Advancing Healthcare: balancing workload of nurses to enhance quality of care, nurses' health and operational excellence

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De gezondheidszorg een stap vooruit: meer evenwicht in de werkbelasting van verpleegkundigen om zo de kwaliteit van zorg, de gezondheid van de verpleegkundigen en de effectiviteit van de werkprocessen te verbeteren

(met een samenvatting in het Nederlands)

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It's not what you look at that matters, it's what you see
Henry David Thoreau

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Outline and scope of the thesis

This thesis sheds light on the challenges of developing an evidence-based workload management method for nurses in surgical wards. The study combines findings from a Delphi study on patient characteristics (Chapter 3) and a time study on nurses' activities (Chapter 4), in order to estimate required care time provided by nurses (Chapter 5) and nurses' workload (Chapter 6). Chapter 6 also explores the relation between the modelled workload and the perceived workload and studies the impact of specific personal resources, job resources and job demands on this relation. The aim is to develop a simple, user-friendly workload management method that encompasses all activities of nurses, takes into account nurse education and working experience, and can be used for planning purposes. Gaining insight in the dynamics around workload and the factors that are of influence will help in decision making, focusing attention, and allocating resources.

Chapter 1 sheds light on the current challenges in balancing workload of nurses in hospitals in the context of ever-increasing demand and steadily diminishing budgets for healthcare.

Chapter 2 presents the study design as outlined at the start of the research. It provides an overview of the currently available workload management methods and what our study adds to these.

Chapter 3 describes the process of determining a new set of patient characteristics relevant to care time.

Chapter 4 investigates how nurses in the study setting spend their time and highlights and explains differences between wards.

Chapter 5 combines the results of the study on patient characteristics and the time study to estimate care time required by nurses for each patient characteristic. Defines and estimates a baseline care time. Compares estimates for care time per patient on different wards, for two patient profiles.

Chapter 6 describes the calculation of an objective, modelled workload of nurses and studies the relation between this modelled workload and five measures of perceived workload. Studies the impact of specific personal resources, job resources and job demands on this relation.

Chapter 7 contains a general discussion of the work presented in this thesis

Chapter 1

Introduction

Background

Healthcare providers globally are being challenged to simultaneously provide a high quality of medical care and control healthcare expenditure. Expenditure is increasing due to factors such as technological progress and an ageing population with more chronic conditions [1-3]. In addition, many western countries are also dealing with shortages of healthcare professionals [4-6]. Shortages of medical professionals can increase the workloads to potentially alarming levels, which brings risks for the patients [7, 8], but also for the healthcare professionals, since the health of medical staff may be compromised [9-11]. Caregivers' health can deteriorate from emotional exhaustion or even burnout due to high workload [12, 13].

The challenges around increasing workload concern all types of staff involved in healthcare; doctors, paramedics, nurses and support staff. Nurses however seem to be especially prone to suffer the consequences of these pressures: recently, there have been indications that nurse workload globally is increasing to unacceptable levels. Workload is considered unacceptable, if it prevents nurses from being able to meet patients' needs, physical as well as emotional [7]. In February 2018, over 500 Canadian doctors and medical students protested their own salary raise [14] in favor of allocating more budget for nurses and other healthcare workers, to relieve workload and understaffing and importantly provide better access to care for patients. In July 2018, nurses in New Zealand started an unprecedented nationwide 24 hour strike [15],which caused hundreds of scheduled surgeries and hospital admissions to be cancelled. Nurses felt overworked and underpaid, working under unsafe conditions leading to burnout and exhaustion. According to the nurses, patient care and staff well-being were routinely compromised. In the Netherlands, nurses are also demanding measures to decrease workload [16]. The Dutch Federation of Academic Hospitals negotiated for months to close a new collective labor agreement in 2018, due to extensive protests of nurses in all eight academic hospitals [16]. In a 2017 survey among 600 nurses in the United States [17], 46% of the nurses reported an increased workload and half of the nurses considered to leave the profession. Main reasons for leaving included feeling overworked, too much paperwork and not enough patient time. The report also states that it is expected that between 2014 and 2020, 1.2 million vacancies for registered will have emerged in the United States, where the current nursing workforce comprises 3 million nurses.

There is overwhelming evidence of the adverse effects of high workload of nurses. There is a direct relation between nurses' workload and patient satisfaction [18], patient outcomes [8, 19-23]

and nurse reported quality of care and performance [24-26]. High workload is also a predictor for nurses' job dissatisfaction, stress, burnout [27-29] and absenteeism [30], and has generally been shown to have a negative effect on job outcomes [13] and nurses' intention to leave [31, 32] , both directly and as a mediating factor. High turnover of nursing staff results in higher costs for training of new nurses, or hiring of temporary staff [21, 33] and therefore should be avoided. Nurses also report that when workload is high, they cannot deliver all care that they believe they should [34]. Tasks that are considered important, such as tending to patients' emotional and psychological needs, are left undone, which results in nurses feeling unsatisfied with their job and occupation, which in turn leads to an increasing intent to leave, lower reported quality of care and deteriorating patient satisfaction [34]. In addition, shortage of nursing staff also gives indirect undesirable effects; for example operations may have to be cancelled or postponed due to a shortage of staff on nursing wards, leading to deteriorating patient outcomes and also to reduced income for the hospital. The latter, in turn, may lead to reduced available budgets for nursing staff: a downward spiral that is difficult to reverse. Market research at five large hospital groups in the United States found that on average 49% of hospital expenditure comprise salary expenses and on average 30 % of those salary expenses are nursing costs, which is an extra incentive to take care of this important group of caregivers [35].

As a society, we urgently need to rise to the challenge and support nurses in their efforts to deliver high quality of care, in a way that keeps nurses healthy and engaged but at the same time allows them to work in a cost-effective manner. Optimizing the workload of nurses is an important means to this end.

Workload

Despite the fact that a high workload can have such far-reaching practical implications, the concept of workload is not always clearly defined in research. It is often measured by using staffing ratios or determined by questionnaires regarding perceived workload. Also, many studies examine only one dimension of workload, such as perceived mental load or amount of work [36]. Holden [37] describes three different types of perceived workload: task-level, job-level and unit-level workload. Unit-level workload refers to the balance between patient acuity and staffing, job-level workload considers general and specific demands of the job such as the general amount and difficulty of the work and the amount of concentration required to do it, and task-level workload relates to the demands and resources for a specific task such as medication preparation. These workload types describe different dimensions of workload and each type of workload has a

specific effect on burnout, job dissatisfaction and the likelihood of medication errors. Holden's study did not consider emotional and physical workload, but recommended also taking these into account. Alghamdi [38] defined workload as the amount of time and care that a nurse can devote (directly and indirectly) towards patients, workplace and professional development. This definition covers direct and indirect patient care but also non-nursing activities such as meetings and attending seminars. Alghamdi advocated a holistic approach and determined five defining attributes of nursing workload: the amount of nursing time spent on nursing care known as patient acuity; the level of nursing competency; the weight of nursing intensity (direct patient care); all the physical, mental and emotional efforts; and the ability of the nurse to change the plan (complexity of care). In the Netherlands, the Questionnaire on the Experience and Evaluation of Work (QEEW[39]), an evidence based questionnaire, is widely used by Dutch occupational health services to measure the (psychosocial) working environment. It defines four types of workload: work pressure (a combination of work pace and amount of work), emotional load, mental load and physical effort.

We chose to include both objective (observed, measured) and subjective (perceived) workload measures in our study, because this research originated from the practical need to make an objective comparison of workload between wards. Nurses in our hospital often expressed that they experienced high workload and that they believed that the workload was not equally distributed across wards. Paradoxically, all nurses felt they were too busy, but they also suspected that nurses of other departments were less busy than they were. We wanted to get to the bottom of this; is the workload objectively different between wards or is this only a perception, a persistent misunderstanding? What is the role of nurse competencies in this? And what factors other than the objective workload may influence this perception?

Modelling workload

Several studies have suggested ways to calculate an objective workload measure. There is evidence that simple measures of determining nurse workload based on nurse-patient ratios or nursing hours per patient day (NHPPD) are not accurate [33, 40], since these do not take into account the different needs between patients nor the differences in experience and education level of nursing staff. Twigg [33] argued that relying on expert opinion in setting standards for workload, in their study a standard NHPPD per ward, was not optimal and recommended using a standardized patient acuity measurement.
In other methods, workload is predicted by quantifying the effect of patient characteristics or

characteristics of the treatment on the workload. Mueller et al. [41] tested the correlation between the Barthel index scores and Acute International Classification of Functions core sets and nurses' workload and found that 20 to 44% of perceived nurses' workload variance was explained by these scores. This suggests that patient characteristics do influence nurses' workload. That study was performed in a critical care setting and has not yet been replicated in other types of hospital wards or other environments. In Belgium, all hospitals register the Belgium Nursing Minimum Data Set (B-NMDS) in order to benchmark hospitals on several dimensions, including workload. Van den Heede [42] showed that 70% of variation in nursing staff per unit was predicted by the B-NMDS item hospital type with the covariates nursing intensity and service type. They recommended using a NHPPD corrected for nursing intensity, as an alternative for working with NHPPD only. In a 2008 study [43] however, Sermeus stated that the B-NMDS nursing intensity did not necessarily give an adequate indication of *required* nursing time. The B-NMDS also requires extensive amount of additional registration [44]. Myny et al. [44] determined a set of 28 measurable factors expected to influence workload of nurses, of which three are recommended for incorporation in a workload management method: the number of work interruptions, the patient turnover rate and the number of mandatory registrations. It is noted that Myny et al. performed their research in Belgium, where hospitals are required by law to participate in the B-NMDS, which could explain the perceived high importance of registration on workload. In our current study, we strive for minimum additional registration.
The RAFAELA™ patient classification system [45] defines optimum levels of nursing intensity. The RAFAELA™ system consists of the Oulu Patient Classification instrument [46], a system that records daily nursing time, and the Professional Assessment of Optimal Nursing Care Intensity Level questionnaire. The three are combined to measure nursing intensity.
RAFAELA™ measures only the patient-related workload of nurses, other tasks are not included [47]. This method is not used for prospective workload management but for evaluation of past workload. For optimal and timely scheduling of nursing staff, we are interested in the total workload of nurses (not only the patient related workload) and we are interested in creating a model that can also be used to predict future workload.

O'Brien-Pallas et al. [48] have shown that the actual worked hours per patient were likely to increase for patients with a higher number of nursing diagnoses. Hoi [49] developed a workload intensity management system (WIMS) by defining 28 relevant nursing diagnoses and performing a work sampling study on nurses' activities. For each ward the significant nursing diagnoses were determined and for each diagnosis the nursing time per day was determined. Hoi developed a

prediction model, with a fixed component of nursing time for each patient admitted to a ward, additional nursing time for each of the nursing diagnoses and time needed for indirect patient care. Required nursing time can then be forecast based on the number of patients and the patient mix. In Hoi's study, 60-70% of variance in nursing time was explained by these nursing diagnoses. Education and working experience of nurses was not included in this model.

We plan to combine different elements of existing methods into a new approach, as illustrated in

Figure 1.

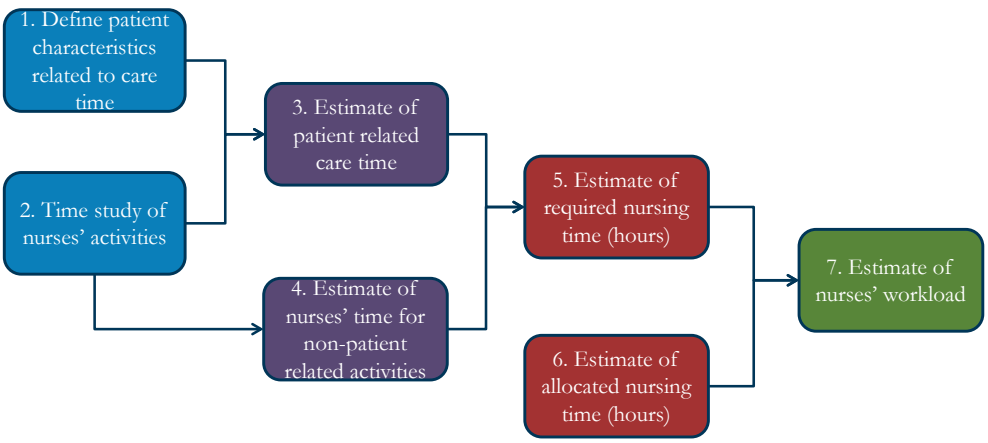

Figure 1: Workload management method for balancing nurses' workload

Currently available models to predict workload do not include corrections for experience or education levels of nurses. There is evidence that suggests that a higher proportion of registered nurses in the nursing staff results in lower perceived workload and better patient outcomes [50, 51]. However, there is no known literature that includes the link between nurses' expertise and perceived workload in the calculations of workload. We expect that educational level and working experience of nurses are important factors to take into account when calculating workload; a novice nurse is likely to spend more time on an activity than an experienced nurse. Also, if the proportion of fully qualified, experienced nurses on a ward is high, the ward will probably be able to handle more work than if it were staffed with mainly student or novice nurses. We were keen to learn the impact of these factors and have included them in our research.

The first aim of the work presented in this thesis is to develop a method to predict nurses' workload that is user-friendly (easy to interpret and requiring limited additional registration); can be applied to different types of hospital wards; covers all activities of nurses (not only those activities that are directly patient-related); is suitable for prospective planning purposes and takes into account nurses' proficiency (the level of education and work experience). Ultimately we are looking for a practical tool to help us optimize nurses' workload, where quality of care is ensured, nurses stay healthy and motivated and wards are staffed in a more efficient manner. We expect that by balancing the modelled workload, perceived workload will also be balanced. We will study the relation between the two workload measures in order to test whether this is indeed the case.

The relation between modelled and perceived workload

The perceived workload is influenced not only by the objective workload measure, but by many other factors known to be important.

Figure 2 shows a sketch of a mind map that was made in the context of this study, which illustrates the complexity of understanding workload and the many relevant variables.

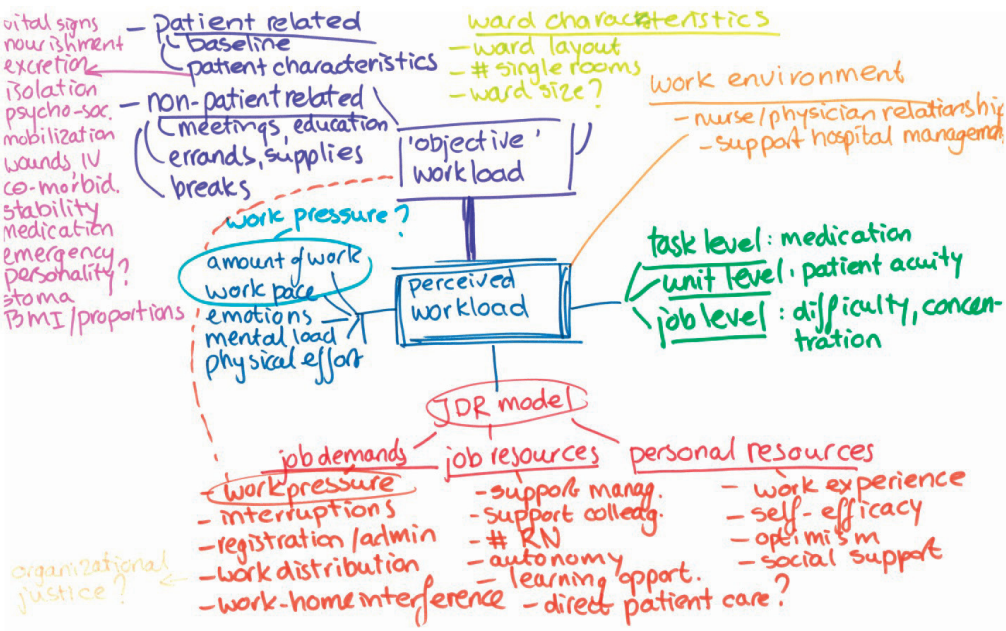

Figure 2: Mind map made during study design

The second aim of our research is to explore the relation between perceived workload and workload as we model it, and to examine the effects of specific job demands, job resources and personal resources on this relation. We chose to use the well-known Job Demands and Resources (JDR) model [9] as a framework. The JDR model describes a health impairment process where high job demands lead to exhaustion and burnout. Job demands are those aspects of a job that require effort. Workload is considered a job demand in the JDR model. This thesis considers two types of workload: modelled (calculated) workload and perceived workload and we are interested to see how they are related. We consider the influence of four other job demands on this relation: perceived interruptions, equal work distribution, time spent on registration and time spent on direct patient care. Dutch occupational health surveys, used by occupational health and safety services for preventive medicine purposes, often include questions on work interruptions and equal work distribution. There is evidence that strongly relates the number of work interruptions to patient outcomes [52, 53] and nurses' workload [44, 54]. Equal work distribution has not been related to perceived workload in literature before. Registration requirements, by the government, insurance companies and hospital management, are one of the reasons nurses experience a high workload. Myny [44] found a link between perceived workload and the number of mandatory registrations. Van Bogaert [7] also identifies a growing problem of additional registration. There are also indications that increased administration consumes time that was supposed to be spent on patient care; Khademi [55] stated that one of the important sources for increased nursing workload was an overemphasis of managers on frequent report writing which competed with patient care delivery. It is also possible that workload is experienced differently when the proportion of time that nurses can spend on direct patient care is low, whether this is due to increased registration or other reasons.

The JDR model also postulates that the health impairment process can be mitigated by job resources and personal resources. These resources help employees to achieve goals and stimulate personal development, resulting in intrinsic motivation and engagement [9-11, 56-58]. Yanchus [59] found that the job resource teamwork (i.e, colleagues helping and backing-up each other) counterbalances the effects of understaffing and high workload. Sexton's research [60] showed something similar: workload pressures can be offset by a positive nursing team environment on a unit. This shows that teamwork is an important factor in perceived workload. Van Bogaert et al. [7] found the same results in their study on the predictors of burnout, work engagement, nurse reported job outcomes and quality of care. Van Bogaert et.al. [61] also reported that hospital management directly influences nurses' perceived workload. In MacPhee's study on the impact of

heavy perceived workload of nurses on patient and nurse outcomes [8], it was noted that unit level leaders in particular can influence perceived quality of care and job outcomes by monitoring and responding to workload demands. In addition, there is much evidence that a nurse staff mix with a large proportion of registered nurses results in better patient outcomes [50, 51, 53]. The effect of the mix of nurses on perceived workload has not been extensively studied, although there is evidence that skill-mix is an important factor when considering workload [47]and a lower proportion of registered nurses on a ward leads to increased workload [62]. The present study will include three job resources: support from colleagues, support from management, and the proportion of registered nurses on the ward.

Two personal resources have also been included in this study: self-efficacy and nurse proficiency. Spence Laschinger [63] found a significant correlation between workload (as one of the areas of work life) and occupational coping self-efficacy. Occupational coping self-efficacy is defined as the self-appraisal of the ability to cope with the occupational burden in the workplace [64]. When the areas of work life, such as workload, are balanced, this has a positive effect on occupational coping self-efficacy. In the hospice setting, the stress of staff shortages decreased with increasing self-efficacy [65]. Schmidt et al. [57] found that self-efficacy had a direct effect on job strain in nursing homes, but they did not find evidence for an interaction between self-efficacy and perceived workload. Brunetto et al. showed that self-efficacy reduced the effects of stress and enhances job satisfaction, and thereby reduced nurses' intentions to leave the job, though they did not study the effects of self-efficacy on perceived workload [66].

Nurse proficiency, which we define as a combination of nurses' education and experience, is related to clinical expertise [67]. A fully qualified, experienced nurse may be more likely to handle workload better than a novice nurse. This study will test whether nurses with more working experience and who are considered to be more proficient experience workload differently than other nurses.

We chose to include the four job demands (interruptions, work distribution, time spent on registration, time spent on direct patient care) and three job resources (support from colleagues, support from management, proportion of registered nurses on the ward) as potential effect modifiers of the relation between modelled and perceived workload. Personal resources were assumed to have a direct effect on perceived workload. Effects were explored separately for each outcome measure.

Four hypotheses were tested in this study. We assumed there is a correlation between the modelled (objective) workload measure and perceived (subjective) workload. Also, we expected perceived workload to be lower when personal resources self-efficacy and nurse proficiency were higher. In addition, moderation of the job resources support from management, support from colleagues and proportion of registered nurses was expected on the relation between modelled and perceived workload. Lastly, we assumed that all job demands in the study (proportion of direct patient care, proportion of administration, work interruptions and perceived equality of work distribution) were moderators of the relation between modelled and perceived workload.

Chapter two of this thesis presents a study design for developing a workload management method; the first aim of this thesis. Chapters three to five describe the first steps of this method; composing a set of patient characteristics relevant to care time, performing a work sampling study of nurses' activities and using linear mixed effects modelling to determine which patient characteristics have a significant effect on care time. These three steps are needed to calculate the modelled workload, which is elaborated in chapter six. This chapter also presents the results of the testing of hypotheses 1 to 4; the second aim of this thesis.

This thesis considers an objective workload measure and five perceived workload measures in one model. Most studies only use perceived workload as reported by nurses. Our study includes six different wards, examines results from all six different measures of workload per individual nurse per day and contains consecutive measurements of these workloads over time. Such a multilevel, longitudinal study on six dimensions of workload (1 objective and 5 subjective) has not been described in literature before.

In addition, this study gives insight into the relation between the objective, modelled workload measure and the subjective, perceived workload measures and the effect of specific job demands, job resources and personal resources on this relation. Findings will help understand which interventions could be most effective to balance workload, within and between wards, in order to maintain high quality of care, a healthy and engaged nursing staff and an efficient, cost-effective operation.

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CHAPTER 2

BALANCING NURSES' WORKLOAD IN HOSPITAL WARDS: DEVELOPING A METHOD TO MANAGE WORKLOAD

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Abstract

Introduction

Hospitals pursue different goals at the same time: excellent service to their patients, good quality care, operational excellence, retaining employees. This requires a good balance between patient needs and nursing staff. One way to ensure a proper fit between patient needs and nursing staff is to work with a workload management method. In our view, a nursing workload management method needs to have the following characteristics: easy to interpret, limited additional registration; applicable to different types of hospital wards; supported by nurses; covers all activities of nurses; and suitable for prospective planning of nursing staff. At present, no such method is available.

Methods/analysis

The research follows several steps to come to a workload management method for staff nurses. First, a list of patient characteristics relevant to care time will be composed by performing a Delphi study among staff nurses. Next, a time study of nurses' activities will be done. The two can be combined to estimate care time per patient group and estimate the time nurses spend on non-patient related activities. These two estimates can be combined and compared to available nursing resources: this gives an estimate of nurses' workload. The research will take place in an academic hospital in the Netherlands. Six surgical wards will be included, capacity 15 to 30 beds.

Ethical considerations

The study protocol was submitted to the medical ethical review board of the UMC Utrecht and received a positive advice, protocol number 14-165/C.

Discussion

This method will be developed in close cooperation with staff nurses and ward management. The strong involvement of the end users will contribute to a broader support of the results. The method we will develop may also be useful for planning purposes; this is a strong advantage compared to existing methods, which tend to focus on retrospective analysis.

Introduction

Hospital management is exploring ways to ensure a good balance between patient needs and nursing staff size and expertise in order to deliver good quality care and excellent service to their patients while managing operational excellence. At the moment, it is challenging to objectively determine whether nursing capacity is optimally matched to patient needs on the hospital wards. We aim for a fair and sensible distribution of nursing staff over the wards, resulting in an equally-distributed and manageable workload for all nursing staff. This requires a good fit between patients' needs and nursing staff. One way to ensure a proper fit is to work with a workload management method for nursing staff. In theory this should help balance required resources with available resources, which prevents extra costs for overstaffing a nursing ward and on the other hand prevents a decline in patient experiences or employee engagement by understaffing a ward. There is a direct relationship between nurses' workload and patient outcomes [1-4] and nurse reported quality of care [5]. Good workload management will also help keep employees healthy, as high workload is a predictor for burnout [6, 7] and absenteeism [8]. Bakker and Demerouti [9] found a relation between job demands such as workload and performance. In their systematic literature review, Toh et. al [10] found a positive bi-directional relation between the nursing shortage and oncology registered nurses' job dissatisfaction, stress and burnout.
In addition, nursing staff is relatively scarce in the Netherlands and it is not expected that this will change in the near future. Labor demand is expected to increase as the population ages, with consequences for future skills and competences while the number of health professionals decreases, resulting in health care labor shortages [11]. Workload has been shown to have an effect on nurses intention to leave [12, 13] and on job outcomes [14], both directly and as a mediating factor. High turnover of nursing staff results in higher costs for training of new nurses or using temporary staff [3, 15] and therefore needs to be minimized.

There is extensive literature that describes workload of nurses. Workload is often not clearly defined and is usually measured by asking nurses to fill out questionnaires about perceived workload, mostly one dimension of workload such as mental load or amount of work [16]. Holden [17] describes three different dimensions of workload: task level, job level and unit level workload. These workload types describe different dimensions of workload. Task level has an effect on medication errors likelihood, unit level on job dissatisfaction and task and unit level on burnout. In their work Holden et al. recommend also taking emotional and physical load into account.

Many studies have identified factors that predict workload of nurses. There is evidence that these nurse-patient ratios or nursing hours per patient day (NHPPD) do not accurately predict workload or nurses [18], since these do not take into account the different needs between patients nor the differences in experience and education level of nursing staff. Twigg argues that relying on expert opinion in setting standards for workload, in their study a standard NHPPD per ward, is not optimal and recommends using a standardized patient acuity measurement [15].
In other methods, workload is predicted by quantifying the effect of patient characteristics or characteristics of the treatment on workload. Mueller et al. [19] tested the correlation between the Barthel index scores and Acute ICF (International Classification of functions) core sets and nurses' workload. In this research, 20 to 44% of perceived nurses' workload variance is explained by these scores. This indicates that patient characteristics matter in nurses' workload. This research was performed in a critical care setting and has not yet been replicated in general hospital wards or other environments. In Belgium, hospitals are required to register the Belgium Nursing Minimum Data Set (B-NMDS) in order to benchmark hospitals on several dimensions, among which workload. Van den Heede shows that 70% of variation in nursing staff per unit is predicted by the B-NMDS item hospital type with the covariates nursing intensity and service type [20]. They recommend that instead of working with NHPPD, a NHPPD corrected for nursing intensity is a better measure. However, Sermeus stated in a 2008 study [21] that the B-NMDS nursing intensity did not necessarily give an indication of required nursing time. Another drawback of the B-NMDS is the extensive amount of registration required by the hospitals [22]. Hughes [23] found that correcting the standard midnight census measure for patient churn gives a better indication of nurses' workload. Myny et al [22] determined a set of 28 measurable factors that are expected to influence workload of nurses, of which 3 are recommended for incorporation in a workload management methods: the number of work interruptions, the patient turnover rate and the number of mandatory registrations. It is noted that Myny et al. performed their research in Belgium, where hospitals are required by law to participate in the B-NMDS, which would explain the perceived high importance of registration on workload.

Several workload management methods are found in the literature. The RAFAELA™ patient classification system [24] is an instrument to assess optimum levels of nursing intensity. We consider this a form of workload management. The RAFAELA™ system consists of the Oulu Patient Classification instrument [25], a system that records daily nursing resources, and the Professional Assessment of Optimal Nursing Care Intensity Level questionnaire. The three are combined to measure nursing intensity. RAFAELA™ measures only the patient-related workload

of nurses and does not include other tasks [26]. This method is widely used in Finland; while promising, it is not used for prospective workload management but only for assessments of workload in the past. For optimal versatility of nursing staff, prospective insight is of great value. Hoi [27] developed a workload intensity management system (WIMS) by defining 28 relevant nursing diagnoses and performing a work sampling study on nurses' activities. A nursing time per day was identified for each diagnosis, and for each ward the significant nursing diagnoses were determined . Hoi developed a prediction model, with a fixed component of nursing time for each patient admitted to a ward, a fixed nursing time for each occurrence of a diagnosis and a fixed time for indirect patient care. Depending on the number of patients and the patient mix, a forecast of required nursing time could be made. In this study, 60-70% of variance in nursing time was explained by these nursing diagnoses. Hoi also found that his patient dependency measurements was not correlated with nursing time.

Some aspects that influence workload fall outside the scope of the current project. Some research has examined the relation between nurses' workload and unit-related characteristics such as ward layout and number of single rooms in a ward [22]. Since we cannot influence these factors without major renovations, we chose not to include them in our research. Furthermore, some studies focus on the relation between nurses' perceived workload and job resources such as support from colleagues or ward management or relationship with medical staff [14, 16]. We chose not to focus on this domain at the moment. We are aiming for a fair distribution of work between our wards, regardless of ward-specific job resources that can counter the job demand workload.

Workload is dependent not only on the amount of work that is given to the staff, but also on the resources available to handle this amount of work. There is literature that suggests that a higher proportion of registered nurses in the nursing staff results in lower workload and better patient outcomes [28, 29], but there is no research that quantifies differences in proficiency in nursing staff: what are the required nursing resources when we account for numbers of students of different levels and experience of registered nurses?

Some countries such as Australia seem to have commercial packages that manage workload, but there is no scientific evidence to support their effectiveness and these packages are not available in the Netherlands.

Our goal is to find a better match between required and allocated nursing staff, under the condition of at least the same levels of patients' experiences and nurses' engagement. With this study we aim to contribute to developing a workload management method that is user-friendly (easy to interpret and requiring limited additional registration); is applicable to different types of hospital wards; will differentiate between different levels of nurses' proficiency; is endorsed by nurses and nurse management and covers all activities of nurses (not only those activities that are directly patient-related). In a later phase we will study whether the method is suitable for prospective planning of nursing staff.
This study protocol describes the steps we will take to develop a new workload management method and suggests a method to test its validity.

Method

UMC Utrecht has experience with a workload management method developed by the former Dutch National Hospital Institute, NZi [30]. We use the framework of this methodology as a starting point to develop our own workload management method, because it already meets many of the requirements stated previously. The NZi methodology consisted of the following items:

1. A checklist of nine patient characteristics that lead to classification light, moderate, heavy and intensive care
2. Time study of nurses' activities, registering time spent on direct and indirect patient care, unit related tasks and other tasks
3. Estimate of allocated nursing resources
4. Questionnaire of perceived workload and perceived quality of work

These data are combined to estimate and validate workload of nurses.

The NZi method has several advantages: it is easy to use, does not require much additional registration and can be used in a wide variety of hospital wards. However, the method also has some drawbacks. Nurses feel that important factors that influence care time are missing in the patient classification, such as isolation measures and psychosocial care. Nurses often feel that after classification of a patient the resulting class does not reflect the actual workload. Also, the patient classification is rather crude: is consists of 4 categories (intensive, intermediate, moderate, light) of which only 3 occur on regular hospital wards. In addition to this, the method does not differentiate for levels of nursing experience; student nurses are obviously not as efficient as experienced, certified nurses. Lastly, the checklist used to measure nurses' perceived workload is

not validated. Due to these disadvantages, the method was not supported by the nursing staff and was eventually discontinued.

We will use the NZi workload management method *framework* as a basis for our development though, since it has potential to fulfil the requirements we stated earlier, but will make several adjustments to correct for above-mentioned drawbacks. Since the patient classification in this method is neither evidence-based nor widely supported by nurses, we will use a new list of patient characteristics expected to influence care time. Also, we will more specifically determine required nurse resources, differentiating for levels of education and experience. Lastly, we plan to use a validated questionnaire to determine nurses' perceived workload. We choose to measure five dimensions of perceived workload: work pace (time pressure), amount of work, emotional load, physical load and mental load, as experienced by nurses. This will result in the following adjusted approach, **Figure 1**.

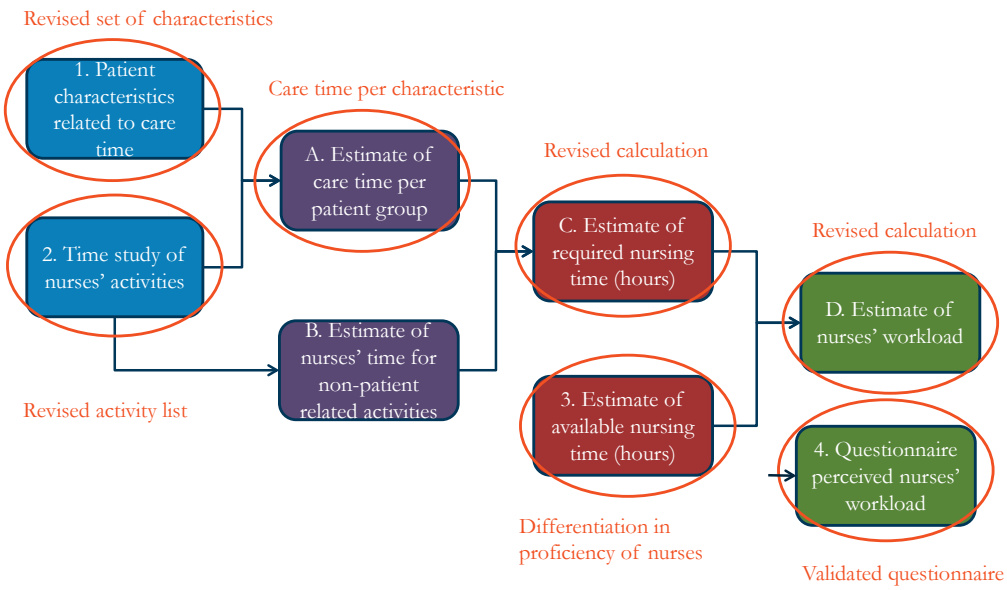

Figure 1: Components of new workload management method

The research will take place in an academic hospital in the Netherlands. Six surgical wards will be included, ward capacity varying from 15 to 30 beds (2 wards with 15 beds, 4 wards with 30 beds). We will focus on nurses' workload in the day shift. Workload of other types of ward staff (doctors, assistants, cleaners, et cetera) will not be considered in this study. In the following

paragraphs we give an extensive explanation of the procedural steps for setting up the workload management method described in **Figure 1.**

Identifying relevant patient characteristics

We decided that we do not want to classify patients in categories of intensity of care, but prefer to directly predict care time of patient characteristics. The composition of a list of patient characteristics relevant to care time will be done in a Delphi study consisting of five phases. In this study, we will identify relevant patient characteristics for the specific setting of our study (6 surgical wards). If successful, we can extend this method to a larger setting in a later phase. We choose the Delphi method in order to acquire an expert opinion on relevant characteristics [31]. Representatives from all six wards will take part in Delphi rounds to determine patient characteristics that, in their opinion, have the most influence on care time and thus on nurses' workload. All participants should be experienced senior nurses or nurse team leaders, with one representative from each ward. All participants will receive extensive information about the purpose of the research and how the Delphi study contributes to it. The central question will be: which patient characteristics cause nurses to spend more time caring for a patient? When a patient is admitted to a ward, nurses will always spend a certain amount of care time for this patient, regardless of the reason for admission. For example, time that is spent on handing out meals, having a chat or tidying up. On top of this "baseline" care time, nurses spend time catering to specific needs for a particular patient, based on characteristics of that patient (for example the procedure the patient has undergone). We assume that there is always a baseline amount of care that is provided to a patient when admitted to a ward, as also suggested by Hoi [27]. This baseline care time will not be defined beforehand, because what is considered baseline care may differ from ward to ward. We will let the study results define the baseline care time per ward. Our study will focus on finding patient characteristics that are expected to cause additional care time, on top of this baseline care time.

Phase 1. Delphi group composition and interviews

Based on separate interviews with all six Delphi group members, a starting set of characteristics, with corresponding definitions, will be composed. Clear definitions of characteristics are necessary to make sure they will be uniformly interpreted and do not overlap. Results will be shared and the Delphi group will comment on the clarity of the definitions. Definitions will be refined and results shared.

