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RESCHEDULING SUDDEN ABSENCES OF NURSING STAFF IN HOSPITAL SETTINGS

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ABSTRACT

The aim of this study is to evaluate the management of sudden absences of nursing staff in hospital settings. In addition, this study aims to describe nurse managers' daily work regarding rescheduling due to sudden absences of nursing staff, from the perspectives of using a paper-based system or an IT-based rescheduling solution. The dissertation also includes an analysis of experiences of nursing staff floating.

In Phase I, a scoping review was carried out to identify the IT-based rescheduling solutions for the daily rescheduling of nursing staff in a hospital setting, and rescheduling outcomes for patients, nursing staff and originations. In Phase II, a developed IT-based rescheduling solution was implemented at one university hospital department and a quasi-experimental pre- and post-test design was used to evaluate the nurse managers' (n=17) work tasks with the Rescheduling Task Survey (RTS) during the rescheduling process of nursing staff. The quasi-experimental pre- and post-test design was repeated with a large sample of nurse managers (n=61), and the duration of the rescheduling process was observed. The usability of the IT-based rescheduling solution was evaluated with the System Usability Scale (SUS). In Phase III, the associations between stress, psychosocial factors and floating experience among nursing staff (n=1336) was evaluated, and the experiences nursing staff (n=747) with floating shifts during the past year were described.

There is limited research on IT-based rescheduling staffing solutions and their outcomes for nursing staff, organizations and patients. Before and after implementation, the IT-based rescheduling solution nurse managers reported a total of 2,612 sudden absences with 5,800 rescheduling tasks such as phone calls and conversations. The main reason for sudden absence was unplanned sick leave (79%). After the implementation of the IT-based rescheduling solution, nurse managers' rescheduling tasks, unstaffed and unplanned shift changes, the use of float pool nurses and floating nurses increased significantly. The implementation of the IT-based rescheduling process also revealed significant cost saving opportunities for hospitals. During this study's short follow-up period, altogether €31,878 was saved with the use of floating nurses to cover sudden absences. There are no previous studies investigating floating and its association with stress among nursing staff. In this study, reported experience of stress did not differ significantly between participants with or without floating experience. However, there are factors related to floating that increase stress among nurses. Nurse managers need to ensure clear instructions for floating shifts on their units and that those instructions are followed.

KEYWORDS: Nursing management, nurse managers, nursing staff, staffing, absence, floating, stress, staffing system, hospital

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TIIVISTELMÄ

Tämän tutkimuksen tarkoituksena oli analysoida hoitotyön esimiesten päivittäiseen resursointiin liittyvää työtä heidän korvatessaan hoitajien äkillisiä poissaoloja. Päivittäisen resursoinnin prosessia tutkittiin ennen ja jälkeen sähköisen resursointisovelluksen käyttöönottoa. Lisäksi kartoitettiin hoitohenkilökunnan kokemuksia koetusta stressistä sekä tehdyistä lainavuoroista. Lainavuoroilla tässä tutkimuksessa tarkoitetaan työvuoroa, jossa hoitaja siirtyy tilapäisesti toiseen yksikköön tekemään suunnitellun työvuoronsa, mikäli oman yksikön tilanne sen sallii.

Tämä tutkimus toteutettiin kolmessa vaiheessa. Tutkimuksen ensimmäisessä vaiheessa toteutettiin kirjallisuuskatsaus, jonka avulla kartoitettiin päivittäiseen resursointiin soveltuvia sovelluksia sekä päivittäisen resursoinnin seurauksia potilaalle, hoitohenkilökunnalle ja organisaatiolle. Toisessa vaiheessa implementoitiin kehitetty päivittäisen resursoinnin sovellus yhden yliopistollisen sairaalan toimialueelle. Lisäksi hoitotyön lähijohtajien (n=17) käyttämiä työsuoritteita arvioitiin ennen ja jälkeen päivittäiseen resursointiin tarkoitetun sovelluksen käyttöönottoa. Tutkimus toistettiin suuremmalla otoksella (n=61) ja lisäksi työsuoritteiden ajallinen kesto arvioitiin havainnoinnin avulla sekä päivittäisen resursoinnin sovelluksen käytettävyys arvioitiin. Tutkimuksen kolmannessa vaiheessa tutkittiin hoitajien (n=1336) koetun stressin, työn psyykkisten ja sosiaalisten tekijöiden sekä lainavuorokokemusten välistä yhteyttä.

Tutkimustulokset osoittivat, että päivittäiseen resursointiin soveltuvia järjestelmiä on kuvattu vähän ja tietoa päivittäisen resursoinnin seurauksista on saatavilla rajoitetusti, erityisesti potilaiden näkökulmasta. Tässä tutkimuksessa hoitotyön esimiehet raportoivat yhteensä 2612 äkillistä poissaoloa, joiden pääasiallinen syy oli äkillinen sairausloma (79 %). Työsuoritteita, esim. puhelu tai keskustelu, raportoitiin yhteensä 5800. Päivittäiseen resursointiin tarkoitetun sovelluksen käyttöönoton jälkeen esimiesten työsuoritteet vähenivät merkitsevästi, kuin myös aliresursoidut työvuorot ja hoitohenkilökunnan äkilliset työvuorojen vaihdot. Myös vara- ja lainahenkilöstön käyttö tehostui. Sovelluksen käyttöönotto toi sairaaloille myös kustannussäästöjä; seuranta-ajan (neljä viikkoa) aikana kustannussäästöjä syntyi yhteensä 31 878 euroa. Tämän tutkimuksen mukaan lainavuorokokemus ei lisännyt hoitajien kokemaa stressiä. Sen sijaan lainavuoroon liittyy tekijöitä, jotka stressaavat hoitajia. Hoitotyön esimiesten tulee varmistaa, että lainavuoromallille on laadittu selkeät ohjeet, joita yksiköissä noudatetaan.

AVAINSANAT: Hoitotyön johtaminen, hoitotyön lähijohtaja, hoitohenkilökunta, henkilöstömitoitus, resursointi, stressi, sovellus, sairaala

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Abbreviations

CNA	Canadian Nurses Association
EDU	End-users development
ETENE	Valtakunnallinen sosiaali- ja terveysalan eettinen neuvottelu-kunta
Eurostat	European statistics
FTE	Full-Time Employees
GDPR	General Data Protection Regulation
HPPD	Number of nursing hours per patient day
IHME	Institute for Health Metrics and Evaluation
IT	Information Technology
KMO	Kaiser-Meyer-Olkin Test
LPN	Licensed practical nurse
NEF	Survey for evaluating Nursing staff experience of floating
NHS	National Health Service
PNRs	Patient-to-nurse ratios
PCA	Principal Component analysis
QATSDD	Quality Assessment Tool for Studies with Diverse Designs Critical appraisal tool
QPSNordic34+	A short version of The General Nordic Questionnaire
RN	Registered nurse
RTS	Rescheduling Task Survey
SAS	Statistical analysis software
SD	Standard Deviation
SPSS	Statistical Package for the Social Sciences
SUS	System Usability Scale
TENK	Finnish Advisory Board on Research Integrity
WHO	World Health Organization

List of Original Publications

This dissertation is based on the following original publications, which are referred to in the text by their Roman numerals:

I.   Tuominen O, Lundgrén-Laine H, Flinkman M, Boucht S, & Salanterä S. 2018. Rescheduling nursing staff with information technology-based staffing solutions: a scoping review. Int. J. Healthcare Technology and Management. 17(2/3): 145-167.

II. Tuominen O, Lundgrén-Laine H, Kauppila W, Hupli M & Salanterä S. 2016. A real time Excel-based scheduling solution for nursing staff reallocation. Nursing Management (Harrow) Sep 30; 23(6):22-29.

III. Tuominen O, Lundgrén-Laine H, Teperi S & Salanterä S. 2019. Comparing the two techniques for nursing staff rescheduling to streamline nurse managers' daily work in Finland. CIN: Computers, Informatics, Nursing. Publish Ahead of Print, October 23, 2019. DOI: 10.1097/CIN.0000000000000567.

IV. Tuominen O, Rantalainen T, Lundgrén-Laine H, Löyttyniemi E, Rehnback K & Salanterä S. Association between stress, psychosocial factors of work and floating experience among nursing staff in Finland: A survey study. Submitted 10.11.2019.

The list of original publications have been reproduced with the permission of the copyright holders. The thesis also contains unpublished material about Phases I and III.

1 Introduction

A few years ago, I worked as a nurse manager for float pool nurses. The pool consisted of 16 nurses who were hired to cover the sudden absences of over 300 nurses annually in one department at Turku University Hospital. These nurses were designated to continually change units. However, the organization managed float pool nurses using paper shift lists, which were disorganized and often led to misunderstandings and overlapping when booking float pool nurses. The main problem was the advanced booking of the float pool nurses shifts. When shift lists of float pool nurses were published, usually for six-week periods at a time, it took approximately two days and each shift was filled by nurse managers of various units. This model did not enable float pool nurses to cover sudden absences of nursing staff on a daily basis. At the same time, the department had an urgent need to streamline the use of other available nurses, later called floating nurses. Floating nurses were nurses who were permanently assigned to one unit but would occasionally move between units a few times a year. This model was based on variations in the volume of inpatients and intensity of care. Floating nurses were managed via phones, emails, conversations and other arrangements. The practice showed that there was a clear need to link float pool nurses and floating nurses on a single platform, which could be managed more effectively.

Staffing has been the interest of nurse managers and policy makers for a long time, in terms of adequate staffing levels (Griffiths et al., 2018; Cho et al., 2016). Long-term shift scheduling is based on a unit-level need of nurses to ensure safe care for patients in every shift, 24/7. This subject has been studied from the perspectives of patients (Aiken et al., 2018; Griffits et al., 2018; Peršolja 2018; Recio-Saucedo et al., 2018; Xue et al., 2012), nursing staff (Bakhamis et al., 2019; Burmeister et al., 2019; Cho et al., 2016; Bae & Fabry, 2014) and organizational outcomes (Arefian et al., 2017; de Cruppé & Geraedts, 2017; Mira et al., 2014), but to a much lesser degree, as a part of nurse managers' work. I became interested in short-term staffing solutions and how other organizations managed the challenge of covering sudden absences of nursing staff. Surprisingly, there is little information on short-term staffing (Clark et al., 2015), reasons for and numbers of sudden absences, even though rescheduling due to absences is a daily task for nurse managers. In addition to using

float pool nurses, floating nurses and temporary nurses to cover sudden absences of nursing staff, nurses permanently stationed at the unit were often asked to work overtime or were even called in to work on their day off (Stimpfel et al., 2012). These alternatives have been managed with paper-based practices and with IT-based solutions (Bard & Purmono, 2005). There is only a limited amount of literature on IT-based solutions and short-term shift scheduling based on the sudden need of nursing staff (later rescheduling) (Clark et al., 2015; Ramsey-Coleman, 2012; Kulma & Springer, 2006; Notarantonio 2006). The terms *shift bidding, shift bidding management, open shifts and open shift management ar*e used in software producers' solutions for covering sudden absences of nursing staff.

The work of nurse managers consists of various responsibilities. Human resources management is a daily part of the job, but it is unclear how worktime is divided between the various tasks of human resource management (Bjerregård Madsen et al., 2016.) In daily management practices, nurse managers use the majority of their time solving problems rather than preventing them. This is understandable, as nurse managers work with tight schedules and with too much work due to the high number of employees or duties. There is an obvious need for more research on rescheduling, to get more information on rescheduling as a daily practice of nurse managers.

According to previous research, a common type of absence from work is sick leave. EU countries spent over €138 billion on sick leave benefits in 2014, which was 1% of the EU Gross Domestic Product (Eurostat, 2018.) In Finland, a total of 286,600 people received sick leave benefits in 2017, and the amount of compensation was over €800 million to income loss during absence (Statistical Yearbook of the Social Insurance Institution, 2017). The recipients of compensation increased by 1.8% from the previous year. In EU countries, employees had approximately 11.6 days of absence from work in 2015 (European Health Information Gateway 2018). In Finland, registered nurses took an average of 20 sick leave days, and licensed practical nurses took an average of 26 (Kunta10, 2017). In practice, this means that if nurse managers have 20 registered nurses and five licensed practical nurses working for them, they would altogether have approximately 530 sick leave days annually.

Ideally, a nurse manager hires a substitute nurse to cover a sudden absence in nursing staff (Simpson & Simpson, 2019; Hurst & Smith, 2010). However, hospitals have limited budgets for staffing. In Finland, the cost of one sick leave day for the employer is, on average €177 (STM, 2014). Also, the availability of educated nurses is a challenge. It has been estimated that in Finland, 20,547 of the total nursing workforce of 81,500 will retire between 2010 and 2030 (The Finnish Nurses Association, 2015). This directly affects the number of available nurses, but also sets geographic challenges; it may be even more challenging to get nurses in rural areas (Nordic

Council of Ministers, 2014). Nursing students provide one solution to the problem, but nursing students have limited rights in the role of nurse. Both substitute nurses and nursing students may be unfamiliar with the organization in which they are placed and need at least a short orientation (Hoffman & von Sadovszky, 2018; Garrison, 2018; Unruh & Nooney 2011). For example, in Finnish hospitals, substitute nurses are not allowed to participate in medication if they have not obtained a medical treatment license, and nursing students are not allowed to complete one before they graduate.

Sudden absences of nursing staff and the process of rescheduling increase daily demands on nurse managers. Despite rescheduling being a daily practice, the subject has been scarcely studied, leaving a question of how nurse managers handle these rescheduling tasks and how nursing staff floating affects nurses. This study aims to fill some of these gaps in current knowledge.

2 Review of the Literature

Existing literature does not address the issue of how nurse managers reschedule sudden absences of nursing staff. This literature review describes the current knowledge about nursing staff absence on a general level in terms of reasons for absence. Additionally, consequences for patients, nursing staff and organizations, including the work of nurse managers, have been reviewed as elements behind nursing staff scheduling and rescheduling in hospital environments.

An overview of the literature on nursing staff absence management in hospital settings was conducted, not using a systematic review process, but focusing on phenomena of sudden absences of nursing staff, rescheduling nursing staff and the outcomes of such. The following MeSH-terms were used, without year limitation: *nurse manager*, *nursing staff*, *hospital*, *patient care*, *outcome assessment* (health care), *absenteeism*, *sick leave*, *personnel staffing and scheduling*, *personnel staffing and scheduling information systems*. In addition, wildcards (*) were used, such as *floating**, *rescheduling**, *absence**, *work**, *substitute nurse**, *temporary nurse**, *agency nurse**, *bank nurse**, *unstaffed shift**, *inadequate staff** and *adequate staff**. Combinations of terms were searched for using the Boolean search terms *AND* and *OR*. PubMed was used as the primary database, but manual search techniques were also used. The central concepts and definitions used in this study are presented in Table 1.

Table 1. Definition of used terms.

