" OR "unit manager*" OR "charge nurse" OR "in charge" OR "head of department" OR "attending physician*" in Title, Abstract, Keywords in Cochrane Reviews'	1
	There are 19 results from 9841 records for your search on "'day-to-day" OR operational OR "first-line" OR "front-line" OR tactical in Title, Abstract, Keywords not drugs in Cochrane Reviews' NOT drugs	19
	There are 7 results from 9841 records for your search on "MeSH descriptor: [Management Information Systems] explode all trees in Cochrane Reviews" Limitations: Cochrane reviews	7
	Duplicates within database searches	0
	TOTAL	**27**
Medic (87)	(Organization and Administration OR "shift leader*" OR "nurse manager*" OR "unit manager*" OR "head* of department" OR "attending physician*" OR "hospitalist*" OR "fellow*" OR "first-line" OR "front-line") AND hospital* Limited to doctoral research	87
	Duplicates within database searches	0
	TOTAL	**87**
Scopus (557)	("day-to-day" OR operational OR "first-line" OR "front-line" OR operational OR process OR tactical OR unit OR department) AND (managerial OR manager* OR coordination OR coordinator* OR organisation) AND hospital* Limitations: article, conference proceeding, review	365

	(TITLE ("shift leader*" OR "nurse manager*" OR "nursing management" OR "unit manager*" OR "charge nurse" OR "in charge" OR "head of department" OR "attending physician*") AND TITLE (hospitals OR "hospital unit" OR "hospital department"))	192
	Duplicates within database searches	30
	TOTAL	**527**
The Web of Science (177)	You searched for: TITLE: ("day-to-day" OR operational OR "first-line" OR "front-line" OR operational OR process OR tactical OR unit OR department) AND TITLE: (managerial OR manager* OR coordination OR coordinator* OR organisation) AND TITLE: (hospitals OR "hospital unit" OR "hospital department") Timespan: All years. Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC.	102
	You searched for: TITLE: ("shift leader*" OR "nurse manager*" OR "nursing management" OR "unit manager*" OR "charge nurse" OR "in charge" OR "head of department" OR "attending physician*") AND TITLE: (hospitals OR "hospital unit" OR "hospital department") Timespan: All years. Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC.	75
	Duplicates within database searches	3
	TOTAL	**174**

Total number of findings	**2873**
Duplicates within database searches	236
Remaining total number	2637
Duplicates between database searches	347
Remaining number of articles for screening on title level	2290
Articles excluded based on title	1142
Remaining number of articles for screening on abstract level	1148
Articles excluded based on abstract	952
Remaining number of articles for screening on full text level	196
Articles excluded based on full text	84
Total number of articles included in review	**112**

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