Phase 2. Prioritization

In the next phase, the Delphi group will be asked to prioritize the characteristics by dividing a fixed number of points over the characteristics. The group will be free to divide the points as they see fit, so they can allocate 0 points to a characteristic if they consider it to be irrelevant, or all points if they consider the characteristic as the only relevant one on the list. Perceived importance of characteristics is expected to vary per ward. Characteristics with close to 0 points total score will be removed from the checklist. Results will be shared in the group and combined in a checklist. In preparation of the next phase, a test-version of this checklist of patient characteristics will be implemented in the hospital information system. This checklist will consist of all identified patient characteristics, with a yes or no tick box beside each characteristic. For each characteristic, the full definition will be visible.

Phase 3. Preliminary testing

Nine new members will be added to the Delphi group, all senior staff nurses or team leaders. The whole Delphi group will be trained in how to use the new digital checklist. They will be asked to fill out the checklist for ten random patients admitted on their wards. These will be the first ten patients on their ward overviews of one particular day (to be selected). After this test, the Delphi group members will be interviewed and asked if the test-version of the checklist is complete, if the definitions are sufficiently clear and if characteristics are mutually exclusive. They will also be asked if the checklist is not too time-consuming: is the administrative burden of filling this out for every patient every day reasonable? Based on this test period, definitions will be refined and the new version of the checklist will be uploaded in the hospital information system.

Phase 4. Extensive testing

After the preliminary testing, a new, extensive test period will start. All wards will select nurses to the daily task of filling out the checklist of patient characteristics for all patients on the ward. These nurses will all be uniformly trained in how to use the checklist. The training will consist of information on the purpose of the research and how the filling out of the checklist contributes to the research. The importance of accuracy will be stressed and nurses will be informed that checklist input will also be monitored by random checks. This is done in order to detect mistakes early but also to avoid manipulation of input. The process of development of the checklist will be explained and each characteristic and definition will be clarified. Each nurse will be personally instructed and a short guidebook will be available next to every computer on every ward. For a period of one month, checklists will be filled out every day shift for every patient on every ward

participating in the study. A medical student will be trained in how to use the checklist as well. This student will retrospectively check the registrations in 40 randomly selected checklists filled out by the nurses during the test period. At the end of this test period, the Delphi group members will be interviewed again and, where necessary, changes will be made and definitions will be sharpened.

Phase 5. Implementation

Test results will be processed and a final version of the checklist will be composed and entered in the hospital information system. All involved nurses will be informed of the changes and will receive new working instructions. A reporting tool will be developed to track actual usage of the checklist. During the time study period (see 2.1.2) this reporting tool will be used to make sure a checklist is filled out daily for each patient present in the day shift on each ward.

Time study nursing staff

In order to determine whether above-mentioned patient characteristics indeed affect care time, a work sampling study will be done. Work sampling results in a random sample of the activities of nurses and is a useful and cost-effective methodology to explore work-related activities [32]. From this study we expect to gain broad insight in the way nurses spend their working hours, and to what extent their work is directly patient-related. Ampt et al. suggested working with trained observers as an alternative to self-reporting, because the latter can be prone to bias [33]. This is only possible when the staff to be observed is in an area that can be overseen by the observer and the observer can determine the activities relatively easily. For example if work sampling is done on staff that is moving great distances or is performing mostly cognitive tasks, then self-reporting can be better. They also advocate the use of handheld computers to make registration faster and more accurate.

Sittig [34] gave important tips when designing a work sampling study in health care: involve the nurses and nurse management in the study, determine relevant activities to register and make foolproof definitions, identify the right observers and train them well, do pilot samples to test the set-up.

The same six surgical wards mentioned above will participate in this study. The study will focus on activities of nurses in the day shift. Weekends will be excluded because task mix and staffing is very different in weekends and cannot be compared to day shifts of regular weekdays. Team leaders and students will be included in the study. Ward managers will be excluded because they are not active in direct patient care.

A set of activity groups will be identified as the relevant activities to register. For each activity group we will describe which activities are related to these groups. The activity groups will be grouped into 4 categories: direct patient care, collective patient care, general tasks and other tasks. Direct patient care is defined as care that can be directly related to one specific patient. This includes 12 activity groups, with activities amongst others assistance with bathing or eating, handing out medication, changing bed linen, wound care, communication with patient or family. Collective patient care is defined as tasks that are patient-related, but are impossible to attribute to a specific patient. This includes 4 activity groups, with activities amongst others general preparation of medication, patient handover, bringing a collection of samples to the laboratory. General tasks includes 5 activity groups, with such activities as education, meetings, organization of work (planning), administrative duties and domestic duties. Other tasks includes 3 activity groups, with activities such as lunch and coffee breaks and personal time. This set of activities will be determined by the same group of nurses in the Delphi group who will also determine relevant patient characteristics. There will only be one round of evaluation since we do not expect much disagreement.

During the time study all nurses in the day shift will be observed approximately every ten minutes. Trained observers will register activities approximately every 10 minutes in the day shift, starting at 07:30 hours and finishing at 16:00 hours. Observations will be registered on a handheld computer. Exact start and finish times will depend on the random time interval generator of the handheld computer. Time intervals will be automatically randomized between 8 and 13 minutes, with an average of ten minutes. Observers will be asked to register three things each time they make an observation: the name of the nurse, the activity the nurse is performing and, when the activity is patient-related, the details of the patient concerned. This way, a random survey of nurses' activities in day shifts will be done.

First, a test study will be performed. The aims of this test study are as follows:

- To test the hand held computer equipment and its accessories: do they work properly and are they easy to use?
- To test the activities list: is it complete and easy to interpret?
- To test the workload of the observers: how many nurses can be observed by one observer?

Subsequently, the actual work sampling study will be planned. A representative time period will be carefully selected. The study needs to be planned in a period in which workload is expected to be average; outside holiday seasons, periods with especially high or low occupancy rates (for example, due to reduction of operating room capacity) or periods with enhanced or reduced nursing capacity (for example, due to planned education). Also, the number of observations in the work sampling study needs to be sufficiently large. For practical reasons, UMC Utrecht wants to limit the work sampling study to three weeks, or 15 day shifts. The main practical obstacles are that we will not be able to find and train enough observers to cover a longer time period and the high costs of extending the duration of the study. A preliminary question round with ward nurses indicates that we can expect to find a maximum of 15-20 patient characteristics. The participating wards have an average of 25 patients admitted per ward at any given time. In this context, one observation is the measurement of care time for one patient during one day shift. This means a total of 150 (6x25) observations per day shift. The maximum of 3 weeks (15 working days) of study time period then limits us to a maximum of 15x150=2250 observations for each patient characteristic. Since we do not know which characteristics we will identify as relevant, it is not possible to estimate what the chances are that this characteristic will be observed sufficiently often during a 15 day time period. When sampling nurses' activities every ten minutes, we will generate approximately 54.000 observations (=15 study days x 6 wards x 12 nurses per ward x 50 observation rounds per day shift) of nurse activities. Based on a previous time study of ten day shifts in 2003 on three of the same wards at the UMC Utrecht, we estimate that we will define between 25 and 30 activities. This 2003 study worked with 23 activities, which are all still relevant today. We do miss items such as handover though, so we assume we will determine a few more activities in this study. The database from the 2003 study is lost, but the reports on the overall results are still available. From the 2003 time study we know that the most observed activity accounted for +/- 9% of observations in 2003. This translates to a maximum of +/- 4.860 observations per activity in our study.

Observers will be selected and uniformly trained in how to register nurses' activities. Observers will be either nurses from wards in the study (observing on *other* wards than their own) or medical students. We prefer to work with nurses as observers where possible, because they are motivated to register activities accurately and they are familiar with the activities and therefore less likely to misinterpret or make mistakes. As a bonus, nurses learn about working procedures on other wards besides their own, which broadens their horizon and will help exchange ideas and understanding between wards.

During the work sampling, observers will register two or three variables with each observation: name of the observed nurse, activity and - when applicable - the related patient. All are categorical variables with many possible categories to choose from: up to 15 names of nurses, up to 20-30 activities and up to 30 patients. For an accurate end result, it is important that all three variables are registered correctly. To test the reliability of the registrations, an inter-rater agreement test will be planned during the 3 week time study period during which the work sampling will take place. For this test, a second observer will temporarily join the scheduled observer. Both observers will have had the same training and both will have already done at least one shift of observing during the time study. Regular tests for inter-rater agreement, such as Cohen's Kappa or intra-class correlation, cannot be applied here because these assume that only one variable is observed and Kappa also assumes that a variable is classified in a limited (i.e. maximum of 4) number of categories [35]. Therefore we will determine inter-rater agreement as the percentage of exact agreement on all three variables.

Estimating required care time

Paragraphs 2.1.2 and 2.1.3 described how data will be gathered. In this section we describe how we plan to analyze the data in order to derive required care time.

Results of the patient characteristic checklist will be combined with work sampling results. Data will be analyzed from the perspective of the nurse (how do they spend their time?) and the perspective of the patient (how much time is spent on caring for patients?). When analyzing from patient perspective, we will combine information on patient characteristics and care time per patient per date. This way, it is possible to analyze the relation between patient characteristics and care time: does care time increase when certain characteristics apply? And what is the baseline care time for a patient when none of the characteristics apply?

For the analysis of care time per patient, we will use linear mixed effects models [36]. These models will be used to determine the significance of the characteristics in relation to care time and to estimate the additional care time per significant characteristic. This method has not been used before in studies in this field. We choose linear mixed effects models because we will be working with multi-level data: care time will be measured more than once for most patients, since the majority will be admitted for more than one day. We therefore wish to explain variability of care time within the length of stay of a patient, but also variability of care time between patients. In the mixed models, the ward and patient characteristics will be taken as fixed effects (since we are specifically interested in analyzing the effects of these). A random intercept, and potentially a

random slope for time, per patient will be included in the models to adjust for clustering of measurements within patients.

Results of this analysis can be used for planning purposes: we plan to register the significant patient characteristics continuously and fill a database with the results. This database can be used to define patient profiles (linked to diagnoses or treatment types), where a profile of expected patient characteristics per treatment day can be determined. These profiles can be regularly updated and used for planning purposes, for example when linked to the OR schedule, to predict expected workload in the future. An example of such a profile can be found in **Table 1**.

Table 1: Workload profile for patient group X (fictitious example)

Patient characteristic / day of stay	**Care time for characteristic**	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**
Characteristic 1	20 minutes	X				
Characteristic 2	10 minutes	X	X	X		
Characteristic 3	15 minutes			X	X	
Characteristic 4	15 minutes					X
Characteristic 5	5 minutes					X
	Total care time per day:	**30**	**10**	**25**	**15**	**20**

As stated above, we assume that there is a 'baseline' care time: an amount of time that is spent on caring for a patient when none of the above-mentioned characteristics apply. We will derive estimated means from the linear mixed effects model for a patient profile in which none of the characteristics are present. This way we can estimate this baseline care time.

Nurses also spend time on other activities that are not directly patient-related, such as household tasks, administration, taking care of supplies, training students, etc. Per ward, we will determine the percentage of time that nurses spend on tasks that are not directly patient-related from the work sampling results. These estimated percentages will added to the estimated time for patient-related tasks, so that the total required nursing resources (expressed as care time) can be calculated.

Estimating allocated care time

Allocated care time can be calculated by simply counting the number of nursing in a shift and multiplying this amount with the shift hours. However, there is evidence that indicates that a staff mix with a large proportion of registered nurses results in better quality of care and better managed workload [28, 29]. Therefore it is necessary to introduce nurse education levels into the

workload equation. But besides this, we believe that working experience of nurses is also a factor of importance; nurses' experience is related to clinical expertise [37]. There have not been any studies to relate clinical expertise to perceived workload, but we believe that a more experienced nurse is more likely to handle workload better than a relatively newly registered nurse. Our hospital works with different types of student nurses. Dependent on the type of education these students are following and the study year they are in, they are more or less proficient; depending on their proficiency, they can be allocated to more or less different tasks. In order to capture all these types of differences in nursing staff, we introduce a proficiency percentage. A fully registered nurse that has more than one year experience on the ward he or she is allocated to, is set to a proficiency percentage of 100%. These nurses are qualified to perform all different tasks in the unit and have sufficient experience to be proficient in them. If nurses are not fully trained yet, or have not been working in the specific specialty for a long time, then they are likely to be less proficient than nurses who have. We will ask ward management (head nurses) for their expert opinion to define a proficiency % of all less experienced nurses (<one year experience on the ward they work in) and student nurses (for two education types known in the Netherlands and the status of their education-senior or junior students). Management is asked to determine proficiency of this type of nurses against the 100% standard. Determination of proficiency for individual nurses in the study will be done by classifying nurses in this framework. We will translate this proficiency into allocated care time: a nurse in an 8-hour shift with 100% proficiency will represent allocated care time of 8 hours. A nurse with 75% proficiency will represent 6 hours of allocated care time in an 8-hour shift.

Estimating nurses' workload

An estimate of nurses' workload can be made by dividing the estimate of required care time by the estimate of allocated care time.

Table 2 displays our plan for processing above-mentioned components into a workload management method.

Table 2: Workload management method (fictitious example)

Ward X		**Monday June 4**	**Tuesday June 5**	**Wednesday June 6**
Care time for direct patient care (hours)		46	39	46
Time for indirect patient care & additional tasks (hours)		48	40	48
Outcome C: Total required care time (hours)		**94**	**79**	**94**
Nurse qualifications	**Proficiency**	**Allocated care time (hrs)**	**Allocated care time (hrs)**	**Allocated care time (hrs)**
Registered nurse >=1 year experience	100%	10	8	9
Registered nurse <1 year experience	85%	0	1	1
Student nurse Senior	70%	2	0	2
Student nurse Junior	45%	1	0	0
Outcome 3: Total allocated care time (hours)		**95**	**71**	**90**
Outcome D: Expected % over- or understaffing (workload indication)		99%	111%	104%
Outcome 4: Average perceived workload (scale of 1 to 5)		3,1	4,2	3,2

Note: for full explanation of C, D, 3 and 4 see main text

Patient type profiles for all admitted patients in a shift can be added up to get to the total required care time for patient-related activities (A) for that shift.
From the time study, an estimate for time spent on non-patient-related activities (B) per shift can also be made. Together, derived components A and B can be combined to determine the estimated required nursing time (C). The allocated nursing time (3) is determined by counting the number of nurses on duty and multiplying this by the shift time. This will be done for each type of nurse on duty (registered, student, etc.).
Dividing the required nursing time (C) by the allocated time (3) gives an indication of nurses' workload (D): 100% is assumed to be a perfect fit, lower numbers indicate overstaffing and higher numbers understaffing. This indication will then be compared to the perceived workload (4) from questionnaires answered by nurses on duty during that shift.
When this workload management method is used, the only registration that has to be made on a daily basis is the patient classification, which should only take a few minutes per day per ward.

Measuring perceived nurses' workload

Job demands and job resources will be assessed with shortened scales [38] of the validated questionnaire on the experience and evaluation of work (QEEW), which is widely used by Dutch occupational health services and applied researchers [39, 40].

The QEEW has been validated for determining engagement and related resources (such as support from colleagues) and related demands (such as workload). The QEEW will be measured once as a baseline measure for engagement of nurses. The questionnaire contains 98 questions, so it is not practical to use it for measurements on a daily basis. Therefore, we have selected 12 questions to measure outcomes such as stress level and engagement, but also resources and demands on a daily basis. Of these 12 questions, 5 questions consider different demands related to workload (pace and amount of work, emotional load, physical effort and mental load). The following table shows these five questions, measured on a five-point response scale (**Table 3**):

Table 3: Questionnaire perceived workload

		Answer				
Nr	Question	Not at all	Sometimes	Regularly	Often	All the time
1	Did you have to work very fast today?	O	O	O	O	O
2	Did you have too much work to do today?	O	O	O	O	O
3	Did you consider your work mentally very challenging today?	O	O	O	O	O
4	Did your work demand a lot from you emotionally today?	O	O	O	O	O
5	Did you find your work physically strenuous today?	O	O	O	O	O

Every answer option corresponds with a certain weight (points ranging from 1 to 5 for the answers "Not at all" to "All the time"). We will test the internal consistency of the workload items by calculating Cronbach's alpha. We will also test what happens to Cronbach's alpha if one of the items is deleted from the questionnaire. We expect that every question has an equal weight in measuring workload.

The shortened 12-item questionnaire will be filled out every day during the work sampling period by each nurse on duty, at the end of the day shift. Per ward, individual scores of workload are added up and averaged for all nurses in the day shift on that ward. The shortened questionnaire will be validated against the QEEW.

Validation

We plan to validate the workload management method by comparing the estimated nurses' workload to the workload as it was perceived by the nurses on duty, see **Table 4**.

Table 4: Workload management method - validation

Ward X		**Monday June 4**	**Tuesday June 5**	**Wednesday June 6**
Care time for direct patient care (hours)		46	39	46
Time for indirect patient care & additional tasks (hours)		48	40	48
Outcome C: Total required care time (hours)		**94**	**79**	**94**
Nurse qualifications	**Proficiency**	**Allocated care time (hrs)**	**Allocated care time (hrs)**	**Allocated care time (hrs)**
Registered nurse >=1 year experience	100%	10	8	9
Registered nurse <1 year experience	85%	0	1	1
Student nurse Senior	70%	2	0	2
Student nurse Junior	45%	1	0	0
Outcome 3: Total allocated care time (hours)		**95**	**71**	**90**
Outcome D: Expected % over- or understaffing (workload indication)		99%	111%	104%
Outcome 4: Average perceived workload (scale of 1 to 5)		3,1	4,2	3,2

When measured over time, the two workload measurements (D and 4) should be consistent. This way the estimated nurses' workload can be validated. This will be done by determining the correlation between the workload indication and the perceived workload.

We aim to balance nurses' workload without deteriorating patient experiences and nurses' engagement. In the Netherlands, academic hospitals have chosen to use the validated Consumer Quality Index questionnaire to measure patient experiences [41]. The questionnaire focuses on specific experiences such as whether information was passed on to the patient in a timely manner or whether nurses have sufficient time to answer patients' questions. This specific information gives clear direction to health care providers for improving their processes. We will perform a baseline measurement of patient experiences before we start the time study. After we have developed the above-mentioned workload management method and have completed implementation, we will do a repeat measurement of patient experiences to see whether

controlling workload of nurses influences patient experiences. We expect to find a non-linear relation, shaped like an example shown in **Figure 2**.

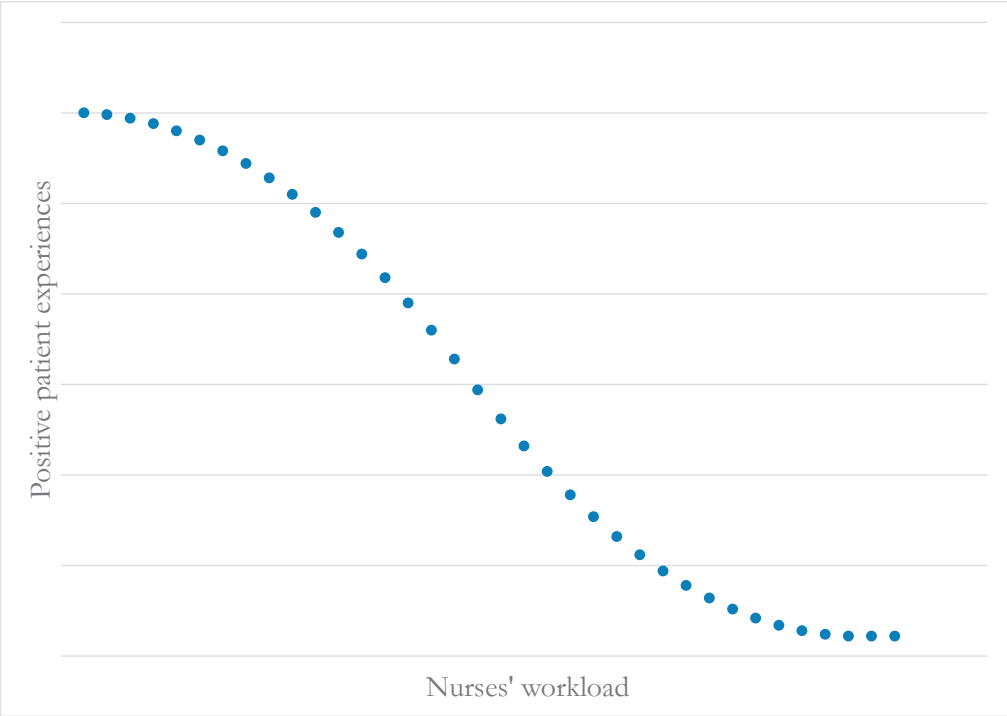

Figure 2: example of expected relationship between positive patient experiences and nurses' workload

After development and implementation of the workload management method we will do a follow up measurement to determine effects on nurses' engagement as well as patient experiences.

Ethical considerations

The study will guarantee the privacy of participating patients and staff. Only the lead researcher has access to the master data. Data will be processed in such a way that nothing can be traced back to specific persons.

The study protocol was submitted to the medical ethical review board of the UMC Utrecht and received a positive advice, protocol number 14-165/C.

Discussion

With this study, we aim to add several new dimensions to nurses' workload management methods. This method will be developed in close cooperation with participating staff nurses and ward management; the strong involvement of the end users of the method will contribute to the usefulness of the method and a broader support of the results. We expect that the method we will develop may also be useful for planning purposes: this is a strong advantage over existing methods, which tend to focus on retrospective analysis. Also, we will analyze data using a mixed model to correct for multilevel data, where usually this is ignored and data is analyzed using simple regression. In our study we introduce nurses' proficiency as a new dimension in determining workload.

Our study is set in one academic hospital (six wards); the UMC Utrecht. It is unclear whether study results can be readily applied to different settings, such as general hospitals. Patient characteristics in general hospitals may be different from characteristics of patients in academic hospitals (since patients with co-morbidity or complicated illness are usually referred to academic hospitals, some characteristics are more likely to occur in patients in an academic hospital than in a general hospital). This should not be a problem when applying the study results to general hospitals, since we expect that the biggest difference will be in the frequency of occurrence of characteristics, and not in the types of characteristics or their effect on workload.

Further, the study is set in 6 surgical wards of 6 different specialties: this means that when applying the results to other specialties, adjustments will need to be made. Nurses on internal medicine wards spend their time on different activities than nurses on surgical wards. For example, wound care is not expected to be a predominant activity, but nurses are likely to spend a lot of time on, for example, blood transfusions, dialysis or chemotherapy. Different specialties have different working processes, so our study results can be most easily applied to surgical wards. In addition, working processes, organizational structure and outside influences (new laws or protocols, IT developments, etcetera) may require adjustment to the workload management method.

However, we expect that the *framework* of the workload management method can be applied in any hospital: it would result in different checklists of patient characteristics and work sampling results though. We aim to develop a method that is generally applicable or can be modified easily for different hospital settings, specialties or even different types of health care providers and that is robust to organizational and process changes.

At the UMC Utrecht, hospital management will use this tool to ensure a better balance between patient needs and nursing staff size and expertise. At the moment, we cannot objectively

determine whether our nursing capacity is optimally matched to the hospital wards. Nurse management indicates that there are signals that our nurses believe some wards have a much higher workload than others. We aim for a fair and sensible distribution of nursing staff over the wards, resulting in an equally distributed and manageable workload for all nursing staff.

The data collected during the work sampling study are also very interesting from an operational excellence perspective. When further analyzed, this data can give valuable insight in the working processes of different wards and can help compare operational excellence between wards and explain differences.

Abbreviations

UMC Utrecht: University Medical Center Utrecht

ICF: International Classification of Functions

TISS: Therapeutic Intervention Scoring System

B-NMDS: Belgium Nursing Minimal Data Set

OPC: Oulu Patient Classification

NZi: Dutch National Hospital Institute (Nationaal Ziekenhuis Instituut)

QEEW: Questionnaire on the Experience and Evaluation of Work

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Data sharing

Statistical code and dataset available from the corresponding author.

Contributorship statement

Authors of this manuscript are W.F.J.M. van den Oetelaar, MSc (WO, corresponding author and guarantor), Dr. H.F. van Stel (HS), Prof. Dr. W. van Rhenen (WR), R.K. Stellato, MSc (RS) and Prof. Dr. W. Grolman (WG). WO and WG conceived the study. WO, WG, WR, RS and HS participated in its design. WO gathers and cleans data, coordinates the study and drafted this manuscript. RS performs statistical analysis. HS helped to draft the manuscript. All authors revised the manuscript drafts and approved the final manuscript.

Competing interests

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: no support from any organization for the submitted work; no financial relationships with any organizations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

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CHAPTER 3

IDENTIFYING PATIENT CHARACTERISTICS RELATED TO CARE TIME: A DELPHI STUDY IN SURGICAL HOSPITAL WARDS

Abstract

Aim

To determine a clear and complete set of patient characteristics that influence care time provided by ward nurses.

Background

Balancing nursing staff in relation to patients is important for hospitals to remain efficient. One way to ensure a proper fit between patient needs and nursing staff is to work with a workload management method. Many workload management methods use patient classification to estimate nurse workload.

Design/Method

The research took place in 2012 in a university hospital. Six surgical wards were included, capacity 15 to 30 beds. The research consists of 4 phases to develop an observation list with patient characteristics that are expected to be relevant to care time provided by ward nurses: Delphi group composition and first round of interviews, prioritization, preliminary testing and lastly extensive testing and implementation. The Delphi group consisted of 15 expert nurses, representatives of all six wards.

Results/Findings

The result was an observation list with 15 patient characteristics: personal patient characteristics (bodily proportions, psychosocial condition) and consequences of disease/treatment (isolation measures, amount of IV or drains, assistance with meals).

Conclusion

Expert opinions of ward nurses and ward management lead to the development of this list. The list included items that have not been studied before in relation to care time, such as bodily proportions of the patient. A new concept, 'patient requiring one-on-one care', was introduced. This set of patient characteristics will be combined with time study results, to determine if these patient characteristics actually influence care time.

Introduction

Balancing the number of staff in relation to the number of patients is important for hospitals to remain efficient [1]. Nursing staff is an important part of this balance. There needs to be a good fit between patient needs and nursing staff on hospital wards in order to deliver good quality of care and to work efficiently.

A good balance can prevent extra costs for overstaffing a ward but will also prevent deteriorating patient outcomes and increased stress or burnout in nurses by understaffing wards. After all, there is a direct relationship between nurses' workload and patient outcome [2-5] as well as workload and burnout [6, 7]. Furthermore, Van Bogaert et al. showed that there is a relation between workload and nurse assessed quality of care [8]. Research of Toh found a positive bi-directional relationship between the shortage of oncology nurses and registered nurses' job dissatisfaction, stress and burnout [9]. Besides this, healthcare labor shortages are expected in the future [10] while retaining nursing staff will be a challenge. Since workload is also related to intention to leave [11, 12] and training of new staff is costly, this is another reason to help align nursing staff with patient needs .

In a previously published study protocol (*No reference due to blind peer review*) we described the development of a new workload management method for balancing workload of nurses in hospital wards. In this study workload is defined as the proportion of *available* nursing resources to *required* nursing resources, where nursing resources are expressed in hours. This is an objective measure of workload, as opposed to the perceived workload of nurses. The first step in determining the required nursing resources is identifying patient characteristics that influence care time.

Several patient characteristics have already been found to influence the workload of nurses or care time provided by nurses [13-16]. Most studies focus on characteristics that are already available in the hospital information systems, in order to prevent additional registration. Mueller [13] studied the correlation between the Barthel index scores and Acute ICF (International Classification of functions) core sets and nurses' workload in a critical care setting. In this research, 20 to 44% of perceived nurses' workload variance is explained by these scores. Another method is the TISS (Therapeutic Intervention Scoring System [17]). This classification system was developed in the early seventies. In 1996 this system was refined to TISS-28 [18] and later further simplified to the Nine Equivalents of Nursing Manpower [15]. Both methods have been validated internationally, but only for ICU wards. The authors suggest that the Nine Equivalents of Nursing Manpower may not be a strong predictor for workload related to individual patients.

Perroca [16] validated a patient classification system to identify patients' care requirements and care category. This classification may help assess nurse workload. The system covers 9 care areas and each area is scored in four gradations of increasing complexity. The total score determines in which one of four defined care complexity gradations the patient belongs. Perroca's classification system has the downside that it awards a maximum gradation of 4 to each care area, resulting in a maximum of 4 classes (from minimal care to intensive care), limiting differentiation of care intensity on a patient level. Perroca did not perform a time and motion study to prove if scores on a care area are indeed related to actual care time of nurses.

Myny [19] studied a set of 13 complex patient related nursing activities of which seven turned out to be significant in influencing care time: BMI, level of assistance for positioning, level of hygiene care, stoma care (level of education needed), level of wound care, level of pressure ulcer prevention and level of assistance with feeding.

Another system that connects patient characteristics to nurses' workload is the RAFAELA™ patient classification system [14]. This is an instrument to assess optimum levels of nursing intensity. The system consists of a patient classification instrument (Oulu Patient Classification questionnaire), a system recording daily nursing resources and a questionnaire for nurses to assess the optimal nursing intensity. The patient classification instrument has the downside that some sub-areas cluster nursing needs that can each be quite intensive in their own right. For example one sub-area clusters assistance with nutrition and medication, which can both require extensive additional nursing time.

Sermeus et al [20] use the Belgian Nursing Minimum Data Set to calculate nursing intensity. To calculate this, 23 nursing activities are assessed for a patient and scores result in a classification in one of four nursing intensity categories. Each category can be assigned standard times for nursing care. In Belgium, all hospitals routinely record these nursing activities (4x a year for 15 days) so this information is already available. However, the categorization is quite crude: only 4 categories, including intensive care.

Hoi [21] found 10 nursing diagnoses that significantly influence nursing time and determined standard nursing times for diagnosis in each department in their study. These 10 diagnoses explain 61-73% of variation in nursing time on the wards participating in the study, which is quite a high percentage considering the limited amount of diagnoses in the study and the relatively wide range of specialties in the participating wards.

Currently available patient classification systems may be improved by adjusting the clustering of patient characteristics. Also, the currently available systems may not cover all patient

characteristics relevant to care time. For example, characteristics on caring for a patient with complex co-morbidity or a patient that needs extensive health information.

We aim to develop a more complete set of relevant patient characteristics, with a clear and logical clustering of characteristics. We plan to keep additional registration to a minimum, since this could lead to additional workload for the nurses. Strong involvement of the nursing staff in the study helps in gaining a better understanding of all patient characteristics that are expected to influence care time and will help to get full support of the nurses for the end result of the study. Relationships between these patient characteristics and actual care time will be established by performing a time study.

Method

As described in the above mentioned study protocol for developing a workload management method for staff nurses, identifying relevant patient characteristics is the first of several steps.

The first step is to compose a list of patient characteristics relevant to care time, by performing a Delphi study among staff nurses. Next, a time study of nurses' activities will be done. Results of these two steps can be combined to estimate care time per patient group and estimate the time nurses spend on (non-)patient related activities. These estimates of required nursing time can be compared to available nursing resources: this gives an estimate of nurses' workload. To validate this calculated workload estimate, it can be offset to the *perceived* workload of nurses, which will be measured by an existing, validated questionnaire. **Figure 1** shows all steps, with the first step encircled in red.

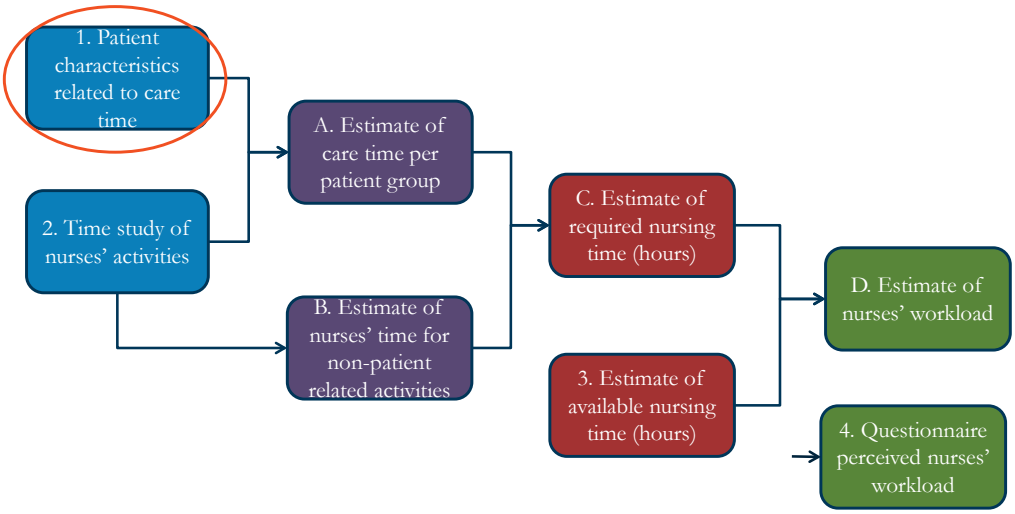

Figure 1: Developing a workload management method for staff nurses

In the current paper, we describe the first step in developing this workload management method: identifying patient characteristics that are expected to influence care time. This is done in four phases. The different phases are described in chronological order. As each consecutive phase uses the results of the previous phase, we describe for each phase first the method and then the results. The four phases are:

1. Delphi group composition and first round of interviews
2. Prioritization
3. Preliminary testing
4. Extensive testing & implementation

The next step in the development of a workload management method for nursing staff is the time study (see Figure 1). In this time study, all nurses will be observed for a certain period of time. We will note which activities the nurses do and if applicable, for which patient. During the time study period, above observation list will be filled in every dayshift for every patient admitted. The combined data of the time study and the observation lists will make it possible to test if all the above mentioned patient characteristic indeed influence care time and if so, to what extent. All other steps as described in Figure 1 will be described in subsequent publications.

Sample/participants

The research took place in 2012 in one academic hospital in the Netherlands. Six surgical wards have been included, ward capacity varying from 15 to 30 beds (2 wards of 15 beds, 4 wards of 30 beds). We focused on workload of nurses in the dayshift. Workload of other types of ward staff (doctors, assistants, cleaners, etcetera) was not considered in this study.

Experts from all six wards have taken part in Delphi rounds. Ward management assigned one expert per ward to participate in the study. All participants were experienced (senior) nurses or nurse team leaders.

In this study we focus on the effects of patient characteristics, number of patients and nursing staff mix on workload of nurses; we do not include effects of job resources such as support of medical staff or nurse management in our study, nor do we look at ward characteristics such as the number of single rooms in a ward or layout of the wards.

Data collection

The composition of the list of relevant patient characteristics has been done by performing a study consisting of four phases:

Phase 1. Delphi group composition and first round of interviews

We chose the Delphi method to acquire an expert opinion on relevant characteristics [22]. This is a proven method for this purpose, where we need to reach consensus on a uniform list of expected relevant patient characteristics for all participating wards. Each ward cares for a different category of patients: patient groups included patients undergoing head and neck surgery, gastro-intestinal surgery, plastic surgery, trauma and orthopedic surgery, eye surgery, genitourinary surgery and vascular surgery. We aim to develop one uniform list of relevant patient characteristics, that can be used in all surgical wards in the study, and potentially in other settings as well.

In our research, we made an important assumption. When a patient is admitted to a ward, we assume that nurses will always spend a certain amount of care time for this patient, regardless of the reason why the patient is admitted. For example time that is spent on handing out meals, having a chat or tidying up. We call this "baseline" care time. We assume that there is always a baseline amount of care that is provided to a patient when admitted to a ward, as also suggested by Hoi [21]. Besides this baseline, nurses also spend time to cater to other needs for a patient,

based on specific characteristics of the patient, for example related to health status of the patient at admittance or the procedure the patient has undergone. Our study will focus on finding patient characteristics that are expected to cause additional care time, on top of this baseline care time. We will test if these characteristics can be used to predict care time provided by nurses.