Central concepts	Definition	References
Nursing staff	1) Licensed professionals; registered nurses (RN) and 2) protected occupational title; practical nurses for social and health care; licensed practical nurses (LPN) that are employed by hospitals.	National Supervisory Authority for Welfare and Health (Valvira)
Sudden absence	A situation in which nursing staff members are not at work when they should be. The main reason for sudden absence of nursing staff is unplanned sick leave.	Belita, Mbindyo & English, (2013) Schalk, (2011)
Nurse managers	Nursing professionals that are responsible for daily management of nursing staff. In terms of rescheduling, nurse managers manage day shifts from Mondays to Fridays. During evenings, nights and weekends, units usually have named staff nurses.	Sveinsdóttir et al., 2018 Siirala et al., 2016 Clark et al., 2015
Rescheduling	Short-term shift scheduling based on the sudden need of nursing staff. Nursing staff shifts are usually planned in three-week periods in Finland. *Rescheduling* is the term used for the need to cover sudden absence of nursing staff on a shift-to-shift level. Rescheduling may cause changes in planned work shifts of nursing staff.	Tuominen et al., 2016 Clark et al., 2015
IT-based rescheduling solution	Solution for supporting rescheduling management process to cover sudden absences of nursing staff with float pool and floating nurses.	Tuominen et al., 2016 Clark et al., 2015 Ramsey-Coleman, 2012

2.1 Alternatives to covering sudden absences of nursing staff

In this study, the term *substitute nursing staff* is used to describe nurses that are hired from outside the hospital as agency nurses to cover sudden absences of nursing staff (Tuominen et al., 2019). Additionally, hospitals may have a pool of bank nurses (Dean, 2016) or an organized float pool (Hoffman & Sadovszky, 2018) of nurses who can cover a sudden absence. Hospitals may also use floating nurses (who are permanently hired in a hospital unit), and in some cases, for example, sudden absences, they may be reassigned to another ward during their planned shift (Tuominen et al., 2019; Garrison, 2018; Hoffman & Sadovszky, 2018; van Schingen et al., 2017; Tuominen et al., 2016). Terms used to describe alternatives to cover sudden absences differ between hospitals and countries. Descriptions of used options are presented in Table 2.

The use of temporary nurses to cover sudden absences of nursing staff needs the consideration of nurse managers. Nurse managers have to evaluate every unstaffed shift to determine if the use of temporary staff would help or complicate a particular shift? Sometimes nurses do better coping with understaffing, for example, if there is no time for an orientation for a temporary nurse to the unfamiliar environment. In these situations, nurse managers should consider the opinions of the nurses.

Table 2. Definition of the roles of nurses in terms of rescheduling.

	Definition of the roles of nurses	References
Float pool nurses	*Float pool nurses* are permanent hospital staff members with permanent work contracts. They are hired directly into an organizations' float pool to cover mainly sudden absences of nursing staff. Nurses may float in multiple areas or they are centralized, e.g., floating between three units. Float pool nurses may even change units on a daily basis. Float pool nurses have equal rights (for example, annual holidays) as other permanent staff.	Hoffman & Sadovszky, 2018; Lebanik & Britt, 2015; Overman et al., 2014; Larson et al., 2012; Dziuba-Ellis 2006
Floating nurses	*Floating nurses* are permanent hospital staff members with permanent work contracts. They are employed on one hospital ward, and in some cases (for example, sudden absence), they may be reassigned to another unit during their planned shift. Floating is usually based on the organization's need to cover unstaffed shifts rather than voluntary (see definition of bank nurses).	Garrison, 2018; van Schingen et al., 2017; Hoffman & Sadovszky, 2018; Good & Bishop 2011
Bank Nurses	Other terms can be used for floating (and float pool) nurses. For example, *bank nurse* is the term used for flexible staffing mainly in the UK. The role of bank nurses in the hospitals is similar to that of float pool and floating nurses. A nursing bank is a similar option to float pools. Bank nurses can be divided into two categories: a group of flexible employees contracted to work at short notice to cover planned and unplanned unstaffed shifts, and a hospital's permanent full-time or part-time nurses that voluntarily want to earn some extra money. In the UK, bank nurses are National Health Service (NHS) employees, recruited and trained within the parent NHS organization. Bank nurses are usually managed through a hospital bank coordinator or centralized bank offices.	Dean ,2016; Massey et al., 2009
Supplemental nurses	*Supplemental nurses* (also called *temporary nurses*) are nurses hired on a temporary basis, usually only to work during daytime shifts. Supplemental nurses can also be ungraduated nursing students. *Agency nurses* are another example of supplemental nurses that hospitals use to cover unfilled shifts. Agency nurses are managed through a private contractor outside the hospital. Sometimes permanent nursing staff may work extra shifts as an agency nurse in addition to their main job. Costs for agency nurses are estimated to be the highest of nursing costs for hospitals.	Hurst & Smith 2010; Simpson & Simpson 2019; Berg Jansson & Engströn 2017; Massey et al., 2009; Manias et al., 2003

2.2 Absence at work

Although it is known that sudden absences from work are common among nursing staff, their reasons and causes have been less considered. Most sudden absences are due to sick leave. In Finland, the five main groups of diseases among the general population (for which compensation is paid) are: musculoskeletal and connective tissue disorders (29%), mental and behavioral disorders (21%), injury, poisoning and certain other consequences of external causes (15%), respiratory diseases (6%) and digestive system diseases (5%) (Statistical Yearbook of the Social Insurance Institution, 2017). Besides unplanned sick leave, there are other reasons that causes sudden absences from work. For example, in Finland, a parent has the right to stay home a sudden illness (Social Insurance Institution of Finland-Kela, 2018).

There are numeral factors affecting nursing staff absences. Internationally, musculoskeletal disorders have been shown to be among the most common reasons for nursing staff absences (Ribeiro et al., 2017; d´Errico et al., 2013). Nurses suffer from the symptoms mainly in the dorsal region, back, neck and shoulders (Ribeiro et al., 2017; Bernal et al., 2015). Symptoms are similar to those of the other professions that include physical work (Rizzello et al., 2019; Pekkala et al., 2018; Farioli et al., 2014). In hospital settings, the physical nature of the work tasks of nursing staff often lead to symptoms of musculoskeletal disorders. These tasks include working while standing, bending and rotation of body, and repetitive arm movements. (Ribeiro et al., 2017.) In addition, gender (female), age (Burmeister et al., 2019), length of recruitment, years in present position, shift work and the number of nursing staff per shift are factors that can affect back pain among nursing staff (Skela-Savič et al., 2017). There is also an association between nursing staff work-related psychosocial factors and musculoskeletal disorders, such as lower back pain and shoulder pain (Bernal et al., 2015).

More than one in six people suffer from mental health issues in the EU countries. Mental health problems, such as anxiety, depression and bipolar disorders, have been reported more commonly among women. (IHME, 2018.) Sick leave due to mental and behavioral disorders have become more common in recent years in Finland (Statistical Yearbook of the Social Insurance Institution, 2017), especially among young adults (Mattila-Holappa, 2017). This phenomenon can be seen among young nurses as well. Based on self-reported sick leave, reasons related to mental health were more often reported by younger nurses. Also, shift working, reported abuse at work and previous mental health problems may predict sickness-related absences of nursing staff. (Lamont et al., 2017.)

Work-related stress can often lead to absence. Work-related stressors on a general level among nursing staff are linked to high workloads, time pressure and conflicts of roles (Freimann & Merisalu, 2015). Stressors can also be associated with the working environment. Nurses working in critical or emergency care units, oncology

or mental health nursing and midwifery have been found to have higher percentages of secondary posttraumatic stress. (Missouridou, 2017.) For example, one small study sample showed that nurses who worked in a pediatric cardiac intensive care unit had a high occurrence, 41 (45%) out of 92, of mental health problems (Tito et al., 2017). In addition, the nature of the work can influence mental health. Workflow interruptions are associated with nursing staff's experiences of stress and safe patient care (Weigl et al., 2017; Elfering, 2015).

Injury, poisoning and certain other consequences of external causes are also reasons for absence among nursing staff in hospital. A study of sharp instrument injuries (surgical needle insertion, removing an arteriovenous needle from a patient and recapping the needle) showed that the highest incidence of sharp instrument injuries exists in the environment of nursing care. Although there was no mention of absences related directly to sharp instrument injuries, these are known to cause psychological distress, fear, tension and anxiety, which can in turn increase absences. (Huang et al., 2017.) It has been shown that by reducing the mental workload of nursing staff, the rate of occupational injuries, and thus socio-emotional stress, decreases, which then increases safety and work satisfaction (Hosseinabadi et al., 2019).

There are several other factors that can affect sick leave among nursing staff. Shift-scheduling can support nurses' well-being or, alternately, increase the possibility of absences. Length and type of shift (Rajbhandary & Basu, 2010), especially short rest periods (<11 hours) between shifts (Vedaa et al., 2019) and routine implementation of long shifts without evaluation of the consequences for nurses and patients. (Dall'Ora et al., 2019; Harris et al., 2015.) Working overtime has been identified as a predisposing factor (Han et al., 2015), as have increased psychosocial job demands (Roelen et al., 2018), leadership effectiveness (Schreuder et al., 2010) and working in a hospital environment (Rajbhandary & Basu, 2010). Further, high rates of absence have been associated with lower job satisfaction (Burmeister et al., 2019; Zboril-Benson, 2002).

2.3   Inadequate staffing

Inadequate staffing may be due to sudden absences of nursing staff, but also to increased nursing intensity (Rauta et al., 2017; Dini et al., 2014; Navarra et al., 2013) or increased numbers of patients (Unruh & Nooney, 2011), lower competency levels for nursing staff in relation to the treatment required by patients (Vermin et al., 2014) and the ratio of qualified nurses in relation to unqualified nurses (Recio-Saucedo et al., 2018; Chau et al., 2015; Xue et al., 2012). It is challenging for nurse managers

to ensure the safe care of the patients with the best available resources. Notwithstanding the reasons, inadequate staffing can have consequences for patients, nursing staff and the organization. In some cases, there may be consequences for all parties.

2.3.1 Consequences of inadequate staffing for patients

Inadequate staffing has negative consequences for patients, most notably in mortality rates (Jansson et al., 2019; Ball et al., 2018; Driscoll et al., 2018; Recio-Saucedo et al., 2018; Liang et al., 2012; Xue et al., 2012), increased incidents of falls (Burns et al., 2016; Morello et al., 2015) or sepsis (Arefian et al., 2017). It has been shown that when the number of patients per registered nurse decreased from 12 to 8 to 4 patients, the average number of incidents of missed care (e.g., skin care or pain management), decreased from 4.4 (out of 13) to 3.8 to 3.2 (Aiken et al., 2018).

There is some evidence that the use of substitute nurses to cover sudden absences of nursing staff may have a negative impact on patient care outcomes, such as missed care (Griffiths et al., 2018; Xue et al., 2012), medication errors (Xue et al., 2012), urinary tract infections (Recio-Saucedo et al., 2018; Chau et al., 2015), patient falls (Chau et al., 2015; Hinno et al., 2012), pressure ulcers (Chau et al., 2015), critical incidents (Recio-Saucedo et al., 2018), and patient readmissions to the hospital (Recio-Saucedo et al., 2018; Flanagan et al., 2016.). However, In Finland, only registered nurses (RN) and licensed practical nurses (LPN) for social and health care are employed by hospitals. Assistant nurses (without education) are not used in hospitals in Finland. Instead, the use of supplement nurses, including nursing students, is common.

2.3.2 Consequences of inadequate staffing for nursing staff

The consequences of sudden absences for nursing staff has been extensively studied in terms of work-related psychosocial factors, such as job demands. The experience of job demands varies from person to person. For example, the demands of newly licensed nurses are related to the experience of job difficulties, such as inadequate orientation or higher numbers of patients. (Unruh & Nooney, 2011.) Nurse managers should pay attention to nurses' experiences of increased job demands. Higher numbers of patients per nurse increase nurses' workloads, but may also expose nurses to work-related injuries, such as cuts or lacerations (Unruh & Asi, 2018). Increased job demands may have impact on nurses' mental health by causing symptoms of depression (McGilton et al., 2016) and increasing the risk of work-related burnout (Bakhamis et al., 2019).

When a shift's staffing level suddenly decreases below the planned level, the nurses on duty must cope with the available temporary staffing resources, or sometimes, with understaffing. Depending on work experience, temporary nurses usually need at least a brief orientation, which can be challenging to implement in situations where the unit is already understaffed. Still, situations where there is no orientation for unplanned temporary staff have been scarcely studied. Studies on orientation focus on long-term orientation for recently graduated nurses entering the workforce (Pasila & Kääriäinen, 2017). Inadequate resources for orientation can impede the success of the orientation (Lindfors et al., 2018), and the altogether lack of orientation is one predictor of intention to leave the profession among newly graduated nurses (Flinkman & Salanterä, 2015). Additionally, sudden absences influence the planned shift scheduling of nurses.

Understaffing may be covered with permanent nursing staff working overtime or working extended shifts, both of which increase nurses' workload. Overtime work may consist of extended shift length or extra shifts during the shift-scheduling period and may be voluntary or mandatory. (Bae & Fabry, 2014.) Overtime work is associated with work-related injuries, such as work-related musculoskeletal injuries (Trinkoff et al., 2006), emotional disorders (Bae & Fabry, 2014), burnout and job satisfaction (Bae & Fabry, 2014; Stimpfel et al., 2012), less collaboration with other health care workers on the unit level (Ma & Stimpfel 2018), poor quality of nursing (Cho et al., 2016) and also intention to leave the organization or profession (Burmeister et al., 2019; Moloney et al., 2018; Leone et al., 2015; Stimpfel et al., 2012). Both mandatory and voluntary overtime work is associated with negative outcomes for nursing staff, such as injury and needlesticks during voluntary overtime work, and needlesticks, injury, illness and absenteeism in mandatory overtime work (Bae & Fabry, 2014). Overall, the risk for sickness-related absence increases when the number of hours worked increases (Schreuder et al., 2010).

Contrarily, the use of supplemental nurses as agency nurses may mean that the substitutes bring extended knowledge, which can have positive effects. Although agency staff does not usually participate in the routines that do not involve patients (Berg Jansson & Engström, 2017), bank nurses and float pool nurses often care for an equal number of acute patients and sometimes an even greater number of patients than the unit's permanent nurses (Larson et al., 2012). However, there has not been much research done on floating nurses.) It is beneficial for floating nurses to have work partner during shifts, brief and concisely written information about the unit and its routines, and a small orientation to the unit, ideally before the floating, as good orientation has been shown to enhance the comfort level of newly graduated nurses when floating (Garrison, 2018; Hoffman and von Sadovszky, 2018; Unruh & Nooney, 2011). In time-constrained situations, sufficient support for substitute nurses, float pool nurses and especially floating nurses, may be lacking.

2.3.3   Consequences of inadequate staffing for organizations

The consequences of inadequate staffing for nursing staff and patients are strongly linked to the organization, so it is difficult to assess organization-related consequences on their own. One way to evaluate the outcomes of inadequate staffing for organizations is to look at costs. A large percentage of annual staffing costs for hospitals are for nursing staff salaries, and the use of temporary nurses to cover sudden absences create additional costs (Hurst & Smith, 2011; Welton, 2011).

Unstaffed shifts and patient care outcomes may also increase financial costs for hospitals. For example, it has been found that lower staffing levels increases the occurrence of falls (Kim et al., 2019; He et al., 2016; Morello et al., 2015) and sepsis (Arefian et al., 2017; Twigg et al., 2017). Therefore, preventative hospital care to limit negative consequences is crucial from a cost perspective. In general, the medical costs of adult patient are significant, and were from $637.5 million to $31.3 billion for patients aged 65 or older in 2015 in the US. One fatal fall costs an average of $25,487 and a non-fatal fall $9,463 (Burns et al., 2016). In Australian hospitals, 27,026 admissions to hospitals between 2011 and 2013 included a total of 1,330 falls and 418 falls with injuries. The total hospital costs were over £5.7 million (€11.4 million): £1.9 million (€3.9 million) of this went towards fall-associated injuries (Morello et al., 2015). The hospital-related median of mean costs of sepsis per patient is $32,421 (IQR $20,745–$40,835). Specifically, ICU costs for sepsis per patient are $27,461 (IQR $16,007–$31,251), based on a systematic review (Arefian et al., 2017).

As mentioned above, inadequate staffing has consequences for patient care. This can affect a hospital's reputation and patients' hospital selection. Patients may choose their hospital based on a personal experience during a hospital stay (Mira et al., 2014), suggestions from relatives, available outpatient services or distance from home (de Cruppé & Geraedts, 2017).