Ward management selected one staff nurse of each ward to be the representative for their ward in the Delphi group. All participants in the study received extensive information about the purpose of the research and on how the Delphi study contributes to this. Participants were asked to identify the patient characteristics that, in their opinion, have the most influence on care time. One-on-one interviews were performed with all six Delphi group members by the lead researcher of this study. The main question for the Delphi group was: which patient characteristics cause nurses to spend more than the baseline care time on caring for a patient?
Each Delphi group member was interviewed separately on this topic. Summarized results of this first round of interviews were shared by email with the entire Delphi group. The group commented by email on the list of characteristics and the clarity of the definitions. Clear definitions of characteristics are necessary to make sure the characteristics are uniformly interpreted and do not overlap. The comments were used to refine the list and the definitions.

Phase 2. Prioritization

In the next phase, each member of the Delphi group was asked to prioritize the characteristics by allocating a total of 140 points to the characteristics (ten points x 14 characteristics). Prioritizing was done based on the amount of extra care time that was expected to be related with the characteristic: the higher the expected care time, the higher the allocated amount of points. The members were free to divide the points as they saw fit (all ranges were allowed, anything between 0 to 140 points for one characteristic). Two smaller departments with similar patient groups prioritized together, in the results shown as one department: A.

Phase 3. Preliminary testing

In preparation of this phase, observation list Version 1 was incorporated into the hospital information system. This observation list consisted of 14 patient characteristics shown in Table 1, with a 'yes' or 'no' tick box placed beside each characteristic. Some characteristics required a more elaborate clarification. For each such characteristic, the full definition and clarification was shown in the observation list.
Nine additional experienced senior nurses were requested to participate in this step of the study, to form a group of testers, together with the original members of the Delphi group from Phase 1

and 2. Each ward manager was asked to select a maximum of two senior staff nurses. Some ward managers selected one nurse, others two. All selected nurses were again senior staff nurses or team leaders. After adding the nine new members, the testing group totaled to fifteen. The testing group was larger, to broaden the support for the end result.

The testing group was trained by the lead researcher in how to use the new digital observation list. The training consisted of the purpose of the observation list, an explanation of how the list was composed and how to interpret the descriptions of the characteristics and the corresponding definitions.

Then all group members were asked to fill in the observation list for the first ten patients that were admitted on their wards on one particular day. This was a randomly selected working day, but it was selected within a time period where there were no special circumstances, such as reduced operating room capacity or holiday periods. The group returned their test results and the results were summarized in an Excel spreadsheet.

After the test, the group members were interviewed. The interviews were performed by the lead researcher and were done per ward: so all representatives of the same ward were interviewed together. They were asked if the test-version of the observation list was complete, if the definitions were sufficiently clear and if characteristics were indeed mutually exclusive.

Phase 4. Extensive testing & implementation

After the preliminary testing phase, a new, extensive test period started. All wards appointed a minimum of two staff nurses to perform the daily task of filling in the observation list of patient characteristics. The observation list was filled in each dayshift for all patients that were admitted on the ward during (part of) that dayshift. Also for patients that were not present during the whole dayshift, for example because they were being operated on or were discharged during the dayshift.

The appointed nurses were all uniformly trained in how to use the new observation list. The training started with information on the purpose of the research and how using the observation list would contribute to this. Also, the process of development of the observation list was explained and each characteristic and definition was clarified. Each nurse received a personal instruction from the lead researcher. A summary of the guidelines on how to use the observation list was put up next to every computer on every participating ward. The importance of accuracy in registering was stressed and nurses were informed that observation list input was also going to be monitored by random checks. These checks done planned in order to detect mistakes early but also to avoid manipulation of input. Then the test period started. For a period of one month,

observation lists were filled in every dayshift for every patient admitted on each of the six participating wards.
At the end of this test period, the testing group members were interviewed again: what were the experiences on their wards with the new checklist?

Ethical considerations

The study guarantees the privacy of involved staff. Only the lead researcher has access to the source data. Data have been processed in such a way that results cannot be traced back to specific persons.
The study protocol was submitted to the medical ethical review board and was approved, protocol number 14-165/C.

Results

Phase 1. Delphi group composition and first round of interviews

The result of this phase was a first draft of a list of relevant patient characteristics and is shown in **Table 1.** This list was shared with the Delphi group by email and approved as a starting point for the next phase.

Table 1: Identifying relevant patient characteristics - Version 1

Nr	Characteristic	Clarification
1	Patient needs partial assistance bathing, mobilization	F.e. assistance transfer bed/chair, to bathroom or shower, in/out of bed, getting upright, walking, partial assistance washing in bed
2	Patient needs full assistance bathing, mobilization or care for incontinent patient	F.e. weight lift, full assistance washing in bed, care for bedridden patient or incontinence (only if 3 or more changes per shift)
3	Patient needs full assistance with meals, providing drip feed (portioned or by triple lumen) or TPN	Continuous drip feed excluded, unless medication needs to be provided through feed or the patient needs to be taught selfcare and extensive education is in order
4	Patient with IV, drip or drain: 2 or more	Only applies when 2 or more drains/drips are in place. Periferal IV without medication is excluded.
5	Patient requiring inspection or minor activity every 1 or 2 hours	F.e. fluids balance, vital signs after surgery/examination, pupil examination, hyperactivity, etc. Regular inspections such as temperature checks are excluded.
6	Patient requiring inspection or minor activity several times an hour	F.e. administring eye drops. Regular inspections such as temperature checks are excluded.
7	Patient requiring additional psychosocial support, for patient or family	Delirium, agression, retardation/dementia (in case the patient does not have a chaperonne), foreign language, psychiatric/suicidal patient, support after bad news
8	Patient with exeptional bodily proportions	
9	Patient with extensive wound/fistula	
10	Patient with new tracheostoma/ileostoma/urostoma/colostoma	
11	Patient with emergency admittance, complex discharge procedure, transfer from other department/hospital	Select only when additional activities *other* than mentioned above are required.
12	Patient of other specialty or with complex additional co-morbidity	Select only when additional activities *other* than mentioned above are required.
13	Patient in isolation	Patient is cared for in full isolation or contact isolation measures apply
14	Patient unstable	

Phase 2. Prioritization

The prioritization gave the following result, shown in **Table 2**. Results of the prioritization were shared with the entire Delphi group. The weight that departments assigned to a certain characteristic varied quite a lot between departments: anything between 1 and 20 points. Sometimes the weight of an item varied between 1 and 12 points (item 9) but also between 10 and 20 points (items 7 and 2). So estimated effect on care time of the characteristics varied between departments, but none of the characteristics were given 0 points. Therefore, no changes

were made to the list of patient characteristics: Version 1 of the observation list of relevant patient characteristics was maintained and taken into the next phase.

Table 2: Prioritization of patient characteristic

Nr	Patient characteristic	Ward 1	Ward 2	Ward 3	Ward 4	Ward 5&6	Mean	Standard deviation
1	Patient needs partial assistance bathing, mobilization	6	7	10	5	8	7,0	2,2
2	Patient needs full assistance bathing, mobilization or care for incontinent patient	10	10	20	14	12	13,5	4,7
3	Patient needs full assistance with meals, providing drip feed (portioned or by triple lumen) or TPN	10	7	10	10	9	9,3	1,5
4	Patient with IV, drip or drain: 2 or more	7	3	5	10	9	6,3	3,0
5	Patient requiring nspection or minor activity every 1 or 2 hours	8	7	7	5	6	6,8	1,3
6	Patient requiring inspection or minor activity several times an hour	10	7	13	10	13	10,0	2,4
7	Patient requiring additional psychosocial support, for patient or family	12	20	10	14	13	14,0	4,3
8	Patient with exeptional bodily proportions	12	8	10	10	9	10,0	1,6
9	Patient with extensive wound/fistula	12	7	5	4	1	7,0	3,6
10	Patient with new tracheostoma/ileostoma/urostoma/colostoma	12	10	10	14	11	11,5	1,9
11	Patient with emergency admittance, complex discharge procedure, transfer from other department/hospital	8	7	5	10	11	7,5	2,1
12	Patient of other specialty or with complex additional co-morbidity	8	7	10	10	10	8,8	1,5
13	Patient in isolation	15	20	20	14	16	17,3	3,2
14	Patient unstable	10	20	5	10	12	11,3	6,3
	TOTAL:	**140**	**140**	**140**	**140**	**140**		

Note: two smaller departments with similar patient groups prioritized together, as one: Ward 5 & 6

Phase 3. Preliminary testing

The testing lead to several new insights. Some of the definitions and clarifications of characteristics were not clear enough or needed a more extensive clarification to understand which activities were (or were not) included. Also, the participants unanimously agreed that there was a need for one more characteristic: One-on-one care. They argued that some patients required so much care, that one nurse would be busy a whole working day with taking care of just this one patient. The characteristics available in the list could not fully represent this type of care, but we could not identify relevant additional characteristics. Apparently in this case the sum of care time for the separate characteristics does not equal the total care time for the patient.

Based on the insights, the descriptions of items 9 and 11 were changed, the definitions of items 2, 4, 8-12 and 14 were changed and one item was added to the list: one-on-one care.

The group was also asked whether filling in the observation list was time-consuming: was the administrative burden of filling it in for every patient in every dayshift reasonable or too high? The additional administrative burden was unanimously considered acceptable. Also, the clustering of characteristics was discussed. The clustering was considered practical, in the sense that status or activities clustered in one patient characteristic are very unlikely to occur at the same time with one patient on the same day. That means that the care time related to this characteristic is expected to be stable.

Based on this test period, changes in definitions and clarifications were made and one characteristic was added. The new version of the observation list was uploaded in the hospital information system. This new version is shown in **Table** 3 below.

Table 3: Identifying relevant patient characteristics - Version 2

Nr	Characteristic	Clarification
1	Patient needs partial assistance bathing, mobilization	F.e. assistance transfer bed/chair, to bathroom or shower, in/out of bed, getting upright, walking, partial assistance washing in bed
2	Patient needs full assistance bathing, mobilization or care for incontinent patient	F.e. alternate positioning, weight lift, full assistance washing in bed, care for bedridden patient or incontinence (only if 3 or more changes per shift)
3	Patient needs full assistance with meals, providing drip feed (portioned or by triple lumen) or TPN	Continuous drip feed excluded, unless medication needs to be provided through feed or the patient needs to be taught selfcare and extensive education is in order
4	Patient with IV, drip or drain: 2 or more	Only applies when 2 or more drains/drips are in place. Catheters are included, but CAD is excluded, unless used for bladder chemotherapy or urology patients. Periferal IV without medication is excluded. Exception: if only 1 drain is present but with bile return, then this characteristic applies.
5	Patient requiring inspection or minor activity every 1 or 2 hours	F.e. fluids balance, vital signs after surgery/examination, pupil examination, hyperactivity, etc. Regular inspections such as temperature checks are excluded.
6	Patient requiring inspection or minor activity several times an hour	F.e. administring eye drops. Regular inspections such as temperature checks are excluded.
7	Patient requiring additional psychosocial support patient or family	Delirium, agression, retardation/dementia (in case the patient does not have a chaperonne), foreign language, psychiatric/suicidal patient, support after bad news
8	Patient with exeptional bodily proportions	Select only when characteristic demands considerable extra care time
9	Patient with extensive wound/fistula and/or VAC bandages	Select only when characteristic demands considerable extra care time
10	Patient with new tracheostoma/ileostoma/urostoma/colostoma	Select only when stoma demands considerable extra care time during the shift (f.e. because patient is too sick to do this themselves or to help the patient learn how to do this themselves)
11	Patient with emergency admittance, complex discharge procedure, transfer from other department/hospital, extensive health education	Select only when additional activities other than mentioned above are required. Select only when characteristic demands considerable extra care time.
12	Patient of other specialty or with complex additional co-morbidity	Select only when additional activities other than mentioned above are required. Select only when characteristic demands considerable extra care time.
13	Patient in isolation	Patient is cared for in full isolation or contact isolation measures apply
14	Patient unstable	Early Warning Score of 3 or higher
15	One-on-one care	1 nurse spends an entire shift on caring for this patient only and has no time for other tasks.

Phase 4. Extensive testing & implementation

The most important finding in this phase was that there was confusion about the timing of observation of the patient: how should we fill in the checklist on the day of surgery or the day of release of the patient? Do we fill in the observation list for the patients in their condition before or after surgery? Do we also fill in an observation list for patients that are released that day before 10 o'clock in the morning? We discussed this with ward management and it was decided that on the day of surgery, we would fill in the observation list for the (expected or observed) postoperative condition of the patient. A remark about this was added on the top of the observation list. For the day of release, we agreed to only fill in the observation list if the nurses put in a substantial amount of work that day to care for this patient. As this was an exploratory phase, the judgment of what was substantial was left to the professional opinion of the nurses. Also, we found that items 13 (Patient isolation) and 14 (Patient unstable) could be automatically extracted from the hospital information system, so nurses would not have to register information about this in the observation list as well.

Test results were processed and a new, final version of the observation list was composed. This list is shown in **Table 4**. Please note that in the list that appeared in the hospital information system, items 13 and 14 were no longer visible.

Table 4: Identifying relevant patient characteristics - Version 3

Important: on the day of surgery, always observe the patient in their (expected) postoperative condition		
Nr	**Characteristic**	**Clarification**
1	Patient needs partial assistance bathing, mobilization	I.e. assistance transfer bed/chair, to bathroom or shower, in/out of bed, getting upright, walking, partial assistance washing in bed
2	Patient needs full assistance bathing, mobilization or care for incontinent patient	I.e. alternate positioning, weight lift, full assistance washing in bed, care for bedridden patient or incontinence (only if 3 or more changes per shift)
3	Patient needs full assistance with meals, providing drip feed (portioned or by triple lumen) or TPN	Continuous drip feed excluded, unless medication needs to be provided through feed or the patient needs to be taught selfcare and extensive education is in order
4	Patient with IV, drip or drain: 2 or more	Only applies when 2 or more drains/drips are in place. Catheters are included, but CAD is excluded, unless used for bladder chemotherapy or urology patients. Periferal IV without medication is excluded. Exception: if only 1 drain is present but with bile return, then this characteristic applies.
5	Patient requiring inspection or minor activity every 1 or 2 hours	I.e. fluids balance, vital signs after surgery/examination, pupil examination, hyperactivity, etc. Regular inspections such as temperature checks are excluded.
6	Patient requiring inspection or minor activity several times an hour	I.e. administring eye drops. Regular inspections such as temperature checks are excluded.
7	Patient requiring additional psychosocial support patient or family	Delirium, agression, retardation/dementia (in case the patient does not have a chaperonne), foreign language, psychiatric/suicidal patient, support after bad news
8	Patient with exeptional bodily proportions	Select only when characteristic demands considerable extra care time
9	Patient with extensive wound/fistula and/or VAC bandages	Select only when characteristic demands considerable extra care time
10	Patient with new tracheostoma/ileostoma/urostoma/colostoma	Select only when stoma demands considerable extra care time during the shift (I.e. because patient is too sick to do this themselves or to help the patient learn how to do this themselves)
11	Patient with emergency admittance, complex discharge procedure, transfer from other department/hospital, extensive health education	Select only when additional activities other than mentioned above are required. Select only when characteristic demands considerable extra care time.
12	Patient of other specialty or with complex additional co-morbidity	Select only when additional activities other than mentioned above are required. Select only when characteristic demands considerable extra care time.
13	Patient in isolation (AUTOMATICALLY DERIVED FROM HOSPITAL INFORMATION SYSTEM)	Patient is cared for in full isolation or contact isolation measures apply
14	Patient unstable (AUTOMATICALLY DERIVED FROM HOSPITAL INFORMATION SYSTEM)	Early Warning Score of 3 or higher
15	Patient requiring one-on-one care	1 nurse spends an entire shift on caring for this patient only and has no time for other tasks.

All involved nurses were informed of the changes and received new working instructions.

A reporting tool was developed to track actual usage of the observation list. This reporting tool will be used to make sure an observation list is filled in every dayshift for all admitted patients on the participating wards.

We have trained a medical student in the use of the observation list and this student has checked 40 random observation lists that were filled in by nurses. The student checked the entries in the observation list for consistency with other entries in the patient file, for example the consultation reports, correspondence and diagnostic reports. The student did not find any mistakes (data not shown).

Discussion

Findings

We composed a set of 15 characteristics that influence care time, according to nurses in the surgical hospital wards participating in the study. The set includes both personal patient characteristics (bodily proportions, psychosocial condition) and consequences of disease or treatment (isolation measures, amount of IV or drains, assistance with meals).

Prioritizing the characteristics by nurses showed that disease or treatment related characteristics are expected to have the biggest influences on care time. Also, it shows that the weight that departments assigned a certain characteristic can vary quite a lot between departments: anything between 1 and 20 points (with a possible range from 1 to 140). For some items the weight varied between 1 and 12 points (for example item 9, wound care etc.) , for other items between 10-20 points (for example item 2, full assistance bathing etc.). The differences in wound care can be explained because some specialties leave bigger wounds after surgery than others. But some results were surprising: for example we expected assistance with bathing to be equally time consuming everywhere, because assistance with bathing should require the same time regardless of the type of patient group. After consideration, we suspect that all characteristics are evaluated in the context of the specific ward: if characteristics are often observed on a certain ward, nurses may consider them as more important, even if the amount of additional care time is less than of other characteristics. Also, there may be interaction between characteristics. For example if isolation measures apply, the resulting additional care time is different when a patient is stable and self-reliant or if a nurse needs to come in to monitor vital signs every hour. More research is needed to test these hypotheses.

We assured content validity by the repeated Delphi procedure in which a large group of experienced nurses participated.

Comparison

Several other studies looked at characteristics that influence care time. Reis Miranda [15] showed a high correlation between the Nine Equivalents of nursing Manpower Score and the actual daily workload of a nursing ward [23]. Nine Equivalents of nursing Manpower was developed for ICU and the equivalents cover several ICU interventions such as dialysis and (supplementary) ventilatory support, but also basic monitoring and intravenous or vasoactive medication. Characteristics caring for patients in isolation or psycho-social support are not included in the this score. Perroca's patient classification system [16] covers 9 care areas: Care Process Planning and Coordination; Investigation and Monitoring; Personal Hygiene and Eliminations; Nutrition

and Hydration; Locomotion or Activity; Therapeutics; Emotional Support; Health Education; Skin Integrity. Our findings correspond with this; we found characteristics that roughly match these care areas, although we found other characteristics as well and we chose a different clustering of activities. For example we defined two characteristics concerning regular inspection or minor activity, based on frequency of this. Perroca defines one care area for monitoring and investigation. Within this care area, 4 gradations of complexity are defined, so there is differentiation possible within one care area. However, Perroca's study does not mention the definitions of the care areas so comparison is limited.

Myny found in their 2014 study [19] that BMI, positioning, hygiene care, stoma care, wound care, pressure ulcer prevention and assistance with feeding were complex nursing activities that make nursing labor intensive. Our study generally corresponds with Myny's findings. Van Oostveen [24] studied 17 patient characteristics expected to influence the cost of care. Seven of these turned out to be significantly associated to cost of care: age, number of complications, ASA-class, nutritional status, admission type, number of medications during hospitalization and surgical specialty. In line with Van Oostveen's findings we also have admission type in our characteristics list, but we combined it with other extensive procedural characteristics such as extensive discharge procedure or health education procedure. This because these are expected to require about the same additional care time and do not occur with one patient on the same day. In our study, we are not primarily interested in costs, but in nurses' workload. Therefore, we preferred to start with a clean slate to determine patient characteristics and not automatically include all of Van Oostveen's findings. For example, surgical specialty may correlate with costs due to relatively expensive methods of treatment and not due to care time.

The Belgian Nursing Minimum Data Set [20] consists of 23 characteristics: care relating to hygiene, care relating to mobility, care relating to elimination, care relating to feeding, tube feeding, mouth care, prevention of pressure sores: changing position, assistance in getting dressed, care of patient with tracheotomy or endotracheal tube, nursing admission assessment, training in activities of daily living, emotional support, care of a disoriented patient, isolation for preventing contamination, monitoring vital signs, monitoring clinical signs, cast care, taking blood samples, medication management (intramuscular, subcutaneous), medication management (intravenous), infusion therapy, surgical wound care, traumatic wound care. Many of the Belgian Nursing Minimum Data Set items were also mentioned in our study. However cast care was not mentioned at all, even though the orthopedics/trauma ward is included in our study. Mouth care was also not found in our study. We also made a different clustering: for example we did not split

monitoring of vital and clinical signs, but chose to cluster based on the frequency of observation. And we clustered emotional support and care for disoriented patient in one characteristic.
In the Belgian Nursing Minimum Data Set isolation measures are included, as in ours, but Van Oostveen found that isolation measures were not significantly related to care costs. They did note that some results may turn out to be significant if more observations are done in the study.
The nursing diagnoses that Hoi [21] found were related to nutrition, mobility, skin integrity, confusion, incontinence and tissue perfusion. In our study we found the same characteristics as Hoi did, but we combined some of these with other characteristics, for example confusion is combined together in one characteristic with amongst others retardation and language barrier.

We also found several characteristics that have not been studied before for their relation to care time or nurses' workload. For example unusual bodily proportions of the patient. In other studies such as Myny [19], BMI is usually the measure of choice. However, it can also be very time consuming to help a very tall (and thus heavy) patient with bathing, even though the patient's BMI is normal.
We also introduced a characteristic for patients who require inspection by nurses or minor nursing activity once or several times an hour. One such inspection of activity may not take a lot of time, but the high frequency of these activities can add up. One example of such an activity is having to administer eye drops to a patient every fifteen minutes or regular checking of vital signs. Sermeus [20] also mentions two nursing activities concerning monitoring (vital signs and clinical signs) and one minor activity (blood drawing) in his study. We chose to combine these in one characteristic. We made this decision because defining these smaller activities separately will make the checklist of patient characteristics longer and besides this, these activities do not often occur simultaneously for one patient on one shift and if they do, nurses tend to combine these activities in one visit to the patient, which can save a lot of time. If in that case all would be registered separately, the measurements may give the wrong indication. Where possible we combined characteristics together in one, especially when characteristics were in the same domain (for example psycho-social care) and it was expected that the chances of them occurring simultaneously were small.

One on one care is a new concept in the context of patient classification. In previous studies, this has not been mentioned or described. When testing a draft patient characteristics checklist in practice, we found that for some very complex patients, registering the separate patient characteristics did not do justice to the amount of care that is required. Hence we introduced this

new characteristic 'one-on-one care', which can be used when the total amount of required care is expected to exceed the sum of required care that is related to the separate characteristics.

In several studies [14, 16, 20] patient classification is done by asking nurses to award points or a score to an area of nursing need or care area, which results in classifying the patient in one of four (or more) classes. These classes range from minimal care to intensive care, which is quite a broad range. In our study, instead of asking nurses to make an estimate or score, we ask nurses to only observe characteristics. Estimates for care time are derived from a planned time study. With this, we expect to be able to make a more exact estimate of care time related to each individual patient characteristic and of total required nursing time on a ward.

Limitations

This study was done on surgical wards in one academic hospital. We would need to test whether the results could be extended to other hospitals, both academic and general. The characteristics that were found will surely be found in surgical wards of general hospitals as well, but maybe more or less frequently. The outline of the study can be used on other types of wards as well, but will most likely result in different types of characteristics, since nurses on other wards may perform very different activities.

A big effort was made to refine the definitions of the characteristics. However, it proved quite hard to make the definitions completely foolproof, without making them too extensive or too restrictive. For example, in several definitions the words "considerable extra care time" are part of the definition. Obviously, the question what is considerable is subject to the judgment of the nurses. We considered specifying this definition too for example "a minimum of 15 minutes of additional care time" but opted against this, because we did not want to introduce a predefined cut-off point without solid argumentation. We chose to let measurements in the planned time study tell us what 'considerable' is. We will measure this by doing an extensive time study on nurses' activities. The procedure is outlined in our above mentioned study design article [25].

We chose to group some characteristics that are expected to cause about the same amount of extra care time. For example, the definition of characteristic 6 includes dementia as well as aggression or speaking a foreign language. Of course these are very different conditions, but they all result in additional psycho-social care and are expected to cause about the same extra care time. We considered the possibility that more than one of these conditions could apply to a patient at the same time, but assumed that this chance was minimal.

Interpretation

We believe that by empowering our staff nurses in this study, we gained a broader view on patient characteristics that influence their workload. Our study was set up in very close cooperation with staff nurses and ward management. They were involved in advising about the study design, the execution of the study and the interpretation of results. The staff nurses and nurse management were continuously consulted throughout the entire study process, where they advised the researchers not only on practicalities, but also on fundamental choices in the study design. They were given complete freedom in defining what they believed were relevant patient characteristics for care time. For example we did not limit them to only come up with characteristics that were already available in the hospital information system or that were very easy to define or register. Because the experts were in charge, the content reflects current nursing practice. On the other hand, some characteristics that were expected to be relevant were not mentioned, for example age and gender. The nurses indicated that such a characteristic in itself was not the reason for more or less care time spent on a patient. Some elderly people are remarkable fit and some young people more out of shape than you would expect. Gender was not considered relevant at all. Also, sharing information on care processes on the different wards and sharing ideas on what is considered time consuming when caring for patients helped participants to understand each other's perspectives.

Nurses and ward management appreciated this approach because they were recognized as experts in their field. The fact that nurses themselves were in the lead contributed to the acceptance of the end result by all nurses of the participating wards.

Conclusion

By using the Delphi method, we have come to a more complete set of relevant patient characteristics that influence care time on surgical wards. Content validity of the end result (the observation list) is good, since experienced nurses and nurse management of all participating wards were closely involved in the development. The observation list is easy to use and interpret and does not require much extra registration time. Since the research took place in surgical wards, the observation list cannot be used in different types of nursing environments without adaptation. However, the observation list could be used as a starting point for development in other types of wards and hospitals. The same Delphi method and testing protocol can be used to develop a tailor-made list.

The results of this study give new perspectives to balance the workload of nurses; nurses are hospital staff that make an important contribution to patient outcome and patient experiences.

In the next phase of our research, a time study will be done to test whether above mentioned characteristics indeed significantly increase needed care time. This is very relevant since if this is the case, we can take the next step and study whether we are able to make a workload management method that can better estimate expected workload of nurses. If this method turns out to be successful, we can test its usefulness in other hospitals as well.

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CHAPTER 4

MAPPING NURSES' ACTIVITIES IN SURGICAL HOSPITAL WARDS: A TIME STUDY

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Abstract

Background

Balancing the number of nursing staff in relation to the number of patients is important for hospitals to remain efficient and optimizing the use of resources. One way to do this is to work with a workload management method. Many workload management methods use a time study to determine how nurses spend their time and to relate this to patient characteristics in order to predict nurse workload.

Objective

In our study, we aim to determine how nurses spend their working day and we will attempt to explain differences between specialized surgical wards.

Setting

The research took place in an academic hospital in the Netherlands. Six surgical wards were included, capacity 15 to 30 beds.

Method

We have used a work sampling methodology where trained observers registered activities of nurses and patient details every ten minutes during the day shift for a time period of three weeks.

Results

The work sampling showed that nurses spend between 40.1% and 55.8% of their time on direct patient care. In addition to this, nurses spend between 11.0% and 14.1% on collective patient care. In total, between 52.1% and 68% of time spent on tasks is directly patient related. We found significant differences between wards for 10 of the 21 activity groups. We also found that nurses spend on average 31% with the patient (bedside), which is lower than in another study (37%). However, we noticed a difference between departments. For regular surgical departments in our study this was on average 34% and for two departments that have additional responsibilities in training and education of nursing students, this was on average 25%.

Conclusions

We found a relatively low percentage of time spent on direct plus indirect care, and a lower percentage of time spent with the patient. We suspect that this is due to the academic setting of

the study; in our hospital, there are more tasks re-lated to education than in hospitals in other study settings. We also found differences between the wards in our study, which are mostly explained by differences in the patient mix, nurse staffing (proportion of nursing students), type of surgery and region of the body where the surgery was performed. However, we could not explain all differences. We made a first attempt in identifying and explaining differences in nurses' activities between wards, however this domain needs more research in order to better explain the differences.

Introduction

Balancing the amount of nursing staff in relation to the amount of patients is important for hospitals to remain efficient [1]. Hospitals intend to deliver good quality of care and also work efficiently. To ensure this, there needs to be a good fit between patient needs and nursing staff on hospital wards. The amount of work that nurses do, their workload, needs to be well balanced, in order to prevent extra costs for overstaffing a ward but also to prevent deteriorating patient outcomes and increased stress or burnout in nurses by understaffing wards. There is a direct relation between nurses' workload and patient outcome [2-5] and workload is also a predictor for burnout [6, 7]. Bakker found a relation between job demands such as workload and performance [8], and Toh's study showed a positive bi-directional relation between the nursing shortage and oncology nurses' job dissatisfaction, stress and burnout [9]. Also, in the near future healthcare labor shortages are expected to occur [10], so retaining nursing staff will be a challenge. Workload is related to intention to leave [11, 12] and besides this, training of new staff is also costly. Many studies have identified factors that predict workload of nurses. There is evidence that these nurse-patient ratios or nursing hours per patient day (NHPPD) do not accurately predict workload of nurses [13], since these do not take into account the different needs between patients nor the differences in experience and education level of nursing staff. Twigg argues that relying on expert opinion in setting standards for workload, in their study a standard NHPPD per ward, is not optimal and recommends using a standardized patient acuity measurement [14].
In Belgium, hospitals are required to register the Belgium Nursing Minimum Data Set (B-NMDS) in order to benchmark hospitals on several dimensions, among which workload. Van den Heede showed that 70% of variation in nursing staff per unit was predicted by the B-NMDS item hospital type with the covariates nursing intensity and service type [15]. They recommended that instead of working with NHPPD, a NHPPD corrected for nursing intensity is a better measure. However, Sermeus stated in a 2008 study [16] that the B-NMDS nursing intensity did not necessarily give an indication of required nursing time. Another drawback of the B-NMDS is the extensive amount of registration required by the hospitals [17]. The RAFAELA™ patient classification system [18] is an instrument to assess optimum levels of nursing intensity. We consider this a form of workload management. The RAFAELA™ system consists of the Oulu Patient Classification instrument [19], a system that records daily nursing resources, and the Professional Assessment of Optimal Nursing Care Intensity Level questionnaire. The three are combined to measure nursing intensity. RAFAELA™ measures only the patient-related workload of nurses and does not include other tasks [20]. This method is widely used in Finland; while

promising, it is not used for prospective workload management but only for assessments of workload in the past. For optimal versatility of nursing staff, prospective insight is of great value.

In a previous publication [21], we describe the development of a framework for a new workload management method. The first step in this method is to determine patient characteristics that are relevant to nurses' workload. The second step in this method is to gain insight in what nurses' activities are on a day to day basis. Quite some research has already been done in this area. In 2000, Rasmussen [22] selected examples of work sampling studies of nurses' activities done in the 10 year time span from 1986 until 1996,. This overview showed results of studies in several settings (army hospital, regular hospital, different specialties including pediatrics and critical care), clustering activities in the categories Direct Care, Indirect Care (some studies have one category for the two), Unit-Related tasks and Personal Time (Prescott, [23]).

Duffield [24] performed a work sampling study of nurses and also worked with the same four different categories, as also used by Urden [25]. Direct care is defined as patient-related activities performed in the presence of the patient and indirect care is defined as patient-related activities away from the patient. It is assumed that patient-related activities can always be attributed to a single patient.
In 2008, Hendrich [26] performed a time- and motion study of nurses' activities in 36 hospitals. Their goals were "to reveal drivers of inefficiency in how nurses spend their time and to identify opportunities to improve efficiency through changes to unit design and/or organization" [26]. With these goals in mind, nurses' time was divided into 4 categories of activities: nursing practice, unit-related functions, nonclinical activities, and waste. These 4 categories were in turn divided in a total of 12 subcategories. Unit-related functions were not divided in sub-categories of activities. However, unit-related functions also included patient related activities, such as transporting patients between wards. The subcategories were not specified, so subcategories of category Waste such as Looking/retrieving, Waiting and Delivering are difficult to interpret.
In 2011, Westbrook also performed a time and motion study [27], using the Work Observation Method by Activity Timing method. They focused on ten work tasks, amongst which direct care, indirect care and ward-related activities and social activities. These are partly the same as the 4 categories mentioned by Duffield, however some specific activities were classified under a separate work task, for example the engagement of nurses with other healthcare providers, supervision, documentation and medication activities. Activities within work tasks were not registered separately, the study registered activities on work task level.

In 1988, in the Netherlands, the Dutch Hospital Institute (NZi) developed a workload management method using an activities list consisting of 23 activity groups which are clustered into categories Direct patient Care, Collective patient Care, Unit-Related tasks and Other time (which includes personal time and official breaks). These activity categories are quite similar to Prescott's, but the clustering of activities under Direct patient care and Collective patient care is different. This was done with the purpose that all activities under Direct patient care can be linked to one specific patient. Activities under Collective patient care are often harder to attribute to one specific patient, for example collective preparation of medication or collective handover. When performing a time study with observation rounds done every ten minutes, each time an observation is done, 10 minutes of care time is attributed to the observed activity and also to the related patient. We believe that for some patient related activities like handover and collective preparation of medication, this would overestimate care time for certain patients and under estimate care time for other patients, because the time spent per patient is usually only a minute or two in these activities. In our study to develop a workload management method, we are interested in relating nurse care time to patient characteristics, so we are not primarily interested in where an activity took place or with whom, but if the activity and the related care time can be accurately related to a specific patient or not. We chose to use the NZi method as a starting point, because it fits this purpose. Also, the NZi list contains 23 activity groups, which is more than in other studies and helps us better evaluate and understand differences in working processes between nursing wards[28]. Lastly, several years ago, a small scale time study using the NZi method was performed in the same wards that are involved in the current study. Ward management and most nurses were still familiar with this list.

The current article describes a time study on activities of nurses, which is an important step in developing a new workload management method. We will describe how nurses spend their working day and the more detailed level of data collection will help understand differences between wards.

Method

Background

Performing a time study of nurses' activities is the second of several steps in developing a workload management method for staff nurses. **Figure 1** describes these steps. The full study protocol for developing this workload management method is described in our 2016 publication [21].

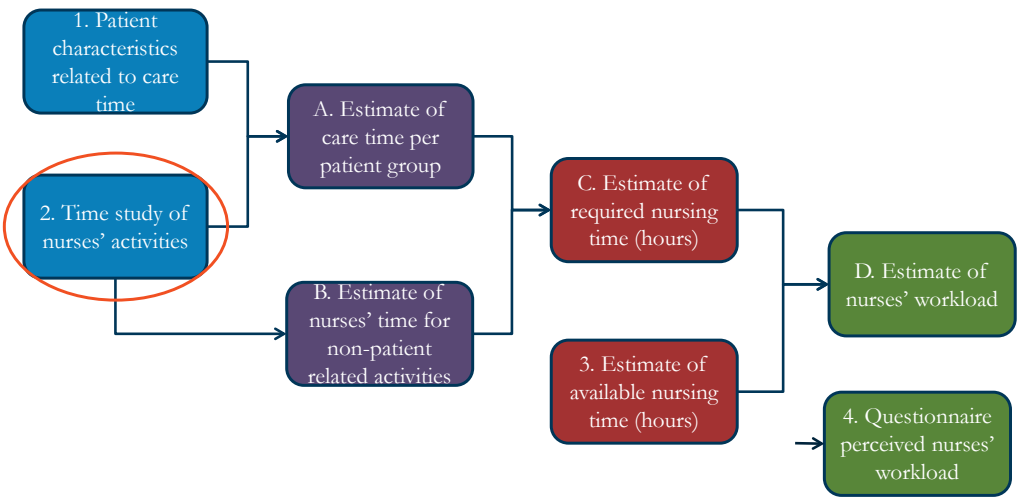

Figure 1: Developing a workload management method for staff nurses

Scope

The research took place in an academic hospital in the Netherlands. Six surgical wards were included, with 2 wards with 15 beds and 4 wards with 30 beds. Ward specialties were orthopedic/trauma surgery, vascular surgery, surgical oncology, otolaryngology, maxillofacial surgery and ophthalmology and urological surgery. The time study was done during the day shift. We chose to focus on the day shift, because this is the shift when the most nursing staff is required and most clinical nursing activities are performed. Weekends were excluded because task mix and staffing is very different in weekends and cannot be compared to day shifts of regular weekdays. We prioritized analyzing day shifts because controlling workload there will affect the most staff. In a later phase we plan to translate results to other shifts. Student nurses were included in the study; team leaders and ward managers were excluded because they are not involved in direct nor indirect patient care.