Over 25% of working women in Finland are employed in social welfare and health care services, and it has been estimated that over 49% of nursing personnel will retire between 2010 and 2030 (The Finnish Nurses Association, 2016). Each trained nurse will be needed in the future to cover these vacancies. In the RN4Cast study, 9% of the nurses considered leaving their profession (Heinen et al., 2013). Recent research has shown that one of the reasons for nurses intend to change employers or even leave the nursing profession is inadequate staffing, which leads to high workloads (Burmeister et al., 2019; Moloney et al., 2018; Leone et al., 2015; Stimpfel et al., 2012). Therefore, nurse managers and policy makers should pay attention to the association between inadequate staffing and nurses' intention to leave their hospital or even their profession, to help ensure the future safety of patient care.

2.4 Rescheduling and the consequences of nurse managers' work

Rescheduling of nursing staff is a daily responsibility for nurse managers. The job of nurse manager consists of various responsibilities that vary between organizations, but ensuring adequate staffing levels is a major part of the job (Siirala et al., 2019; Sveinsdóttir et al., 2018; Cadmus & Wisniewska, 2013). However, it is still uncertain how the time allocation between the different tasks of human resource management is divided. For example, sometimes nurse managers' tasks are delegated to assistant nurse managers (Bjerregård et al., 2016) and nurse managers often do several tasks simultaneously (Bjerregård et al., 2016; Sveinsdóttir et al., 2017).

Rescheduling to cover sudden absences of nursing staff is one of the nurse managers' tasks and often handled during other human resources-related management tasks. How nurse managers handle rescheduling, though, has been scarcely studied. Rescheduling often requires fast decision-making from nurse managers. They must evaluate whether they can manage with understaffing or if the understaffed shift needs to be filled. Generally, nurse managers ask the under-staffed unit's nurses to work extra shifts, change their planned shifts or work unplanned long days, or they might utilize float pool staff, floating nurses or other supplemental staff (Tuominen et al., 2019; Tuominen et al., 2016). The most commonly used method is the use of supplemental staff, such as agency nurses, if the organization has a flexible staffing budget (Simpson & Simpson, 2019; Massey et al., 2009; Manias et al., 2003). Notwithstanding the method used, nurse managers have to make phone calls, have in-person conversations or send emails to cover the unstaffed shifts (Tuominen et al., 2019; Tuominen et al., 2016). In some hospitals, rescheduling solutions can be available for nurse managers. However, there is lack of evidence for how a model-based tool for rescheduling could assist nurse managers' daily rescheduling tasks (Clark et al., 2016).

Staffing management can be stressful and even an ethical issue for nurse managers. Coping with adequate staffing is challenging due to the lack of qualified or competent nursing staff and because of limited staffing budgets (Fast & Rankin, 2018). From an ethical perspective, nurse managers have to make staffing decisions based on which units or patients need staff most, knowing that all units and patients have an equal right for adequate staffing levels (Aitamaa et al., 2010). Coping with insufficient staffing is also connected to nurse managers' intent to stay at their position (Hewko et al., 2015).

Further, most of the studies concerning the ensuring of adequate staffing levels focus on consequences of inadequate staffing, but the role of management in preventing absences has been less studied. However, nurse managers can affect nurses' well-being and workload in several ways that can reduce sudden absences due to stress, burnout and job dissatisfaction. Nurses' intentions to leave their work is

strongly associated with negative experiences of leadership (Halter et al., 2017; McGilton et al., 2016; Lagerlund et al., 2015; Heinen et al., 2013). Intention to change employers is also associated with burnout (Lagerlund et al., 2015; Heinen et al., 2013) and stress, which also increase the risk of absences (Halter et al., 2017; McGilton et al., 2016).

Shift work and overtime work can cause fatigue among nurses. In shift scheduling, nurse managers should avoid too short resting periods between shifts (Min et al., 2019; Vedaa et al., 2019) and notice the impact that shifts of over 12 hours have on nurses' health (Dall'Ora et al., 2019; Harris et al., 2015). Overtime work is the generally used method for covering sudden absence, even if it can be a burden to nursing staff. Nurses who work ten-hour or longer shifts will be more likely to experience burnout and job dissatisfaction and will be more likely to consider leaving their job. (Han et al., 2015; Stimpfel et al., 2012.) Overtime is associated with work-related injuries (Trinkoff et al., 2006). In addition, overtime work increases staffing costs (CFNU, 2015). On the other hand, overtime work offers a way to cover sudden absences with familiar staff.

Besides ensuring adequate staffing, nurse managers should also pay attention to nurses' planned shifts and days off. Nurse managers should allow nurses to decline to work overtime without retribution (Stimpfel et al., 2012), especially as overtime work affects the health of nursing staff and can cause work-related injuries (Bae & Fabry, 2014; Trinkoff et al., 2006). If nurses feel respected by their superiors, they are less likely to have many periods of short sick leave (Schreuder et al., 2010).

2.5   Approaches to measuring adequate staffing

"*Safe nurse staffing requires that there are sufficient nurses available to meet patient needs, that nurses have the required skills and are organized to enable them to deliver the highest care possible*" (Drennan et al., 2018). It is challenging to evaluate and measure adequate staffing levels in a hospital environment, but the importance of measurement is obvious. The measurement of staffing levels provides key information for nurse managers to resolve questions, such as knowing the ideal number of employees to hire to ensure adequate staffing levels.

There are various tools for measuring adequate staffing levels, such as calculating patient-to-nurse ratios (Chang et al., 2019; Driscoll et al., 2018; Schwab et al., 2012; Minnick & Mion, 2009), the number of full-time equivalents (FTE) (Unruh & Zhang, 2012; Harless & Mark, 2011), the number of nursing hours per patient day (HPPD) (Griffiths et al., 2018; Min & Scott, 2016; Choi & Staggs, 2014; Kalisch et al., 2011), the skill mix of nursing personnel (Choi & Staggs, 2014; Buchan et al., 2000) and the measurement of nursing intensity (Rauta et al., 2017; Dini et al., 2014; Navarra et al., 2013). These tools, summarized in table 3, are commonly used to

evaluate long-term staffing needs, but can vary between hospitals. For example, patient-to-nurse ratios are useful in long-term care, where the number of patients is constant.

Hardly any of these tools present an evaluation of adequate staffing levels on a shift-to-shift level, or at least the automated assessment method is not available for supporting nurse managers' decision-making. The number of patients and care intensity vary unpredictably in a hospital unit that takes care of emergency patients, so the use of measurement tools is challenging. Still, in cases of sudden absence of nursing staff, the decision to hire extra staff is usually based on the knowledge of the nurse managers and staff nurses: how many patients there are, how many patients need extra attention, how experienced are the nurses on the shift, etc.

Nurse managers' decision-making plays a significant role in patient safety and nurses' well-being, but also in the hospital's staffing costs. Even though staffing decisions of nurse managers are often based on their knowledge and experience, tools for measuring adequate staffing levels should be considered as a part of the process of patient classification systems. There is evidence that evaluation based on individual patients' nursing care needs from a patient classification system offers comparable data between units and hospitals in terms of patient care costs and staffing costs (Stafseth et al., 2018; Fagerström et al., 2018).

Table 3. Measurement tools for assessment staffing levels.

Measurement tools	Definition of the measurement	References
Patient-to-nurse ratios (NPRs)	Using NPRs is one way to express how many nurses are needed to work per shift in a 24-hour period by number of beds or number of patients (NPRs can also be divided by using HPPD). Example (Chang et al., 2019): $$\frac{\textit{[(number of nursing personnel in three shifts} \times 8)}{\textit{(number of beds} \times \textit{bed occupancy rate)]}}$$	Chang et al., 2019; riscoll et al., 2018; Schwab et al., 2012; Minnick & Mion 2009
Number of RN full-time employees (FTE)	With the FTE, staffing levels can be calculated including fulltime equivalents (RN) per 1000 inpatient day, taking into account the weekly working hours, productive hours (excluding, e.g., breaks). Example (Harless & Mark 2011): $$\frac{\textit{"(Registry hours RN productive hours/0.875)}}{\textit{Inpatient Days/1000"}}$$	Unruh & Zhang, 2012; Harless & Mark, 2011

Measurement tools	Definition of the measurement	References
Number of nursing hours per patient day (HPPD)	Nursing hours for patient care can be calculated as productive (may be combined with unproductive) hours provided including direct-care per patient by an RN, in a 24-hour period with available data, such as number of inpatients. Sometimes indirect patient care (other activities than patient care) may be included in the calculation, and in some cases indirect care may include other care providers, e.g., those who coordinate patient care. Example: "Total nursing HPPD was computed for each unit by dividing the total number of productive nursing hours provided by direct care RNs, LPNs, and UAP assigned to the unit by the total number of patient days for that unit during a calendar month" (Choi & Staggs 2014).	Griffiths et al., 2018; Min & Scott; 2016; Choi & Staggs, 2014; alisch et al., 2011
Skill-mix	Optimizing staff by using a skill-mix of nursing staff based on the use of lower-qualified health care workers with RNs to decrease nurses' workload and ensure adequate staffing levels. A skill-mix is estimated as HPPD, separating the direct care provided by an RN.	Choi & Staggs, 2014; Buchan et al., 2000
Nursing intensity	Nursing intensity defines the relationship between patient-related nursing activities (indirect and direct patient care activities) and the number of nurses who perform these tasks. Patient classifications are tools used to measure patients' care needs with available nursing resources. Example: "The PPCI consists of 11 care indicators. Each indicator is assessed with the help of four situations, scored in rising order according to the care demand. The sum of the scores permits classifying the patient in one of the five care categories established in the literature: Minimal (11–17 points), Intermediary (18–23 points), High dependence (24–30 points), Semi-intensive (31–36 points) or Intensive (37–44 points)" (Fagerström et al., 2000).	Fagerström et al., 2018; Rauta et al., 2017; Dini et al., 2014; Navarra et al., 2013

The use of tools to measure adequate staffing levels, in addition to nurse managers' knowledge and experience, can offer hospitals information that can be used to support nurse managers' decision-making. In order to achieve these benefits, management systems should provide real-time data for supporting nurse managers' knowledge-based decision-making. However, this alone is not enough. Nurse managers' need to have several competencies; for example, they need to use the nursing and patient care data to improve practices, support IT implementations and have sufficient computers skills (Strudwick et al., 2019), in addition to financial knowledge

(Collins et al., 2017). In Finland, nurse managers possess various kinds of professional nursing backgrounds, and they usually have experience from clinical work and/or have specific education for management; unit level assistant nurse managers have a bachelor's degree and nurse managers have a master's degree. Hospital managers should ensure that nurse managers have sufficient support when transitioning from a clinician to a manager (Warshawsky et al., 2019).

2.6 Gaps in the knowledge of existing literature

There are some work-related factors that can predict nursing staff absences, such as length and type of shift (Rajbhandary & Basu, 2010), short rests between shifts (Vedaa et al., 2019), long shifts (Dall'Ora et al., 2019; Harris et al., 2015), working overtime (Han et al., 2015), increased psychosocial job demands (Roelen et al., 2018), leadership effectiveness (Schreuder et al., 2010) and working in a hospital environment (Rajbhandary & Basu, 2010). Overall, nursing staff absences are a daily phenomenon and difficult to predict. Float pool nurses (Hoffman & Sadovszky, 2018; Lebanik & Britt, 2015; Overman et al., 2014; Larson et al., 2012; Dziuba-Ellis, 2006), floating nurses (Garrison, 2018; Hoffman & Sadovszky, 2018; van Schingen et al., 2017; Good & Bishop, 2011) and supplemental staff such as agency nurses (Simpson & Simpson, 2019; Massey et al., 2009; Manias et al., 2003) are options used to cover sudden absences of nursing staff. In addition, unit nurses may be requested to work overtime (Min et al., 2019) or longer shifts (Stimpfel et al., 2012), or make sudden shift changes if other options are not available. Traditionally, nurse managers have handled the rescheduling process with paper-based methods, using phone calls, emails, in-person conversations and other tasks, such as contacting the deputy office manager to reach extra staff for the understaffed shift.

Even though rescheduling nursing staff on the shift-to-shift level is a daily task for nurse managers, there has been little research done on it in terms of nurse managers' decision-making and work. Nurse managers' decision-making, as a process during rescheduling has been described (Clark et al., 2016), but the specific tasks involved in rescheduling, how often it happens and how much time nurse managers spend rescheduling is still unknown. The assumption is that rescheduling is a time-consuming task for nurse managers. This study aims to streamline the rescheduling process with the use of an IT-based staffing scheduling solution. Previously, the use of IT-based staffing solutions for rescheduling and its outcomes have been scarcely studied. (Clark et al., 2016.)

There is also a need to understand the consequences of rescheduling on nursing staff, and examine how sudden absences of other nurses affect planned shifts, how often nurses must work overtime, change planned shifts or work unplanned long days, or cope with understaffed shifts. Nurses floating to another unit has been used

as an option for covering sudden absences (Garrison, 2018; Hoffman & Sadovszky, 2018; van Schingen et al., 2017; Good & Bishop, 2011). However, floating has not been studied in detail in terms of nursing staff experiences (van Schingen et al., 2017) This study adds new information on how the rescheduling of nursing staff is conducted from the perspective of nurse managers, how floating is related to nurses' experiences of stress, and how floating as a practice should be further developed.

3   Aim of the Study

The aim of this study is to evaluate how nurse managers in hospital settings handle sudden absences of nursing staff using an IT-based rescheduling solution, and examine nursing staff's experiences with floating. This study consists of three phases, described below.

Phase I: To identify the current IT-based rescheduling solutions for nursing staff's daily rescheduling (Paper I)

- What does existing literature reveal about the outcomes of IT-based rescheduling solutions for nursing staff, patients and organizations in terms of daily rescheduling? (Paper I)

Phase II: To pilot and implement an IT-based rescheduling system and to evaluate its outcomes from the perspectives of nurse managers and nursing staff (Papers II and III)

- How did the IT-based rescheduling solution affect nurse managers' work? (Papers II and III)

- How did the nurse managers evaluate the usability of the IT-based staffing rescheduling solution? (Paper II)

- How did the use of the IT-based rescheduling solution affect the nursing staff work scheduling? (Papers II and III)

Phase III: To evaluate nursing staff's experiences about floating (Paper IV)

- How did nursing staff describe the experience of floating shifts?

- What did nursing staff report about the association between stress and floating?

4 Materials and methods

4.1 Methodological approach

The methodological approach in this study is both qualitative and quantitative. First, qualitative methods were used to identify the outcomes of IT-based rescheduling solutions in a scoping review (Phase I). Second, quantitative methods were used with a quasi-experimental pre-and post-test design for capturing the nature of nurse managers work. The quantitative data was enriched with qualitative data by observing the task duration of nurse managers (Phase II). Last, quantitative methods were used to conduct a survey for nursing staff (Phase III). Multiple data collection methods were used in the literature review (Phase I), surveys (Phases II, III), usability evaluation and observation (Phase II). Data analysis was carried out using different techniques: quantitative statistical methods (Phases 1, II, and III) and qualitative content analysis (Phases I, II). The aims, methods and purposes of the designs of each phase are presented in Table 4.

4.2 Design and setting

Phases aims, methods and purposes of the design is presented in the Table 5. This study focused on the daily management practices of rescheduling nursing staff in hospital settings. The amount of nurse manager tasks was measured with a quasi-experimental pre- and post-test de-sign (Papers II and III). Nursing staff from four university hospitals' pediatric and adolescent medicine departments, and five central hospitals including adult and child care, were invited to participate in Phase IV. All hospitals included in this study provided inpatient care 24/7 as well as outpatient care.

Phase I: A scoping review was used to identify the IT-based rescheduling solutions for nursing staff's daily rescheduling in hospital settings, which determined the scope of the available literature (Levac et al., 2010; Arksey & O'Malley, 2005). Both quantitative and qualitative literature and studies were accepted in this review. The scoping review was carried out based on Arksey's and O'Malley's (2005) five-stage methodological framework for conducting scoping reviews: identifying the research

question, identifying relevant literature, study selection, charting the data and collating, summarizing and reporting the results (Paper I).

Table 4. Aims, methods and purposes of the design of each phase.

Phase	Phase aim	Methods	Purpose of design
Phase I (Paper I)	To identify IT-based rescheduling solutions for nursing staff daily rescheduling	Scoping review	Both quantitative and qualitative data (including grey literature) were used to gather results. Qualitative data (case reports) strengthened the results when a limited amount of qualitative or quantitative studies were available.
Phase II (Papers II and III)	To develop and implement an IT-based rescheduling solution for nursing staff's daily management	A quasi-experimental pre- and post-test study design was used in Papers II and III. In addition, observation was used in (Paper III).	The RTS was developed to identify nurse managers' rescheduling tasks, reasons for sudden absences of nursing staff and rescheduling outcomes (Papers II and III) and evaluate the usability of the IT-based rescheduling solution. Observation was needed to enhance a primary method for capturing the nature of nurse managers' daily work task duration during rescheduling of nursing staff (Paper III).
Phase III (Paper IV)	To evaluate nursing staff's experiences with floating	Survey study	A quantitative approach was used to identify associations of nursing staff's psychosocial factors of work, work-related stress and floating experience. The study design allowed the comparison of stress between nurses with and without floating experience.

Phase II: A quasi-experimental pre- and post-test pilot study design was used to gather the implementation results of nurse managers daily work tasks during rescheduling of nursing staff with a paper-based system and an IT-staffing solution (Papers II, III). The development of the IT-based rescheduling solution and the testing of the Rescheduling Task Survey (RTS) were conducted in one university hospital department that focused on children and adolescents (aged 0–16 years) care (Paper II). The data used in Paper III were collected from eight departments of one university hospital and one central hospital, both of which were responsible for children and adult care; the data was used to evaluate the IT-based staffing system (Paper III). Observation of the duration of nurse managers' tasks was conducted in the university hospital units, (n=3) (Paper III).

Phase III: Cross-sectional surveys were administered to evaluate nursing staff's experiences with floating. Moreover, associations between psychosocial factors of work and work-related stress were evaluated among nurses with and without experience of floating. Surveys were sent to the nursing staff of four university hospitals' pediatric and adolescent departments and five central hospitals responsible for both adult and child care (Paper IV).

4.3 Developing an IT-based rescheduling solution

The process of developing the IT-based rescheduling solution is described in detail in Paper II. The development of the IT-based solution was based on one organization's needs; the scheduling of float pool nurses and rescheduling of floating nurses had previously been managed using a paper-based system. All available shifts of float pool nurses were reserved from a printed scheduling list (Picture 1). When printed lists were available for reservation, all floating nurses were reserved almost as soon as it was possible. Floating nurses were allocated to a specific unit with paper-based methods, which relied on phone calls, emails and meetings. This was time-consuming for nurse managers and confusion was common. It became evident that there was a need to streamline the scheduling process of float pool nurses and the process of rescheduling the floating nurses. The expectations that were given for the new IT-based rescheduling solution are presented in Table 5 (Paper II).

Table 5.   Expectations for the new IT-based rescheduling solution.

The IT-based rescheduling solution should be easily integrated into the organization's HR systems, particularly into the shift scheduling program that has been used to schedule float pool nurses' shifts in a three-week rotation.
It should enable the booking of floating nurses and float pool nurses in the same solution.
It should be low-cost and offer cost savings for the organization.
It should be usable by nursing staff outside of office hours.
It should provide open data about the scheduling of float pool nurses and rescheduling of floating nurses.

Picture 1. Printed scheduling list (paper-based system) of float pool nurses.

The development process was carried out in collaboration with nurse managers from the pilot departments of Turku University Hospital, the Department of Nursing Science (Turku University) and the Development Manager from Fujitsu Finland. The role of nurse managers was to propose ideas for creating and modifying the IT-based rescheduling solution. This role can be defined in terms of end-user development (EDU): "EDU can be defined as a set of methods, techniques, and tools that allow users of software systems, who are acting as non-professional software developers, at some point to create, modify, or extend a software artefact." The role of end-users is remarkable, ensuring solution customization for the end-user's needs (Lieberman et al., 2006).

The development of the IT-based rescheduling solution for the scheduling and rescheduling of floating nurses and float pool nurses contains a Microsoft SQL server, a database management method with the central function of storing and retrieving data as requested by another software solution. Microsoft Excel was used as the user interface. The total cost of the development process was €27,000. The developed IT-based rescheduling solution does not have any license fees and it has its own budget in the organization, which covers the possible needs for updates (Tuominen et al., 2016). All nurse managers had the opportunity to participate in the education for end-users. The education included lectures about the solution's functions and usability, and the main rules for use of floating nurses were presented. In addition, end-users were sent the same information by email. If needed, end-users were given personal support from OT.

In the implementation phase (Paper II), improvements were made based on the nurse managers' feedback. Open access for both nurse managers and nursing staff,

as they were the end-users, was the main principle of the developed system. Existing solutions were intended only for nurse managers. All information related to resource management was available to the whole organization, staff and managers. The development process took six months, including the piloting phase. Based on given feedback by end-users, the third version of the IT-based rescheduling solution was accepted into daily use. The final version included options to book float pool nurses and floating nurses, an option to request extra staff and an option for nursing staff to volunteer for extra shifts.

The IT-based rescheduling solution contained the following data; 1) information about the booking unit and the name of the person who made the booking, 2) reasons for sudden staff absences: sick leave, other leaves of absence (paid or unpaid), competence level, high nursing intensity, annual leaves, education, and orientation, 3) the number of booked floating shifts per unit, 4) the number of unstaffed shifts and 5) the number of staff employed as temporary nursing staff. Figures 1 and 2 are presented as examples of data collected from one department. All saved information was dependent on the activity of end-users, as the developed IT-based staffing system did not collect data automatically from any database. The description of the IT-based rescheduling solution is presented in Paper III.
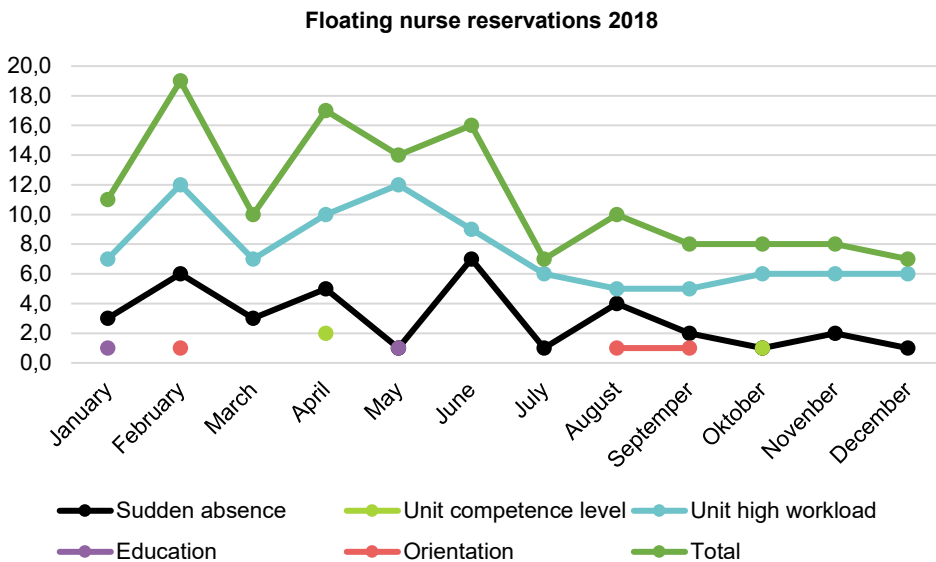

Figure 1. One department's actualized floating shifts with reasons for reservations in 2018.
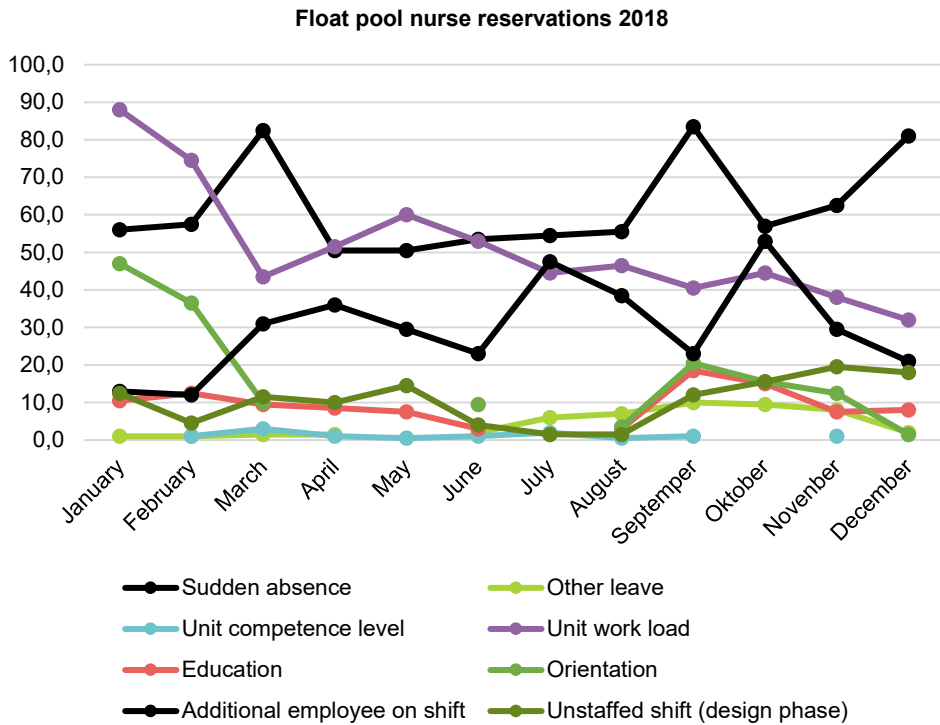
Float pool nurse reservations 2018

Figure 2. One department's actualized float pool nurse shifts with reasons for reservations in 2018.

4.4   Participants

The study participants were nurse managers and nursing staff. The role and responsibilities of nurse managers may have varied by organization, but they all had daily responsibilities to schedule and reschedule nursing staff. The selection of participants was done practically by inviting all recruited nurse managers from hospitals that had made the decision to implement the IT-based rescheduling solution, and all recruited nurses were from hospitals that used floating nurses to cover sudden absences of nursing staff. The nursing staff included RNs (n=1148) and licensed LPNs (n=158), working in all fields of specialized care, at inpatient or outpatient clinics. All nurses in this study had similar opportunities to be elected as floating nurses.

In **Phase I**, a scoping review consisted of all available literature and studies about IT-based rescheduling solutions in hospital settings. Moreover, the outcomes of the solutions were studied from the perspectives of nursing staff, patient care and organizations (CNA, 2012). The sampling included the following inclusion criteria: IT-based rescheduling solutions were implemented in real-life situations in a hospital environment, and the selected papers (n=10) included the use of float pool nurses

and/or floating nurses rescheduling. There were no limits as to the study design of the included studies.

The setup of **Phase II** is outlined in Table 6, including participants in piloting and collecting rescheduling tasks with the RTS (Paper II and III), evaluated usability of the IT-based staffing solution, and observation of the duration of rescheduling tasks (Paper III).

In **Phase III**, 1,457 (out of 4,454) nurses participate in the study that examined the association between stress, psychosocial factors of work and floating experience among nursing staff. However, 121 surveys were selected; surveys were excluded if they had more the one missing answer per survey (n=81) or if the participant was working in a profession other than nursing (n=61). The response rate was 32%. The study was conducted in four units of the university hospital's pediatric and adolescent departments and five central hospitals in Finland. The selection of participants was done practically by inviting the selected hospitals that regularly used floating nurses to cover sudden absence of nursing staff to participate.

Table 6. Participants in Phase II.

Steps	Number of participants	Additional information: organization's permanently employed staff
Piloting and collecting rescheduling tasks with the RTS (Paper II)	Nurse managers (n=8) and assistant nurse managers (n=9) from one university hospital department. Response rate 100%.	212 RN and 23 LPNs. The whole nursing staff was considered as floating nurses. In addition, 18 permanent float pool nurses worked in this department.
Collecting rescheduling tasks with the RTS (Paper III)	Nurse managers (n=47) and assistant nurse managers (n=14) from one university hospital and one central hospital. Response rate 34%.	The university hospital had eight service departments, 127 nurse managers, 1,395 RNs, 235 LPNs and 292 float pool nurses. The central hospital had three service departments, 54 managers, 664 RNs and 64 float pool nurses.
Usability test with SUS (Paper III)	Nurse managers (n=105) from one university hospital and one central hospital. Response rate 58%.	Same as above.
Observation of duration of rescheduling tasks (Paper III)	Ten Nurse managers (n=10) from one university level hospital were invited.	The university hospital had eight service departments, 127 nurse managers, 1,395 RNs, 235 LPNs and 292 float pool nurses.

4.5 Data collection instruments

In Phase I, the scoping review included a data extraction template for a data charting grid with the following information: authors, year of publication, study location, form of research, aim of the study, study population (floating nurses/float pool nurses), sample size (number of hospitals), number of beds and nursing staff (if available), used method for floating nurses and/or float pool nurses scheduling/rescheduling and key findings, and follow-up time. Outcomes of the review were presented using the Staff Mix Decision-making Framework as a systematic approach (CNA, 2012). In addition, the used method's (IT-based rescheduling solutions) data charting is described in Figure 3 (Paper I).
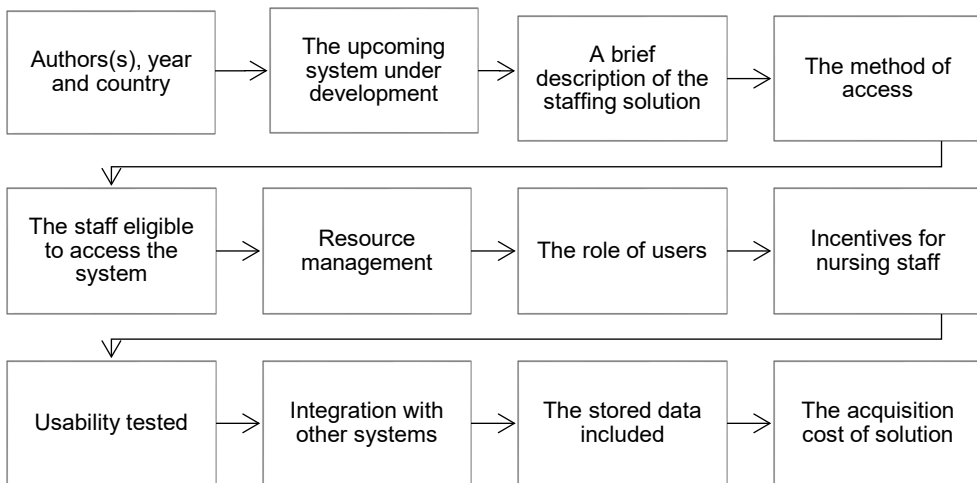
Figure 3. IT-based rescheduling solution's data charting.

In **Phase II**, a structured data collection, an RTS was developed and tested to identify nurse managers work tasks during the rescheduling of nursing staff due to sudden absences. With the RTS, nurse managers documented every task that they made to cover a sudden absence (Figure 4.). Documented tasks included conversations, phone calls, emails or other tasks (open question), reasons for sudden absences and how the sudden absences were covered (substitute nurse, float pool nurse, floating nurse or other option, unplanned long working day, sudden shift changes or unstaffed shift) (Papers II, III). An observation of nurse managers' work tasks was conducted by one observer using the RTS (Paper III).