Activities of other types of ward staff (doctors, assistants, cleaning staff, etcetera) were not considered in this study.
In our study, 87% of the nurses were female nurses, 62% were registered nurses and 38% nursing students. As shown in **Table 1**, 82% of the nurses is under 40 years of age.

Table 1: Age categories of nurses in study

Type nurse/age (years)	<20	20-30	30-40	40-50	>=50
Registered Nurse	0%	31%	14%	6%	11%
Student Nurse	4%	32%	2%	1%	0%

Of the registered nurses, 29% had less than 5 years' work experience in the study hospital, 13% had 5-10 years' experience and the others more than 10 years.

Work sampling
To accurately map nurses' activities, a work sampling methodology was used. Work sampling is a useful and efficient methodology to explore work-related activities [29]. In work sampling, activities of subjects are observed or registered every so many minutes, resulting in a sample of the activities of nurses. This way, we gain insight into the way nurses spend their working hours, for example to what extent their work is directly patient-related or which percentage of their working time is spent on administrative duties.
Pelletier and Duffield [29] suggest working with trained observers as an alternative to self-reporting, because the latter can be prone to bias. This is only possible when the staff to be observed works in an area that can be surveyed by the observer, and the observer can determine the activities relatively easily. For example, if work sampling is done on staff that is moving great distances or is performing mostly cognitive tasks, then self-reporting can be better. They also advocate the use of handheld computers to make registration faster and more accurate.
Sittig [30] also gives important tips for designing a work sampling study in healthcare: involve the nurses and nurse management in the study, determine relevant activities to register and make foolproof definitions, identify the right observers and train them well, and perform pilot samples to test the setup. We have followed up on these suggestions, in the next paragraphs we will elaborate on this.

Activities
Nurses perform many different activities in a day shift. Registering this multitude of activities separately is virtually impossible. We therefore first identified groups of activities that we wanted

to register during the work sampling. The basis for this was the list of activity groups that is part of the workload management method developed by NZi (Dutch Hospital Institute, [31]). We used the Delphi method to evaluate the activity groups: the Delphi method is a structured form of communication in order to acquire an expert opinion on a certain topic [32]. In two or more rounds questionnaires are answered. In between rounds a facilitator gathers response and provides an anonymized summary of experts' opinion, including the motivation of the experts. Experts can revise their opinion, based on the judgments of the other experts, working towards an end result with a good level of consensus.

Ward management selected one staff nurse of their ward to be the expert in the Delphi group. All selected nurses were experienced nurses in the specialty of the ward they work in.

The group was asked to comment on the NZi list of activity groups and corresponding activities. The activity groups were clustered into 4 categories: direct patient care, collective patient care, general tasks and other tasks. *Direct patient care* was defined as care time that can be directly related to one specific patient. This includes assistance with bathing or eating, handing out medication, changing bed linen, wound care, communication with the patient or family, etcetera. *Collective patient care* was defined as tasks that are patient-related, but are difficult to attribute to one specific patient. This includes general preparation of medication, patient handover, bringing a collection of samples to the laboratory, etcetera. *General tasks* includes education/supervision, meetings, organization of work (planning), administrative duties and domestic duties. *Other tasks* includes lunch and coffee breaks and personal time.

In one-on-one interviews with the lead researcher, members of the group commented on the list. Based on the group's comments the list was adjusted: activities were added, group labels were adjusted and new groups were defined. Results were shared and the Delphi process was repeated, which resulted in a new, definitive activity group list (see **Table 2**). Note that this list shows only the activity groups and categories. Details of which activities are placed in the activity groups are not shown (data available on request).

Table 2: List of activity groups of nurses

Activity Category	Activity group
Direct patient care (DPC)	1. Fluid/tissue sampling for laboratory research
	2. Assistance of doctors or others
	3. Communication with patient and/or family
	4. Oral communication/reporting about patient (not in presence of patient)
	5. Positioning and exercise
	6. Preparing/administering of medication (for individual patient)
	7. Observation of vital signs and routine check-ups
	8. Written/digital reporting, administration or transfer of information
	9. Transport of patient
	10. Personal care of patient
	11. Assistance meals and/or excretion
	12. Nurses' professional activities
Collective patient care (CPC)	13. Errands (away from ward)
	14. Collective handover of patient information (for multiple patients)
	15. Medication preparation (for multiple patients)
	16. Meals-related activities
General tasks (GT)	17. General administration
	18. Domestic activities
	19. Education and guidance
	20. Organization of work
	21. Meetings
Other tasks (OT)	22. Coffee break (authorized)
	23. Lunch break (authorized)
	24. Personal time

Observer selection and training

Observers were selected and trained uniformly in how to register nurses' activities. Observers were either nurses from involved wards (observing on wards *other* than their own) or medical students. We preferred to work with nurses as observers where possible, because they are motivated to register activities accurately and are familiar with nurses' activities, and therefore less likely to misinterpret or make mistakes. In addition, nurses learn about working procedures on other wards, which broadens their horizon and will help exchange ideas and increase understanding among wards. However, it was not possible to schedule sufficient nurses to cover all observer duties and we hired medical students where necessary. There were 49 observers in the study of which 18 were medical students.

Observer training consisted of a theoretical part (purpose of research, explanation of work sampling method, importance of accurate observation and registration) and a practical part (how to use the handheld computer, trial observations, examples of pitfalls). Attendance was mandatory for all observers and the training included a practical test under time pressure, and using all equipment that was to be used at the actual time study. Working instructions with all the

work sampling study information were handed out to all observers. Observers were trained to always confirm with the nurses they were observing which activity the nurses were doing and - when relevant- for which patient. This procedure was introduced to prevent observers from making wrong assumptions.

Registration of observations

During the work sampling study all nurses were observed approximately every ten minutes. Observers registered their observations with a handheld computer (Symbol PDT-3100 barcode scanner, with SCO software), by scanning predefined barcodes. Time intervals between observations were automatically randomized, with an average of ten minutes. Observers were asked to register three things each time they made an observation: the name of the nurse; the activity the nurse was performing; and, when the activity was patient-related, patient details. There were three barcode sheets available to the observers. Each sheet showed all possible entries for one variable, in a logical order. One sheet showed barcodes for all names of the nurses, another showed all barcodes for the predefined activity groups and the last sheet showed barcodes for all patients on the ward. Barcodes were positioned in such a way on the sheet that chances of accidental miscoding were minimized. By registering which activities the nurses were doing every ten minutes, a random sample of nurses' activities in day shifts was taken.

Test work sampling

Before doing the actual work sampling study, a test sampling study was performed. The purpose of this test study was to:

- Test the handheld computer and the barcode sheets: do they work properly and are they easy to use?
- Test the activities list: is it complete and easy to interpret?
- Test the workload of the observers: how many nurses can be observed by one observer and how long can an observer work uninterrupted?

We actively looked for flaws in the registration process so we could prevent registration errors in the actual work sampling study. Four observers received a uniform, standardized training and spent a minimum of three hours observing nurses on different wards. After this test study, the observers were interviewed. The equipment worked well and turned out to be reliable. Based on the observers' experiences, choices were made regarding procedures:

- We changed the order and position of the barcodes to make them easier to locate and scan properly.

- A notepad was added to the observer's equipment to note mistakes that could not be corrected on the spot.
- We decided to work with one observer per ward, with a maximum of 4 working hours in one observation shift.

Work sampling period

Next, the actual work sampling study was planned. A representative time period was selected, in which workload was expected to be average: outside holiday seasons and periods with especially high or low occupancy rates (for example, due to reduction of operating room capacity) and periods with enhanced or reduced nursing capacity (for example, due to planned education). Also, the number of observations that were to be made in the work sampling study needed to be sufficiently large. For practical reasons, there was a limit to the amount of days that we could observe our staff. It is costly to arrange observers, and nurses will get tired of being observed. Ward management was asked to advise on the maximum amount of time study days that they felt was reasonable, and they advised a maximum of fifteen consecutive working days. When sampling nurses' activities every ten minutes, this would generate approximately 54,000 observations (=15 study days x 6 wards x 12 nurses per ward x 50 observation rounds per day shift) of nurses' activities. The actual number of observations of nurses' activities was 54.663, which were aggregated to 290 observations of percentage of time spent on activities per nurse in a ward.

Work sampling study

All nurses on duty in the day shift of six wards were observed during the selected observation period of 15 working days (Monday through Friday). Trained observers registered activities approximately every 10 minutes in the day shift, starting at 07.30 hours and finishing at 16.00 hours. Exact observation moments and start and finish times were dependent on the random time interval generator of the handheld computer.

The standard training for observers included a procedure for correction of mistakes. If an observer made a mistake that could not be corrected on the spot, he or she would note details on the time, involved nurse and nature of the mistake on a note sheet on the clipboard. These notes were evaluated by the lead researcher, and checked by another researcher that was not directly involved in performing the work sampling. When corrections were approved by both researchers, they were corrected in the data. All corrections were logged uniformly.

Interrater agreement

To test whether two observers registered the same activity in the same way, an interrater agreement was determined. Regular tests for interrater agreement, such as Cohen's Kappa or intraclass correlation cannot be applied here, because these assume that only one variable is observed and also that this variable is classified in a limited number of categories [33]. In our research, we have three variables (nurse/activity/patient), all with many possible categories: up to 15 names of nurses, 25 activities and up to 30 patients. For the study on differences of nurses' activities between wards it is important that at least two variables (nurse name and activity group) were registered correctly. We decided to calculate an exact agreement percentage between the raters on these two variables.

To test the reliability of the registrations, an interrater agreement study was planned. The interrater agreement study was planned during the 3-week work sampling period. For this study, a second observer temporarily joined the scheduled observer. Both observers had the same training and both had already done at least one observation shift during the work sampling period. The agreement study was done twice, on two different wards with two different pairs of observers. One study was planned in the morning and one in the afternoon of the day shift. The observers walked their rounds in pairs and were instructed not to speak to each other or share registration results. On every observation round, one of the observers asked the nurses they observed which activity they were doing and, when applicable, for which patient. Both observers independently registered results in their own handheld computer. The interrater agreement was 88.4% exact agreement on 242 observations. We consider this an acceptable agreement percentage. The probability of an agreement occurring by chance is low, because there are so many selections possible for registration of nurse (15) and activity (25).

Analysis

We analyzed our work sampling data in two steps:

Descriptive analysis

This analysis gives a general impression of the way nurses spend their time, for the different wards that participated in the study. The descriptive analysis gives the mean percentage of time spent by nurses on the activity groups. However, this analysis does not give any information on variation within a department on the different activity groups, nor does it indicate whether observed differences could have been due to chance.

Compositional analysis

We also studied whether there were statistically significant differences between wards on the time their nurses spent on the various activities. The times spent on different activities are correlated: if one increases, another must decrease, since the total always amounts to 100%. Compositional analysis is an appropriate method for such data, since it allows for correlated outcome variables that sum to a fixed total [34].

We first analyzed differences between wards on the activity categories: Direct Patient Care (DPC), Collective Patient Care (CPC), General Tasks (GT) and Other Tasks (OT).

Compositional analysis dictates that one variable needs to be chosen as a reference variable, to compare the others against. The category OT was expected to be the most stable category, because the activity groups (duration of coffee and lunch breaks) that fall into this category are mostly standardized; therefore we chose OT as a reference category. The other three variables were compared to OT as follows: we calculated 3 ratios for each nurse in the study: DPC/OT, CPC/OT and GT/OT. Since ratios are difficult to handle mathematically and statistically [34], we converted the ratios to log-ratios. For each nurse in the study we defined three correlated log-ratios. The next 3 steps in the analysis were as follows:

1. **MANOVA on activity categories**. Since we had three correlated observations per subject (nurse), we used multivariate analysis of variance (MANOVA) to find significant differences on one or more of these variables between wards [34]. We used a significance threshold of 0.05 for the MANOVA.
2. **ANOVA on activity categories.** If the MANOVA indicated significant differences between wards, we wished to discover for which activity categories these differences materialize. This was done by an analysis of variance (ANOVA) for each of the three log-ratios separately. Again, a significance threshold of 0.05 was used.

3. **Post-hoc between wards on activity categories**. If the ANOVA indicated differences between wards on an activity category, then the next step was to make pairwise comparisons on each combination of wards for this activity category using a Tukey correction. This post-hoc test will indicate which wards differ from each other for time spent on a particular activity category.

After the analysis on activity categories, we performed a more detailed analysis in which we compared 21 separate activity groups to the reference category OT (the sum of three activity groups in category "Other Tasks"). Again, we first used a MANOVA on all activity groups and, if significant differences were found an ANOVA was performed separately for each activity group. Tukey post-hoc tests were carried out for activity categories for which the ANOVA indicated significant differences between the wards. Due to the large number of comparisons being made, we lowered the significance threshold to 0.01 for this analysis. The descriptive analysis was performed in Excel and the compositional analysis using the package "compositions" in R version 3.3.2 [35]. For help in interpretation, we discussed the results of the compositional analysis with the nurse managers.

Ethical considerations

The study guaranteed the privacy of involved staff. There was no patient data recorded besides patient registration number. Only the lead researcher (lead author of this manuscript) has access to the master data and coded the data. Data have been processed in such a way that nothing can be traced back to specific persons. The study protocol was submitted to the medical ethical review board of the University Medical Center Utrecht and was approved, protocol number 14-165/C.

Results

Descriptive analysis

The mean percentage of time nurses spent on the 24 activity groups is shown in **Table 3:**

Table 3: Descriptive analysis of nurses' activities

Activity Category	Activity group	Ward 1 Mean	Ward 2	Ward 3	Ward 4	Ward 5	Ward 6
Direct patient care (DPC)	1. Fluid/tissue sampling for laboratory research	0.8	0.9	0.5	0.4	0.3	0.3
	2. Assistance of doctors or others	2.1	1.8	2.2	1.4	1.4	1.4
	3. Communication with patient and/or family	7.6	4.4	4.2	4.2	5.1	7.8
	4. Oral communication/reporting about patient (not in presence of	3.7	2.8	4.0	5.0	3.4	3.9
	5. Positioning and exercise	1.1	1.1	1.3	1.9	0.6	0.5
	6. Preparing/administering of medication (for individual patient)	6.6	4.3	3.6	3.2	2.9	1.9
	7. Observation of vital signs and routine check-ups	1.7	2.1	1.9	1.7	1.9	1.4
	8. Written/digital reporting, administration or transfer of	13.8	11.4	12.8	13.0	12.3	11.4
	9. Transport of patient	5.3	3.1	3.1	2.9	3.6	3.4
	10. Personal care of patient	6.1	10.0	6.7	11.9	5.2	4.1
	11. Assistance meals and/or excretion	2.4	2.0	2.0	3.2	0.9	1.2
	12. Nurses' professional activities	4.5	3.3	4.3	4.4	2.4	3.0
Total DPC		**55.8**	**47.3**	**46.8**	**53.2**	**40.1**	**40.4**
Collective patient care	13. Errands (away from ward)	0.4	0.3	0.5	0.8	1.3	1.3
	14. Collective handover of patient information (for multiple patients)	11.1	10.9	9.0	9.1	10.1	12.3
	15. Medication preparation (for multiple patients)	0.7	1.8	1.4	2.1	0.6	0.4
	16. Meals-related activities	0.0	0.0	0.1	0.0	0.1	0.1
Total CPC		**12.2**	**13.1**	**11.0**	**12.1**	**12.0**	**14.1**
General tasks (GT)	17. General administration	0.4	1.2	0.6	0.9	0.9	0.7
	18. Domestic activities	2.4	1.6	3.0	3.0	3.2	2.8
	19. Education and guidance	9.8	10.7	9.7	5.1	16.6	16.2
	20. Organization of work	1.3	3.7	3.8	1.7	2.2	5.9
	21. Meetings	2.7	2.5	6.6	3.7	7.5	4.1
Total GT		**16.5**	**19.7**	**23.7**	**14.5**	**30.3**	**29.7**
Other tasks (OT)	22. Coffee break (authorized)	3.0	5.3	6.2	5.9	4.1	4.6
	23. Lunch break (authorized)	8.9	10.7	9.2	10.0	9.2	8.1
	24. Personal time	1.6	0.8	1.7	1.4	3.0	1.9
Total OT		**13.5**	**16.8**	**17.1**	**17.2**	**16.3**	**14.6**
	25. Not found	2.0	3.1	1.4	3.0	1.3	1.2
Total not found		**2.0**	**3.1**	**1.4**	**3.0**	**1.3**	**1.2**

Note: measurements in Table 3 were only for nurses that were involved in direct care for patients. Team leaders and care assistants were excluded here, because not every ward has care assistants and on some wards team leaders spend much more time caring for patients than in other wards.

Compositional analysis

We will show results for the activity categories and activity groups in separate paragraphs.

Compositional analysis activity categories

The MANOVA on the activity categories indicated significant differences between wards ($p < 0.001$) and the ANOVAs detected significant differences between wards on all three categories. The post-hoc tests showed significant differences for many different combinations of wards, see **Table 4**.

Table 4: ANOVA activity categories

	P-value (<0.05)		
Wards	**DPC**	**CPC**	**GT**
1-2	**<0.001**	0.251	0.784
1-3	**<0.001**	**0.013**	0.818
1-4	**0.015**	0.194	0.697
1-5	**<0.001**	0.186	0.128
1-6	**0.002**	0.977	**0.020**
2-3	0.997	0.773	0.058
2-4	0.949	0.999	0.999
2-5	0.975	0.999	**<0.001**
2-6	0.999	**0.030**	**<0.001**
3-4	0.788	0.867	**0.038**
3-5	0.999	0.944	0.706
3-6	0.999	**<0.001**	0.250
4-5	0.628	0.999	**<0.001**
4-6	0.939	**0.021**	**<0.001**
5-6	0.993	**0.023**	0.977

Pairwise comparison between wards for activity categories Direct Patient Care (DPC), Collective Patient Care (CPC) and General Tasks (GT). Significant differences are printed in bold

Ward 1 differed from all other wards on time spent on Direct Patient Care (DPC) in proportion to Other Time (OT). Since OT was relatively stable across wards, we can conclude that nurses on ward 1 spent significantly more time on DPC than nurses on other wards. The descriptive analysis suggested that ward 1 spent less time on General Tasks (GT) than the other wards, but only the difference between ward 1 and 6 was significant in the post-hoc comparison.

Compositional analysis activity groups

The MANOVA analysis on the activity groups resulted in a p-value of < 0.001, implying differences in time spent on activity groups between wards. The ANOVA per activity group detected significant differences between wards on many activity groups and the post-hoc results indicated which wards differed from one another. These results were added to the descriptive analysis and are displayed in **Table 5**.

Table 5: ANOVA activity groups

Activity Category	Activity group	Ward 1 Mean	Ward 2	Ward 3	Ward 4	Ward 5	Ward 6	Differences between wards
Direct patient care (DPC)	1. Fluid/tissue sampling for laboratory research	0.8	0.9	0.5	0.4	0.3	0.3	4- 2
	2. Assistance of doctors or others	2.1	1.8	2.2	1.4	1.4	1.4	**No**
	3. Communication with patient and/or family	7.6	4.4	4.2	4.2	5.1	7.8	2- 1, 3- 1, 4- 1, 5- 1, 6- 2, 6- 3, 6- 4
	4. Oral communication/reporting about patient (not in presence of patient)	3.7	2.8	4.0	5.0	3.4	3.9	**No**
	5. Positioning and exercise	1.1	1.1	1.3	1.9	0.6	0.5	**No**
	6. Preparing/administering of medication (for individual patient)	6.6	4.3	3.6	3.2	2.9	1.9	2- 1, 3- 1 , 4- 1 , 5- 1 , 6- 1, 6- 2
	7. Observation of vital signs and routine check-ups	1.7	2.1	1.9	1.7	1.9	1.4	**No**
	8. Written/digital reporting, administration or transfer of information	13.8	11.4	12.8	13.0	12.3	11.4	**No**
	9. Transport of patient	5.3	3.1	3.1	2.9	3.6	3.4	3- 1 , 4- 1
	10. Personal care of patient	6.1	10.0	6.7	11.9	5.2	4.1	6- 2, 6- 4, 5- 4
	11. Assistance meals and/or excretion	2.4	2.0	2.0	3.2	0.9	1.2	5- 1, 5- 4
	12. Nurses' professional activities	4.5	3.3	4.3	4.4	2.4	3.0	5- 1, 5- 3
Total DPC		**55.8**	**47.3**	**46.8**	**53.2**	**40.1**	**40.4**	
Collective patient care (CPC)	13. Errands (away from ward)	0.4	0.3	0.5	0.8	1.3	1.3	**No**
	14. Collective handover of patient information (for multiple patients)	11.1	10.9	9.0	9.1	10.1	12.3	**No**
	15. Medication preparation (for multiple patients)	0.7	1.8	1.4	2.1	0.6	0.4	6- 2, 5- 2
	16. Meals-related activities	0.0	0.0	0.1	0.0	0.1	0.1	**No**
Total CPC		**12.2**	**13.1**	**11.0**	**12.1**	**12.0**	**14.1**	
General tasks (GT)	17. General administration	0.4	1.2	0.6	0.9	0.9	0.7	**No**
	18. Domestic activities	2.4	1.6	3.0	3.0	3.2	2.8	**No**
	19. Education and guidance	9.8	10.7	9.7	5.1	16.6	16.2	6- 1, 6- 2, 6- 3, 6- 4, 5- 4
	20. Organization of work	1.3	3.7	3.8	1.7	2.2	5.9	**No**
	21. Meetings	2.7	2.5	6.6	3.7	7.5	4.1	5- 1, 5- 2, 5- 4, 3- 2
Total GT		**16.5**	**19.7**	**23.7**	**14.5**	**30.3**	**29.7**	
Other tasks (OT)	22. Coffee break (authorized)	3.0	5.3	6.2	5.9	4.1	4.6	**=reference category**
	23. Lunch break (authorized)	8.9	10.7	9.2	10.0	9.2	8.1	**=reference category**
	24. Personal time	1.6	0.8	1.7	1.4	3.0	1.9	**=reference category**
Total OT		**13.5**	**16.8**	**17.1**	**17.2**	**16.3**	**14.6**	
	25. Not found	2.0	3.1	1.4	3.0	1.3	1.2	
Total not found		**2.0**	**3.1**	**1.4**	**3.0**	**1.3**	**1.2**	

**Note: the differences shown in the last column are the significant differences between wards on log-ratios of the activity group as compared to the reference category OT. Category "Not found" are missing data. Only significant differences are shown for the post-hoc tests.*

Direct patient care:

- ***Fluid/tissue sampling***: ward 2 (surgical oncology) spent more time on this than ward 4 (vascular surgery) due to frequent wound samples.
- ***Communication with patient/family***: ward 6 (oral maxillofacial surgery) differs from all other wards, except for ward 5 (otolaryngology) and ward 1 (urology/ ophthalmology), and spends more time on communication than the others. This is likely because surgery in the maxillofacial area often leads to problems of speech. Ward 1 also spends more time on communication (differing from all but ward 6) due to the fact that many of the patients have vision problems. Nurses on this ward have to read labels and other information out loud to patients.
- ***Nurses' professional activities*** : ward 5 (otolaryngology) spends less time on this than wards 1 (urology/ophthalmology) and 3 (vascular surgery).
- ***Preparing medication***: ward 1 (urology/ophthalmology) spends more time on this than all other wards. Ward 6 (maxillofacial surgery) differs from ward 2 (surgical oncology) as well, it is unclear why.
- ***Transport of patient***: ward 1 (urology/ophthalmology) spends more time on this than wards 3 (vascular surgery) and 4 (traumatology/orthopedics), which can be explained by the complexity of the patient population and the resulting length of stay. Urology and ophthalmology patients typically have a short length of stay, and therefore more patients are admitted and transported to the operating rooms.
- ***Personal care of patient***: ward 4 spends more time on this than wards 5 and 6, and ward 6 also spends less time on this task than ward 2. We could not explain these differences.
- ***Assistance with meals and/or excretion***: ward 5 (otolaryngology) spends less time on this task than wards 1 (urology/ophthalmology) and 4 (orthopedics, traumatology). Ear nose and throat surgery patients often cannot eat solid food (and therefore need no help in eating), whereas urology patients often need help with excretion by catheterization. The same goes for immobile patients from orthopedics and traumatology wards.

Collective patient care:

- ***Medication preparation***: ward 2 (surgical oncology) spends more time on medication preparation than wards 5 (otolaryngology) and 6 (oral maxillofacial surgery).

General tasks:

- ***Education and guidance***: ward 6 spends more time on this task than all other departments but ward 5, and ward 5 spends more time on this than ward 4. This can be

explained by the fact that wards 5 and 6 together form a special learning environment, where a relatively high number of young nurses are trained.

- ***Meetings***: ward 5 spends more time on this than wards 1, 2 and 4 and ward 3 in turn spends more time on meetings than ward 2.

Discussion

Findings

The work sampling showed that nurses spent between 40.1% and 55.8% of their time on direct patient care. In addition to this, nurses spent between 11.0% and 14.1% on collective patient care. In total, this is between 52.1% and 68% of time spent on tasks that are directly patient-related.

We found significant differences between wards for 10 of the 21 activity groups. The biggest differences can be found for activity groups "Education/guidance" and "Medication preparation", followed by activity groups "Assistance meals/excretion", "Communication patient/family", "Personal care" and "Meetings". The results of the compositional analysis were used in discussions with ward managers on observed discrepancies between wards The diversity is mostly explained by differences in the patient mix, nurse staffing (proportion of nursing students), type of surgery and region of the body where the surgery was performed.

Comparison to other work sampling studies

The NZi workload management method that we based our study on, employs a list of activity groups very similar to Duffield's [24]. There is an important difference, though: NZi distinguishes a category called "Collective patient care (CPC)" which includes activities that are patient-related but cannot easily be attributed to a single patient. For example NZi classifies "Handover" as CPC because during a handover, each patient is discussed only for a short time. If during a work sampling study a handover meeting was observed and the full 10 minutes attributed to the patient being discussed at that moment, it would be an unfair allocation of time to that patient. In our study we were not only interested in the way nurses spend their time, but also in the relationship between nurses' activities and patient characteristics (care time per patient group). Because of this, we chose to use a different list of activity groups and categories. We did not distinguish direct and indirect care activity groups on the basis of the location of the nurse (with the patient or away from the patient), but based on whether activities could be related to a single patient or not. Therefore we cannot directly compare our categories "Direct patient care" and "Collective patient care" to the categories "Direct care" and "Indirect care". However, we can compare the sum of these categories.

In the studies shown in Rasmussen's overview of work sampling studies of nurses' activities [22] , the sum of direct care plus indirect care makes up 59.7% to 67.6% of the activities of nurses. In our study, we found between 52.1% and 68% of nurses' time was spent in these two categories, with an average of 60.9%. Our study was performed in a setting of surgical wards in an academic

hospital, which is quite different to the settings in the studies mentioned by Rasmussen: amongst others a military hospital, critical care wards, psychiatric wards and pediatric wards. We suspect that part of the difference can be explained by the educational tasks inherent in the academic setting; as shown in **Table 1**, a substantial part of our workforce are nursing students: 38%. These students require education by the registered nurses, which explains part of the difference. In our study, wards with the highest percentage of time spent on educational activities also spent the least time on direct patient care.

Unit related tasks for the wards take up between 16 and 30% of nurses' time in studies in Rasmussen's overview [22]. In our research we found that General Tasks (which includes the same activity groups as unit-related tasks) comprised between 14.5% and 30.3% of time of the nurses. Personal time seems to vary considerably in Rasmussen's overview: between 4% and as much as 20.7% of nurses' time. Our study indicated less variation: between 13.5% and 17.2%. Personal time is quite standardized in our hospital: all nurses have one coffee break in the morning and a one-hour lunch break in the afternoon.

In 2008, Hendrich [26] performed a time- and motion study of nurses' activities in 36 hospitals. We cannot compare our activity categories to this study, because the activity categories were too different from ours. For example, Hendrich defined a "Waste" category, which includes waiting, looking/retrieving and delivering. In our study, these activities were always related to a specific activity group. However, they concluded that nurses spend a smaller part of their time on patient care activities and more time on documentation, coordination of care, medication administration, and movement around the unit. This generally corresponds with our findings.

Westbrook also performed a time and motion study [27] in which observers shadowed nurses for blocks of, on average, one hour at a time. Westbrook found that the percentage of time spent on direct and indirect care (according to our definitions) was 76% and 81% in two consecutive measurements, which is much higher than in earlier studies. They also found that nurses spent around 37% of their time with patients. In our study, we found this to be on average 31%. However, we noticed a difference between departments. For regular surgical departments this was on average 34% and for the two departments that have additional responsibilities in training and education of nursing students, this was on average 25%. This explains why our average is much lower: the educational responsibilities in our academic setting influences how nurses spend their working day. This is interesting because there is evidence that the more time nurses spend with the patient, the higher the patient satisfaction [36] and the better outcomes [37-39].

We did not find any other study that analyzed the differences in time spent by nurses between different wards with different specialties. In our study we made a first attempt in identifying and explaining differences in nurses' activities between wards, however we acknowledge this domain needs more research in order to better explain the differences and that these differences may vary between settings and countries.

Study limitations

Our study was set in an academic hospital, which potentially limits the generalizability of the study results to different settings, such as general hospitals. Nurses' activities in general hospitals may be different from activities in academic hospitals.

Also, the study was set in surgical wards; when applying the results to other specialties, adjustments will need to be made. Nurses on internal medicine wards spend their time on different activities than nurses on surgical wards. For example, wound care is not expected to be a predominant activity on internal medicine wards, but nurses there are likely to spend more time on blood transfusions, dialysis or chemotherapy, for example. Different specialties have different working processes, so our study results can be applied most easily to surgical wards. However, we expect that the method we used can be applied in any hospital, though it would likely result in different activity groups and different work sampling results.

One of our goals was to compare the percentage of time spent on activities between wards. For this purpose, we have 290 observations (observations of nurse/ward combination). This number allows for sufficiently detailed analysis of activities and differences between wards. The compositional analysis found significant differences on all levels, which supports this view.

Interrater agreement was 88.4%. There is no clear rule of thumb in literature that defines whether this is acceptable or not. Though our measure did not correct for accidental agreement, the chances of accidental agreement are very small due to the large number of categories for all three variables registered (15-25 per variable). Therefore we believe that 88.4% interrater agreement is sufficient.

We expected OT to be the most stable category, but there was still some variation between wards on this category. We did not find an explanation. However, we still stand by our choice to use this as a reference category, because it was the smallest category and the least interesting to compare across wards.

Further research

More in-depth analysis is needed to study differences between wards that could not be readily explained. As said, this work sampling study will also be used for developing a workload management system. The care time that nurses spent on specific patients will be related to patient characteristics that are expected to increase care time, such as isolation, psycho-social care or assistance with bathing. This way, we can calculate how much additional care time is needed when one or more of these characteristics applies to patients on a ward, forming the basis for a workload management method.

Clinical implications and conclusion

The data collected in the work sampling study are very interesting from an operational excellence perspective. This study formed a basis for discussing the working processes of different wards and helped to identify and understand differences in processes and operational excellence between wards. The results can be analyzed further and provide a starting point for improvements. Results of this work sampling study will be combined with data on patient characteristics and lead to insight in required resources per patient and per ward. This, in turn, will be used to further develop a workload management method, as described in section 2.1.

Abbreviations

NZi: Nationaal Ziekenhuis Instituut (Dutch Hospital Institute)

DPC: Direct Patient Care

CPC: Collective Patient care

GT: General Tasks

OT: Other tasks

ANOVA: analysis of variance

MANOVA: multivariate analysis of variance

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S1 Table supporting information time study

Supporting information fort his study can be found in supporting table S1 Table.