Date	*Reason for absence	Phone calls						Emails						Conversations						Other arragments		Result of rescheduling	
		Unit own nurse	Float pool nurse	Nurse manager of float pool nurses	Nurse manager of other unit	Director of nursing	Other unit nurse	Unit own nurse	Float pool nurse	Nurse manager of float pool nurses	Nurse manager of other unit	Conversations	Other unit nurse	Unit own nurse	Float pool nurse	Nurse manager of float pool nurses	Nurse manager of other unit	Director of nursing	Other unit nurse	Notice board	Other, what:	**Yes 1/2/3	*** No 1/2/3
1.4	5									I												2	
3.4	1			I										II		I	I						3

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*Reasons for absence:
1) Sick leave, 2) Unplanned education day 3) Unit work load 4) Unit nurses' competence level 5) Other reason, what:
Results of scheduling Yes:
** 1) float pool nurse, 2) floating nurse 3) substitute nurse outside the organization
Results of scheduling No:
**** 1) Unplanned long working day, 2) Unplanned sudden shift change, 3) unstaffed shift

Figure 4. Rescheduling Task Survey.

Usability of the IT-based rescheduling solution was tested with the System Usability Scale (SUS). The SUS has been developed by Brooke (1996) and designed to measure overall usability. The SUS has good validity, reliability, and sensitivity (Brook, 2013; Bangor et al., 2009). The instrument has 10-items, with a Likert-scale ranging from 1 (strongly disagree) to 5 (strongly agree). For providing an estimate of overall usability, the instrument scores range from 0 to 100; scores higher than 70 are considered acceptable or good, and scores higher than 85 indicate a high level of usability. Usability is considered poor or unacceptable if scores are 50 or below (Paper III) (Brook, 2013).

In **Phase III**, three instruments were used. First, psychosocial and social factors of work were collected with the QPSNordic 34+. The QPSNordic 34+ is a short version of the General Nordic Questionnaire (QPSNordic) developed by Lindström et al. (2000). The QPSNordic 34+ consists of 37 items from the following subgroups: job demands and control, role expectations, predictability and mastery of work, social interaction with co-workers and clients, leadership, organizational climate, interaction between work and private life, work centrality, organizational commitment

and work motives. The questionnaire used a five-point Likert scale: items 1–21 and 27–30 from 1 "Very seldom or never" to 5 "Very often or always"; items 22–25 and 31–34 from "Very little or not at all" to "Very much"; items 35–36 from "Disagree totally" to "Agree totally". The QPSNordic 34+ was available in Finnish. (Lindström et al., 2000.)

The nursing staff's experience of stress was measured with the QPSNordic 34+ question (Q37), "Stress means the situation when a person feels tense, restless, nervous, or anxious, or is unable to sleep at night because his or her mind is troubled all the time. Do you feel this kind of stress these days?" The scale consisted of a five-point Likert scale, from "Not at all" to "Very much". (Lindström et al., 2000.) This single-item measure of stress symptoms is valid for measuring mental-well-being based on stress (Elo, 2003). For more in-depth answers concerning stress, we used the additional question, "If you answered yes, in which aspects of life is your stress: 1) working life, 2) health, 3) financial situation or 4) private life (family and close relationships)?"

Nursing staff Experience of Floating (NEF) was evaluated with an instrument that was developed by exploiting earlier research. The NEF is a self-assessment scale consisting of 21 five-point Likert scale items, from 1 "totally disagree" to 5 "totally agree". The NEF includes four subscales: rewarding, feedback and confidence, implementation of floating rules, implementation of a sense of security and the success of allocation. (Rantalainen, 2014.)

4.6   Data collection

In **Phase I**, the data of the scoping review (Paper I) was collected between April and December 2015 (updated in September 2016 and October 2019). The following nine electronic databases were used for the scoping review: PubMed, The Cumulative Index for Nursing and Allied Health Literature (CINAHL), Embase, Google Scholar, IEEE Digital Library, ProQuest, Scopus, the Web of Science and Wiley Online Library. In addition, manual techniques were used: reference lists of included studies and searches via websites of shift-bidding software companies.

The following search terms were selected to identify relevant papers: *personnel staffing and scheduling*, *personnel staffing and scheduling information*, *allocation staff**, *rescheduling staff** and *resource allocation**. MeSH terms were used if possible, in combination of the Boolean search terms, *AND* and *OR*, and wildcards (*). The search was limited to the years 2005–2015 and texts written in English. Two authors (OT, SB) independently screened abstracts (n=1013) and full texts (n=70). After a systematic study selection, ten papers, published between 2006–2016, met the inclusion criteria.

In **Phase II**, pre- and post-test data in the piloting phase was gathered between November 2012 and July 2013 from nurse managers (n=17), before implementing the developed IT-based rescheduling solution and again after its implementation, when the solution had been used six months in one university hospital pediatric and adolescent department. Each data collection (pre-test and post-test) was done over four-week period (Paper II).

In Paper III, pre-test data was collected between December 2014 and October 2015, and post-test data was collected from October 2015 to January 2016. The time between education and post-test was a minimum of four months and a maximum of seven months, based on each unit's decision to introduce and implement the new system. Data was collected from nurse managers (n=61) during four-week periods (pre-test and post-test) from one university hospital and one central hospital, which both offered care for children and adults. Data by observation was collected with an RTS as a structured observation list by shadowing nurse managers' (n=10) work one week during their shifts. The observer recorded the time that nurse managers spent on each rescheduling task, including conversations, phone calls, emails or other used methods (Paper III).

In **Phase III**, data collection was carried out using a web-based survey between April 2017 and December 2017. Variations in data collection times were based on when each organization decided to start collecting data. Nursing staff (n=1,336) from four university hospitals' pediatric and adolescent departments (n=476) and five central hospitals (n=858) including children and adult care in Finland participated in the study. A power analysis was calculated before the survey was administered; we wanted to detect a 0.4 mean difference between nurses with floating experience and nurses without floating experience, so we needed 64 subjects per group with an 80% statistical power and a 5% significance level (two-tailed). However, information on how much nurses actually floated was missing. Therefore, we conducted the study at several hospitals.

4.7   Data analysis

In **Phase I**, the included studies in the scoping review were analyzed with deductive analysis for testing previously presented categories, and the data was coded according to the categories to guide the decision-making of the staffing using the Staff Mix Decision-making Framework. The three decision-making themes were from the perspectives of patient care (in the original framework the term is *client care*), staff and organizational outcomes. All categories included five to seven sub-themes (CNA, 2012). In addition, Cambridge Online Dictionary (2011) was used to obtain accurate definitions of the outcomes.

During the process, two researchers independently coded the papers with the themes of the Staff Mix Decision-making Framework. The data analysis process included discussions between the researchers; modifying was done during the process to find a consensus. Outcomes were gathered in the tables in the results section. The studies included in the scoping review presented five IT solutions for nursing staff rescheduling. The functions of the solutions were analyzed, including open coding, creating categories and abstraction with twelve themes (Figure 4) (Elo & Kyngäs, 2008). To ensure the correctness of terms, a software engineer was consulted. Outcomes were presented on a grid. The quality of the studies was assessed with a critical appraisal tool (QATSDD) developed by Sirreyeh et al. (2012). The QATSDD contains 16 criteria scored on a scale from 0 (Not at all) to 3 (Complete).

In **Phase II**, the quantitative data from the RTS was returned anonymously. The nurse managers tasks were analyzed before and after the implementation of the developed IT-based rescheduling solution. The means were calculated for sum variables of the nurse managers' conducted tasks during rescheduling (phone calls, emails, conversations and other tasks based on the RTS). Descriptive statistics were presented as a percentage, mean and standard deviation (SD). Distribution of the RTS was not normally distributed, and it included multiple zero values due to the nature of the RTS. Therefore, a non-parametric Mann-Whitney U-test was used for the RTS. Chi-square test was used to compare the staffing outcomes before and after the implementation of the IT-based rescheduling solution. P-values less than 0.05 (two-tailed) were considered statistically significant. (Gray, Grove & Sutherland, 2017; Heikkilä, 2010.) SPSS Statistics 20, an IBM software package used for statistical analysis (IBM Corp. in Armonk, NY), was used for statistical reporting (Paper II).

The number of nurse manager tasks during the rescheduling of nursing staff's sudden absences were analyzed before and after the implementation of the developed IT-based rescheduling solution (Paper III). The survey included identifier information for pre- and post-measurements, so the dependence of these two measurements was taken into account in the statistical analyses. Descriptive statistics were presented as a percentage, mean and standard deviation for SUS (Paper III).

Continuous dependent variables, such as nurse managers' tasks, were completed using a hierarchical mixed linear model with a compound symmetry covariance structure. Measurements over time for a single nurse manager were considered repeated measurements. Time and location were included as categorical factors in all analyses. Statistical analyses of categorical dependent variables (e.g., absence rescheduling method) were performed using a hierarchical generalized linear mixed model. All categorical dependent variables were considered nominal; therefore, generalized logic was used as a link function in the model. The model was the same as

described above. A descriptive analysis was used to describe the duration of the re-scheduling tasks (Paper III).

Responses were excluded from the analyses if the pre- and post-test forms were not combinable due to missing or ambiguous identifier information. Altogether eight RTS forms were excluded from the study from the pre-test and six from the post-test. The statistical significance level was set at 0.05 in all tests (two-tailed). The quantitative data was analyzed using the SAS system, version 9.4, for Windows (SAS Institute Inc., Cary, NC, US) (Paper III).

In **Phase III,** continuous variables were presented with the mean and standard deviation (SD) or the median with lower (Q1) and upper (Q3) quantiles, and categorical variables with frequency and percentage distributions. Demographics variables were compared between general stress levels using the Kruskal-Wallis test for continuous variables and Fisher's exact test for categorical variables. The Kruskal-Wallis test was used when a variable did not follow normal distribution (Gray, Grove & Sutherland, 2017; Heikkilä, 2010). Association between psychosocial and social factors of work (The QPSNordic 34+) and specific stress questions were analyzed using Fisher's exact test (using Monte-Carlo estimates). Also, association between stress groups and level of stress for nurses with and without floating experience was analyzed similarly. Furthermore, the same method was used to study the association between the NEF items and stress levels. The descriptive analysis was used to describe nursing staff experiences with floating shifts during the last year. P-values less than 0.05 (two-tailed) were considered statistically significant. The analysis was performed using the SAS system, version 9.4, for Windows (SAS Institute Inc., Cary, NC, US). Internal consistency of the QPSNordic 34+ and NEF were evaluated by counting the Cronbach's alpha (Gray, Grove & Sutherland, 2017), with SPSS Statistics 24, an IBM software package (Paper IV). The analyses are summarized in Table 7.

Table 7. Analyses used in the study.

Phase	Outcome of interest	Analyses
I	IT-based rescheduling solutions outcomes for nursing staff, patients and organization	Themes were deductive, compiled with the Staff Mix Decision-Making Framework
	IT-based rescheduling solutions content from the perspective of daily rescheduling	Themes were inductive, complied under twelve themes
II	The number of nurse manager tasks before and after IT-based rescheduling solution (Paper II)	Mann-Whitney U-test
	The number of successful floating shifts, unscheduled shifts, unplanned shift changes, unplanned long working days, understaffed shifts and the number of substitute nurses before and after the IT-based rescheduling solution (Paper II)	Chi-Square and descriptive analysis
	The number of nurse manager tasks before and after the implementation of the IT-based rescheduling solution (Paper III)	Mixed linear model
	Reasons for sudden absences (Paper III)	Generalized linear mixed model
	The number of successful floating shifts, unscheduled shifts, unplanned shift changes, unplanned long working days, understaffed shifts and the number of substitute nurses before and after IT-based rescheduling solution (Paper III)	Generalized linear mixed model
	Usability of IT-based rescheduling solution and duration of rescheduling tasks (Paper III)	Descriptive analysis
III	Association between participants' demographics variables and stress levels	Kruskal-Wallis test and Fisher's exact test
	Association between psychosocial aspects of the work environment and stress	Fisher's exact test
	Association between floating experience and stress levels	Fisher's exact test
	Association between floating experience during last year and stress	Fisher's exact test
	Secondary analyses: Nursing staff's experience of floating	Descriptive analysis

Summary of the used materials and methods in Phases I, II and III are presented in Figure 5.
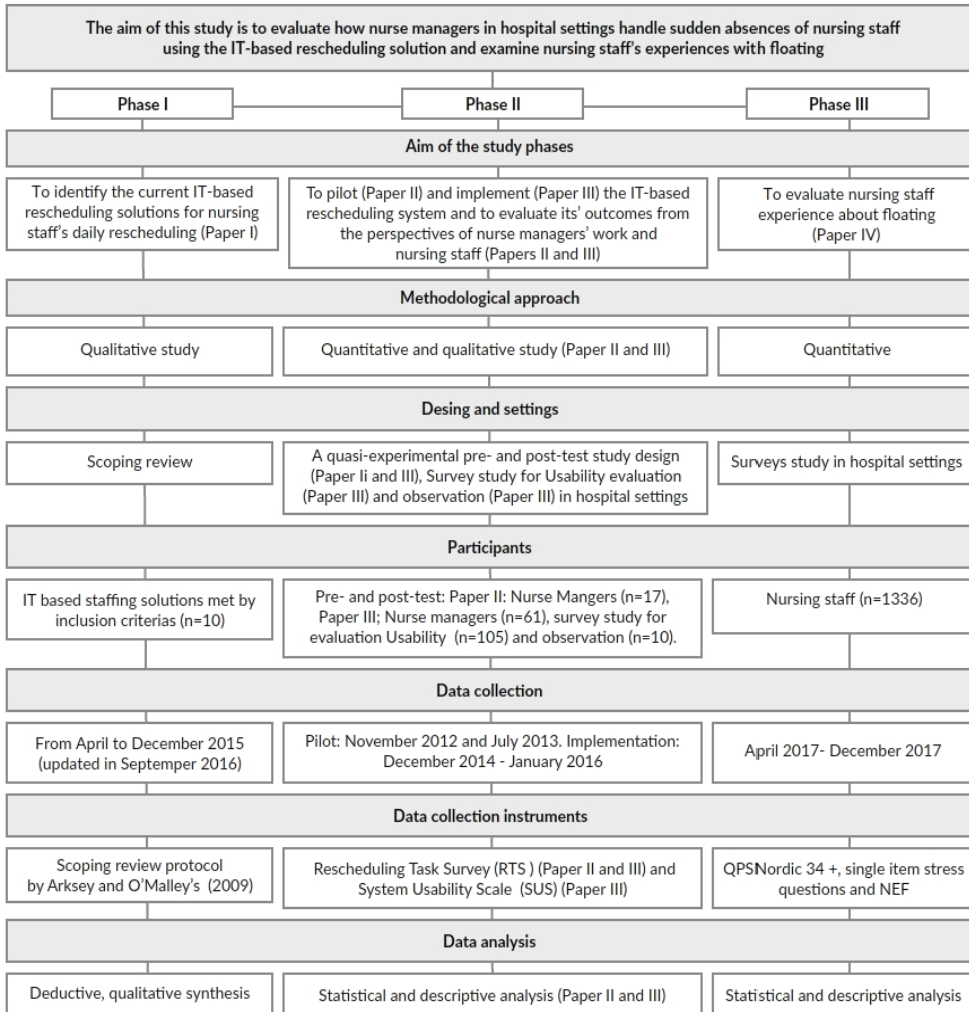
The aim of this study is to evaluate how nurse managers in hospital settings handle sudden absences of nursing staff using the IT-based rescheduling solution and examine nursing staff's experiences with floating		
Phase I	Phase II	Phase III
Aim of the study phases		
To identify the current IT-based rescheduling solutions for nursing staff's daily rescheduling (Paper I)	To pilot (Paper II) and implement (Paper III) the IT-based rescheduling system and to evaluate its' outcomes from the perspectives of nurse managers' work and nursing staff (Papers II and III)	To evaluate nursing staff experience about floating (Paper IV)
Methodological approach		
Qualitative study	Quantitative and qualitative study (Paper II and III)	Quantitative
Desing and settings		
Scoping review	A quasi-experimental pre- and post-test study design (Paper Ii and III), Survey study for Usability evaluation (Paper III) and observation (Paper III) in hospital settings	Surveys study in hospital settings
Participants		
IT based staffing solutions met by inclusion criterias (n=10)	Pre- and post-test: Paper II: Nurse Mangers (n=17), Paper III; Nurse managers (n=61), survey study for evaluation Usability (n=105) and observation (n=10).	Nursing staff (n=1336)
Data collection		
From April to December 2015 (updated in Septemper 2016)	Pilot: November 2012 and July 2013. Implementation: December 2014 - January 2016	April 2017- December 2017
Data collection instruments		
Scoping review protocol by Arksey and O'Malley's (2009)	Rescheduling Task Survey (RTS) (Paper II and III) and System Usability Scale (SUS) (Paper III)	QPSNordic 34 +, single item stress questions and NEF
Data analysis		
Deductive, qualitative synthesis	Statistical and descriptive analysis (Paper II and III)	Statistical and descriptive analysis

Figure 5. Summary of the used materials and methods.