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Supplementary table S1 (1 of 6)

Ward	Nurse Nr	1. Fluid/tissue sampling for laboratory research	2. Assistance of doctors or others	3. Communication with patient and/or family	4. Oral communication/reporting about patient (not in presence of patient)	5. Positioning and exercise	6. Preparing /administering of medication (for individual patient)	7. Observation of vital signs and routine check-ups	8. Written/digital reporting, administration or transfer of information	9. Transport of patient	10. Personal care of patient	11. Assistance meals and/or excretion	12. Nurses' professional activities	13. Errands (away from ward)	14. Collective handover of patient information (for multiple patients)	15. Medication preparation (for multiple patients)	16. Meals-related activities	17. General administration	18. Domestic activities	19. Education and guidance	20. Organization of work	21. Meetings	22. Coffee break (authorized)	23. Lunch break (authorized)	24. Personal time	Not observed
1	5	2,0%	5,9%	7,8%	5,9%	2,0%	7,8%	2,0%	25,5%	5,9%	9,8%	3,9%	2,0%	0,0%	2,0%	0,0%	2,0%	0,0%	2,0%	0,0%	0,0%	0,0%	2,0%	7,8%	0,0%	3,9%
1	10	0,0%	2,1%	8,8%	5,7%	0,0%	14,9%	0,5%	15,5%	4,6%	2,6%	0,5%	2,1%	0,0%	12,9%	1,5%	0,0%	1,0%	1,5%	3,6%	5,2%	3,6%	3,1%	7,2%	1,5%	1,5%
1	15	0,0%	3,5%	5,0%	1,0%	0,0%	2,0%	6,0%	5,5%	5,0%	9,5%	4,5%	5,0%	3,0%	10,6%	0,0%	0,0%	0,5%	4,0%	16,1%	0,0%	2,0%	3,0%	9,5%	3,5%	0,5%
1	17	0,0%	2,6%	8,6%	2,6%	0,7%	3,9%	0,7%	17,8%	2,0%	9,2%	2,0%	3,9%	0,0%	15,1%	1,3%	0,0%	1,3%	5,3%	1,3%	0,0%	4,6%	2,6%	9,2%	4,6%	0,7%
1	30	0,0%	0,0%	5,0%	2,0%	1,0%	6,0%	0,0%	13,0%	1,0%	8,0%	4,0%	7,0%	0,0%	12,0%	0,0%	0,0%	0,0%	3,0%	10,0%	0,0%	11,0%	2,0%	10,0%	0,0%	5,0%
1	35	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	100,0%
1	40	0,0%	2,7%	10,1%	6,8%	0,7%	11,5%	0,7%	10,1%	2,0%	7,4%	0,0%	7,4%	0,7%	11,5%	1,4%	0,0%	0,0%	4,7%	0,7%	0,0%	8,8%	2,7%	8,8%	0,7%	0,7%
1	76	0,0%	0,0%	16,8%	4,0%	1,0%	3,0%	2,0%	29,7%	9,9%	1,0%	2,0%	4,0%	0,0%	6,9%	0,0%	0,0%	0,0%	2,0%	0,0%	2,0%	0,0%	5,0%	8,9%	1,0%	1,0%
1	80	0,3%	1,3%	7,9%	3,8%	3,8%	3,5%	2,2%	17,4%	3,2%	8,2%	6,6%	5,4%	0,0%	9,8%	0,0%	0,0%	0,0%	2,2%	7,3%	0,0%	0,0%	2,2%	10,4%	0,0%	4,7%
1	90	5,0%	0,0%	9,9%	5,0%	1,0%	11,9%	1,0%	12,9%	8,9%	1,0%	2,0%	2,0%	2,0%	6,9%	1,0%	0,0%	1,0%	5,9%	2,0%	5,0%	2,0%	5,0%	6,9%	0,0%	2,0%
1	97	0,0%	1,4%	12,8%	5,0%	0,7%	7,8%	4,3%	12,1%	5,7%	5,7%	1,4%	9,2%	0,0%	11,3%	3,5%	0,0%	0,0%	0,7%	4,3%	0,0%	0,7%	2,8%	9,2%	0,7%	0,7%
1	99	3,4%	2,5%	4,9%	2,0%	0,5%	6,9%	2,9%	13,2%	2,9%	8,8%	1,5%	6,4%	0,0%	13,7%	0,5%	0,0%	0,5%	1,5%	3,4%	3,4%	4,4%	3,4%	10,8%	0,5%	2,0%
1	120	0,0%	5,8%	8,7%	1,0%	1,9%	12,6%	0,0%	16,5%	4,9%	4,9%	0,0%	1,0%	0,0%	16,5%	1,0%	0,0%	0,0%	1,9%	0,0%	1,9%	2,9%	1,9%	9,7%	4,9%	1,9%
1	124	0,0%	1,3%	10,6%	6,3%	0,0%	3,8%	3,8%	11,9%	9,4%	1,3%	3,8%	6,3%	0,0%	13,1%	0,6%	0,0%	0,6%	4,4%	0,0%	0,6%	3,8%	1,9%	6,9%	1,3%	8,8%
1	125	0,0%	4,7%	11,6%	7,0%	2,3%	4,7%	0,0%	18,6%	0,0%	2,3%	2,3%	9,3%	0,0%	16,3%	0,0%	0,0%	0,0%	2,3%	4,7%	0,0%	0,0%	2,3%	9,3%	2,3%	0,0%
1	128	2,3%	2,3%	9,6%	5,2%	2,6%	9,8%	0,5%	15,5%	5,4%	5,9%	2,3%	5,9%	1,0%	10,1%	0,8%	0,0%	0,0%	1,8%	2,1%	2,8%	2,6%	1,6%	9,3%	0,0%	0,5%
1	129	0,3%	2,0%	5,3%	2,3%	0,6%	3,2%	4,1%	9,1%	2,9%	12,0%	5,0%	4,4%	0,6%	12,0%	0,3%	0,0%	0,0%	2,9%	12,9%	1,2%	1,8%	2,6%	10,2%	1,2%	3,2%
1	130	1,0%	3,0%	7,1%	4,0%	1,3%	9,4%	1,7%	14,8%	9,8%	6,7%	2,4%	4,0%	0,3%	10,4%	1,7%	0,3%	0,0%	1,3%	1,3%	1,0%	2,4%	3,7%	9,4%	2,4%	0,3%
1	131	0,5%	5,1%	5,6%	4,6%	2,0%	6,6%	1,0%	19,2%	3,6%	5,6%	1,5%	7,9%	0,3%	11,3%	0,5%	0,3%	0,5%	1,5%	5,1%	0,8%	2,0%	3,1%	7,9%	1,8%	1,5%
1	133	0,0%	0,7%	3,6%	2,1%	2,9%	6,4%	0,7%	17,9%	2,9%	12,9%	7,1%	2,9%	0,0%	7,1%	0,0%	0,0%	0,0%	1,4%	10,7%	2,1%	0,7%	3,6%	9,3%	4,3%	0,7%
1	134	0,3%	0,5%	4,3%	1,5%	1,8%	0,3%	0,0%	2,6%	3,8%	9,9%	1,0%	1,5%	1,0%	12,5%	0,0%	0,0%	0,0%	4,3%	37,5%	0,0%	1,5%	3,3%	8,9%	2,3%	1,0%
1	135	0,4%	4,0%	14,2%	2,8%	0,4%	9,3%	3,2%	13,4%	10,9%	1,6%	2,4%	0,8%	0,0%	11,7%	0,8%	0,0%	0,4%	1,2%	2,4%	0,8%	4,0%	2,4%	10,5%	0,4%	1,6%
1	136	1,4%	1,4%	12,5%	1,4%	0,7%	11,1%	2,1%	17,4%	8,3%	6,3%	2,1%	4,2%	0,7%	10,4%	0,7%	0,0%	0,0%	2,8%	0,0%	1,4%	4,2%	2,1%	8,3%	0,0%	0,7%
1	138	0,0%	3,1%	7,3%	1,0%	0,0%	9,4%	0,0%	14,6%	7,3%	4,2%	0,0%	2,1%	1,0%	11,5%	0,0%	0,0%	0,0%	2,1%	10,4%	6,3%	2,1%	3,1%	10,4%	1,0%	3,1%
1	150	4,1%	0,0%	2,0%	2,0%	0,0%	10,2%	0,0%	16,3%	8,2%	10,2%	4,1%	0,0%	0,0%	10,2%	0,0%	0,0%	0,0%	2,0%	14,3%	0,0%	2,0%	4,1%	8,2%	0,0%	2,0%
1	170	2,2%	2,2%	7,8%	5,6%	0,0%	13,3%	1,1%	14,4%	0,0%	8,9%	3,3%	10,0%	0,0%	13,3%	0,0%	0,0%	1,1%	1,1%	3,3%	0,0%	4,4%	6,7%	0,0%	0,0%	1,1%
1	173	0,0%	0,0%	12,0%	8,0%	0,0%	8,0%	0,0%	16,0%	6,0%	4,0%	0,0%	4,0%	0,0%	8,0%	0,0%	0,0%	2,0%	8,0%	0,0%	4,0%	4,0%	2,0%	8,0%	2,0%	4,0%
1	179	0,0%	0,0%	10,4%	2,1%	0,0%	8,3%	2,1%	16,7%	20,8%	2,1%	2,1%	0,0%	0,0%	4,2%	6,3%	0,0%	0,0%	2,1%	4,2%	2,1%	0,0%	4,2%	10,4%	0,0%	2,1%
1	180	0,3%	1,3%	8,4%	4,1%	0,0%	10,2%	1,0%	20,4%	6,4%	1,8%	1,0%	2,0%	0,3%	11,2%	0,0%	0,0%	1,3%	1,0%	8,4%	0,5%	2,0%	2,8%	9,9%	3,3%	2,3%
1	190	1,5%	2,0%	3,5%	2,0%	0,0%	3,0%	0,5%	16,7%	2,0%	6,1%	3,0%	8,1%	0,0%	17,2%	2,0%	0,0%	0,5%	3,0%	5,1%	1,0%	4,0%	2,5%	11,6%	1,5%	3,0%
1	200	2,1%	3,1%	11,3%	8,2%	0,0%	6,2%	2,1%	16,5%	2,1%	2,1%	4,1%	8,2%	1,0%	8,2%	1,0%	0,0%	0,0%	2,1%	1,0%	3,1%	2,1%	5,2%	7,2%	2,1%	1,0%
1	205	0,7%	4,0%	3,4%	6,7%	5,4%	7,4%	1,3%	12,1%	2,7%	10,1%	3,4%	8,1%	0,7%	10,7%	0,7%	0,0%	2,0%	1,3%	4,7%	1,3%	1,3%	2,0%	8,7%	0,7%	0,7%
2	1	0,0%	5,3%	5,3%	3,8%	3,1%	2,3%	2,3%	14,5%	1,5%	4,6%	1,5%	6,9%	0,0%	11,5%	2,3%	0,0%	0,8%	3,1%	3,1%	5,3%	0,8%	3,8%	9,9%	2,3%	6,1%
2	2	0,9%	1,8%	5,3%	4,4%	2,6%	5,3%	6,1%	7,0%	0,9%	9,0%	1,8%	2,6%	0,0%	15,8%	0,9%	0,0%	5,3%	0,9%	2,6%	4,4%	1,8%	5,3%	7,0%	0,9%	7,0%
2	4	1,1%	0,0%	1,6%	1,6%	0,0%	7,1%	0,0%	8,2%	3,8%	9,3%	1,1%	4,9%	0,5%	15,4%	4,9%	0,5%	0,0%	1,1%	7,7%	4,9%	3,8%	6,0%	11,5%	2,2%	2,2%
2	5	0,0%	5,3%	3,9%	3,9%	1,3%	1,3%	0,0%	14,5%	1,3%	13,2%	0,0%	3,9%	0,0%	5,3%	0,0%	0,0%	2,6%	0,0%	2,6%	18,4%	3,9%	5,3%	10,5%	0,0%	2,6%
2	6	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	92,9%	7,1%	0,0%	0,0%	0,0%	0,0%
2	7	0,8%	0,0%	3,9%	7,9%	0,8%	5,5%	0,8%	13,4%	2,4%	3,1%	4,7%	5,5%	0,8%	12,6%	2,4%	0,0%	0,8%	2,4%	3,9%	3,1%	3,1%	7,9%	9,4%	2,4%	2,4%
2	8	0,0%	3,2%	6,5%	3,2%	0,0%	12,9%	0,0%	3,2%	6,5%	6,5%	0,0%	16,1%	3,2%	0,0%	12,9%	0,0%	0,0%	0,0%	3,2%	0,0%	3,2%	6,5%	12,9%	0,0%	0,0%
2	9	0,0%	6,5%	12,9%	6,5%	0,0%	3,2%	0,0%	16,1%	12,9%	0,0%	6,5%	3,2%	0,0%	3,2%	9,7%	0,0%	0,0%	0,0%	0,0%	0,0%	3,2%	3,2%	12,9%	0,0%	0,0%
2	10	0,6%	3,0%	4,7%	1,2%	0,6%	3,0%	1,8%	10,1%	4,1%	10,7%	2,4%	5,9%	1,2%	8,3%	4,7%	0,0%	0,6%	1,8%	8,3%	5,9%	3,0%	2,4%	11,2%	0,6%	4,1%
2	11	0,0%	0,0%	0,0%	6,5%	6,5%	12,9%	0,0%	6,5%	0,0%	0,0%	0,0%	22,6%	0,0%	0,0%	6,5%	0,0%	6,5%	0,0%	6,5%	3,2%	6,5%	6,5%	9,7%	0,0%	0,0%
2	12	3,2%	3,2%	6,5%	0,0%	0,0%	3,2%	0,0%	22,6%	0,0%	6,5%	0,0%	19,4%	0,0%	0,0%	3,2%	0,0%	3,2%	0,0%	3,2%	0,0%	3,2%	0,0%	9,7%	0,0%	12,9%
2	13	0,0%	3,2%	3,2%	3,2%	3,2%	0,0%	6,5%	6,5%	16,1%	6,5%	3,2%	0,0%	0,0%	6,5%	0,0%	0,0%	0,0%	9,7%	3,2%	3,2%	9,7%	6,5%	6,5%	0,0%	3,2%
2	14	6,5%	9,7%	6,5%	0,0%	0,0%	0,0%	0,0%	22,6%	0,0%	0,0%	0,0%	9,7%	3,2%	0,0%	6,5%	0,0%	3,2%	6,5%	0,0%	0,0%	3,2%	6,5%	9,7%	0,0%	6,5%
2	15	0,0%	0,0%	0,0%	3,2%	6,5%	6,5%	6,5%	16,1%	3,2%	9,7%	0,0%	3,2%	0,0%	3,2%	3,2%	0,0%	0,0%	9,7%	9,7%	0,0%	6,5%	6,5%	6,5%	0,0%	0,0%
2	16	0,0%	50,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	50,0%	0,0%	0,0%	0,0%	0,0%
2	17	0,0%	6,5%	9,7%	6,5%	6,5%	3,2%	6,5%	12,9%	3,2%	0,0%	3,2%	0,0%	0,0%	0,0%	6,5%	0,0%	9,7%	0,0%	0,0%	0,0%	6,5%	6,5%	12,9%	0,0%	0,0%
2	18	0,0%	3,2%	3,2%	0,0%	0,0%	3,2%	0,0%	6,5%	0,0%	0,0%	0,0%	3,2%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	6,5%	41,9%	16,1%	6,5%	3,2%	0,0%	6,5%

Supplementary table S1 (2 of 6)

Ward	Nurse Nr	1. Fluid/tissue sampling for laboratory research	2. Assistance of doctors or others	3. Communication with patient and/or family	4. Oral communication/reporting about patient (not in presence of patient)	5. Positioning and exercise	6. Preparing/administering of medication (for individual patient)	7. Observation of vital signs and routine check-ups	8. Written/digital reporting, administration or transfer of information	9. Transport of patient	10. Personal care of patient	11. Assistance meals and/or excretion	12. Nurses' professional activities	13. Errands (away from ward)	14. Collective handover of patient information (for multiple patients)	15. Medication preparation (for multiple patients)	16. Meals-related activities	17. General administration	18. Domestic activities	19. Education and guidance	20. Organization of work	21. Meetings	22. Coffee break (authorized)	23. Lunch break (authorized)	24. Personal time	Not observed
2	19	0,0%	0,0%	6,5%	6,5%	0,0%	3,2%	3,2%	48,4%	6,5%	0,0%	3,2%	3,2%	0,0%	0,0%	3,2%	0,0%	3,2%	0,0%	0,0%	0,0%	3,2%	3,2%	6,5%	0,0%	0,0%
2	21	0,8%	1,7%	4,5%	4,5%	0,8%	8,7%	0,4%	16,1%	3,7%	12,8%	1,7%	4,5%	0,8%	9,5%	2,1%	0,0%	0,0%	0,4%	2,5%	0,4%	2,9%	5,8%	11,2%	0,8%	3,3%
2	25	1,4%	2,1%	7,1%	1,4%	0,0%	3,5%	3,5%	16,3%	1,4%	12,8%	2,1%	4,3%	0,0%	7,8%	3,5%	0,0%	1,4%	2,8%	0,7%	0,7%	1,4%	5,7%	10,6%	1,4%	7,8%
2	26	2,2%	4,4%	0,0%	11,1%	0,0%	8,9%	2,2%	20,0%	8,9%	13,3%	2,2%	0,0%	0,0%	6,7%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	4,4%	13,3%	0,0%	2,2%
2	27	0,0%	0,0%	7,9%	3,0%	1,0%	4,0%	1,0%	18,8%	4,0%	7,9%	1,0%	9,9%	0,0%	12,9%	0,0%	0,0%	1,0%	3,0%	4,0%	3,0%	3,0%	5,0%	9,9%	0,0%	0,0%
2	28	1,4%	0,7%	4,9%	0,7%	0,7%	4,2%	2,1%	12,6%	4,2%	7,7%	4,2%	4,2%	1,4%	12,6%	3,5%	0,0%	2,1%	2,8%	8,4%	0,7%	0,0%	6,3%	9,8%	0,0%	4,9%
2	31	0,4%	1,5%	7,0%	4,8%	1,1%	7,0%	1,5%	6,3%	3,3%	9,9%	2,9%	5,5%	0,0%	9,9%	0,7%	0,0%	0,0%	1,8%	9,6%	1,5%	1,8%	4,4%	11,4%	0,7%	7,0%
2	41	2,0%	2,0%	5,3%	3,3%	1,3%	9,3%	0,7%	12,0%	1,3%	17,3%	3,3%	7,3%	0,0%	8,0%	0,7%	0,0%	0,7%	0,0%	1,3%	0,0%	2,7%	3,3%	11,3%	0,0%	6,7%
2	43	0,7%	1,3%	2,7%	4,0%	1,3%	8,0%	1,3%	12,7%	1,3%	12,0%	5,3%	4,7%	0,0%	10,0%	8,7%	0,0%	0,0%	1,3%	2,7%	0,0%	2,0%	6,7%	10,0%	0,7%	2,7%
2	45	0,0%	0,0%	1,6%	1,6%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	1,6%	9,5%	0,0%	0,0%	25,4%	0,0%	7,9%	31,7%	0,0%	6,3%	9,5%	0,0%	4,8%
2	47	0,7%	2,7%	4,1%	3,1%	1,4%	2,1%	6,2%	12,0%	2,7%	11,7%	1,4%	2,7%	0,3%	10,3%	0,0%	0,0%	1,0%	1,0%	14,8%	0,0%	1,7%	5,2%	11,7%	0,7%	2,4%
2	55	1,6%	2,2%	7,1%	6,0%	0,5%	8,8%	0,5%	13,2%	3,8%	8,8%	1,1%	3,8%	1,1%	9,3%	0,5%	0,5%	0,5%	2,2%	1,6%	1,6%	0,0%	4,9%	10,4%	0,0%	9,3%
2	57	0,0%	1,5%	2,6%	3,6%	2,1%	3,6%	1,5%	11,9%	1,5%	13,9%	3,6%	2,1%	0,0%	8,2%	0,0%	0,0%	0,0%	1,5%	17,5%	0,5%	5,2%	7,2%	9,8%	0,0%	2,1%
2	60	0,5%	1,6%	8,8%	1,6%	3,1%	1,6%	4,1%	8,8%	9,3%	13,5%	4,7%	2,1%	0,5%	5,7%	0,0%	0,0%	2,6%	2,1%	8,3%	1,6%	0,0%	4,1%	10,4%	2,1%	3,1%
2	63	0,5%	0,8%	4,4%	1,8%	1,0%	3,1%	5,1%	14,1%	3,1%	10,0%	4,4%	4,1%	0,0%	11,0%	1,0%	0,0%	0,0%	3,1%	10,8%	0,5%	2,8%	4,9%	10,5%	0,3%	2,8%
2	64	1,0%	0,3%	3,7%	1,3%	1,0%	1,0%	3,0%	9,7%	1,3%	14,4%	2,0%	0,3%	0,0%	8,7%	0,7%	0,0%	0,0%	1,3%	30,1%	0,3%	1,7%	5,4%	10,4%	1,0%	1,3%
2	65	0,7%	3,5%	2,1%	2,1%	0,7%	0,0%	0,0%	11,2%	2,1%	4,2%	0,0%	0,0%	0,7%	27,3%	1,4%	0,0%	2,1%	0,7%	11,2%	7,0%	4,9%	5,6%	7,7%	0,0%	4,9%
2	67	2,1%	0,0%	2,1%	2,1%	0,0%	2,1%	0,0%	14,9%	6,4%	2,1%	0,0%	2,1%	0,0%	14,9%	2,1%	0,0%	0,0%	2,1%	10,6%	2,1%	0,0%	10,6%	14,9%	0,0%	8,5%
2	68	2,5%	2,0%	3,0%	2,5%	2,0%	2,5%	0,5%	16,9%	1,0%	11,4%	2,5%	4,0%	0,0%	10,4%	3,0%	0,0%	0,5%	1,0%	6,5%	2,5%	5,0%	6,5%	10,9%	3,0%	0,0%
2	70	1,6%	5,7%	7,4%	4,9%	0,0%	6,6%	1,6%	12,3%	3,3%	7,4%	0,0%	3,3%	0,0%	5,7%	0,8%	0,0%	2,5%	0,0%	2,5%	9,8%	2,5%	6,6%	9,0%	1,6%	4,9%
2	72	1,5%	4,4%	2,2%	2,2%	0,7%	1,5%	0,7%	7,4%	0,0%	5,2%	1,5%	4,4%	0,0%	18,5%	0,0%	0,0%	18,5%	0,7%	2,2%	8,1%	2,2%	4,4%	11,9%	0,7%	0,7%
2	73	0,0%	2,0%	2,0%	3,4%	2,7%	9,5%	4,1%	17,7%	2,7%	8,2%	1,4%	4,1%	0,0%	10,2%	2,0%	0,0%	0,0%	0,0%	5,4%	0,0%	3,4%	7,5%	10,9%	0,0%	2,7%
2	74	0,5%	0,5%	3,3%	0,3%	1,5%	0,8%	3,3%	4,3%	1,5%	8,1%	0,0%	0,5%	0,3%	6,3%	0,5%	0,0%	0,0%	2,8%	46,2%	0,3%	1,0%	5,3%	10,7%	0,5%	1,5%
2	75	2,0%	1,4%	3,4%	0,0%	2,7%	6,1%	1,4%	10,9%	4,1%	10,2%	3,4%	6,8%	0,7%	15,0%	4,8%	0,0%	0,0%	2,0%	2,0%	0,7%	2,7%	6,8%	10,9%	0,7%	1,4%
2	76	0,8%	0,4%	2,8%	2,0%	0,8%	1,2%	2,0%	4,0%	5,6%	8,8%	2,4%	0,4%	1,6%	10,0%	0,0%	0,0%	0,0%	2,0%	37,8%	0,4%	1,2%	5,6%	10,4%	0,0%	0,0%
2	80	1,4%	1,4%	7,6%	2,4%	1,4%	4,5%	2,4%	15,1%	5,8%	12,7%	3,4%	1,0%	0,3%	9,6%	1,4%	0,0%	0,3%	0,7%	5,5%	0,7%	0,7%	6,2%	11,3%	1,4%	2,7%
2	85	1,4%	3,0%	3,7%	3,7%	0,7%	4,3%	1,6%	6,2%	2,3%	8,7%	1,1%	2,7%	0,7%	17,1%	0,9%	0,0%	1,4%	0,2%	5,7%	11,6%	4,6%	5,0%	11,4%	0,2%	1,8%
2	87	0,0%	2,3%	6,8%	2,3%	0,0%	4,5%	2,3%	20,5%	0,0%	4,5%	4,5%	4,5%	0,0%	11,4%	4,5%	0,0%	0,0%	9,1%	0,0%	2,3%	2,3%	4,5%	11,4%	2,3%	0,0%
2	90	0,4%	1,3%	1,8%	1,3%	0,0%	5,3%	2,2%	8,0%	3,1%	6,6%	1,8%	3,1%	0,4%	21,7%	0,9%	0,4%	0,9%	2,2%	3,1%	10,2%	7,5%	4,4%	11,5%	0,4%	1,3%
2	105	0,0%	4,4%	8,9%	6,7%	0,0%	2,2%	0,0%	33,3%	4,4%	4,4%	0,0%	2,2%	0,0%	6,7%	6,7%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	4,4%	11,1%	2,2%	2,2%
2	108	0,0%	1,0%	4,0%	0,0%	0,0%	9,0%	3,0%	15,0%	3,0%	24,0%	1,0%	2,0%	0,0%	7,0%	1,0%	0,0%	0,0%	5,0%	0,0%	1,0%	2,0%	2,0%	10,0%	1,0%	9,0%
2	110	1,0%	3,1%	10,4%	2,1%	2,1%	6,3%	2,1%	11,5%	3,1%	13,5%	2,1%	4,2%	0,0%	6,3%	0,0%	0,0%	1,0%	5,2%	2,1%	2,1%	3,1%	5,2%	8,3%	1,0%	4,2%
2	112	2,1%	0,0%	0,0%	8,3%	0,0%	6,3%	2,1%	20,8%	10,4%	6,3%	0,0%	0,0%	2,1%	8,3%	0,0%	0,0%	0,0%	0,0%	6,3%	0,0%	8,3%	6,3%	12,5%	0,0%	0,0%
2	125	0,0%	2,4%	2,9%	2,9%	0,0%	4,1%	0,6%	15,6%	1,2%	7,6%	0,3%	4,7%	0,0%	17,6%	0,3%	0,0%	1,2%	1,2%	6,5%	7,9%	5,9%	5,3%	9,4%	0,3%	2,1%
2	135	0,0%	0,0%	4,3%	2,9%	4,3%	0,7%	3,6%	13,8%	1,4%	11,6%	2,9%	2,2%	0,0%	13,8%	0,0%	0,0%	0,7%	0,7%	15,2%	0,0%	0,7%	8,0%	11,6%	0,7%	0,7%
2	140	0,8%	2,4%	3,2%	1,6%	1,6%	9,7%	2,8%	12,5%	4,4%	17,7%	2,0%	2,8%	0,0%	6,0%	4,8%	0,0%	0,0%	0,8%	2,0%	0,0%	1,6%	4,8%	11,3%	0,8%	6,0%
2	142	2,0%	0,0%	9,8%	9,8%	0,0%	5,9%	2,0%	17,6%	5,9%	9,8%	2,0%	2,0%	2,0%	11,8%	0,0%	0,0%	0,0%	2,0%	0,0%	2,0%	0,0%	5,9%	9,8%	0,0%	0,0%
2	155	3,2%	0,0%	3,2%	8,4%	1,1%	1,1%	2,1%	9,5%	5,3%	0,0%	1,1%	6,3%	0,0%	21,1%	7,4%	0,0%	2,1%	3,2%	3,2%	3,2%	0,0%	7,4%	9,5%	0,0%	2,1%
2	156	0,7%	1,3%	8,1%	4,7%	0,0%	8,7%	0,7%	17,4%	3,4%	9,4%	2,0%	2,7%	0,0%	10,7%	2,0%	0,0%	0,7%	2,0%	4,7%	2,0%	0,7%	4,0%	10,7%	0,7%	2,7%
2	172	2,0%	1,0%	6,5%	2,5%	2,0%	5,0%	2,0%	12,1%	2,5%	19,1%	1,0%	4,5%	0,5%	11,1%	1,0%	0,0%	0,0%	1,5%	3,5%	2,0%	2,0%	4,5%	11,6%	1,0%	1,0%
2	175	0,2%	2,2%	3,1%	2,9%	0,4%	3,5%	0,8%	9,4%	1,8%	6,5%	2,7%	1,2%	0,0%	15,9%	4,1%	0,0%	2,0%	1,6%	5,3%	12,9%	2,9%	6,1%	10,2%	2,0%	2,2%
2	178	1,4%	1,4%	4,7%	1,7%	0,3%	2,4%	2,7%	5,1%	1,7%	15,9%	1,0%	3,4%	0,0%	6,1%	0,0%	0,0%	0,3%	0,3%	25,7%	0,3%	2,0%	6,4%	10,8%	1,4%	5,1%
2	179	0,0%	1,4%	6,8%	2,7%	0,7%	7,5%	1,4%	9,6%	1,4%	13,0%	1,4%	3,4%	0,0%	8,9%	3,4%	0,0%	0,0%	0,7%	11,6%	1,4%	2,1%	5,5%	11,6%	2,1%	3,4%
2	180	3,1%	3,1%	2,1%	3,1%	0,0%	6,2%	0,0%	17,5%	7,2%	12,4%	1,0%	6,2%	1,0%	9,3%	3,1%	0,0%	0,0%	0,0%	5,2%	2,1%	0,0%	3,1%	12,4%	0,0%	2,1%
3	1	0,0%	8,3%	4,2%	2,1%	2,1%	0,0%	8,3%	10,4%	0,0%	8,3%	2,1%	2,1%	0,0%	12,5%	0,0%	0,0%	0,0%	2,1%	18,8%	0,0%	0,0%	10,4%	8,3%	0,0%	0,0%
3	5	2,2%	8,7%	2,2%	8,7%	0,0%	4,3%	0,0%	23,9%	0,0%	2,2%	0,0%	15,2%	4,3%	0,0%	2,2%	0,0%	2,2%	0,0%	0,0%	0,0%	6,5%	6,5%	6,5%	4,3%	0,0%
3	6	0,0%	8,7%	2,2%	4,3%	0,0%	2,2%	0,0%	19,6%	0,0%	13,0%	4,3%	6,5%	2,2%	4,3%	0,0%	0,0%	2,2%	0,0%	0,0%	0,0%	19,6%	4,3%	6,5%	0,0%	0,0%
3	7	2,2%	13,0%	6,5%	0,0%	0,0%	2,2%	0,0%	17,4%	2,2%	2,2%	4,3%	8,7%	6,5%	4,3%	6,5%	0,0%	0,0%	0,0%	0,0%	0,0%	8,7%	2,2%	8,7%	2,2%	2,2%
3	8	2,2%	2,2%	6,5%	2,2%	0,0%	2,2%	2,2%	21,7%	0,0%	6,5%	2,2%	8,7%	6,5%	4,3%	0,0%	0,0%	0,0%	6,5%	6,5%	0,0%	6,5%	6,5%	6,5%	0,0%	0,0%
3	9	0,0%	2,1%	4,3%	9,6%	0,0%	2,1%	4,3%	23,4%	2,1%	4,3%	0,0%	5,3%	4,3%	2,1%	0,0%	0,0%	0,0%	6,4%	0,0%	1,1%	9,6%	8,5%	6,4%	2,1%	2,1%

Supplementary table S1 (3 of 6)

Ward	Nurse Nr	1. Fluid/tissue sampling for laboratory research	2. Assistance of doctors or others	3. Communication with patient and/or family	4. Oral communication/reporting about patient (not in presence of patient)	5. Positioning and exercise	6. Preparing/administering of medication (for individual patient)	7. Observation of vital signs and routine check-ups	8. Written/digital reporting, administration or transfer of information	9. Transport of patient	10. Personal care of patient	11. Assistance meals and/or excretion	12. Nurses' professional activities	13. Errands (away from ward)	14. Collective handover of patient information (for multiple patients)	15. Medication preparation (for multiple patients)	16. Meals-related activities	17. General administration	18. Domestic activities	19. Education and guidance	20. Organization of work	21. Meetings	22. Coffee break (authorized)	23. Lunch break (authorized)	24. Personal time	Not observed
3	10	0,0%	6,5%	4,3%	6,5%	0,0%	4,3%	4,3%	19,6%	2,2%	10,9%	2,2%	6,5%	4,3%	6,5%	0,0%	0,0%	0,0%	0,0%	0,0%	4,3%	4,3%	2,2%	6,5%	4,3%	0,0%
3	11	0,0%	1,4%	11,1%	2,8%	3,5%	6,3%	2,1%	9,7%	3,5%	2,8%	0,7%	5,6%	2,1%	4,2%	0,7%	0,7%	0,7%	6,3%	2,8%	1,4%	8,3%	6,3%	10,4%	2,8%	4,2%
3	13	0,3%	2,2%	5,2%	7,7%	1,5%	6,8%	2,8%	12,3%	5,9%	5,2%	3,7%	3,1%	0,6%	8,3%	0,9%	0,0%	0,0%	2,8%	3,7%	1,9%	8,3%	6,2%	9,6%	0,6%	0,3%
3	14	0,0%	4,3%	0,0%	0,0%	0,0%	8,7%	0,0%	17,4%	0,0%	15,2%	4,3%	2,2%	4,3%	8,7%	4,3%	0,0%	2,2%	0,0%	6,5%	0,0%	4,3%	4,3%	6,5%	4,3%	2,2%
3	15	0,4%	2,0%	1,6%	6,8%	0,0%	3,2%	1,2%	12,4%	2,0%	5,2%	1,2%	1,2%	0,0%	10,4%	2,0%	0,0%	0,4%	2,4%	2,0%	23,7%	5,6%	7,6%	6,8%	1,2%	0,4%
3	16	2,2%	0,0%	2,2%	0,0%	0,0%	4,3%	2,2%	10,9%	0,0%	10,9%	0,0%	6,5%	4,3%	8,7%	4,3%	0,0%	2,2%	2,2%	2,2%	0,0%	2,2%	10,9%	6,5%	13,0%	4,3%
3	17	0,0%	0,0%	4,3%	2,2%	0,0%	0,0%	8,7%	19,6%	0,0%	10,9%	0,0%	6,5%	2,2%	6,5%	0,0%	0,0%	0,0%	4,3%	8,7%	0,0%	2,2%	6,5%	6,5%	10,9%	0,0%
3	18	0,0%	0,0%	6,5%	8,7%	2,2%	0,0%	2,2%	13,0%	4,3%	6,5%	0,0%	10,9%	2,2%	4,3%	0,0%	0,0%	2,2%	0,0%	6,5%	2,2%	4,3%	6,5%	6,5%	8,7%	2,2%
3	19	0,0%	0,0%	4,3%	4,3%	0,0%	0,0%	0,0%	17,4%	4,3%	19,6%	2,2%	8,7%	0,0%	6,5%	0,0%	0,0%	0,0%	4,3%	2,2%	6,5%	4,3%	6,5%	6,5%	2,2%	0,0%
3	20	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	33,3%	0,0%	0,0%	66,7%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
3	28	1,9%	0,0%	7,7%	1,9%	0,0%	0,0%	7,7%	11,5%	7,7%	1,9%	1,9%	5,8%	3,8%	9,6%	3,8%	1,9%	0,0%	1,9%	13,5%	0,0%	5,8%	1,9%	9,6%	0,0%	0,0%
3	30	3,0%	4,0%	2,0%	0,0%	0,0%	3,0%	1,0%	21,2%	6,1%	4,0%	1,0%	1,0%	1,0%	14,1%	1,0%	0,0%	2,0%	0,0%	9,1%	0,0%	7,1%	7,1%	10,1%	0,0%	2,0%
3	70	0,6%	2,7%	6,4%	4,5%	1,6%	2,9%	2,3%	14,8%	3,9%	6,6%	3,1%	4,5%	0,0%	9,7%	0,8%	0,6%	0,4%	2,9%	4,5%	0,4%	7,4%	6,4%	9,9%	2,3%	0,6%
3	71	0,0%	0,5%	2,5%	1,5%	2,5%	2,5%	2,5%	11,4%	3,0%	13,4%	2,5%	2,0%	0,0%	5,5%	0,5%	0,5%	0,5%	2,0%	9,5%	0,5%	9,5%	5,0%	9,5%	2,5%	10,4%
3	72	3,8%	0,0%	3,8%	5,8%	1,9%	0,0%	0,0%	7,7%	1,9%	11,5%	1,9%	1,9%	0,0%	19,2%	1,9%	0,0%	1,9%	0,0%	7,7%	1,9%	1,9%	9,6%	9,6%	0,0%	5,8%
3	75	0,3%	0,3%	3,7%	1,7%	1,3%	3,7%	1,0%	8,4%	1,0%	1,7%	0,7%	2,4%	0,0%	9,4%	1,3%	0,3%	0,3%	1,3%	4,7%	36,4%	7,7%	3,7%	7,1%	1,0%	0,3%
3	80	2,1%	14,6%	4,2%	0,0%	0,0%	4,2%	0,0%	14,6%	2,1%	2,1%	0,0%	4,2%	0,0%	12,5%	12,5%	0,0%	0,0%	2,1%	4,2%	6,3%	0,0%	2,1%	10,4%	2,1%	0,0%
3	90	0,0%	1,7%	2,3%	2,0%	0,6%	1,4%	2,0%	7,7%	3,4%	6,3%	2,0%	2,6%	0,3%	9,7%	0,0%	0,0%	0,6%	3,7%	29,1%	0,0%	5,7%	6,3%	10,3%	0,9%	1,4%
3	100	0,7%	5,3%	4,0%	2,6%	0,7%	9,3%	0,0%	10,6%	4,6%	7,9%	2,6%	4,6%	0,7%	13,2%	4,6%	0,0%	0,0%	2,6%	2,6%	2,0%	5,3%	5,3%	9,9%	0,7%	0,0%
3	105	1,0%	4,6%	2,1%	6,2%	1,0%	4,6%	1,0%	15,4%	5,1%	6,2%	0,5%	4,6%	0,0%	5,6%	0,5%	0,0%	0,5%	5,1%	5,1%	1,0%	7,2%	7,7%	11,8%	1,5%	1,5%
3	107	0,0%	1,2%	6,4%	5,2%	0,8%	4,8%	0,8%	16,1%	4,4%	3,2%	1,6%	4,4%	0,4%	9,6%	3,2%	0,4%	1,2%	5,2%	3,6%	0,4%	8,8%	5,6%	9,6%	0,4%	2,4%
3	108	0,0%	0,9%	2,3%	0,9%	1,2%	1,4%	3,7%	7,8%	1,4%	8,9%	0,9%	2,6%	0,6%	8,9%	0,3%	0,0%	0,3%	2,6%	31,7%	0,6%	4,9%	5,2%	10,4%	0,9%	1,7%
3	120	0,9%	0,5%	3,2%	4,8%	2,0%	1,1%	2,5%	14,7%	5,2%	8,1%	2,3%	4,5%	0,5%	9,3%	0,5%	0,0%	0,5%	4,3%	8,1%	0,5%	7,5%	5,4%	11,1%	2,3%	0,5%
3	123	0,0%	4,2%	10,4%	0,0%	6,3%	2,1%	6,3%	12,5%	4,2%	8,3%	6,3%	4,2%	0,0%	4,2%	2,1%	0,0%	0,0%	0,0%	8,3%	0,0%	4,2%	6,3%	8,3%	2,1%	0,0%
3	125	0,0%	2,1%	7,9%	2,5%	2,5%	3,7%	0,4%	18,3%	2,9%	8,3%	2,9%	3,7%	1,2%	9,5%	0,4%	0,0%	0,0%	2,9%	4,6%	1,2%	7,5%	5,4%	9,1%	1,7%	1,2%
3	126	1,1%	7,6%	7,6%	5,4%	0,0%	3,3%	0,0%	12,0%	1,1%	5,4%	5,4%	2,2%	0,0%	12,0%	3,3%	0,0%	0,0%	0,0%	2,2%	0,0%	6,5%	8,7%	10,9%	2,2%	3,3%
3	127	0,7%	5,0%	4,3%	7,1%	2,1%	9,2%	0,7%	16,3%	0,0%	5,7%	0,7%	6,4%	0,0%	8,5%	0,7%	0,0%	0,0%	3,5%	5,7%	0,7%	4,3%	5,7%	11,3%	0,0%	1,4%
3	128	0,0%	0,6%	2,2%	5,1%	1,7%	1,7%	1,7%	19,7%	2,2%	12,9%	3,4%	2,8%	1,1%	9,6%	1,1%	0,6%	0,6%	3,4%	8,4%	0,0%	2,2%	6,7%	9,0%	3,4%	0,0%
3	129	0,0%	1,1%	5,4%	2,2%	3,2%	2,2%	4,3%	9,7%	3,2%	14,0%	4,3%	1,1%	0,0%	8,6%	1,1%	0,0%	0,0%	3,2%	15,1%	0,0%	0,0%	5,4%	9,7%	5,4%	1,1%
3	131	1,0%	5,0%	4,5%	8,0%	1,5%	3,0%	2,0%	13,0%	3,5%	6,5%	1,5%	4,0%	0,0%	10,0%	2,5%	0,0%	0,5%	2,5%	6,0%	1,5%	7,0%	4,5%	9,5%	1,5%	1,0%
3	141	0,0%	1,1%	6,1%	2,9%	1,1%	1,1%	4,2%	16,7%	1,9%	6,3%	2,9%	6,9%	0,0%	10,1%	0,5%	0,0%	0,8%	2,6%	12,4%	0,0%	4,2%	6,6%	9,0%	1,3%	1,3%
3	142	0,8%	0,8%	3,1%	6,9%	0,0%	3,8%	0,0%	10,8%	7,7%	3,1%	0,0%	3,8%	0,8%	10,8%	3,8%	0,8%	0,8%	3,1%	3,1%	0,0%	16,9%	6,2%	9,2%	0,8%	3,1%
3	144	0,7%	3,5%	2,8%	7,0%	0,0%	7,0%	0,0%	18,2%	3,5%	2,8%	0,0%	4,2%	0,0%	4,9%	0,0%	0,0%	0,7%	2,1%	13,3%	2,1%	11,2%	5,6%	8,4%	0,0%	2,1%
3	150	1,2%	4,1%	4,1%	5,0%	0,8%	7,5%	0,8%	12,4%	2,1%	7,5%	1,7%	2,5%	0,0%	7,9%	1,2%	0,4%	0,4%	2,1%	10,8%	1,2%	3,3%	6,6%	11,2%	2,5%	2,5%
3	153	0,0%	1,9%	1,9%	5,8%	5,8%	5,8%	1,9%	11,5%	1,9%	5,8%	0,0%	7,7%	0,0%	17,3%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	7,7%	11,5%	9,6%	3,8%	0,0%
3	155	1,4%	1,2%	2,0%	3,0%	1,2%	3,4%	2,0%	10,5%	3,0%	7,9%	2,2%	5,3%	0,2%	8,1%	1,8%	0,0%	0,0%	2,4%	18,1%	0,4%	7,1%	6,5%	9,9%	1,2%	0,8%
3	160	0,0%	2,3%	5,4%	3,9%	1,3%	1,3%	3,6%	9,8%	3,6%	7,0%	2,6%	3,6%	0,0%	7,7%	0,8%	0,0%	0,5%	3,6%	13,7%	1,0%	9,0%	5,2%	10,1%	2,6%	1,5%
3	164	0,0%	2,1%	0,0%	2,1%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	2,1%	0,0%	10,4%	0,0%	0,0%	10,4%	0,0%	0,0%	37,5%	2,1%	14,6%	0,0%	0,0%	18,8%
3	165	0,2%	1,9%	3,6%	2,3%	1,9%	2,3%	2,7%	13,5%	3,4%	8,7%	2,5%	4,9%	0,0%	10,1%	0,8%	0,0%	0,4%	2,7%	12,4%	0,8%	5,7%	7,2%	9,7%	1,9%	0,6%
3	167	0,0%	1,4%	2,7%	4,1%	0,7%	4,7%	0,7%	12,2%	4,7%	4,1%	1,4%	2,7%	0,0%	8,8%	0,7%	0,0%	8,1%	3,4%	4,7%	0,7%	17,6%	6,8%	8,8%	1,4%	0,0%
3	168	0,0%	2,9%	8,8%	4,4%	1,5%	1,5%	1,5%	16,2%	5,9%	1,5%	0,0%	5,9%	4,4%	1,5%	1,5%	0,0%	1,5%	16,2%	0,0%	0,0%	13,2%	4,4%	7,4%	0,0%	0,0%
3	170	0,7%	0,0%	2,1%	2,8%	2,8%	0,0%	3,5%	7,8%	5,0%	9,9%	2,1%	5,0%	0,0%	5,7%	0,7%	0,7%	0,0%	2,1%	27,7%	2,1%	0,7%	6,4%	8,5%	2,1%	1,4%
3	175	0,0%	1,8%	2,7%	3,1%	0,0%	3,6%	0,0%	6,7%	0,0%	2,7%	0,4%	0,4%	0,0%	6,2%	0,9%	0,0%	0,9%	1,8%	2,2%	44,9%	3,1%	10,7%	3,6%	2,7%	1,8%
3	180	1,5%	2,6%	7,2%	3,6%	1,0%	5,6%	0,0%	7,7%	2,6%	4,6%	1,0%	9,7%	0,5%	9,7%	1,0%	0,0%	0,0%	1,0%	9,2%	0,0%	12,3%	3,6%	8,2%	3,6%	3,6%
3	185	0,3%	2,0%	5,9%	3,4%	2,0%	5,7%	0,8%	14,4%	2,8%	5,9%	1,1%	5,4%	0,6%	11,0%	2,5%	0,0%	0,3%	5,4%	7,9%	0,3%	5,1%	5,9%	9,3%	0,8%	0,8%
3	190	0,0%	3,1%	3,8%	6,5%	1,4%	7,2%	0,7%	13,3%	4,4%	7,2%	1,4%	6,8%	0,0%	9,9%	3,8%	0,0%	0,7%	3,4%	2,7%	1,0%	4,4%	5,5%	10,2%	2,4%	0,3%
3	195	0,0%	2,0%	3,4%	3,4%	2,7%	9,5%	0,0%	15,0%	1,4%	6,8%	3,4%	4,8%	0,0%	10,2%	4,8%	0,0%	0,0%	2,0%	12,9%	0,7%	5,4%	4,1%	6,8%	0,7%	0,0%
3	200	0,0%	3,1%	2,6%	4,6%	2,1%	4,1%	3,1%	11,8%	1,5%	7,7%	4,6%	4,6%	1,0%	10,3%	0,0%	0,0%	1,5%	4,1%	11,3%	1,5%	4,1%	6,2%	10,3%	0,0%	0,0%
4	1	0,0%	2,0%	10,2%	10,2%	0,0%	2,0%	0,0%	22,4%	0,0%	8,2%	0,0%	2,0%	0,0%	8,2%	2,0%	0,0%	2,0%	2,0%	0,0%	0,0%	6,1%	6,1%	10,2%	2,0%	4,1%
4	4	0,0%	2,4%	2,4%	4,9%	0,0%	7,3%	2,4%	17,1%	2,4%	12,2%	0,0%	14,6%	0,0%	4,9%	0,0%	0,0%	0,0%	2,4%	0,0%	0,0%	2,4%	4,9%	14,6%	2,4%	2,4%