4.8 Ethical considerations

Research ethics were considered at each stage of the study, from the planning of the study to the reporting of the results (TENK, 2012). Research permissions was obtained from the institutions participating in the research used in this doctoral thesis (Phases II, III). In addition, ethical approval was granted by the Joint Commission

on Ethics of Hospital district of Southwest Finland for Phases II and III. The permission to use the instruments in this study (NEF) was given by the instrument owner. Other used instruments (SUS and QPSNordic 34+) were free to use without permission. This study did not directly involve patients and did not include particularly vulnerable groups at any stage.

The data was collected before the General Data Protection Regulation (GDPR) came into full effect on May 25, 2018. The GDPR sets the rules for handling information relating to research participants; however, the GDPR did not change the legal requirements for autonomy and privacy of research participants when research data includes confidential information. Collected data is personal data, as long as participants can be identified by the data; therefore, data should be pseudonymized or anonymized as soon as possible, and researchers should collect personal data judiciously. The GDPR ensures an individual's right to, for example, request the removal of personal data or to be made aware of how and for what purpose his personal data are processed. To protect the confidentiality of research data in this study, the collected data from the RTS in paper format were transferred to Microsoft Excel and stored securely on a memory stick, which was stored in a locked cabinet. The data was coded with ID-numbers for anonymity. The original RTS questionnaires were disposed of as printed confidential waste. Collected data via the online surveys (SUS, QPSNordic 34+, single item stress question and NEF) were coded with ID numbers for anonymity and stored securely on a memory stick. Results of the questionnaires have been disposed of using a web-based data collection platform. Individuals cannot be identified from the reported outcomes.

Written informed consent was not requested separately, but responding to the questionnaire was considered to be informed consent. The cover letter for participants provided the knowledge needed for informed consent by stating the purpose of the study, how long participation would last, who was involved in the study, the procedures involved, how participants' data would be managed and contact details, and by encouraging participants to ask if they had further questions. Participants were free to withdraw from the study at any time without explanation (TENK, 2012).

Participants could ask questions during the study. Three participants did so in Phase II; each question concerned nurse managers' tasks. Participants wanted to discuss their tasks to ensure that they were marked correctly the RTS. In Phase III, one participant wanted confirmation that gender would not be able to be identified in the study results.

Ethically acceptable research should report sources of financing, conflicts of interest or other commitments relevant to the conduct of research to all members of the research project and when publishing the research results (TENK, 2012). All listed authors have made useful contributions during the process and are listed as authors in the studies in order of their contributions. The primary data (Phases I–III)

have only been published once. Required citations have been made carefully throughout the studies to avoid plagiarism, and the results have been carefully documented.

The IT-based rescheduling solution was developed in collaboration with one pilot department from Turku University Hospital, the Department of Nursing Science (Turku University) and the Development Manager from Fujitsu Finland. This research did not benefit financially or otherwise from the collaboration. The costs of the developed IT-based rescheduling solutions were covered by the Turku University Hospital's IT budget. Phase I included a description of the rescheduling solutions. These solutions are available in the inclusion and exclusion criteria of this study; these rescheduling solutions should not be preferred over other similar methods.

From an ethical perspective, the effect of my role as a researcher on the study must also be considered. For practical reasons, this study began in the researcher's own organization department, where I was an assistant nurse manage. My role as a researcher was an insider-expert among the other nurse managers in the developing phase of the IT-based rescheduling solution. During the data gatherings in Phase II, nurse managers voluntarily participated in developing and testing the RTS. Data were collected without any personal details, and participants could not be identified from the data in the development stage (Paper II). These nurse managers (n=17) did not participate in the data collection later in the study. The later quantitative data were collected form four University level hospitals departments for children and adolescents and five central hospitals that cared for children and adults (Paper III). This also included nursing staff from my own hospital department. Nurses had the right to decide if they want to participate in the study. The response rate (65%) was highest in this department. It is unclear whether active participation was due to my influence of the researcher or the participants' interest in the research topic, which has not been previously studied.

5   Results

The results of this thesis are presented according to the three phases of the study: a review of IT-based rescheduling solutions for the daily rescheduling of nursing staff; the development and implementation of an IT-based rescheduling solution, an evaluation of nurse managers' work during the rescheduling process and outcomes of the IT-based rescheduling solution; and nursing staff's experiences with floating. In addition, a summary of the main findings is presented for supporting the management of sudden absences of nursing staff in hospital settings.

5.1   IT-based rescheduling solutions for the daily rescheduling of nursing staff

The aim of Phase I was to identify IT-based rescheduling solutions for the daily rescheduling of nursing staff and to describe nursing staff's rescheduling outcomes (Paper I).

The five presented IT-based rescheduling solutions were all suitable for the rescheduling of nursing staff on a shift-to-shift level (Figure 6). Based on the results of the scoping review, the development of all solutions was described on a general level; all hospitals had used a paper-based system for rescheduling (phone calls, meetings, etc.) before the implementation. For the most part, end-users were satisfied with the use and usability of the presented solutions, even though actual usability tests were not presented in any of the papers. A detailed description of the IT-based rescheduling solutions is presented in Paper I.
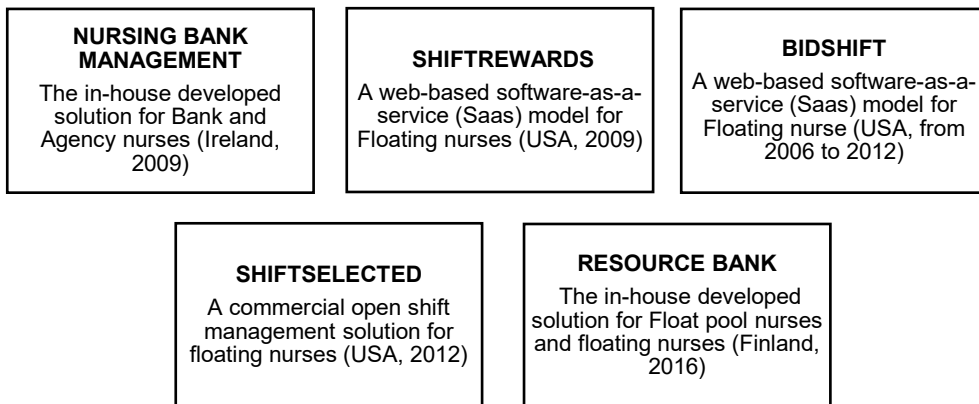
Figure 6. Five identified IT-based rescheduling solutions.

The results showed that the rescheduling outcomes have been scarcely studied in terms of patients, nursing staff and organizational outcomes. In this study, the results were presented by adapting the Staff Mix Decision-making Framework outcomes as a guide for the results (CNA, 2012). Quality assessments were done with the QATSDD (Sirreyeh et al., 2012) on ten papers. Criteria were scored on a scale from 0 to 3 (0 = not at all, 1 = very slightly, 2 = moderately, 3 = complete). The maximum score of the quantitative and qualitative studies was 42. In our review, the average of the studies was 9.3 (out of 42), which shows their low quality.

While it is known that understaffing has significant consequences for patients, it was the least studied outcome of rescheduling of nursing staff. Papers focused on the quality of care under the assumption that the employee information (e.g., skills and experience) was a sufficient measurement of positive patient outcomes (Valentine et al., 2008; Brown, 2007; Kulma & Springer, 2006; Notarantonio, 2006). The other outcomes included quality of life, satisfaction of care. The continuity of care and the care provider were not mentioned. Nursing staff outcomes occurred more frequently, but with an emphasis on quality of nursing staff's work life in terms of satisfaction of work life (Ramsey-Coleman, 2012; Lackey, 2009; Valentine et al., 2008; Brown, 2007; Ellerbe 2007; Kulma & Springer, 2006; Notarantonio, 2006) and satisfaction with floating (Ramsey-Coleman, 2012). Overtime (Tuominen et al., 2016; Ramsey-Coleman, 2012; Brown, 2009) and illness (Tuominen et al., 2016; Valentine et al., 2008; Notarantonio, 2006) were reported as negative. However, the lower turnover rate was reported, after IT-based rescheduling solution was implemented. The usability of the IT-based rescheduling solution was mentioned once, usability was tested but the results were not described (Brown, 2007).

The outcomes focused mainly on organizational outcomes: nurse managers' span of control, human resource costs, quality of work environment, evidence-informed practice, safety and quality of care or unit-level costs. All studies that were included referred to the access to rescheduling solutions and nurse managers' span of control. Rescheduling was more easily managed via IT-based solutions (Tuominen et al., 2016; Ramsey-Coleman, 2012; Brown, 2009; Lackey, 2009; Williams, 2009; Valentine et al., 2008; Ellerbe, 2007; Brown, 2006; Kulma & Springer, 2006; Notarantonio 2006). Nine papers out of ten mentioned human resource cost savings, but only one study presented how the cost savings were calculated (Tuominen et al., 2016; Ramsey-Coleman, 2012; Brown, 2009; Lackey, 2009; Williams, 2009; Valentine et al., 2008; Ellerbe, 2007; Brown, 2006; Notarantonio 2006). All selected papers described that changing from a paper-based method to an IT-based solution saved nurse managers time and made the process of covering sudden absences of nursing staff more effective (Tuominen et al., 2016; Ramsey-Coleman, 2012; Brown, 2009; Lackey, 2009; Williams, 2009; Valentine et al., 2008; Ellerbe, 2007; Brown, 2006; Kulma & Springer, 2006; Notarantonio 2006). However, exact details of how time was saved were missing from each paper; one paper revealed that nurse managers saved about one hour per day, and on a weekly level, up to four to five hours (Valentine et al., 2008). Evidence-informed practice, safety and quality of care and unit-level costs were not mentioned at all. A detailed summary of the conclusions about the outcomes for patients, nursing staff and organizations is presented in Paper I.

Since the review was conducted 2005–2016, the search was updated, for 2017–2019. The update was conducted as the original review in Paper I (search terms, databases, inclusion and exclusion criteria) (see more details in Paper I). Altogether 308 papers were screened through the databases CINAHL (n=35), Embase (n=1), Google Scholar (n=177), IEEE Digital Library (n=30), PubMed (n=48), Scopus (n=13), the Web of Science (n=2) and Wiley Online Library (n=2). The updated search did not produce any new outcomes.

5.2 Outcomes of piloting and implementation of the IT-based rescheduling solution

The aim of Phase II was to implement a developed IT-based rescheduling solution for the daily management of nursing staff (Papers II and III). The adaption and use of the IT-based rescheduling solution was conducted in one university hospital's department (Paper II). The implementation included an educational part, which was conducted in close collaboration with solution developer and department's nurse managers (n=17). In addition, nurse managers made rules for using the solution and also for the use of float pool and floating nurses in daily rescheduling; the rules have

been updated four times throughout the course of this research. These rules benefitted nurse managers as well as staff nurses during evenings, nights and weekends. The rules for daily rescheduling included a part about the use of float pool nurses and floating nurses, specifically, when and what kind of absences could be covered with these groups of nurses. The baseline, which was later called *paper-based method*, was described carefully (see more details in Paper II). At baseline, nurse managers rescheduled nursing staff via paper scheduling lists and the following tasks: phone calls, emails and meetings with other nurse managers and unit nurses (more information in Figure 8) (Paper II).

Table 8. Comparison of two rescheduling processes (Paper II).

	Notice of sudden absence	Checking available float pool nurse or floating nurse	Ensuring available float pool nurses or floating nurses	Covering sudden absence
Baseline: Paper-based rescheduling	Via phone calls, emails, conversations or other arrangements	Paper scheduling lists available in one unit nurse manager's office	Yes: Via phone calls, emails, conversations or other arrangements	Every third absence was covered with a float pool nurse or floating nurse in the implementation phase
IT-based rescheduling	Via phone calls, emails, conversations or other arrangements	IT-based solution: available in every nurse manager's office	No: or occasionally via phone calls, emails, conversations or other arrangements	Every second absence was covered with a float pool nurse or floating nurse

The RTS was developed for this study based on the nurse managers (n=17) input, i.e., what tasks they did during the rescheduling process of nursing staff (Paper II). The selected tasks were phone calls, emails, conversations and other tasks such as messages via social media for available nurses. Nurse managers used the RTS to report the reasons for sudden absences of nursing staff: sudden sickness, unplanned education, workload, competence level or other reasons. In addition, nurse managers reported how the sudden absences were covered: the use of float pool nurse, floating nurse, unplanned long shift, shift changes, unstaffed shift or the use of a temporary nurse from outside the organization (Papers II and III).

Nurse managers (n=17) reported 121 absences at baseline, and after the implementation of the IT-based rescheduling solution, 106 absences (Paper II). The data collection lasted for four weeks for both systems. Seventy percent of absences were due to sick leave. It turned out that the paper-based method was a time-consuming way to manage nursing staff rescheduling on a shift-to-shift level compared to the

IT-based rescheduling solution. The maximum number of tasks was 19 per one absence using paper-based method. During the use of IT-based method, the maximum number of tasks decreased significantly (p=0.022), dropping to only 8 task per absence. On average, it took approximately 2.71 tasks with the paper-based method and 1.56 tasks with the IT-based rescheduling solution to resolve a need for substitute staff. All tasks (phone calls, emails, conversations and other tasks) were used with both systems. The use of emails (p=0.023), phone calls (p=0.013) and other tasks (p=0.035) such as text messages decreased significantly. Conversations (p= 0.090) were still used took place mainly between the unit's nurses, unlike phone calls and emails, which were between nurse managers (Paper II). Figure 7 shows how the tasks were allocated between professionals.
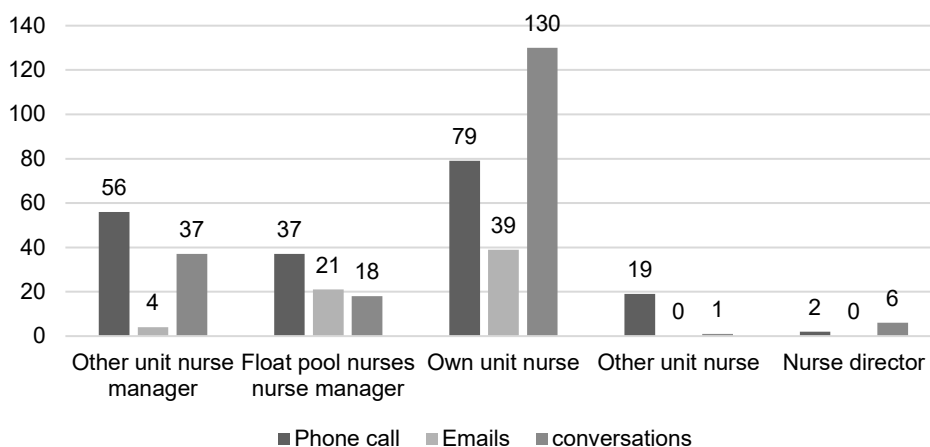
Figure 7. Rescheduling tasks handled by different professions (Paper II).