Supplementary table S1 (4 of 6)

Ward	Nurse Nr	1. Fluid/tissue sampling for laboratory research	2. Assistance of doctors or others	3. Communication with patient and/or family	4. Oral communication/reporting about patient (not in presence of patient)	5. Positioning and exercise	6. Preparing/administering of medication (for individual patient)	7. Observation of vital signs and routine check-ups	8. Written/digital reporting, administration or transfer of information	9. Transport of patient	10. Personal care of patient	11. Assistance meals and/or excretion	12. Nurses' professional activities	13. Errands (away from ward)	14. Collective handover of patient information (for multiple patients)	15. Medication preparation (for multiple patients)	16. Meals-related activities	17. General administration	18. Domestic activities	19. Education and guidance	20. Organization of work	21. Meetings	22. Coffee break (authorized)	23. Lunch break (authorized)	24. Personal time	Not observed
4	5	0,0%	4,9%	9,8%	12,2%	0,0%	2,4%	2,4%	14,6%	0,0%	19,5%	2,4%	0,0%	0,0%	9,8%	0,0%	0,0%	0,0%	4,9%	0,0%	0,0%	2,4%	4,9%	9,8%	0,0%	0,0%
4	6	0,0%	0,0%	2,6%	5,1%	0,0%	7,7%	0,0%	10,3%	5,1%	12,8%	2,6%	10,3%	0,0%	12,8%	7,7%	0,0%	0,0%	2,6%	0,0%	0,0%	2,6%	7,7%	7,7%	0,0%	2,6%
4	7	0,0%	0,0%	0,0%	2,4%	4,9%	2,4%	0,0%	7,3%	0,0%	24,4%	4,9%	2,4%	0,0%	7,3%	0,0%	2,4%	0,0%	4,9%	7,3%	0,0%	4,9%	4,9%	9,8%	4,9%	4,9%
4	8	0,0%	12,2%	2,4%	7,3%	2,4%	4,9%	0,0%	12,2%	0,0%	7,3%	0,0%	4,9%	0,0%	12,2%	4,9%	0,0%	2,4%	0,0%	0,0%	0,0%	2,4%	4,9%	12,2%	4,9%	2,4%
4	9	0,0%	9,8%	0,0%	7,3%	0,0%	4,9%	0,0%	14,6%	0,0%	0,0%	0,0%	2,4%	0,0%	9,8%	0,0%	2,4%	4,9%	0,0%	4,9%	7,3%	2,4%	4,9%	12,2%	4,9%	7,3%
4	10	0,0%	0,0%	7,0%	2,0%	1,5%	2,5%	0,5%	18,6%	6,0%	8,5%	5,0%	6,0%	0,0%	12,1%	1,5%	0,0%	1,0%	3,5%	0,5%	2,0%	1,0%	6,0%	9,0%	1,5%	4,0%
4	12	0,0%	4,9%	7,3%	7,3%	0,0%	2,4%	2,4%	2,4%	4,9%	7,3%	14,6%	2,4%	0,0%	7,3%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	2,4%	7,3%	14,6%	7,3%	4,9%
4	15	0,0%	4,3%	3,6%	4,3%	0,0%	0,0%	0,0%	15,9%	0,0%	9,4%	3,6%	6,5%	1,4%	10,9%	0,7%	0,0%	2,2%	1,4%	2,9%	0,7%	6,5%	7,2%	12,3%	2,9%	2,9%
4	16	1,1%	0,0%	6,3%	8,4%	0,0%	4,2%	0,0%	13,7%	3,2%	6,3%	2,1%	6,3%	0,0%	11,6%	3,2%	0,0%	0,0%	2,1%	7,4%	0,0%	1,1%	6,3%	10,5%	2,1%	4,2%
4	17	0,5%	0,0%	3,7%	6,5%	1,3%	2,6%	1,3%	14,4%	3,7%	10,2%	6,0%	3,1%	0,3%	6,0%	0,0%	0,0%	0,3%	4,5%	11,8%	1,8%	2,9%	5,5%	9,9%	0,8%	2,9%
4	18	0,0%	0,0%	12,2%	4,9%	2,4%	0,0%	2,4%	19,5%	9,8%	9,8%	2,4%	0,0%	0,0%	0,0%	2,4%	0,0%	0,0%	4,9%	12,2%	0,0%	0,0%	4,9%	9,8%	2,4%	0,0%
4	19	0,0%	0,0%	4,9%	9,8%	0,0%	2,4%	0,0%	7,3%	4,9%	12,2%	4,9%	2,4%	0,0%	4,9%	0,0%	0,0%	0,0%	0,0%	24,4%	0,0%	2,4%	0,0%	14,6%	0,0%	4,9%
4	20	0,0%	0,9%	3,0%	6,1%	0,9%	6,6%	0,2%	18,6%	3,9%	9,8%	1,8%	2,5%	1,1%	8,0%	2,0%	0,0%	1,1%	3,6%	2,7%	0,9%	3,9%	6,8%	11,1%	1,4%	3,0%
4	30	0,7%	1,1%	3,9%	4,8%	0,7%	3,9%	0,9%	13,2%	2,1%	11,4%	1,4%	7,1%	0,9%	12,5%	6,2%	0,0%	1,4%	1,4%	1,4%	0,9%	3,4%	7,1%	8,7%	1,1%	4,1%
4	34	0,0%	0,0%	0,0%	2,0%	0,0%	0,0%	0,0%	5,9%	0,0%	17,6%	0,0%	0,0%	0,0%	7,8%	5,9%	0,0%	0,0%	3,9%	17,6%	2,0%	19,6%	7,8%	9,8%	0,0%	0,0%
4	35	0,0%	3,0%	4,7%	6,6%	1,7%	4,0%	0,0%	10,6%	2,0%	8,3%	1,7%	5,0%	1,7%	9,6%	1,3%	0,0%	1,0%	3,3%	1,7%	6,0%	8,3%	5,6%	11,0%	2,0%	1,0%
4	48	0,0%	1,3%	10,1%	9,4%	1,3%	9,4%	0,7%	16,1%	3,4%	12,8%	2,0%	2,0%	0,0%	5,4%	0,7%	0,0%	0,0%	2,0%	0,0%	1,3%	2,0%	4,7%	11,4%	1,3%	2,7%
4	60	1,0%	1,0%	2,0%	5,0%	1,0%	4,0%	0,0%	15,0%	10,0%	7,0%	1,0%	7,0%	1,0%	13,0%	7,0%	0,0%	2,0%	2,0%	0,0%	1,0%	3,0%	4,0%	7,0%	2,0%	4,0%
4	65	0,0%	0,0%	0,7%	2,7%	0,0%	2,7%	3,4%	25,0%	3,4%	10,8%	3,4%	0,7%	0,0%	11,5%	2,7%	0,0%	0,0%	6,8%	0,0%	0,0%	0,0%	7,4%	11,5%	3,4%	4,1%
4	70	0,0%	0,0%	2,0%	5,4%	1,4%	4,1%	0,0%	24,5%	2,0%	11,6%	1,4%	6,8%	1,4%	4,8%	4,1%	0,0%	0,0%	2,0%	0,7%	4,1%	6,1%	6,1%	8,8%	0,7%	2,0%
4	85	0,5%	1,0%	1,5%	3,0%	1,0%	1,5%	0,0%	13,0%	0,0%	6,5%	0,5%	3,0%	1,5%	9,5%	3,0%	0,0%	1,0%	1,5%	27,5%	5,5%	5,5%	3,0%	7,0%	0,5%	3,0%
4	90	0,5%	0,8%	5,1%	4,3%	3,2%	2,4%	2,4%	17,6%	3,5%	12,0%	5,1%	4,3%	0,3%	7,5%	2,7%	0,0%	0,8%	2,9%	4,3%	2,1%	2,4%	3,2%	9,6%	0,8%	2,1%
4	95	0,0%	6,1%	4,1%	8,2%	4,1%	4,1%	4,1%	10,2%	4,1%	8,2%	8,2%	4,1%	0,0%	10,2%	0,0%	0,0%	0,0%	6,1%	0,0%	0,0%	0,0%	8,2%	10,2%	0,0%	0,0%
4	98	0,0%	1,5%	8,1%	3,5%	3,5%	0,5%	5,6%	12,1%	1,5%	14,6%	2,0%	3,0%	0,0%	2,5%	0,0%	0,0%	0,0%	0,5%	12,1%	1,0%	3,0%	7,1%	10,6%	6,1%	1,0%
4	99	0,0%	0,0%	8,1%	6,0%	2,0%	1,3%	2,7%	17,4%	3,4%	14,1%	2,7%	5,4%	1,3%	6,7%	2,7%	0,0%	1,3%	0,7%	1,3%	2,0%	2,0%	5,4%	10,7%	0,7%	2,0%
4	100	0,0%	0,0%	0,6%	5,1%	3,4%	4,6%	1,1%	8,6%	2,9%	14,3%	1,7%	4,6%	0,6%	12,6%	4,6%	0,0%	0,0%	1,7%	2,9%	1,7%	4,6%	9,1%	11,4%	0,0%	4,0%
4	102	0,3%	0,9%	5,2%	6,4%	4,1%	2,3%	0,3%	20,9%	3,5%	15,4%	3,2%	2,3%	0,3%	6,4%	3,2%	0,0%	0,6%	2,0%	0,9%	1,2%	3,8%	4,6%	9,0%	0,3%	3,2%
4	103	1,0%	0,5%	3,4%	6,3%	0,5%	2,4%	4,4%	13,7%	3,9%	16,1%	3,4%	5,4%	0,5%	13,2%	0,0%	0,0%	1,0%	1,0%	1,5%	2,0%	1,0%	5,4%	9,8%	1,0%	2,9%
4	104	0,0%	0,8%	7,8%	4,5%	0,8%	6,1%	0,0%	13,5%	4,1%	9,0%	4,9%	6,5%	2,4%	7,3%	2,4%	0,0%	0,8%	1,2%	0,4%	0,8%	3,7%	4,9%	11,4%	1,6%	4,9%
4	105	0,0%	0,8%	2,3%	3,5%	3,5%	4,1%	2,3%	11,4%	3,7%	12,2%	3,9%	5,8%	3,5%	6,8%	3,7%	0,0%	0,8%	3,9%	4,3%	0,4%	4,8%	4,5%	9,9%	1,9%	1,9%
4	106	0,0%	0,0%	3,4%	4,0%	2,7%	2,0%	3,4%	6,0%	2,0%	14,8%	2,7%	5,4%	0,7%	9,4%	1,3%	0,7%	0,0%	7,4%	8,1%	0,7%	5,4%	6,7%	10,7%	1,3%	1,3%
4	110	0,0%	3,0%	4,0%	4,0%	0,0%	3,0%	0,0%	6,0%	0,0%	3,0%	1,0%	0,0%	1,0%	20,0%	3,0%	0,0%	9,0%	4,0%	4,0%	4,0%	5,0%	9,0%	12,0%	1,0%	4,0%
4	115	0,0%	0,7%	9,5%	0,0%	2,0%	2,0%	4,7%	4,7%	2,0%	23,6%	3,4%	4,7%	0,7%	11,5%	0,0%	0,0%	0,7%	0,7%	2,7%	0,0%	3,4%	6,1%	11,5%	2,0%	3,4%
4	117	0,0%	0,0%	2,0%	2,0%	2,0%	2,0%	0,0%	11,8%	2,0%	2,0%	0,0%	0,0%	0,0%	23,5%	0,0%	0,0%	5,9%	2,0%	0,0%	21,6%	7,8%	5,9%	0,0%	2,0%	7,8%
4	120	0,0%	0,0%	6,3%	0,0%	8,3%	6,3%	0,0%	2,1%	16,7%	8,3%	6,3%	16,7%	2,1%	10,4%	0,0%	0,0%	0,0%	2,1%	0,0%	0,0%	0,0%	4,2%	6,3%	0,0%	4,2%
4	121	2,5%	0,0%	2,5%	2,5%	2,5%	1,0%	3,0%	6,1%	3,5%	15,7%	4,5%	1,0%	1,0%	7,6%	0,5%	0,0%	0,0%	0,0%	7,6%	13,1%	1,0%	3,0%	6,6%	11,1%	0,5%	3,0%
4	126	0,0%	1,2%	4,9%	4,5%	2,4%	0,8%	2,0%	4,5%	4,1%	16,3%	4,5%	1,6%	0,4%	7,3%	0,0%	0,0%	0,8%	3,3%	15,9%	1,2%	3,3%	6,9%	11,0%	2,4%	0,8%
4	135	0,0%	6,2%	1,0%	5,1%	3,1%	2,1%	0,0%	13,8%	0,5%	8,7%	3,1%	5,6%	0,0%	13,8%	2,6%	0,0%	1,0%	4,1%	1,5%	5,1%	3,6%	6,7%	8,2%	1,5%	2,6%
4	142	1,0%	1,0%	2,0%	2,0%	2,0%	2,0%	3,0%	13,9%	4,0%	6,9%	1,0%	5,0%	1,0%	17,8%	1,0%	0,0%	5,0%	2,0%	5,0%	3,0%	3,0%	6,9%	9,9%	1,0%	1,0%
4	145	0,8%	5,7%	3,7%	7,0%	0,8%	2,9%	0,8%	9,0%	3,3%	9,0%	2,5%	12,3%	0,0%	12,3%	4,1%	0,0%	1,2%	1,2%	3,3%	0,4%	2,9%	5,3%	8,6%	0,4%	2,5%
4	150	1,7%	0,0%	3,1%	6,8%	1,7%	7,1%	1,0%	14,6%	2,4%	12,2%	5,1%	2,4%	0,3%	7,8%	2,7%	0,0%	1,0%	3,1%	1,0%	1,4%	3,7%	6,4%	10,8%	0,7%	3,1%
4	160	0,0%	3,4%	2,0%	7,4%	1,3%	4,0%	0,7%	8,7%	4,0%	12,1%	4,0%	10,7%	1,3%	10,1%	3,4%	0,0%	0,0%	3,4%	2,0%	0,7%	2,7%	4,0%	11,4%	1,3%	1,3%
4	170	0,0%	1,1%	2,1%	8,4%	0,0%	13,7%	1,1%	15,8%	2,1%	10,5%	7,4%	6,3%	0,0%	5,3%	3,2%	0,0%	1,1%	0,0%	0,0%	0,0%	0,0%	9,5%	10,5%	1,1%	1,1%
4	174	3,3%	0,0%	4,9%	2,5%	2,5%	0,4%	7,0%	3,3%	2,5%	14,3%	7,0%	3,3%	1,2%	5,7%	0,0%	0,0%	0,4%	3,7%	11,5%	0,4%	4,9%	7,0%	9,4%	0,0%	4,9%
4	175	0,5%	0,0%	6,5%	5,0%	4,0%	1,0%	2,5%	7,5%	1,0%	17,0%	3,0%	2,0%	0,5%	9,5%	0,0%	0,0%	1,0%	2,5%	11,5%	0,5%	3,0%	6,0%	8,5%	0,5%	6,5%
4	180	0,7%	5,0%	2,9%	2,1%	0,7%	1,4%	0,7%	17,9%	2,1%	11,4%	0,7%	5,7%	0,0%	9,3%	3,6%	0,0%	0,0%	2,1%	12,1%	0,7%	5,0%	6,4%	6,4%	2,1%	0,7%
4	190	0,0%	0,5%	7,0%	1,5%	2,0%	0,5%	3,0%	6,0%	3,5%	13,5%	2,5%	2,0%	1,5%	10,5%	0,5%	0,0%	1,0%	6,0%	7,5%	1,0%	3,5%	7,0%	10,5%	1,0%	8,0%
4	200	0,0%	1,0%	6,0%	5,0%	1,0%	3,0%	1,0%	19,0%	1,0%	16,0%	2,0%	3,0%	0,0%	5,0%	5,0%	1,0%	2,0%	2,0%	0,0%	2,0%	9,0%	5,0%	10,0%	0,0%	1,0%
4	202	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	9,8%	0,0%	0,0%	0,0%	0,0%	0,0%	17,6%	0,0%	0,0%	0,0%	0,0%	17,6%	25,5%	11,8%	2,0%	9,8%	0,0%	5,9%
4	205	0,7%	0,0%	3,4%	11,5%	3,4%	1,4%	5,4%	18,9%	0,7%	14,9%	2,7%	4,7%	1,4%	10,1%	0,0%	0,0%	0,7%	2,7%	0,7%	0,0%	2,0%	5,4%	8,1%	0,0%	1,4%

Supplementary table S1 (5 of 6)

Ward	Nurse Nr	1. Fluid/tissue sampling for laboratory research	2. Assistance of doctors or others	3. Communication with patient and/or family	4. Oral communication/reporting about patient (not in presence of patient)	5. Positioning and exercise	6. Preparing/administering of medication (for individual patient)	7. Observation of vital signs and routine check-ups	8. Written/digital reporting, administration or transfer of information	9. Transport of patient	10. Personal care of patient	11. Assistance meals and/or excretion	12. Nurses' professional activities	13. Errands (away from ward)	14. Collective handover of patient information (for multiple patients)	15. Medication preparation (for multiple patients)	16. Meals-related activities	17. General administration	18. Domestic activities	19. Education and guidance	20. Organization of work	21. Meetings	22. Coffee break (authorized)	23. Lunch break (authorized)	24. Personal time	Not observed
4	210	1,0%	0,0%	3,9%	4,9%	1,0%	2,0%	1,0%	8,8%	4,9%	15,7%	0,0%	7,8%	1,0%	17,6%	1,0%	0,0%	0,0%	2,0%	0,0%	1,0%	7,8%	7,8%	10,8%	0,0%	0,0%
4	220	1,4%	6,8%	4,1%	7,4%	0,0%	2,7%	0,7%	23,6%	1,4%	7,4%	0,7%	0,7%	0,7%	13,5%	1,4%	0,0%	1,4%	1,4%	0,0%	1,4%	1,4%	4,7%	8,8%	1,4%	7,4%
6	1	0,0%	0,0%	0,0%	14,3%	0,0%	2,0%	0,0%	2,0%	4,1%	0,0%	0,0%	4,1%	0,0%	2,0%	0,0%	0,0%	0,0%	4,1%	44,9%	0,0%	4,1%	2,0%	10,2%	0,0%	6,1%
6	2	4,5%	4,5%	20,5%	2,3%	0,0%	0,0%	0,0%	22,7%	0,0%	2,3%	0,0%	2,3%	0,0%	9,1%	0,0%	0,0%	0,0%	0,0%	11,4%	2,3%	4,5%	6,8%	6,8%	0,0%	0,0%
6	4	0,0%	9,1%	4,5%	6,8%	0,0%	0,0%	2,3%	9,1%	11,4%	0,0%	2,3%	0,0%	0,0%	6,8%	0,0%	0,0%	0,0%	2,3%	15,9%	9,1%	9,1%	2,3%	9,1%	0,0%	0,0%
6	6	0,0%	6,8%	2,3%	11,4%	0,0%	2,3%	0,0%	20,5%	4,5%	2,3%	4,5%	9,1%	0,0%	6,8%	0,0%	0,0%	0,0%	0,0%	2,3%	6,8%	4,5%	4,5%	9,1%	0,0%	2,3%
6	7	0,0%	0,0%	9,1%	4,5%	0,0%	0,0%	0,0%	6,8%	6,8%	0,0%	2,3%	0,0%	0,0%	9,1%	0,0%	0,0%	0,0%	0,0%	20,5%	22,7%	4,5%	2,3%	11,4%	0,0%	0,0%
6	9	0,0%	2,3%	11,4%	6,8%	0,0%	0,0%	0,0%	9,1%	13,6%	6,8%	4,5%	6,8%	0,0%	9,1%	0,0%	0,0%	0,0%	0,0%	9,1%	0,0%	4,5%	2,3%	11,4%	2,3%	0,0%
6	10	2,3%	2,3%	13,6%	13,6%	0,0%	0,0%	4,5%	18,2%	4,5%	2,3%	4,5%	4,5%	2,3%	4,5%	0,0%	0,0%	0,0%	2,3%	2,3%	0,0%	2,3%	6,8%	9,1%	0,0%	0,0%
6	11	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	4,3%	0,0%	0,0%	0,0%	0,0%	0,0%	4,3%	0,0%	0,0%	0,0%	4,3%	4,3%	60,9%	0,0%	0,0%	21,7%	0,0%	0,0%
6	12	2,3%	0,0%	13,6%	15,9%	0,0%	0,0%	2,3%	25,0%	4,5%	2,3%	0,0%	2,3%	2,3%	6,8%	0,0%	0,0%	0,0%	0,0%	2,3%	0,0%	4,5%	6,8%	9,1%	0,0%	0,0%
6	13	0,0%	2,3%	11,4%	9,1%	0,0%	2,3%	0,0%	18,2%	6,8%	4,5%	4,5%	2,3%	2,3%	9,1%	2,3%	0,0%	0,0%	0,0%	6,8%	0,0%	4,5%	6,8%	6,8%	0,0%	0,0%
6	14	0,0%	10,0%	5,0%	5,0%	0,0%	0,0%	0,0%	5,0%	0,0%	5,0%	10,0%	10,0%	0,0%	10,0%	0,0%	0,0%	0,0%	0,0%	15,0%	0,0%	10,0%	10,0%	0,0%	0,0%	5,0%
6	20	0,0%	2,0%	7,9%	4,6%	0,0%	0,7%	0,7%	10,6%	7,3%	4,0%	2,0%	4,0%	2,6%	11,3%	0,0%	0,0%	0,7%	1,3%	21,2%	0,7%	5,3%	3,3%	8,6%	0,0%	1,3%
6	23	0,0%	1,3%	3,3%	6,0%	1,3%	6,0%	0,0%	10,0%	0,7%	7,3%	0,7%	2,0%	0,7%	15,3%	1,3%	0,7%	1,3%	3,3%	8,7%	2,0%	10,7%	5,3%	9,3%	1,3%	1,3%
6	24	0,4%	0,8%	2,4%	2,4%	0,8%	0,8%	1,2%	5,2%	6,9%	4,4%	1,6%	0,8%	2,0%	14,1%	0,0%	0,4%	0,0%	1,2%	35,9%	0,4%	2,8%	4,8%	9,3%	0,4%	0,8%
6	30	1,1%	1,4%	8,5%	3,5%	0,7%	3,5%	1,1%	15,9%	1,8%	1,4%	1,8%	2,1%	0,0%	10,6%	0,0%	0,4%	1,1%	1,4%	13,8%	10,6%	6,4%	4,2%	6,0%	1,4%	1,4%
6	36	0,5%	2,0%	11,6%	2,5%	0,5%	0,5%	3,5%	17,7%	5,1%	4,5%	0,0%	6,1%	1,0%	12,6%	0,0%	0,5%	1,0%	1,5%	12,6%	0,0%	4,5%	3,5%	7,1%	1,0%	0,0%
6	40	0,5%	1,0%	5,5%	8,0%	0,5%	2,0%	3,0%	10,0%	2,0%	8,0%	2,5%	3,5%	3,0%	9,0%	0,0%	0,0%	0,5%	7,5%	13,0%	0,5%	3,5%	5,0%	9,5%	1,5%	0,5%
6	58	0,0%	0,7%	8,2%	3,0%	1,0%	2,6%	1,3%	13,2%	3,3%	5,6%	0,0%	3,0%	0,3%	20,7%	0,7%	0,0%	0,7%	1,0%	14,1%	1,0%	4,9%	3,9%	10,2%	0,7%	0,0%
6	60	0,0%	2,7%	2,7%	4,8%	0,7%	4,8%	0,0%	8,8%	2,0%	2,0%	0,0%	1,4%	0,0%	14,3%	1,4%	0,7%	1,4%	0,0%	25,2%	0,7%	9,5%	6,1%	9,5%	0,7%	0,7%
6	75	0,0%	3,0%	4,7%	4,1%	0,0%	3,0%	1,2%	8,3%	4,1%	5,9%	0,0%	9,5%	3,6%	8,9%	0,0%	0,0%	1,8%	3,6%	3,0%	16,6%	2,4%	4,1%	8,9%	3,6%	0,0%
6	80	0,5%	2,0%	4,5%	3,5%	0,0%	5,0%	0,0%	13,1%	3,5%	4,0%	0,0%	1,5%	0,5%	10,6%	1,5%	0,0%	1,0%	2,5%	12,1%	12,6%	4,0%	6,5%	9,5%	1,0%	0,5%
6	81	0,7%	3,5%	7,0%	2,1%	2,1%	5,6%	0,7%	16,1%	2,8%	6,3%	2,8%	5,6%	1,4%	11,2%	0,7%	0,0%	0,7%	2,1%	0,7%	0,7%	7,0%	1,4%	11,2%	4,2%	3,5%
6	85	0,0%	2,0%	8,4%	5,9%	0,5%	1,0%	1,5%	14,3%	3,4%	4,4%	0,0%	1,5%	0,5%	13,3%	0,5%	0,0%	1,0%	2,5%	18,7%	0,5%	2,5%	3,9%	10,3%	2,5%	1,0%
6	89	0,0%	0,0%	21,7%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	7,0%	0,0%	0,0%	2,8%	0,7%	3,5%	47,6%	5,6%	2,1%	6,3%	0,7%	2,1%
6	90	0,4%	0,9%	5,3%	4,9%	0,9%	0,4%	0,4%	9,3%	2,7%	0,4%	0,4%	1,8%	0,9%	15,0%	0,9%	0,0%	2,7%	7,1%	7,1%	12,4%	6,2%	5,3%	7,5%	4,9%	2,2%
6	91	0,0%	1,0%	13,4%	3,0%	2,0%	2,0%	1,5%	11,9%	3,0%	3,0%	2,0%	1,0%	1,5%	18,4%	1,0%	0,0%	0,5%	2,5%	16,9%	0,0%	1,5%	4,5%	7,5%	1,5%	0,5%
6	104	0,0%	3,2%	9,5%	3,2%	0,0%	2,1%	3,2%	13,7%	0,0%	9,5%	3,2%	5,3%	0,0%	5,3%	0,0%	2,1%	0,0%	2,1%	6,3%	2,1%	6,3%	8,4%	10,5%	4,2%	0,0%
6	106	0,5%	2,0%	13,2%	8,3%	0,0%	2,0%	1,0%	11,8%	3,9%	6,4%	0,5%	2,0%	2,0%	16,7%	0,0%	0,0%	0,5%	4,9%	9,3%	0,5%	2,0%	5,9%	6,4%	0,5%	0,0%
6	107	0,9%	1,1%	8,3%	6,3%	0,6%	3,4%	2,3%	15,2%	3,2%	6,6%	0,3%	2,6%	1,1%	12,9%	0,3%	0,0%	0,6%	4,0%	11,7%	1,1%	2,6%	4,3%	7,4%	1,1%	2,0%
6	108	0,0%	0,0%	45,5%	0,0%	0,0%	0,0%	0,0%	3,7%	0,0%	0,7%	0,0%	0,0%	15,7%	8,2%	0,0%	0,0%	4,5%	0,7%	6,7%	0,7%	0,0%	3,7%	3,7%	2,2%	3,7%
6	109	0,0%	0,0%	9,0%	7,0%	0,0%	0,0%	0,0%	24,0%	4,0%	1,0%	3,0%	0,0%	3,0%	10,0%	1,0%	0,0%	2,0%	2,0%	9,0%	0,0%	6,0%	8,0%	8,0%	1,0%	2,0%
6	110	0,0%	0,0%	4,9%	6,9%	0,0%	2,9%	0,0%	3,9%	2,9%	2,0%	1,0%	5,9%	1,0%	12,7%	0,0%	0,0%	0,0%	2,9%	5,9%	17,6%	5,9%	3,9%	3,9%	14,7%	1,0%
6	115	0,7%	1,0%	7,4%	4,2%	0,0%	3,5%	1,2%	16,1%	4,5%	4,7%	2,0%	5,4%	0,5%	12,4%	0,7%	0,0%	0,2%	2,2%	15,6%	0,7%	2,5%	4,5%	8,7%	0,5%	0,7%
6	120	0,0%	0,3%	0,6%	0,0%	0,0%	1,1%	0,0%	2,3%	0,0%	0,3%	0,3%	0,6%	0,6%	9,3%	0,0%	0,3%	0,0%	0,6%	11,6%	52,8%	8,8%	3,1%	6,5%	0,8%	0,3%
6	140	0,0%	1,5%	10,6%	6,0%	0,0%	1,5%	4,0%	14,1%	5,5%	1,0%	1,5%	0,5%	0,5%	9,0%	0,0%	0,0%	0,5%	2,0%	17,1%	0,5%	5,5%	4,0%	8,5%	4,0%	2,0%
6	150	0,0%	2,5%	6,8%	5,0%	0,3%	3,1%	1,2%	14,2%	4,6%	4,6%	0,6%	6,2%	1,2%	17,0%	0,0%	0,0%	0,6%	4,0%	12,4%	1,2%	1,9%	3,1%	7,7%	1,2%	0,3%
6	160	1,0%	1,0%	5,0%	4,0%	0,0%	1,5%	2,0%	8,5%	3,5%	4,5%	2,0%	3,5%	0,5%	8,5%	0,5%	0,0%	0,5%	4,5%	21,5%	2,0%	2,5%	7,0%	9,0%	3,0%	4,0%
6	161	0,0%	1,1%	5,5%	2,0%	1,4%	1,7%	2,9%	7,8%	2,6%	8,9%	2,0%	4,3%	1,1%	10,9%	0,3%	0,0%	0,9%	3,7%	24,4%	0,3%	1,7%	5,5%	9,5%	1,4%	0,0%
6	162	0,0%	0,0%	3,9%	1,3%	0,3%	0,3%	2,0%	8,9%	2,6%	3,9%	0,3%	0,0%	0,7%	15,7%	0,0%	0,0%	0,3%	7,5%	32,1%	0,3%	2,3%	4,9%	9,2%	3,0%	0,3%
6	163	0,0%	1,1%	5,8%	0,8%	0,3%	0,0%	1,8%	7,6%	6,1%	2,9%	1,8%	1,1%	2,4%	12,9%	0,0%	0,0%	0,3%	0,8%	36,6%	0,8%	2,6%	3,9%	7,9%	1,3%	1,3%
6	169	0,0%	0,0%	7,4%	0,0%	3,7%	0,0%	3,7%	7,4%	0,0%	14,8%	3,7%	3,7%	0,0%	40,7%	0,0%	0,0%	0,0%	0,0%	3,7%	0,0%	11,1%	0,0%	0,0%	0,0%	0,0%
6	170	0,0%	0,0%	5,9%	9,8%	0,0%	0,0%	2,0%	11,8%	5,9%	3,9%	0,0%	7,8%	0,0%	13,7%	2,0%	0,0%	0,0%	2,0%	9,8%	3,9%	3,9%	5,9%	9,8%	0,0%	2,0%
6	200	0,0%	1,2%	10,1%	2,3%	0,7%	0,9%	1,9%	14,3%	4,2%	3,3%	1,2%	1,4%	0,2%	13,1%	0,2%	0,0%	0,5%	2,3%	18,8%	0,5%	1,2%	5,4%	8,7%	3,8%	3,8%
5	2	0,0%	4,4%	2,2%	4,4%	2,2%	4,4%	2,2%	13,3%	2,2%	2,2%	0,0%	4,4%	0,0%	8,9%	0,0%	0,0%	0,0%	4,4%	20,0%	2,2%	4,4%	4,4%	8,9%	4,4%	0,0%
5	4	0,0%	0,0%	6,4%	2,1%	0,0%	0,0%	0,0%	25,5%	4,3%	2,1%	0,0%	0,0%	0,0%	4,3%	0,0%	0,0%	0,0%	2,1%	21,3%	0,0%	12,8%	6,4%	8,5%	4,3%	0,0%
5	5	0,0%	0,0%	12,8%	4,3%	0,0%	6,4%	0,0%	14,9%	8,5%	4,3%	0,0%	0,0%	0,0%	4,3%	0,0%	0,0%	0,0%	0,0%	14,9%	2,1%	10,6%	6,4%	10,6%	0,0%	0,0%
5	6	0,0%	2,1%	8,5%	4,3%	0,0%	2,1%	6,4%	14,9%	2,1%	2,1%	0,0%	4,3%	0,0%	4,3%	0,0%	0,0%	0,0%	2,1%	12,8%	0,0%	17,0%	4,3%	8,5%	4,3%	0,0%
5	7	0,0%	0,0%	8,5%	4,3%	0,0%	2,1%	4,3%	10,6%	4,3%	2,1%	0,0%	0,0%	0,0%	6,4%	0,0%	0,0%	0,0%	0,0%	27,7%	0,0%	10,6%	8,5%	10,6%	0,0%	0,0%