The results of the implementation phase show that the IT-based rescheduling solution can positively affect the use of float pool and floating nurses; unstaffed shifts decreased significantly (p=0.004) during the implementation. However, the unplanned long working shifts (p=0.766) and sudden shift changes (p=0.236) were still used as a way to cover sudden absences. The implementation phase verified that the developed solution was useful for the rescheduling of nursing staff in organizations that used float pool nurses and floating nurses to cover sudden absences of nursing staff. Also, the RTS was shown to be a useful method for gathering details about the rescheduling process. However, after the implementation, one reason for sudden absence was added: unplanned short annual leave (Paper III.) After the implementation of the IT-based rescheduling solution was successful, the use of the IT-based rescheduling solution expanded to one university hospital and one central hospital,

including the educational part for nurse managers. Voluntary nurse managers (61 out of 181) were recruited to gather rescheduling information to strengthen the results of the development and implementation, especially the number of and reasons for sudden absences of nursing staff and the rescheduling tasks of nurse managers (Paper III). The main findings are presented in Figure 8.
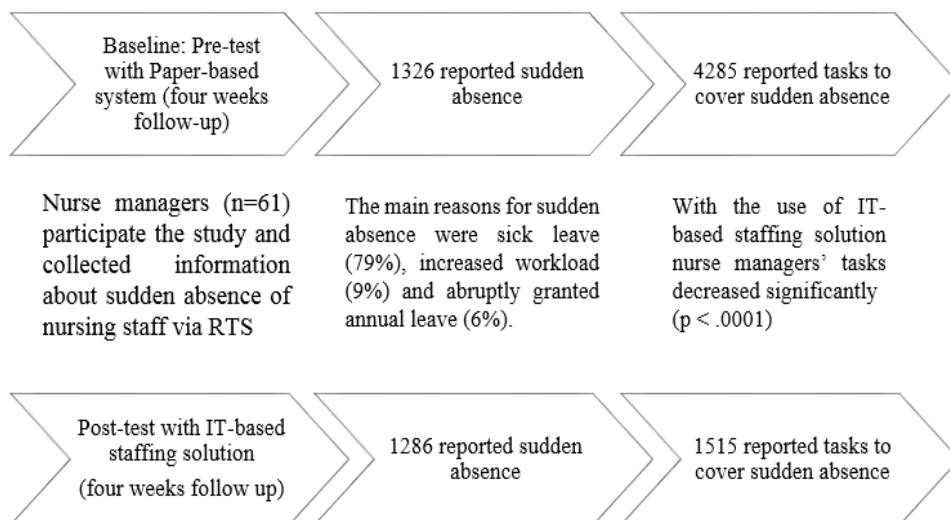

Figure 8. Main results of rescheduling nursing staff with the IT-based rescheduling solution.

It took approximately 3.2 tasks at baseline and 1.2 tasks with the IT-based rescheduling solution for nurse managers to cover a sudden absence. In addition, ten nurse managers were observed over a one-week period, using the RTS report's duration. One task took approximately 3 minutes and 48 seconds, but waiting times between the tasks took approximately 20 minutes and 30 seconds. Taking into account the duration of the tasks and waiting times between tasks, it took approximately 1 hour, 12 minutes and 9 seconds to cover one absence with the paper-based system. With the IT-based rescheduling solution, rescheduling took 24 minutes and 18 seconds in total. In this study, nurse managers solved approximately one absence per working day. This means that on a weekly basis, they would save approximately four hours of working time, and two working days per month. This is a significant amount of saved working time, which can be used for other management activities (Paper III).

The outcomes (Paper III) were also studied in terms of how the sudden absences were covered. It seems that after the implementation of the IT-based rescheduling solution, unstaffed shifts (p<.0001) and unplanned shift changes (p< .0001) decreased statistically significantly, and the use of float pool nurses (p< .0001) and

floating nurses (p< .0001) intensified significantly. However, there was no statistical significance regarding unplanned long working days (p=0.129) or the use of substitute nurses (p=0.539). The use of floating nurses increased with the IT-based rescheduling solution, from 52 to 146 shifts. One floating shift can save a hospital approximately €161 (£137.20) in salary costs. In this study, altogether 198 floating shifts were actualized, 146 of them after the implementation of the IT-based staffing system. Altogether €31,878 was saved during the pre- and post-test, more specifically, €23,506 was saved with the IT-based rescheduling solution during the four-week follow-up period (Paper III).

The usability of the staffing solution in Phase III was evaluated with the System Usability Scale (SUS). All potential participants (n=181) were recruited, and 105 nurse managers participated. The response rate was 58%. The usability score ranged from 76 to 100, showing good usability in both organizations. Even though the usability was estimated to be good, users (n=12) pointed out that the IT-based rescheduling solution was only available at the workplace, and it would be an advantage if it were a browser-based system and could be accessed from home as well (Paper III).

The results of Phase III prove that the use of a IT-based rescheduling solution for rescheduling of nursing staff is a valid option over a paper-based system. The implementation of the IT-based rescheduling solution had positive outcomes for nursing staff, nurse managers and organizations (Papers II and III). From a nursing staff perspective, unstaffed shifts (p< .0001) and unplanned shift changes decreased (p< .0001), and the use of float pool nurses increased statistically significantly (Paper III). These changes can positively affect the well-being of nurses. At the same time, the number of floating shifts (p< .0001) increased significantly (Paper III). For nurse managers, IT-based rescheduling solutions provide an opportunity to streamline the rescheduling process. There are also possibilities for cost savings; during the short follow-up period, savings were achieved by using floating nurses to cover sudden absences of nursing staff instead of substitute nurses from outside the organization (Papers II and III).

5.3   Nursing staff's experiences with stress and floating

Nursing staff's experiences of stress were evaluated with a single item stress question from the QPS Nordic 34+ (Lindström et al., 2000) and with four specifying questions about stress from 1,336 nurses. Experiences of floating were evaluated with the NEF (Rantalainen, 2014). During the last year, 69.7% of nurses (n=746) had had floating experience. The mean age of participants was 42 years, and 55% had over 15 years of work experience. Distribution of nurses working with children (40%) and those working with adults (45%) was similar, and 15% of the nurses

(n=195) reported that they worked with adults and children. It was possible to select several working units. The selected working units are presented in Figure 9. Of the participants, 79% (n=823) reported floating as a mandatory practice in their organization (See Paper IV).
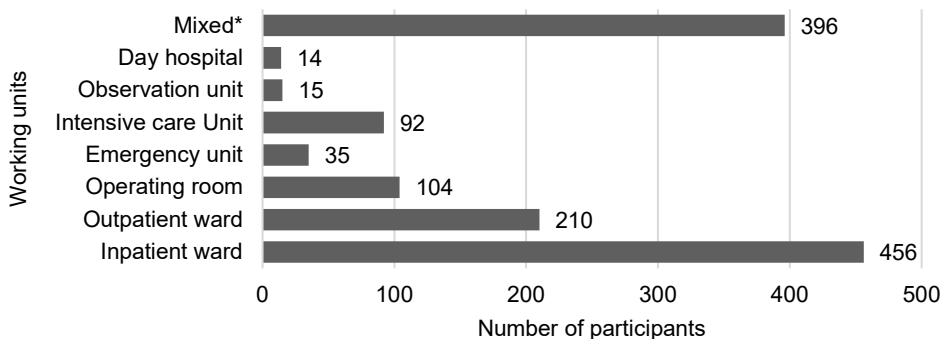

Figure 9. Participants' working units.

Psychosocial factors of work were measured with the QPS Nordic 34+ (Lindström, et al., 2000). The following subgroups were associated (p=<0.0001) with experience of stress: job demands and control of work, role expectations, predictability and mastery of work, social interactions, leadership, organizational culture and climate, interaction between work and private life, organizational commitment and work motives. Only positive challenge of work (p=0.4902) and given support from friends and relatives (p=0.0689) as items were not associated with stress. From the nursing management's perspective, nurse managers can affect nurses' experiences of stress in several ways, for example, supporting nurses more, focusing on nurses' job satisfaction and ensuring the role clarity of nurses (Paper IV).

The main outcome of this phase was that reported experience of stress did not differ significantly between participants with or without floating experience (p=0.626). Both groups experienced similar amounts of stress. However, 253 (20%) participants reported rather much or very much stress, and 346 (30%) participants reported rather much or very much work-related stress. Work-related stress occurred more often than the other stress groups, which included close relationships related stress, health related stress and financial related stress (Paper IV).

Reported stress was higher when nurses were employed as temporary staff (p= 0.030) or floating based on mandatory practice (p=0.002). In addition, more stress was reported when participants had only 1–3 floating shifts during last year (p= 0.0018). There was no significant association between stress and if participants had

had experience of work rotation (p= 0.163) or which unit they worked (p=0.436). However, there were differences: 27% of intensive care unit nurses (n=25) reported rather much, and 4% very much, stress. At the same time, 10% of operation room nurses (n=10) reported rather much, and 3% very much, stress (Paper IV).

Nursing staff's experiences with floating shifts (during the last year) are presented in Table 8. Participants reported positive outcomes about floating (from 4 partially agree to 5 totally agree), for example, 84.7% of floating nurses (n=574) were treated kindly during a floating shift. Help was available for floating nurses (n=508) during 74.1% of their floating shifts, 73.2% felt that patients benefited from the given care by floating nurse (n=499) and 71.6% of floating nurses (n=492) reported that their home unit's staffing allowed the floating shift. In addition, 60% of floating nurses (n=415) reported that floating nurses had sufficient competence for floating. On the other hand, nurses also reported negative outcomes, such as (from 1 totally disagree to 2 partially disagree) 58.6% of floating nurses (n=393) did not receive a short orientation. Also, 52.3% felt that the equipment and supplies were not easy to find for floating nurses (n=359) in another unit and 52.8% felt that information about the floating shift was given too late, from the perspective of a floating nurse (n=358) (Paper IV).

Table 9. Nursing staff experience of floating shifts based on results of the NEF.

Questions	Total		1	2	3	4	5	n
	Mean	SD	%	%	%	%	%	
Floating was agreed upon fairly	3.5	(1.2)	5.1	20.6	17.5	32.9	23.9	687
Information about floating shift was given in due time to the nurse	2.7	(1.4)	25.6	27.2	14.4	20.6	12.2	688
Home unit staffing allow the floating	3.9	(1.1)	2.7	14.1	11.6	34.0	37.6	688
A short orientation was given.	2.5	(1.4)	33.9	24.7	11.3	19.3	10.8	687
A shift report was given.	3.6	(1.4)	9.7	18.9	9.5	28.9	33.0	682
The floating nurse had a named work pair.	3.6	(1.4)	9.7	10.0	10.7	25.4	35.2	684
The floating nurse was treated kindly.	4.2	(0.9)	0.6	6.7	8.4	37.1	47.2	687
The workload was equally divided.	3.8	(1.1)	3.2	13.7	18.2	33.7	31.2	686
Equipment and supplies were easy to find in another unit.	2.7	(1.2)	16.6	35.7	16.6	24.8	6.3	686
Daily information was easy to find in another unit.	2.8	(1.1)	10.5	35.3	23.5	22.7	8.0	686
Patient care instructions were easy to find in another unit.	2.8	(1.1)	10.3	32.3	27.5	23.7	6.2	680
Help (when needed) was available.	3.9	(0.9)	1.2	10.3	14.4	48.7	25.4	686
The floating nurse's competence were sufficient.	3.5	(1.1)	5.0	17.0	18.0	43.0	17.0	683
Was the floating shift necessary in another unit?	3.6	(1.1)	4.4	15.9	17.9	39.8	22.0	686
Did the patients benefit from given care during float shift?	3.9	(0.9)	1.5	6.6	18.8	48.4	24.8	682
Positive feedback about floating shift was given by supervisor.	2.9	(1.3)	22.0	14.5	28.8	23.3	11.4	683
Positive feedback about floating shift was given by (home unit's) colleagues.	2.7	(1.1)	20.5	17.5	39.2	17.9	4.9	678
Positive feedback about floating shift was given by another unit's staff.	3.6	(1.1)	6.0	7.1	23.9	43.5	19.5	681
Floating standards were developed from floating experience feedback.	2.5	(1.1)	24.9	18.0	43.5	11.4	2.2	682
The floating nurse felt trusted and appreciated	2.9	(1.3)	20.7	13.3	30.2	26.3	9.5	685
Monetary incentives were given.	1.6	(1.2)	75.4	5.4	7.6	6.4	5.3	684

*The scale used a 5-point Likert scale from 1 (totally disagree) to 5 (totally agree).

Associations between nursing staff experiences of floating and stress were measured by using the NEF, only from the nurses that reported experience of floating shifts during last 12 months. Altogether 17 items out of 21 were associated with experience of stress. Even though there was no association between stress and floating, floating

as a practice stressed nurses. When nurses had gotten positive feedback from the nurse managers, they experienced less stress (p= 0.0002). Nurse managers can also ensure that floating shifts are agreed upon fairly between nurses and distributed fairly (p=0.0140), and that units have the necessary information available for floating nurses, such as daily information about the unit's routines (p=0.007) or patient care instructions (p=0.0001). In this study, the experience of floating during last year and stress were not associated with having an orientation during the floating shifts (p=0.050), being given a shift report (p=0.4957) or if floating nurse felt that it was necessary to do the floating shift in another unit (0.1394). Floating shifts were not linked with the experience of trustworthiness or appreciation (p=0.1502) (Paper IV).

5.4 Summary of main findings of rescheduling nursing staff

The main findings of this study are discussed below.

Based on the results of the scoping review, IT-based rescheduling solutions are used to manage daily rescheduling staffing in hospital settings. IT-based rescheduling solutions could streamline the rescheduling process and could reduce an organization's staffing costs and nurse managers' work tasks during rescheduling. However, there are still significant limitations of knowledge: nursing staff rescheduling outcomes need further study, particularly regarding patient care outcomes and nursing staff's experiences about floating. There is also a need to study IT-based staffing solutions' usability as well as long-term cost savings.

The developed and implemented IT-based rescheduling solution for the rescheduling nursing staff streamlined the rescheduling process by decreasing nurse managers' work tasks and improving rescheduling outcomes such as fewer unstaffed shifts. The use of float pool nurses and floating nurses became more efficient, and this reduced staff costs. The usability of the IT-based staffing solution was good based on the evaluation by the nurse managers.

Having floating experience was not associated with any types of stress among nursing staff. Both floating and non-floating nurses experienced similar amounts of stress. Nurses has several stressors in their work. Floating is one stressor for nurses, even if it does not generate experiences of general stress. Nurse managers have a significant role in promoting nurses' work-related well-being. To promote successful floating experiences, nurse managers should ensure that nurses receive a short orientation to the unfamiliar unit, a named work partner during the floating shift, written introductions for patient care, and that nurses with previous experience in the unit are chosen if possible. In addition, nurse managers should give positive feedback to floating nurses to reduce nurses' experience of stress.

6 Discussion

6.1 Rescheduling nursing staff with IT-based rescheduling solutions

The scoping review was carried out to identify the current state of IT-based rescheduling solutions for nursing staff that have been studied. The review demonstrated the lack of evidence that focuses on rescheduling nursing staff in hospital settings, even though adequate staffing has been an interest of researchers (Griffiths et al., 2018; Cho et al., 2016). Previous studies show that inadequate staffing levels can have negative, even fatal, consequences for patients (Jansson et al., 2019; Ball et al., 2018; Driscoll et al., 2018; Recio-Saucedo et al., 2018; Liang et al., 2012; Xue et al., 2012). Consequences for nursing staff include work-related injuries (Hosseinabadi et al., 2019; Unruh & Asi, 2018; Stimpfel et al., 2012; Trinkoff et al., 2003) and intention to leave the organization and profession (Burmeister et al., 2019; Moloney et al., 2018; Leone et al., 2015; Stimpfel et al., 2012). Consequences at the organization level are mainly described through the economic consequences of inadequate staffing (Arefian et al., 2017; Burns et al., 2016) or through a hospital's reputation (de Cruppé & Geraedts, 2017; Mira et al., 2014).