Supplementary table S1 (6 of 6)

Ward	Nurse Nr	1. Fluid/tissue sampling for laboratory research	2. Assistance of doctors or others	3. Communication with patient and/or family	4. Oral communication/reporting about patient (not in presence of patient)	5. Positioning and exercise	6. Preparing/administering of medication (for individual patient)	7. Observation of vital signs and routine check-ups	8. Written/digital reporting, administration or transfer of information	9. Transport of patient	10. Personal care of patient	11. Assistance meals and/or excretion	12. Nurses' professional activities	13. Errands (away from ward)	14. Collective handover of patient information (for multiple patients)	15. Medication preparation (for multiple patients)	16. Meals-related activities	17. General administration	18. Domestic activities	19. Education and guidance	20. Organization of work	21. Meetings	22. Coffee break (authorized)	23. Lunch break (authorized)	24. Personal time	Not observed
5	8	0,0%	0,0%	12,8%	2,1%	0,0%	0,0%	2,1%	8,5%	4,3%	0,0%	0,0%	0,0%	0,0%	6,4%	0,0%	0,0%	0,0%	4,3%	21,3%	4,3%	10,6%	6,4%	10,6%	6,4%	0,0%
5	10	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	100,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
5	11	0,0%	0,0%	4,3%	6,4%	0,0%	2,1%	0,0%	10,6%	0,0%	2,1%	0,0%	2,1%	0,0%	4,3%	0,0%	0,0%	0,0%	0,0%	0,0%	23,4%	29,8%	4,3%	8,5%	2,1%	0,0%
5	12	0,0%	0,0%	6,4%	2,1%	0,0%	4,3%	2,1%	8,5%	0,0%	4,3%	0,0%	4,3%	0,0%	2,1%	0,0%	0,0%	2,1%	0,0%	21,3%	2,1%	19,1%	4,3%	10,6%	6,4%	0,0%
5	13	0,0%	0,0%	2,4%	7,1%	0,0%	0,0%	0,0%	9,5%	2,4%	0,0%	0,0%	0,0%	0,0%	4,8%	0,0%	0,0%	0,0%	2,4%	2,4%	9,5%	19,0%	4,8%	11,9%	23,8%	0,0%
5	14	0,0%	0,0%	2,1%	8,5%	0,0%	6,4%	12,8%	10,6%	14,9%	4,3%	0,0%	2,1%	2,1%	4,3%	0,0%	0,0%	0,0%	0,0%	0,0%	2,1%	14,9%	2,1%	10,6%	2,1%	0,0%
5	15	0,0%	0,7%	1,4%	0,7%	0,0%	2,7%	0,7%	14,4%	0,0%	2,7%	0,0%	2,1%	0,0%	6,2%	1,4%	0,0%	1,4%	2,1%	5,5%	3,4%	43,8%	2,7%	5,5%	2,7%	0,0%
5	16	0,0%	0,0%	2,1%	12,8%	0,0%	6,4%	8,5%	8,5%	14,9%	2,1%	0,0%	4,3%	2,1%	4,3%	0,0%	0,0%	0,0%	2,1%	0,0%	0,0%	10,6%	2,1%	10,6%	8,5%	0,0%
5	18	1,3%	3,2%	8,3%	1,9%	0,6%	7,7%	1,9%	19,9%	1,3%	7,1%	0,6%	2,6%	1,9%	12,8%	0,6%	0,0%	0,0%	5,8%	3,8%	0,0%	1,9%	4,5%	7,7%	3,8%	0,6%
5	20	0,0%	0,0%	4,0%	3,2%	0,8%	5,6%	0,0%	21,0%	4,8%	8,9%	0,8%	4,0%	0,0%	16,1%	0,8%	0,0%	0,0%	2,4%	11,3%	0,0%	1,6%	2,4%	8,9%	1,6%	1,6%
5	30	0,6%	1,8%	5,4%	1,2%	0,6%	1,2%	3,6%	4,2%	6,0%	6,5%	3,6%	1,8%	1,8%	4,8%	0,0%	0,0%	1,2%	8,9%	25,6%	0,6%	3,6%	3,6%	9,5%	4,2%	0,0%
5	70	0,7%	1,4%	4,2%	9,9%	2,1%	4,2%	2,1%	7,7%	2,1%	7,7%	2,1%	4,2%	0,7%	9,9%	0,7%	0,0%	0,0%	2,1%	6,3%	1,4%	12,0%	4,9%	9,2%	2,1%	2,1%
5	80	0,0%	3,6%	2,9%	9,4%	2,2%	5,8%	2,2%	10,1%	0,7%	2,2%	0,7%	3,6%	0,7%	12,9%	0,0%	0,0%	0,7%	0,0%	8,6%	2,2%	5,8%	7,2%	10,1%	6,5%	2,2%
5	85	0,0%	4,0%	6,1%	2,2%	0,4%	2,5%	0,4%	11,5%	1,8%	1,4%	0,4%	2,2%	0,4%	12,2%	0,7%	0,0%	1,1%	1,4%	15,5%	13,3%	6,8%	2,2%	9,4%	0,7%	3,6%
5	90	0,0%	0,7%	8,7%	6,0%	0,0%	2,7%	0,0%	24,8%	2,7%	2,0%	0,7%	2,0%	0,0%	8,7%	0,7%	0,0%	1,3%	2,7%	9,4%	2,0%	10,1%	6,0%	8,7%	0,0%	0,0%
5	110	0,0%	2,1%	2,1%	8,5%	0,0%	3,2%	0,0%	22,3%	5,3%	3,2%	1,1%	2,1%	1,1%	8,5%	0,0%	2,1%	0,0%	3,2%	0,0%	2,1%	3,2%	3,2%	12,8%	7,4%	6,4%
5	111	0,0%	0,7%	4,7%	8,0%	0,7%	0,7%	0,7%	18,7%	4,7%	2,0%	2,7%	0,7%	0,0%	10,0%	0,0%	0,0%	0,7%	0,7%	24,0%	1,3%	5,3%	4,0%	8,7%	0,7%	0,7%
5	116	0,0%	0,4%	4,1%	2,6%	0,0%	1,9%	3,0%	8,2%	1,5%	7,9%	2,2%	1,9%	0,0%	11,6%	0,4%	0,0%	0,4%	7,9%	19,1%	0,0%	7,5%	5,6%	9,0%	1,5%	3,4%
5	120	2,0%	7,1%	5,1%	2,0%	0,0%	7,1%	6,1%	14,3%	9,2%	6,1%	2,0%	6,1%	0,0%	8,2%	1,0%	0,0%	0,0%	1,0%	0,0%	1,0%	6,1%	4,1%	7,1%	4,1%	0,0%
5	130	0,7%	1,0%	4,2%	4,2%	0,3%	3,8%	0,7%	11,9%	4,9%	3,8%	0,7%	2,1%	0,7%	14,0%	1,4%	0,7%	0,7%	2,1%	9,1%	0,3%	7,3%	5,6%	9,8%	5,6%	4,2%
5	140	0,0%	2,1%	0,0%	2,1%	0,0%	0,0%	0,0%	4,2%	8,3%	4,2%	2,1%	2,1%	0,0%	8,3%	0,0%	4,2%	0,0%	10,4%	4,2%	0,0%	25,0%	6,3%	8,3%	8,3%	0,0%
5	141	1,2%	2,4%	3,0%	3,7%	0,6%	3,0%	0,0%	6,1%	4,3%	2,4%	0,0%	1,2%	0,6%	9,8%	0,0%	0,0%	1,2%	0,6%	18,3%	5,5%	7,9%	3,0%	20,1%	4,3%	0,6%
5	142	0,0%	1,1%	0,0%	4,3%	0,0%	1,1%	2,1%	13,8%	2,1%	12,8%	2,1%	3,2%	0,0%	13,8%	2,1%	0,0%	0,0%	0,0%	16,0%	2,1%	1,1%	4,3%	10,6%	2,1%	5,3%
5	143	1,7%	1,3%	3,8%	2,6%	0,0%	2,1%	2,1%	18,4%	2,6%	6,0%	0,4%	0,0%	0,4%	12,0%	0,0%	0,0%	3,0%	8,5%	12,8%	0,0%	5,6%	3,0%	9,8%	1,7%	2,1%
5	144	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	8,3%	0,0%	0,0%	0,0%	0,0%	91,7%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
5	145	0,0%	2,4%	6,2%	4,8%	1,4%	2,7%	1,0%	15,4%	2,4%	3,8%	0,7%	1,7%	15,1%	8,6%	1,4%	0,0%	0,3%	6,8%	3,1%	1,4%	9,6%	2,1%	6,8%	1,4%	1,0%
5	148	0,3%	0,3%	3,6%	0,6%	1,8%	0,9%	2,7%	6,9%	3,3%	10,8%	0,9%	0,6%	0,3%	11,7%	0,3%	0,0%	0,9%	1,8%	26,7%	0,9%	7,2%	4,8%	9,3%	2,7%	0,6%
5	149	0,4%	0,0%	3,2%	1,8%	0,4%	1,8%	4,7%	13,4%	4,3%	7,6%	0,4%	1,1%	0,4%	11,2%	0,4%	0,0%	1,1%	2,5%	23,5%	0,7%	4,7%	3,2%	10,1%	1,8%	1,4%
5	150	0,0%	0,0%	8,7%	0,0%	0,0%	2,2%	2,2%	8,7%	0,0%	2,2%	0,0%	0,0%	0,0%	6,5%	0,0%	0,0%	0,0%	0,0%	45,7%	2,2%	0,0%	4,3%	8,7%	8,7%	0,0%
5	155	0,0%	2,1%	6,4%	5,7%	0,7%	5,0%	0,0%	7,8%	5,7%	3,5%	2,1%	5,0%	4,3%	9,9%	1,4%	0,0%	0,7%	5,7%	14,2%	0,7%	5,7%	3,5%	8,5%	0,7%	0,7%
5	160	0,0%	0,0%	5,6%	2,8%	0,0%	2,8%	4,2%	19,4%	0,0%	11,1%	0,0%	2,8%	0,0%	15,3%	2,8%	0,0%	0,0%	4,2%	11,1%	0,0%	1,4%	2,8%	11,1%	2,8%	0,0%
5	165	0,3%	2,0%	6,5%	5,1%	0,0%	3,8%	1,4%	16,0%	1,7%	6,8%	1,0%	3,4%	1,7%	8,9%	2,0%	0,0%	0,0%	4,1%	6,1%	1,0%	6,1%	3,8%	10,9%	5,5%	1,7%
5	170	0,0%	3,0%	1,0%	3,6%	0,5%	6,1%	2,0%	11,2%	6,1%	4,1%	2,0%	1,5%	0,5%	13,2%	1,5%	0,5%	0,0%	2,0%	5,6%	7,1%	7,1%	4,1%	10,2%	7,1%	0,0%
5	172	0,0%	0,0%	8,4%	5,3%	0,0%	3,2%	1,1%	20,0%	1,1%	5,3%	0,0%	3,2%	0,0%	7,4%	2,1%	0,0%	0,0%	1,1%	15,8%	2,1%	9,5%	4,2%	7,4%	1,1%	2,1%
5	175	0,0%	0,7%	7,4%	4,0%	0,0%	2,7%	0,0%	10,1%	4,7%	6,0%	0,0%	3,4%	0,0%	13,4%	1,3%	0,0%	1,3%	3,4%	12,1%	3,4%	11,4%	4,7%	8,1%	0,7%	1,3%
5	180	0,0%	0,3%	1,5%	0,9%	0,3%	1,5%	3,4%	6,8%	3,4%	7,4%	0,9%	0,6%	0,6%	10,5%	0,0%	0,0%	0,3%	4,0%	34,4%	1,2%	6,2%	4,6%	9,3%	1,2%	0,3%
5	185	0,0%	4,3%	14,9%	0,0%	4,3%	2,1%	0,0%	17,0%	0,0%	10,6%	0,0%	10,6%	0,0%	8,5%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	10,6%	2,1%	10,6%	0,0%	4,3%
5	190	0,0%	0,0%	8,8%	5,7%	0,5%	3,6%	0,0%	13,9%	6,2%	2,6%	1,0%	3,1%	1,5%	10,3%	0,0%	0,0%	1,5%	1,0%	16,5%	3,6%	4,1%	4,6%	8,8%	0,5%	2,1%
5	195	0,0%	2,7%	5,3%	3,3%	1,3%	4,7%	0,7%	17,3%	8,7%	4,7%	2,7%	1,3%	0,7%	8,7%	0,7%	0,0%	0,0%	3,3%	14,0%	1,3%	3,3%	5,3%	6,0%	2,7%	1,3%
5	197	0,0%	0,5%	5,1%	0,5%	0,0%	4,6%	3,1%	12,3%	2,1%	10,3%	2,1%	6,2%	1,0%	10,8%	0,0%	0,0%	0,5%	1,5%	14,4%	1,5%	6,2%	4,6%	10,3%	2,1%	0,5%
5	200	0,0%	1,2%	7,1%	0,6%	2,4%	1,8%	4,2%	3,6%	4,2%	7,1%	0,6%	3,6%	0,6%	6,0%	0,0%	0,0%	0,0%	5,4%	29,8%	0,0%	3,0%	2,4%	10,7%	5,4%	0,6%

CHAPTER 5

BALANCING WORKLOAD OF NURSES: LINEAR MIXED EFFECTS MODELLING TO ESTIMATE REQUIRED NURSING TIME ON SURGICAL WARDS

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Abstract

Aim

Quantifying the relation between patient characteristics and care time and explaining differences in nursing time between wards.

Design

Academic hospital in the Netherlands. Six surgical wards, capacity 15-30 beds, 2012-2014.

Methods

Linear mixed effects model to study the relation between patient characteristics and care time. Estimated marginal means to estimate baseline care time and differences between wards.

Results

9 patient characteristics significantly related to care time. Most required between 18 and 35 minutes extra, except 'two or more IV/drip/drain' (8) and 'one-on-one care' (156). Care time for minimum patient profile: 44 to 57 minutes, for average patient profile: 75 to 88 minutes. Sources of variation: nurse proficiency, patients, day-to-day variation within patients. The set of characteristics is short, simple, useful for planning and comparing workload. Explained variance up to 36%. Calculating estimated means per ward has not been done before. Nurse proficiency is an important factor.

Introduction

Healthcare is globally under pressure due to increasing costs [1] and labor shortages [2, 3]. Healthcare costs are increasing every year and this trend is expected to continue [1]. If this rate continues, healthcare may become unaffordable for lower income workers [4]. Balancing workload of hospital nurses is important in this context, for several reasons. Nursing staff is a key element in delivering high quality healthcare: a direct relation has been found between nurses' workload and patient outcomes [5] and nurse assessed quality of care [6, 7]. There is also a relation between workload and employee engagement and performance [7-11] and excessive workload is a predictor for burnout [12, 13] and absenteeism [14]. Retaining nursing staff is important because nursing staff is increasingly scarce [2, 3]. The current healthcare workforce is also aging rapidly [15], which brings challenges in maintaining high skills and competences in the workforce, which is essential in maintaining quality of care. Finally, workload has been shown to have an effect on nurses' intention to leave [16, 17] and on job outcomes [18], both directly and as a mediating factor. High turnover of nursing staff results in higher costs for training of new nurses or using temporary staff [19, 20] and therefore needs to be minimized. The challenge is to support nurses in delivering high quality care to their patients, in a way that both is cost effective and keeps nurses healthy and engaged. Balancing nurses' workload is a key element in this challenge as it will help prevent extra costs for overstaffing a ward and prevent decreasing patient outcomes and employee engagement by understaffing a ward.

Background

One way to balance workload is with a workload management method. Several approaches are described in literature. The simplest approach is the nurse-patient ratio or nursing hours per patient day (NHPPD). There is evidence that this approach does not accurately predict workload of nurses [21], since it does not take into account the different needs between patients nor the differences in experience and education level of nursing staff. Twigg [19] argues that relying on expert opinion in setting standards for workload, in their study a standard NHPPD per ward, is not optimal and recommends using a standardized patient acuity measurement.

In other methods, workload is predicted by quantifying the effect of patient characteristics or characteristics of the treatment on workload. Mueller et al. [22] tested the correlation between the Barthel index scores and Acute International Classification of Functions core sets and nurses' workload and found that 20 to 44% of perceived nurses' workload variance is explained by these scores. This suggests that patient characteristics do influence nurses' workload. That study was performed in a critical care setting and has not yet been replicated in other types of hospital

wards or other environments. O Brien Pallas et al. [23] have shown that the actual worked hours per patient were likely to increase for patients with a higher amount of nursing diagnoses. In Belgium, all hospitals register the Belgium Nursing Minimum Data Set (B-NMDS) in order to benchmark hospitals on several dimensions, including workload. Van den Heede [24] shows that 70% of variation in nursing staff per unit is predicted by the B-NMDS item hospital type with the covariates nursing intensity and service type. They recommend using a NHPPD corrected for nursing intensity, as an alternative for working with NHPPD only. In a 2008 study [25] however, Sermeus stated that the B-NMDS nursing intensity did not necessarily give an adequate indication of required nursing time. The B-NMDS also requires extensive amount of additional registration [26]. Myny et al. [26] determined a set of 28 measurable factors expected to influence workload of nurses, of which three are recommended for incorporation in a workload management method: the number of work interruptions, the patient turnover rate and the number of mandatory registrations. It is noted that Myny et al. performed their research in Belgium, where hospitals are required by law to participate in the B-NMDS, which could explain the perceived high importance of registration on workload. The RAFAELA™ patient classification system [27] defines optimum levels of nursing intensity. The RAFAELA™ system consists of the Oulu Patient Classification instrument [28], a system that records daily nursing time, and the Professional Assessment of Optimal Nursing Care Intensity Level questionnaire. The three are combined to measure nursing intensity. RAFAELA™ measures only the patient-related workload of nurses, other tasks are not included [29]. This method is not used for prospective workload management but for evaluation of past workload. For optimal and timely scheduling of nursing staff, insight in expected required nursing staff in the future is of great value. Hoi [30] developed a workload intensity management system (WIMS) by defining 28 relevant nursing diagnoses and performing a work sampling study on nurses' activities. For each ward the significant nursing diagnoses were determined and for each diagnosis the nursing time per day was determined. Hoi developed a prediction model, with a fixed component of nursing time for each patient admitted to a ward, a fixed nursing time for each occurrence of a diagnosis and a fixed time for indirect patient care. Required nursing time can be forecast based on the number of patients and the patient mix. In this study, 60-70% of variance in nursing time was explained by these nursing diagnoses. Hoi also found that their patient dependency measurements were not correlated with nursing time.

In the current study, an approach similar to Hoi's has been chosen. However, instead of nursing diagnoses, the core of this method is patient characteristics defined by nurses. Estimated nurse proficiency is also included, which has not yet been described in the literature.

The development of this new workload management method has been covered in a previous study protocol [31]. The protocol describes a workload management method that aims to be user-friendly, does not require much additional registration, includes all activities of nurses (not just direct patient care), is based on objective measures where possible and is suitable for staff planning purposes. The method was developed in close cooperation with nurses and ward management (head nurses) of all involved wards. It consists of three steps to calculate a workload estimate. First, a Delphi study was organized amongst senior nurses to identify patient characteristics that were expected to influence care time (manuscript submitted for review). Subsequently, a time study was done to map nurses' activities [32] and, where applicable, to relate these activities to patients. The current article combines results of these two studies.
The aim of this article is threefold: (1) estimating patient related required nursing time by quantifying the relation between the previously identified relevant patient characteristics and care time, (2) determining how much time is spent on patients regardless of these characteristics and (3) testing if there are differences between wards in how much time is spent on patients with the same profile of characteristics.

Design

This study is part of a larger study protocol for developing a workload management method for staff nurses [31]. This workload management method is visualized in **Figure 1**. The Method section below briefly elaborates on the method that was chosen for the first two steps and fully describes the method for step three.

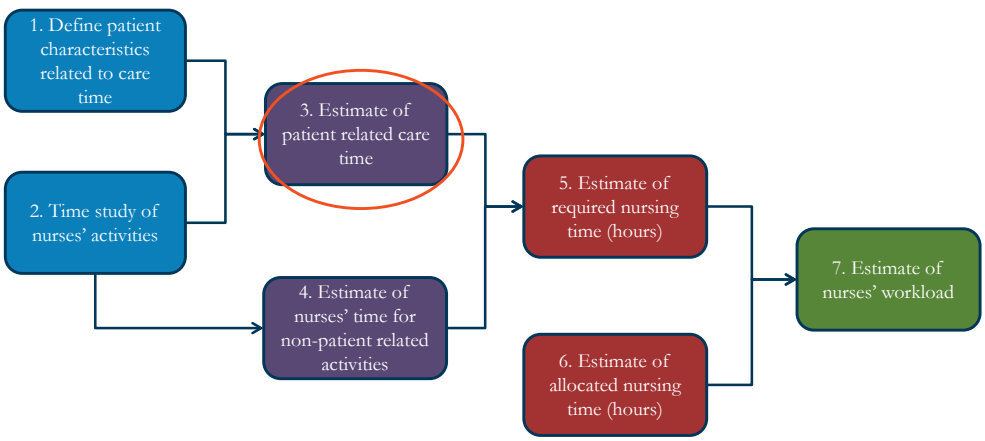

Figure 1: Developing a workload management method for staff nurses

The research took place in an academic hospital in the Netherlands in 2012-2014. Six surgical wards were included (varying from 2 wards with 15 beds to 4 wards with 30 beds). The focus was on workload of nurses during the day shift, because this is the shift during which the most nursing staff is required and most clinical nursing activities are performed.
Weekends were excluded because task mix and staffing are very different in weekends and cannot be compared to dayshifts of regular weekdays. Team leaders and students were included in the study. Ward managers were excluded because they do not participate in direct patient care or activities directly related to patient care. Activities of other types of ward staff (doctors, assistants, cleaning staff, etc.) were not considered in this study.
This study focuses on estimating care time related to patient characteristics. Other factors that may influence nurse workload such as patient turnover [33] and unit-related characteristics such as ward layout and number of single rooms in a ward [26] and proportion of registered nurses on the ward [34, 35] and are not considered in this phase of the study.

Method

Identifying patient characteristics relevant to care time

In the previously mentioned study protocol [31], it is assumed that workload of nurses is partly dependent on patient characteristics. A Delphi study among senior nurses was done to determine a set of patient characteristics that was expected to significantly influence care time (manuscript submitted for review). In the Delphi study, nurses were fully in the lead and had complete freedom to define the characteristics that they feel mattered most. Experts from all six wards took part in Delphi rounds. Ward management assigned one expert per ward to participate in the study. All participants were experienced (senior) nurses or nurse team leaders. The study consisted of four steps. Each consecutive step used the results of the previous one. The first round consisted of exploratory interviews which yielded a draft list of relevant patient characteristics. Results were shared and discussed with the Delphi group. Follow-up interviews were done to prioritize characteristics and to evaluate definitions and clarifications. This resulted in a draft checklist of relevant patient characteristics. The checklist was tested by trained nurses on all participating wards over a period of one month. After interviews with the nurses, the list was adjusted and the final version was implemented in the hospital information system, see **Table 1.**

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Table 1: Patient characteristics expected to influence care time of nurses

Nr	Characteristic
1	Patient needs partial assistance bathing, mobilization
2	Patient needs full assistance bathing, mobilization or care for incontinent patient
3	Patient needs full assistance with meals, providing drip feed (portioned or by triple lumen) or TPN
4	Patient with IV, drip or drain: 2 or more
5	Patient requiring inspection or minor activity every 1 or 2 hours
6	Patient requiring inspection or minor activity several times an hour
7	Patient requiring additional psychosocial support patient or family
8	Patient with exceptional bodily proportions
9	Patient with extensive wound/fistula and/or VAC bandages
10	Patient with new tracheostoma/ileostoma/urostoma/colostoma
11	Patient with emergency admittance, complex discharge procedure, transfer from other department/hospital, extensive health education
12	Patient of other specialty or with complex additional co-morbidity
13	Patient in isolation
14	Patient unstable
15	Patient requiring one-on-one care

During the time study (see paragraph 4.2), nurses registered the patient characteristics each day for each patient.

Time study of nurses' activities

To accurately map nurses' activities, a work sampling methodology was used. Work sampling is a useful and efficient methodology to explore work-related activities [36]. In 2007, Ampt [37] compared results of self-reported work sampling versus observational work sampling and results gave a clear preference for the observational method, hence we chose the same approach. Full details on this time study were previously published [32].

Estimating patient related care time

Care times per patient per day were derived from the time study and were combined with the daily registration of patient characteristics during the same study period. However, there is a relation between staff mix and management of workload [34, 35] and in this study it is assumed that experienced and proficient nurses work faster than novice and student nurses, and that novice nurses are not yet able to perform all tasks. If this assumption is true, then this also needs to be taken into account in staff planning. For this reason, the measurements in the time study were corrected for proficiency. In a mini-Delphi study , ward management (all head nurses with more than fifteen years experience) of all involved wards in the study were asked to define nurse categories and corresponding proficiency levels. There were six participants (one for each ward) and the mini Delphi consisted of two rounds and two sessions to discuss results. The group defined two types of nurses : registered nurses and student nurses. Nurses' aides were not included in this study. Registered nurses were separated into fully qualified, experienced nurses and novice nurses. The group considered a registered nurse who had at least one year of experience of working in the specialty to which he or she was assigned as fully qualified and experienced. All other registered nurses were considered novice nurses in this study.

In the Netherlands, there are two types of nursing educations: one where on the job training is combined with classroom training throughout the education and one where this is separated in time. Classifying students based on this difference and on the seniority of the student resulted in four types of student nurses in our study. In total, the Delphi yielded six nurse proficiency categories. The fully qualified and experienced registered nurse was defined as the standard and set to a proficiency percentage of 100%. The proficiencies of the other five types of nurses were offset against this standard. Results can be found in **Table 2**.

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Table 2: Proficiency of nurses: expert nurses' estimates

Type of nurse	Average Proficiency %
Registered Nurse (> =1 year experience in specialty of department they are assigned to)	100%
Registered Nurse (<1 year experience in specialty of department they are assigned to)	82%
Student nurse (working student 3rd or 4th year)	68%
Student nurse (fulltime student 3rd or 4th year)	47%
Student nurse (working student 1st or 2nd year)	40%
Student nurse (fulltime student 1st or 2nd year)	Not applicable

Correction for nurse proficiency was done in the source data. In the time study, each observation of patient/date/activity was originally allocated 10 minutes of care time, because nurses were observed on average every ten minutes. In the corrected care time, if the nurse delivering the care was only 70% proficient, a care time of 7 minutes instead of 10 minutes would be allocated to the observation. Since the fully experienced registered nurse was chosen as the standard, all estimates for nursing time, required and allocated, were translated to that reference. This means that the times spent by less experienced nursing staff were reduced, in line with the assumption that a fully experienced registered nurse would have spent less time on the same task.

Linear mixed effects models [38] were used to determine the significance of the patient characteristics in relation to care time and to estimate the additional care time per significant characteristic. Since the majority of patients were admitted for more than one day, care time was measured more than once for most patients; linear mixed effects models are appropriate for analyzing such multi-level data. A mixed model gives insight into the variability of care time within the length of stay of a patient, but also the variability of care time between patients. In the models, the ward and the 15 patient characteristics were included as fixed effects. A random intercept per patient was included in the models to adjust for clustering of measurements within patients.

The linear mixed effects modelling was done twice: model 1 used the original care times and model 2 used the care times corrected for nurse proficiency. The percentage of variance in care

time explained by the mixed models (R^2) was estimated using the method described by LaHuis et al. [39].

In addition to care time related to patient characteristics, it is also assumed that there is a 'baseline care time'. When a patient is admitted to a ward, nurses will always spend a certain amount of care time on this patient, regardless of the reason for admission (time that is spent handing out meals, having a chat or tidying up). In this study, it is assumed that there is always a baseline amount of care that is provided to a patient when admitted to a ward, as also suggested by Hoi [30].

To estimate the baseline care time for each ward, estimated means were derived from the linear mixed effects model for a patient profile in which none of the characteristics are present.

Also, estimated means were derived for a patient with the average mix of the patient characteristics (as observed over all wards during our study). Differences between the wards were tested using Sidák's adjustment for multiple testing.

Several interactions were considered to be included in the study (for example between bodily proportions of patient and assistance with bathing and mobilization, and between isolation measures and inspection or minor activity several times an hour), but these did not occur often enough to generate sufficient observations.

Statistical significance level was set to 0.01. All analyses were performed in SPSS version 21.

Ethics

The study guaranteed the privacy of involved staff and patients. Only the lead researcher has access to the source data. Data have been processed in such a way that nothing can be traced back to specific individuals. The study protocol was submitted to the medical ethical review board of the study hospital and was approved, protocol number 14-165/C.

Results

Relation between patient characteristics and care time

After data validation, registration of characteristic 14, 'Patient unstable', turned out to be incorrect and incomplete. It was not possible to retrospectively correct the data in a reliable manner and therefore this variable was excluded from further analysis.

Theoretically, there were 2224 possible observations of patient characteristic and care time during the observation sample period (number of patient days included in the study). Patient characteristics checklists were not always completed, for example in situations when the patient spent most of the dayshift in surgery. In addition, the registration equipment failed several times (download failure), and sometimes patient identification was not registered.

Incomplete checklists and registration failures resulted in missing data for 466 observations, as described in **Table 3**. 1758 observations, from 625 patients, were available for analysis.

Table 3: Missing data

Theoretical maximum observations per characteristic (amount of patient days included the time study period)	**2224**
Missing data due to equipment failure	56
Missing data due to patient identification issues	75
Missing observation list	335
Actual maximum observations per characteristic (amount of times a combined observation of patient/date/observation list was registered)	**1758**

The results of the analysis of the observed care times can be found in **Table 4**.

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Table 4: Linear mixed effects Model 1 (original care time)

Nr	Patient characteristic	Observations *n*	P-value	Estimate (minutes)	Std. Error	99% Confidence Interval	
						Lower Bound	Upper Bound
1	Patient needs partial assistance bathing, mobilization	843	0,000	20,9	3,9	10,9	30,9
2	Patient needs full assistance bathing, mobilization or care for incontinent patient	371	0,000	47,5	5,1	34,2	60,7
3	Patient needs full assistance with meals, providing drip feed (portioned or by triple lumen) or TPN	182	0,000	48,4	5,8	33,5	63,4
4	Patient with IV, drip or drain: 2 or more	516	0,014	8,9	3,6	-0,5	18,2
5	Patient requiring inspection or minor activity every 1 or 2 hours	518	0,180	-4,9	3,7	-14,4	4,5
6	Patient requiring inspection or minor activity several times an hour	61	0,735	2,8	8,3	-18,5	24,1
7	Patient requiring additional psychosocial support patient or family	134	0,000	24,9	6,0	9,5	40,3
8	Patient with exceptional bodily proportions	17	0,002	47,8	15,6	7,7	88,0
9	Patient with extensive wound/fistula and/or VAC bandages	79	0,000	29,0	7,5	9,5	48,5
10	Patient with new tracheostoma/ileostoma/urostoma/colostoma	79	0,000	30,2	8,1	9,4	51,1
11	Patient with emergency admittance, complex discharge procedure, transfer from other department/hospital, extensive health education	24	0,703	4,9	12,8	-28,1	37,9
12	Patient of other specialty or with complex additional co-morbidity	19	0,966	0,6	13,9	-35,3	36,5
13	Patient in isolation	165	0,000	29,0	7,1	10,7	47,2
14	Patient requiring one-on-one care	27	0,000	177,9	13,3	143,5	212,3

In Model 1, nine characteristics were significantly related to care time: characteristics 1, 2, 3, 7, 8, 9, 10, 13 and 14.