Based on the strong evidence of negative outcomes for patients when there is inadequate staffing (Jansson et al., 2019; Aiken et al., 2018; Ball et al., 2018; Driscoll et al., 2018; Griffiths et al., 2018; Recio-Saucedo et al., 2018; Peršolja, 2018; Liang et al., 2012; Xue et al., 2012), it is noteworthy that research on rescheduling nursing staff with IT-based rescheduling solutions did not present any studied patient-related outcomes, such as quality of life, satisfaction of care, continuity of care or care provider. Also, outcomes for nursing staff and hospitals were mainly described on a general level, and not directly studied.

Remarkably, rescheduling of nursing staff with IT-based solutions has scarcely been studied. Still, the results of this study support the assumption that the use of IT-based rescheduling solutions may streamline nurse managers' daily work during the rescheduling of nursing staff, even though strong evidence is lacking.

6.2 Development and Implementation of an IT-based rescheduling solution

The IT-based rescheduling solution was developed in close collaboration with one university hospital department's nurse managers as experts (Paper II). Based on the nurse managers' feedback, the developed solution was suitable for nursing staff rescheduling. At the time, there were no equivalent solutions for nursing staff rescheduling on the market that were meant to be used by nurse managers and nursing staff to manage both floating nurses and float pool nurses outside of the office.

In this study, the baseline was described with a pre-test including all tasks performed by nurse mangers. This study clearly demonstrates that phone calls, emails, conversations and other tasks were used during the rescheduling process (Valentine et al., 2008; Kulma & Springer, 2006). During the piloting phase (Paper II), time-saving was highlighted in a comparison of the amount of tasks involved in nurse managers' rescheduling process at baseline and during the use of IT-based rescheduling solution. Similar to that of other studies, the results show that the number of tasks between the pre- and post-test decreased significantly (p=0.022). Still, phone calls, emails, conversations and other tasks were used with both rescheduling systems.

This is the first time that the daily rescheduling tasks of nurse managers has been described at this level of detail. By using the IT-based rescheduling solution, nurse managers can save the equivalent of up to two working days per month, if they reschedule one absence every working day. The saved time can be used performing other activities. This is a clear advantage as nurse managers usually work with tight schedules and are responsible for too much work due to high numbers of employees or duties (Lyly-Yrjänäinen, 2018).

Besides the number of tasks during rescheduling, this study also focused on the outcomes of nursing staff rescheduling (Papers II and III). The results are encouraging; rescheduling positively affects the use of floating nurses and float pool nurse, and reduces unplanned long shifts, shift changes, unstaffed shifts and the use of temporary nurses from outside the organization. However, overtime work was still relied on. Further study is needed to determine whether overtime work as an option to cover sudden absence of nursing staff can be reduced in the future. As mentioned, overtime work increases nurses' workload, and it has negative outcomes; overtime work is associated with nursing staff absence (Bae & Fabry, 2014; de Castro et al., 2010) as well as burnout and job dissatisfaction (Bae & Fabry, 2014; Stimpfel et al., 2012).

Results suggest that IT-based rescheduling solutions can lead to substantial financial savings (Paper II). The development phase showed an estimation of €9,338 cost savings based on the use of floating nurses over substitute nurses from outside the organization. This finding is important since a major part of hospitals' annual staffing costs are directed to nursing staff (Welton, 2011), including additional costs

of sudden absences of nursing staff (European Foundation for the Improvement of Living and Working Conditions 2010). There is still a need to evaluate cost savings with a larger study sample.

In this study, 79% (2063 out of 2628) of sudden absences of nursing staff were due to unplanned sick leave. Earlier studies have presented that nursing staff sick leave occurs for a variety of reasons (Lamont et al., 2017; Ribeiro et al., 2017; Freimann & Merisalu, 2015; d´Errico et al., 2013). In Finland, the two main reasons for absences are musculoskeletal and connective tissue disorders (29%) and mental and behavioral disorders (21%) (Statistical Yearbook of the Social Insurance Institution 2017). Work-related stress has also been found to be a common reason for nursing staff absences (Tito et al., 2017).

During the implementation of the IT-based rescheduling solution (Paper III), unstaffed shifts decreased significantly, while the use of the floating nurses and float pool nurses increased. However, unplanned long working days were still used as well as sudden shift changes of nursing staff. We documented a total of 2,612 sudden absences of nursing staff. Unstaffed and unplanned shift changes of nursing staff also decreased significantly (p< .0001). Still, there were no statistically significant differences in unplanned long workdays (p =0.1290) or the use of substitute nurses (p = 0.5398). However, the hospitals included the study rarely used substitute nurses to cover sudden absences of nursing staff. It should be considered as an option to avoid overtime, knowing negative consequences of overtime (Bae & Fabry, 2014; de Castro et al., 2010; Stimpfel et al., 2012). However, the use of substitute nurses should be limited, considering the hospital's staffing budget.

Nurse managers need to employ a number of different applications in their work. In addition to the given feedback on the implementation, we measured the usability of the implemented solution. Nurse managers reported that the solution did streamline their work, but it would be an advantage if it could be used via the internet as well, as nurses appreciate flexibility and the option to select shifts from home (Kulma & Springer, 2006).

6.3   Nursing staff's experiences with floating

Associations between nursing staff stress and floating experiences has not been previously studied. In this study, nursing staff's experiences of stress did not associate with the experiences of floating. Both groups reported experiences of stress. This outcome is significant because floating as a practice is a commonly used, but scarcely studied method to cover sudden absences of nursing staff in hospital settings. Nurses also reported a strong association between psychosocial factors of work and stress. Psychosocial factors of work, such as job demands and high workload,

influence nursing staff absences. Job demands are associated with depressive symptoms and work-related burnout. Increased workload is associated with the experience of stress (Niedhammer et al., 2015).

Experience of floating during the last twelve months was measured with the NEF only among the nurses that reported floating experience (746 out of 1,336). Floating as a practice stressed nurses and could be considered to be a stressor for nursing staff in working life. Nurses had difficulties finding equipment, supplies and patient care instructions in the unit that they were floating in. Nurses also felt that they did not receive positive feedback from nurse managers or colleagues or that the given feedback from floating shifts was not used to develop the floating practice. Nurse managers and policy makers should pay attention to these details. Written and informative guidance supplied by the organization can support positive floating experiences. This includes, for example, arranged work pairs during a shift, concise written information (Hoffman & von Sadovszky, 2018) and a small orientation to the unit (Hoffman & von Sadovszky, 2018; Garrison, 2018; Unruh & Nooney, 2011).

It is known that newer nurses are satisfied with floating like their senior colleagues who have floated several times. Short-term floating and floating within one's specialty area supports nurses' satisfaction (van Schingen et al., 2017). Positive outcomes were found in this study. Floating nurses felt that patients benefit from the care given by a floating nurse when the home unit staffing allows floating, and floating nurses were treated kindly and help was available if needed during floating shift. In addition, 66% of floating nurses reported that their competence was sufficient to carry out the floating shift (from 4 partially agree to 5 totally agree). This information is valuable for nurse managers when supporting nursing staff during a floating shift.

6.4   Strengths and limitations of the results

Phase I: A scoping review was chosen as a method, because it allows a way to synthesize all available evidence from research to practice guidelines, in addition to grey literature (Levac et al., 2010; Arksey & O'Malley, 2005). Although using a scoping review as method could be considered a weakness since findings are mainly indicative and cannot be used to recommend a policy or practice (Grant & Booth, 2009), we were able to generate new information about IT-based rescheduling solutions and how outcomes of rescheduling were reported.

This information can be used when developing future rescheduling solutions. This review was carefully conducted by following research methods, and stages such as identifying relevant literature and study selection were implemented by two researchers. During the scoping review, experts were consulted when selecting search and databases and the terms used to describing IT-based staffing solution contents.

Using a scoping review as method does not require a validity assessment of the included studies (Levac et al., 2010; Arksey & O´Malley, 2005). To enhance the internal validity of this scoping review, the included studies were evaluated with a quality assessment tool (QATSDD) that can be used as a quality assessment for both quantitative and qualitative studies (Sirreyeh et al., 2012). The results reflected the low quality of the included studies. Also, a scoring agreement between the two reviewers was calculated using Cohen's kappa, which varied between 0.78 and 1.00 (ten papers), showing from good (= 0.60 to 0.80) to very good agreement (= 0.80 to 1.00).

Phase II: The data were collected with a quasi-experimental pre- and post-test design, which has been criticized for lacking a control group, in contrast to randomized controlled trials (Knapp, 2016). However, we manage to obtain a generalizable sample size (sudden absences). In addition, as a strength, nurse managers were committed to the research, even though the data collection lasted eight weeks. Only eight RTS forms were excluded during pre-test and six during post-test due to missing identity information. The quasi-experimental pre- and post-test design enabled us to present nurse managers' work during rescheduling and its outcomes. Implementation of the IT-based rescheduling solution was successful and the use of it was adopted by nurse managers rapidly. Also, nursing staff started to use the new solution. However, it would have been an advantage for this study if the implementation phase had been documented and reported more carefully, step-by-step, to support future research.

Implementation included development and testing of the RTS. Content validity of the instrument could be obtained from three types of sources: the literature, representatives and content experts (Burns & Grove, 2009). There was a need to report nurse managers' tasks during rescheduling nursing staff, reasons for nursing staff outcomes and how sudden absences were covered. Using an existing instrument with established evidence usually adds research reliability and validity (Kimberlin & Winterstein, 2008); however, there were no existing instruments for that purpose.

The RTS was a simple grid where nurse managers added numbers of tasks done during rescheduling with a mark (X), selected reasons for sudden absences from given options, and selected the ways in which the sudden absences were covered. The RTS grid items were constructed based on nurse managers' (n=8) experience and an expert group of master's-level nursing science students (n=12). For ensuring clarity and relevance of the RTS, nurse managers and the nursing science students were given verbal feedback. Based on the given feedback, the RTS was considered suitable for measuring the rescheduling process of nursing staff. However, no background information was collected during piloting and, as a limitation, the participants could not be compared as individuals. This also limited the statistical testing. Reliability of the RTS could not be tested with a statistical test due the nature of the study

subjects; the grid could be empty if no sudden absences were reported. In addition, the RTS included zero values; nurse managers did not have to use every option, such as phone calls, emails or conversations. Data analysis was conducted with a statistical expert to ensure that the right statistical methods were used.

In summary, one strength of the piloting is that nurse managers as end-users were involved in the development process of the IT-based rescheduling solution and the RTS. It can be assumed that the results describe the rescheduling practices well. It is a clear weakness that, due the nature of the RTS, measuring reliability with a statistical test is not possible.

Phase III: The study design was quantitative. The sampling was practical, as presented earlier; all the selected hospitals used floating nurses to cover sudden absence of nursing staff. It would have been an advantage for this study if the sampling had been done using randomization (Burns & Grove, 2009). This was not possible due to practical issues. The number of floating shifts per nurse was not available.

This is the first study to examine the association between stress and floating experience. The sample size was statistically large enough for the results to be considered representative. The response rate in Phase III was 32%and as Burns and Grove (2009) point out, if the response rate is lower than 50%, representativeness may be questionable. The response rate varied between the hospitals from 9% to 65%. It is unknown how the hospitals encouraged participants to participate, but the hospitals with lower response rates (9% and 11%) were those where information about the study was only provided by email.

Three different instruments were used in Phase III. Nursing staff's psychosocial and social factors of work were collected with the QPSNordic 34+, 2000. The short version (QPSNordic 34+) has been used, for example, to evaluate shift schedules, work factors, onshore and offshore workers' mental health in the Norwegian petroleum industry (Berthelsen et al., 2015), and, in health care field, psychosocial work environments, stress factors and nursing staff's individual characteristics in psychiatric inpatient care (Hanna & Mona, 2014), and the importance of ward atmosphere, in terms of psychosocial work environment, to nurses in psychiatric care (Tuvesson et al., 2011). with the QPSNordic 34+ has good internal validity based on the Cronbach's alpha; and the Cronbach's alpha in this study was 0.732.

The NEF was proven valid and reliable in the development phase. The NEF was used to evaluate nursing staff's experiences of floating (Rantalainen, 2014). In the development phase, the items included in the NEF scale were formulated and operationalized on the basis of the literature. The content validity of the instrument was evaluated by nursing scientists and experts. The understandability and suitable answer options were assessed in a preliminary testing. Construct validity was assessed with the Principal Component Analysis (PCA). The adequacy for the PCA was tested with the Kaiser-Meyer-Olkin test (KMO) (greater than 0,6) and Bartlett test (p <

0.05). The NEF's KMO was 0,709 and Bartlett test result was < 0,001. The reliability was indicated with an item analysis and the Chronbach's alpha. The pilot study was performed among nurses in a special care setting in one university hospital in Finland. In the pilot study, the Chronbach's alpha was 0.912 (n= 56, SD 3,1, Q1 3,7, Q3 4,8, Min-Max 1,5 – 5,7). In this study, the Chronbach's alpha was 0.891.

In summary, the selected instruments were suitable for evaluating the association between stress, psychosocial factors and floating experience among nursing staff. We estimated the needed sample size for the study based on the role clarity question in the QPR Nordic 34+. In the user guide, the standard deviation is 0.8.

6.5   Suggestions for future research

1. IT-based rescheduling solutions could be further developed. If hospitals' resources such as float pool nurses and floating nurses are not available, hospitals could offer shifts for substitute nurses via this type of solution. In addition, the ability to use the rescheduling system via the internet would streamline the rescheduling process even further.

2. Floating as a practice is still an understudied topic especially from the perspective of patients. For evaluating patient safety, one suggestion is to use patient safety notifications reports to conduct a retrospective study by searching for errors related float pool nurses, floating nurses and substitute nurses, and comparing the findings to that of a unit's permanent staff. In addition, patients' experiences about their care given by a float pool nurse or floating nurse could also be evaluated with surveys or interviewing the patient after care. This is a sensitive subject, and the study design would require careful planning.

3. Time used for rescheduling nursing staff was evaluated by observing the duration of nurse managers rescheduling tasks. However, in future research, methods should include larger samples. It would also worthy to study whether centralizing this responsibility could save more time for nurse managers and organizational staffing costs.

4. This study focuses on nursing staff stress. However, it can be assumed that rescheduling as a task, as well as decision-making, is stressful for nurse managers and nursing staff. Nursing staff often handle rescheduling tasks after office hours. This should be taken into account in future research, and stress levels and experiences of rescheduling as a part of daily decision-making from both professional groups should be evaluated.

5. Nursing staff stress levels were evaluated with a single-item stress question. In future research, nursing staff stress and experience of floating could be study

more extensively by interviewing nurses. This information would be especially important for nurse managers, but also for nursing staff.

6. There is need to pay attention to the floating nurses' competence to float. Self-evaluations by nurses or competence assessments could be included in IT-based rescheduling solutions. This would ensure that nurses do not have to take too much responsibility beyond their requirements.

7 Conclusions

The aim of this study was to evaluate how nurse managers in hospital settings handle sudden absences of nursing staff using an IT-based rescheduling solution, and examine nursing staff's experiences with floating.

IT-based rescheduling solutions for nursing staff's daily rescheduling are used, but scarcely studied. There were no strong evidence, what are the rescheduling outcomes for nursing staff and organizations, but especially patient. However, based on results, rescheduling with IT-based staffing solution could save nurse managers time and reduce cost savings.

The use of developed and implemented IT-based rescheduling solution significantly streamline nurse managers' work and influence the hospitals salary costs of nursing staff by reducing the need for substitute nurses. However, to achieve this advantage, both nurse managers and nursing staff have to commit to the same goal: evaluate the need for extra staff on a shift-by-shift basis, and further, reassess whether they can offer extra help to other units.

This was the first study to evaluate the association between nurses' floating experience and stress. The results imply that floating experience has no association with nursing staff's experience of stress. However, floating as practice stresses nurses. Every hospital unit need guidelines to support floating as a practice, to which all nursing professionals can commit.

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Outi

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