The model explained 40% of variation in observed care times between patients, and 25% of variation within patients (day to day variation for a patient). The results of the model for care times corrected for nurse proficiency, Model 2, can be found in **Table 5.**

Table 5: Linear mixed effects Model 2 (care times corrected for nurse proficiency)

Nr	Patient characteristic	Observations *n*	P-value	Estimate (minutes)	Std. Error	99% Confidence Interval	
						Lower Bound	Upper Bound
1	Patient needs partial assistance bathing, mobilization	843	0,000	18,0	3,2	9,8	26,3
2	Patient needs full assistance bathing, mobilization or care for incontinent patient	371	0,000	34,4	4,2	23,6	45,3
3	Patient needs full assistance with meals, providing drip feed (portioned or by triple lumen) or TPN	182	0,000	30,8	4,8	18,5	43,1
4	Patient with IV, drip or drain: 2 or more	516	0,006	8,1	3,0	0,5	15,8
5	Patient requiring inspection or minor activity every 1 or 2 hours	518	0,618	-1,5	3,0	-9,3	6,3
6	Patient requiring inspection or minor activity several times an hour	61	0,311	6,9	6,8	-10,6	24,4
7	Patient requiring additional psychosocial support patient or family	134	0,000	20,0	4,9	7,3	32,6
8	Patient with exceptional bodily proportions	17	0,040	26,4	12,8	-6,7	59,4
9	Patient with extensive wound/fistula and/or VAC bandages	79	0,000	22,7	6,2	6,7	38,7
10	Patient with new tracheostoma/ileostoma/urostoma/colostoma	79	0,002	20,2	6,6	3,1	37,4
11	Patient with emergency admittance, complex discharge procedure, transfer from other department/hospital, extensive health education	24	0,683	4,3	10,5	-22,8	31,4
12	Patient of other specialty or with complex additional co-morbidity	19	0,888	1,6	11,4	-27,9	31,1
13	Patient in isolation	165	0,000	20,9	5,8	5,9	35,8
14	Patient requiring one-on-one care	27	0,000	156,3	10,9	128,1	184,5

In Model 2, nine characteristics were also significantly related to care time (1, 2, 3, 4, 7, 9, 10, 13, and 14). Note that 'Patient with IV, drip or drain: 2 or more' is now significant and that 'Patient with exceptional bodily proportions' is no longer significant.
In the second model, 36% of variation in corrected care times between patients is explained by the model, and 22% of variation within patients (day to day variation for a patient).

Estimated means

The estimated means were calculated per ward, for a patient profile in which none of the patient characteristics was present (minimum profile) and for an average patient profile. Estimated

means were calculated for the original care times (Model 1) and the corrected care times (Model 2). Results can be found in **Table 6**.

Table 6: Estimated means for patient profile with no characteristics present and patient profile with average characteristics mix, for original care times and care times corrected for proficiency

	Model 1: original data		Model 2: data corrected for nurse proficiency	
Ward	**Mean (minutes) Patient average characteristics**	**Mean (minutes) Patient no characteristics**	**Mean (minutes) Patient average characteristics**	**Mean (minutes) Patient no characteristics**
1	104	63	85	54
2	103	62	80	49
3	104	63	85	54
4	98	57	75	44
5	104	64	77	46
6	132	91	88	57

Using the original care times, we see a remarkable difference: ward 6 has a much higher mean than the other wards. For example, care times in Model 1 for patients with an average patient profile range between 98 and 104 for wards 1 to 5, but ward 6 has an average care time of 132; a statistically significant difference with all other departments (all p-values < 0.01). The same significant difference is found in Model 1 for a patient profile where none of the characteristics in the model apply: care time for wards 1 to 5 ranges from 57-64 while care time for ward 6 is 91. This would mean that the nursing staff of ward 6 spend on average much more time caring for the same type of patient. However, after correction for nurse proficiency, the difference in care time between wards is considerably smaller (Model 2) and no longer statistically significant. Using the corrected care times, the mean care time spent on a patient for whom none of the patient characteristics were present was between 44 and 57 minutes per patient (on average 51 minutes). We consider this the baseline care time.

Discussion

Findings

The relation between previously identified patient characteristics and care time was quantified and 9 patient characteristics were found to be significantly related to care time delivered by nurses. The significant characteristics were 'partial assistance bathing, mobilization', 'full assistance bathing, mobilization, care for incontinent patient', 'full assistance meals, dripfeed, TPN', 'two or more IV/drip/drain', 'psychosocial support', 'extensive wound care, fistula, VAC bandages', 'new stoma', 'isolation measures' or 'one-on-one care'. Most characteristics required an additional 18 to 35 minutes on average, with the exception of 'two or more IV/drip/drain' (8 minutes) and 'one-on-one care' (156 minutes). Data was corrected for nurse proficiency. The mean daily care time for patients with a profile where none of the characteristics in our study are present was between 44 and 57 minutes. Mean daily care time for patients with an average patient profile (of the patient characteristics in our study) was between 75 and 88 minutes. Major sources of variation between wards were proficiency of nurses, patients, and day-to-day variation within patients. The models explained more variance (R^2) between patients (36 and 40% for corrected and uncorrected care times, respectively) than within (day-to-day variation for a patient, 22 and 25%, respectively).

One-on-one care is technically not a patient characteristic, but was added to the checklist as a way to indicate that one nurse was busy during the entire shift with caring for one specific patient. A previous study [32] showed that the nurses spent 40 to 56% of their working day on activities that can be directly related to one patient. On the wards where one-on-one care was most often registered (wards 2, 5 and 6) this amounts to between 192 and 227 minutes per dayshift of 480 minutes. If the baseline care time of 51 minutes per patient is subtracted, the result is roughly in line with the average care time of the characteristic one-on-one care that was found before correction for nurse proficiency: 156 minutes. The regular small inspections/activities turned out not to be significant to care time. Perhaps this is the case because these are done when nurses are in the room with the patient anyway, for other, more time consuming, activities. 'Patient with IV, drip or drain: 2 or more' was significant in the corrected times, but not in the uncorrected. 'Patient with exceptional bodily proportions' turned out to be not significant after all, which is likely explained by the small number of observations for this characteristic; 17.

In the estimated means for unadjusted care times, ward 6 stood out; analyses for both patient profiles indicated that significantly more time was spent for the same type of patient on this ward than on other wards. Ward 6 works with more student nurses than other wards, and correcting for nurse proficiency eliminated this difference.

The baseline care time indicates that there is quite a lot of time spent on activities that are patient related, but not explained by the patient characteristics examined: 44-57 minutes per patient. This can be time for example for preparing (standard) medication, reporting or speaking to a patient's family. Baseline care time is approximately 45 minutes to an hour, which is longer than the extra half hour spent on patients with an "average" set of patient characteristics. That means that activities that are considered to be part of baseline care take more time than activities related to the patient characteristics in our study. For the expert nurses in our Delphi group, apparently these activities did not come to mind when considering what leads to additional care time, but they do represent a large proportion of the care time spent on patients. More research is needed on the baseline care time, in order to better understand if relevant patient characteristics have been missed.

Comparison

There is limited literature available that quantifies the relation between patient characteristics and care time in minutes or hours in a non-acute hospital setting.

Myny [40] found 6 groups of activities to be most time consuming: hygiene, urinary and bowel care, emotional support, wound care, education and feeding. Although the definition of activity groups is not exactly the same, all activity groups except education are also significant in our study. Myny uses the Belgian Nursing Minimum Dataset as a basis. Collecting this dataset is mandatory in Belgium, so data is available for all Belgian hospitals, but this is not the case in other countries.

Perroca's patient classification system [41] covers 9 care areas: care process planning and coordination; investigation and monitoring; personal hygiene and eliminations; nutrition and hydration; locomotion or activity; therapeutics; emotional support; health education; skin integrity. Perroca's study does not mention the definitions of the care areas so possibility for comparison is limited.

Van Oostveen [42] studied 17 patient characteristics expected to influence the cost of care. Seven of these turned out to be significantly associated to cost of care: age, number of complications, ASA-class, nutritional status, admission type, number of medications during hospitalization and surgical specialty. Van Oostveen also found that isolation measures were not significantly related to care costs; in our study this is a significant characteristic to care time. Our study aim did not primarily consider costs however, but focuses on balancing nurses' workload. Some patient characteristics may correlate with costs but do not necessarily correlate with care time, for example number of medications.

Hoi [30] found 10 nursing diagnoses that were significantly related to care time. These diagnoses were related to nutrition, mobility, skin integrity, confusion, incontinence and tissue perfusion. The definitions are different from ours and cannot be compared exactly. However, Hoi did find that diagnosis related to tissue perfusion gave the most extra care time per patient, followed by confusion, nutrition and mobility. The extra time varied considerably between disciplines. This is in line with our findings.

Our study describes several characteristics that have not been studied before for their relation to care time or nurses' workload. For example a characteristic called bodily proportions of the patient was introduced. In other studies, such as Myny's [43], BMI is often included. However, even if a patient's BMI is normal, the bodily proportions can result in extra care time: for example when helping a very tall (and thus heavy) patient with bathing.

One-on-one care is a new concept in the context of patient classification. In previous studies, this has not been mentioned or described. Nurses indicated that if many different characteristics apply for one patient, the total care time is higher than you would expect based on the sum of the care times for the separate characteristics.

Study strengths and limitations

Nurses had complete freedom in determining a set of patient characteristics that they believed influence care time the most. This resulted in a new set of characteristics, several of which have not been studied before. The effects of patient characteristics on care time were quantified by work sampling over a relatively long study period of 15 dayshifts. Data were analyzed using a multilevel approach, which is rare in this field of study. Data were corrected for estimated nurse proficiency, which has not been done before and proved to be an important factor to include in the analysis. New concepts 'baseline care time' and 'one-on-one care' were defined and quantified.

Our study was set in an academic hospital, which makes it uncertain whether the study results can be readily applied to different settings, such as general hospitals. Nurses' activities and patient mix in general hospitals are likely to be different than in academic hospitals. The study is based on a random sample of nurses' activities, which gives an estimate of true care time. Activities were sampled approximately every ten minutes, which may not properly reflect reality, although overall there were a large number of observations in the study. The number of observations per characteristic is limited for some characteristics, leading to uncertain estimates. During the time study 21 % of the observation lists were not filled in. The missing lists were randomly distributed across the time study days, patients and across departments, so it is assumed that the missing data

did not affect the study results. This study focuses on the effect of patient characteristics on care time and does not take into account other known factors that influence nursing time (such as patient turnover), unit-related characteristics (such as ward layout and number of single rooms in a ward), or ward team dynamics.

Nurses in the study indicated that patient characteristic 'Patient unstable' was likely to be relevant to care time. In their systematic review on the use of early warning score systems in hospitalized patients, Smith et.al. [44] found that an increasing early warning score was associated with more frequent observations by nurses. Since the registration of early warning scores could not be included in this study, further research on this characteristic in the context of nurse workload is recommended.

Introducing a nurse proficiency estimate in the workload equation proved to be a valuable addition, since our findings indicated that leaving it out may lead to over- or underestimation of workload. In our study, proficiency was estimated by head nurses. The analysis focused on patient-level variation in care time, measured on a daily basis. Work sampling was used to determine care time provided to the patient. Another way to measure the proficiency of nurses would be to keep track of the actual exact time spent on each activity, calculate an estimate per activity per type of nurse and derive the proficiency percentage from these estimates. However, since there were 6 types of nurses and 24 activity groups in the study, this approach would have required a much larger sample size and a more accurate measurement of time spent on an activity than work sampling every ten minutes. For practical reasons (costs, registration), this was not possible, and the choice was made to have ward management estimate nurse proficiency instead. In another study setting, measuring proficiency may well be possible.

Interpretation

The set of relevant patient characteristics that was determined is short, easy to use, and gives an indication of which patient characteristics are most relevant to care time and to what extent. Results can be used for planning purposes and to compare workload between hospital wards. Our set of characteristics explained 36% of variation in care time between patients and 22% of the day-to-day variation in care time within patients. Although expert nurses determined this set with complete freedom, the explained variation is relatively low. This means that other factors influence care time, and those factors may be less obviously related to care time for the expert nurses. Certain additional patient characteristics may have been missed in our study. In the time study [32] results showed that a substantial part of direct patient care consists of administration and reporting (26%) and communication with patient or family (12%). Certain medical or patient

conditions may require additional registration, for example risk assessments on malnutrition or falling, or more communication, for example unstable condition of the patient. These interactions were not included in this study. However, the unexplained variance may also be related to more subjective variables such as the personality of the patient or the nurse. For example some patients or family are likely to demand or get more care time than others, regardless of their condition[45]. Personal connection between patient and caregivers may also be a factor of interest. Also, frequently studied variables such as the number of work interruptions [26, 46] and patient turnover [26, 33, 47] and ward related factors such as available support staff or logistic workers and ward layout [26] may be factors of importance but were not included in this study. Duffield [33] reports that the task most frequently reported as left undone is comforting and talking to patients. When workload is acceptable, there may be time for this activity, which may also explain part of the unexplained variance in care time. Another explanation could be that the study is set in an academic hospital, where multidisciplinary care is common and doctors of several different specialties may be involved in taking care of an individual patient. Multidisciplinary care is not always organized in an optimal way. For example, doctors of different specialties may visit the patient at different times of the day. Each visit may require patient related activities such as wound inspection and consequently care time of nurses to facilitate this. So organizational characteristics such as these can also impact care time of nurses. Further research in that area is recommended.

Calculating the estimated means per ward for a certain patient profile gives additional information on the differences between wards. This method has not been described in literature before.

Conclusion

In short, the conclusion is that our model is useful to gain insight in differences in required care time per patient and to identify differences in care time between wards, but our model does not explain all variation in care time. Further study other factors that influence care time is recommended. It is stressed that nurse proficiency is an important factor in the workload equation, since leaving it out may distort results and lead to false assumptions.

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CHAPTER 6

EXPLORING THE RELATION BETWEEN MODELLED WORKLOAD AND PERCEIVED WORKLOAD OF NURSES AND RELATED JOB DEMANDS, JOB RESOURCES AND PERSONAL RESOURCES, A LONGITUDINAL STUDY

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Submitted

Abstract

Aim

Calculating an objective, modelled workload, exploring the relation between this modelled workload and workload as perceived by nurses and studying the effects of certain job demands, job resources and personal resources.

Design

Academic hospital in the Netherlands. Six surgical wards, capacity 15-30 beds. Data collected over 15 consecutive day shifts.

Methods

Modelled workload is calculated as a ratio of required care time, based on patient characteristics, baseline care time and time for non-patient related activities, and allocated care time, based on the amount of available nurses. Both required and allocated care time are corrected for nurse proficiency. Five dimensions of perceived workload were determined by questionnaires. Both the modelled and the perceived workloads were measured on a daily basis. Linear mixed effects models study the longitudinal relation between this modelled and workload as perceived by nurses and the effects of personal resources, job resources and job demands. ANOVA and post-hoc tests were used to identify differences in modelled workload between wards.

Results

Modelled workload varies roughly between 70 and 170%. Significant differences in modelled workload between wards were found but confidence intervals were wide. Modelled workload is positively associated with all five perceived workload measures (work pace, amount of work, mental load, emotional load, physical load). In addition to modelled workload, the job resource support of colleagues and job demands time spent on direct patient care and time spent on registration had the biggest significant effects on perceived workload.

Conclusions

The modelled workload can be used to detect differences in workload between wards, which may be useful in distributing workload more evenly in order prevent issues in the domain of e.g.

organizational justice. Average patient characteristic profiles per admission day can be composed for treatments such as operations to predict an indication for workload. Extra effort in team building is likely to have a positive effect on perceived workload. A good balance between time spent on direct patient care and registration may also benefit perceptions of workload. The findings of this research can help nursing management in allocating resources and directing their attention to the most relevant factors for balancing workload.

Introduction

In healthcare, there is an increasing pressure on maintaining a high quality of care whilst containing expenditure [1]. Healthcare expenditure is increasing due to factors such as technological progress and an aging population with more chronic conditions [2, 3]. Healthcare providers are expected to maintain a high quality of care under increasing demand, with the same or less funding [4-6]. There is a risk that under these circumstances, nurses' workload will increase to alarming levels. Studies have found negative associations between the workload of nurses and patient outcomes [7, 8], nurse engagement [9-13] and job outcomes [14], and positive relations with nurse burnout [15-17] and nurses' intention to leave the job [18, 19]. Managing the workload will become increasingly important in preventing nurses from leaving the job, which would in turn lead to a greater shortage and an even higher workload.

A previous study by our group presented a method to calculate and predict nurses' workload by means of objective measures [20]. Literature describes several methods to determine workload or nursing intensity [21-24], but none complied to all the demands set by this study team. The objective was to develop a practical tool to predict nurses' workload that is user-friendly (easy to interpret and requiring limited additional registration); can be applied to different types of hospital wards; covers all activities of nurses (not only those activities that are directly patient-related); is suitable for prospective planning purposes; and takes into account nurses' proficiency (the level of education and work experience).

In the study presented in this paper, we build on the findings of this previous research and propose a method to calculate an objective measure for nurses' workload. Balancing this objective (modelled) workload is expected to also balance workload perceptions. The aim of the current study is to understand the relation between the modelled workload and the workload as it is perceived by nurses. To the best of our knowledge, studying the relation between objective and subjective workload, especially in a longitudinal setting, is unique in this field of research.

The perceived workload is reported to be dependent on the ratio of required to allocated nursing times, but other factors are also known to be of influence. Several other variables will be included in the analysis, in order to discover potential interventions for balancing perceived workload in daily practice. Factors that consider employees other than nurses (such as nurse-physician relationships, support from logistic teams), factors that cannot be influenced by nurse management of the ward (such as social support at home) or factors that require major investments (such as ward layout and number of single rooms in a ward) were not included in the scope.

The well-known Job Demands and Resources (JDR) model [25] is chosen as a framework. The

JDR model describes a health impairment process where high job demands lead to exhaustion and burnout. Job demands are those aspects of a job that require effort. Workload is considered a job demand in the JDR model. This paper considers the effects of four other job demands, three job resources and two personal resources on the relation between modelled and perceived workload.

Perceived interruptions, perceived equal work distribution, time spent on registration and time spent on direct patient care are considered job demands in the context of this study. Dutch occupational health surveys, used by occupational health and safety services for preventive medicine purposes, often include questions on work interruptions and equal work distribution. There is evidence that strongly relates the number of work interruptions to patient outcomes [26, 27] and nurses' workload [24, 28]. Equal work distribution has not been related to perceived workload in literature before. Registration required by the government, insurance companies and hospital management, is one of the reasons nurses experience a high workload. Myny [24] found a link between perceived workload and the number of mandatory registrations. Van Bogaert [17] also identifies a growing problem of additional registration. There are also indications that increased administration burden competes with the time intended to be spent on patient care; Khademi [29] stated that one of the important sources of increased nursing workload was an overemphasis of managers on frequent report writing, which competed with patient care delivery. Workload may also be experienced differently if the proportion of time that nurses can spend on direct patient care is low, due to either increased registration or other reasons.

The JDR model also postulates that the health impairment process can be mitigated by job resources and personal resources[25] . These resources help to achieve goals and stimulate personal development, resulting in intrinsic motivation and engagement [9, 10, 25, 30-32]. The present study will include three job resources: support from colleagues, support from management, and the proportion of registered nurses on the ward. Yanchus [33] found that the job resource teamwork (i.e, colleagues helping and backing each other up) counterbalances the effects of understaffing and high workload. Similarly, Sexton's research [34] found that workload pressures can be offset by a positive nursing team environment on a unit. This indicates that teamwork is an important factor in perceived workload. Van Bogaert et al. [17] found the same results in their study on the predictors of burnout, work engagement, nurse reported job outcomes and quality of care. Van Bogaert et.al. [35] also reported that hospital management directly influenced nurses' perceived workload. In MacPhee's study on the impact of heavy perceived workload of nurses on patient and nurse outcomes [8], it was noted that unit level leaders in particular could influence perceived quality of care and job outcomes by monitoring

and responding to workload demands. In addition, there is much evidence that a nursing staff mix with a large proportion of registered nurses results in better patient outcomes [27, 36, 37]. The effect of the skill mix of nurses on perceived workload has not been extensively studied, although there is evidence that skill mix is an important factor when considering workload [38] and that a lower proportion of registered nurses on a ward is associated with increased workload [39]. In the current paper, the proportion of registered nurses on the ward is included and regarded as a job resource.

Two personal resources have been included in the current study: self-efficacy and nurse proficiency. Spence Laschinger [40] found a significant correlation between workload (as one of the areas of work life) and occupational coping self-efficacy, defined as the self-appraisal of one's capability to cope with occupational burden in the workplace [41]. When the areas of work life, such as workload, are balanced, this has a positive effect on occupational coping self-efficacy. In the hospice setting, the stress of staff shortages decreased with increasing self-efficacy [42]. Schmidt et al. [31] found that self-efficacy had a direct effect on job strain in nursing homes, but they did not find evidence for an interaction between self-efficacy and perceived workload. Brunetto [43] found that self-efficacy reduced the effects of stress and enhanced job satisfaction, and herewith reduced nurses' intentions to leave the job; however, they did not study the effects on perceived workload.

Nurses' education and experience are related to clinical expertise [44]. A well-educated, experienced nurse may be able to handle workload better than a novice nurse. This study will test whether nurses with more working experience and who are considered to be more proficient experience workload differently than other nurses.

In this paper, five different measures of perceived workload are included: work pace, amount of work, mental workload, emotional workload and physical workload. The job demands (interruptions, work distribution, time for registration, time for direct patient care) and job resources (support from colleagues, support from management, the proportion of registered nurses on the ward) are included in the analyses as potential effect modifiers of the relation between modelled and perceived workload. Effects will be explored separately for each outcome measure. **Figure 1** presents a visualization of the model to be studied.

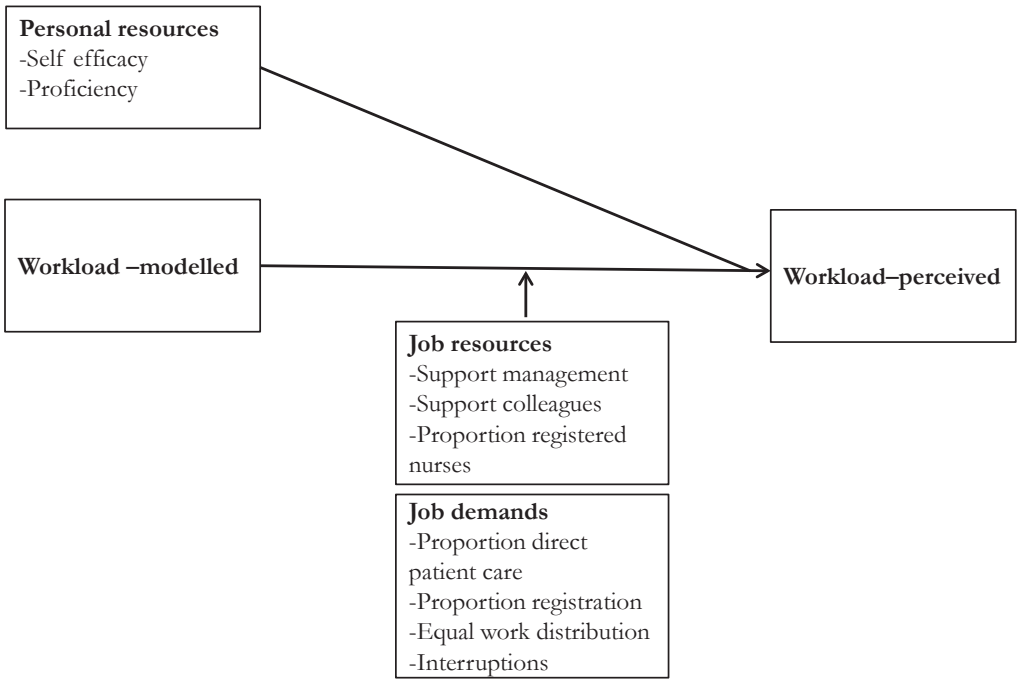

Figure 1: Studying the relation between modelled and perceived workload (our hypotheses)

We will test the following hypotheses:

- *Hypothesis 1*: there is a correlation between the modelled (objective) workload measure and perceived (subjective) workload
- *Hypothesis 2*: perceived workload is lower when personal resources self-efficacy and nurse proficiency are higher
- *Hypothesis 3*: the job resources support from management, support from colleagues and proportion of registered nurses moderate the relation between modelled and perceived workload
- *Hypothesis 4*: the job demands proportion of direct patient care, proportion of administration, work interruptions and perceived equality of work distribution moderate the relation between modelled and perceived workload.

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Method

Study population and setting

The research took place in an academic hospital in the Netherlands. Six surgical wards were included (2 wards with 15 beds, 4 wards with 30 beds). The study focused on the day shift workload, because this is the shift during which the most nursing activities are performed. Weekends were excluded because the task mix and staffing are very different in weekends and cannot be compared to the day shifts of regular weekdays. Registered nurses and nurse students were included in the study. Ward managers were excluded because they do not perform patient-related activities. The study focused on workload experienced by nurses and therefore other professionals such as physicians, physician-assistants, and paramedics were not included in this study.

Outcome: perceived workload

Perceived workload was measured with items derived from the Questionnaire on the Experience and Evaluation of Work (QEEW), which is widely used by Dutch occupational health services to measure the (psychosocial) working environment [44]. The five measures for perceived workload were:

'Did you have too much work to do today', reflecting the amount of work;
'Did you have to work very fast today', reflecting work pace;
'Did you consider your work mentally very challenging today', reflecting mental workload;
'Did your work demand a lot from you emotionally today', reflecting emotional workload;
'Did you find your work physically strenuous today', reflecting physical workload.

Each item had a five-point response scale ranging from 'Not at all' (1) to 'Very often' (5). All measurements were done on a daily basis at the end of the shift.

Independent variable: modelled workload

As mentioned, previous work of this study team contained a study design for developing a workload management method [20]. This method consisted of 7 steps. In step 1, a group of expert nurses composed a list of fifteen patient characteristics they expected to be most relevant to care time. Subsequently, an observational study on nurses' activities (step 2) measured how much time nurses spent on direct patient care (care attributed to an individual patient), collective patient care (patient-related tasks but not attributable to individual patients, e.g. meal distribution) , general tasks (other activities that were not directly patient related such as general administration, meetings, education) and other tasks (breaks and personal time) [45]. The relation

between the patient characteristics and care time was studied in step 3 (*manuscript accepted and in preparation for publication in Nursing Open*). Nine of the fifteen patient characteristics were significantly related to care time: 'partial assistance bathing/ mobilization', 'full assistance bathing/ mobilization', 'full assistance meals/nutrition', 'two or more IV/drip/drain', 'psychosocial support', 'extensive wound care', 'stoma care', 'isolation measures', 'one on one care'. In addition to care time related to patient characteristics, it was also assumed that there would be a patient-related 'baseline care time'. When a patient is admitted to a ward, nurses spend a certain amount of care time on this patient e.g., time that is spent on handing out meals, having a chat or tidying up) , regardless of the patient characteristics that apply. The observational study also yielded how much time nurses spent on non-patient related activities (step 4).The objective modelled workload (step 7) is then calculated by comparing required nursing time (step 5) to allocated nursing time (step 6). The total required nursing time is the result of adding up care time related to patient characteristics, baseline patient related care time and time for non-patient related activities. These times were derived from a time study [45], in which all nurses of the six departments in the study were observed during the day shift, over a period of fifteen working days. During the time study period, nurses on duty registered relevant patient characteristics for each patient each day shift.

Total required nursing time was calculated as follows:

$$(a1 * n1 + a2 * n2 + a..* n.. + ..) + (b * N) = x$$

$$Yreq = \frac{x}{(1 - z)}$$

$a1 = additional\ care\ time\ when\ patient\ characteristic\ 1\ applies\ (minutes)$

$n1 = number\ of\ patients\ in\ the\ dayshift\ for\ whom\ characteristic\ 1\ applies$

$b = baseline\ care\ time\ per\ patient\ (minutes)$

$N = number\ of\ patients\ admitted\ in\ the\ dayshift$

$x = amount\ of\ care\ time\ for\ patient\ related\ activities\ (minutes)$

$z = \%\ of\ time\ spent\ by\ nurses\ on\ non - patient\ related\ activities$

$\boldsymbol{Yreq = total\ required\ nursing\ time\ (minutes)}$

Allocated nursing time was determined by adding up the amount of nurses in the shift, multiplying this by the shift time and correcting for nurse proficiency. Proficiency was estimated by expert nurses. In a mini Delphi study, all six ward managers (all nurses with more than fifteen years of experience) of the wards involved in the study were asked to define nurse categories and corresponding proficiency levels. The mini Delphi consisted of two rounds and two sessions to

discuss results. The Delphi yielded six nurse proficiency categories. One category is the fully qualified and experienced registered nurse: this was defined as the standard and set to a proficiency percentage of 100%. The proficiencies of the other five types of nurses (novice registered nurses, fulltime student nurses in their first or second year, fulltime student nurses in their third or fourth year, working student nurses in their first or second year, working student nurses in their third or fourth year) were offset against this standard.
The allocated nursing time is calculated as follows:

$$(m1 * p1 + m2 * p2 + m..* p.. + ..) = Yall$$

$m1 = amount\ of\ time\ nurse\ 1\ was\ observed\ in\ the\ day\ shift\ (minutes)$
$p1 = proficiency\ of\ nurse\ 1$
$\boldsymbol{Yall = total\ allocated\ nursing\ time\ (minutes)}$

The modelled workload was calculated by dividing required nursing time by allocated nursing time. This ratio gives an objective indication of nurses' workload (W). W = 100% reflects that the allocated nursing time is perfectly balanced to the required nursing time; W<100% indicates overstaffing and W>100% understaffing.

$$W = 100\% * \frac{Yreq}{Yall}$$

$\boldsymbol{Yreq = total\ required\ nursing\ time\ (minutes)}$
$\boldsymbol{Yall = total\ allocated\ nursing\ time\ (minutes)}$
$\boldsymbol{W = modelled\ workload}$ (%)

This modelled workload was calculated retrospectively for each ward on each of the day shifts during the time study period.

Covariates: personal resources, job resources and job demands
Data on personal resources in our study were not expected to vary on a daily basis and were measured once at baseline, three weeks prior to the work sampling period. Personal resource proficiency was estimated by expert nurses, as mentioned above. Personal resource self-efficacy was measured by a scale widely used by Dutch occupational health services in the context of occupational health surveillance. Validation of this scale has not yet been done by means of an international publication. The scale contains five questions: 'When difficult problems occur at work, I know how to deal with them', 'At work, I reach my goal, even when unexpected

situations occur', 'If I encounter obstacles at work, I always find a way around them', 'Even if it takes a lot of my time and energy, at work I achieve what I want' and 'If I encounter something new at work, I always know how to deal with it'. All questions had a five point answer scale, ranging from 'Agree completely' (5) to 'Disagree completely' (1). Scores on the five questions were summed to a total score and then averaged per respondent.

Job resources support from management and support from colleagues were measured on a daily basis for all nurses on duty during the time study period. The questions originated from the Questionnaire on the Experience and Evaluation of Work (QEEW[46]). Support from management was measured by the question 'I could count on my supervisor when I came across difficulties in my work today'. Support from colleagues was determined by the question 'I could count on my colleagues when I came across difficulties in my work today'. Both questions had a 5 point answer scale, ranging from 'Not at all' (1) to 'Very often' (5).

The job resource percentage of registered nurses on the ward was determined by mapping the nurse qualifications of all nurses involved in the study and calculating a percentage of registered nurses on duty on each ward for each day of the time study.

The job demands perceived equality of work distribution and perceived interruptions were also measured once at baseline. Perceived equality of work distribution was measured by the question 'Is the work distributed evenly across all employees of the department?'. Perceived interruptions was determined by the question "Do you have to deal with interruptions in your work?". Both questions had a four point answer scale, ranging from 'Never' (1) to 'Always (4). The proportions of time spent on direct patient care and time spent on registration were derived from the time study results [45] and determined per nurse per day. These questions were also derived from the questionnaires often used by Dutch occupational health services.

Statistical analysis

A one-way ANOVA and Tukey post-hoc tests were performed to determine significant differences between wards for the modelled workload.

Linear mixed effects models [47] were used to study the relation between the modelled workload and perceived workload. Observations were not independent since the majority of nurses were observed more than once during the work sampling period (longitudinal data). Linear mixed effects models are suitable for analyzing longitudinal data. The modelled workload W was the independent variable and the five perceived workload measures were the outcome variables; each model included a random intercept per nurse to account for dependence of measures within nurses over time.

For each of the five perceived workload measures, the relation between the modelled workload *W* and the perceived workload was first tested, with the wards as fixed effects. Subsequently, the personal resources (2 variables), job resources (3 variables) and job demands (4 variables) were added to the model in blocks to test the direct effects on perceived workload. In the last step, interactions between the modelled workload estimate and the four job demands and three job resources were introduced, to test for moderation. This resulted in five estimated models for each of the five outcome measures.

The significance level was set to 0.01. Model fits were evaluated for each outcome measure by comparing the Bayesian Information Criterion (BIC) values. BIC was chosen over the Akaike information criterion and likelihood ratio testing because the models include a relatively large number of independent variables and BIC is more conservative when testing several parameters at once.

Ethical considerations

The study guaranteed the privacy of involved staff and patients. The study protocol was reviewed and approved by the medical ethical review board of the UMC Utrecht, protocol number 14-165/C.

Results

Baseline and daily questionnaires

The daily questionnaire was filled out 694 times, resulting in an average response rate of 58%. The baseline measure questionnaire was returned by 162 nurses; a response rate of 65%. Details on response rates, population characteristics and average responses for personal resources and job resources are shown per ward in **Table 1**.

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Table 1: Response rates, population characteristics and average response of the respondents of the baseline and daily questionnaires

	Ward	1				2				3				4				5				6			
Response		n	%	Mean	SD	n	%	Mean	SD	n	%	Mean	SD	n	%	Mean	SD	n	%	Mean	SD	n	%	Mean	SD
Baseline response		**28**	**72%**			**33**	**73%**			**29**	**54%**			**31**	**62%**			**16**	**53%**			**25**	**83%**		
Gender	Male	2	7%			3	9%			5	17%			6	19%			0	0%			2	8%		
	Female	26	93%			30	91%			24	83%			25	81%			16	100%			23	92%		
Age category	<20	1	4%			0	0%			0	0%			0	0%			0	0%			1	4%		
	20-30	10	36%			15	45%			17	59%			21	68%			8	50%			13	52%		
	30-40	3	11%			9	27%			4	14%			3	10%			2	13%			3	12%		
	40-50	3	11%			4	12%			1	3%			1	3%			0	0%			2	8%		
	>=50	8	29%			2	6%			3	10%			2	6%			5	31%			5	20%		
	Unknown	3	11%			3	9%			4	14%			4	13%			1	6%			1	4%		
Type of nurse	Registered nurse	24	64%			31	70%			20	52%			21	58%			10	44%			16	48%		
	Student nurse	4	36%			2	30%			9	48%			10	42%			6	56%			9	52%		
Self-efficacy (range 1-5)				3,5	0,4			3,6	0,5			3,6	0,4			3,7	0,4			3,6	0,4			3,6	0,5
Interruptions (range 1-4)				2,5	0,8			2,7	0,7			2,3	0,7			2,3	0,8			2,4	0,8			2,0	0,9
Equal work distribution (range 1-4)				2,8	0,5			2,5	0,7			2,7	0,6			2,6	0,7			2,8	0,4			2,6	0,7
Daily response		**91**	**58%**			**107**	**45%**			**141**	**63%**			**151**	**66%**			**93**	**57%**			**111**	**61%**		
Gender	Male	15	16%			3	3%			36	26%			30	20%			8	9%			12	11%		
	Female	68	75%			96	90%			102	72%			95	63%			80	86%			91	82%		
	Unknown	8	9%			8	7%			3	2%			26	17%			5	5%			8	7%		
Age category	<20	3	3%			0	0%			0	0%			11	7%			4	4%			12	11%		
	20-30	49	54%			66	62%			106	75%			98	65%			62	67%			67	60%		
	30-40	8	9%			16	15%			12	9%			9	6%			19	20%			18	16%		
	40-50	13	14%			15	14%			8	6%			4	3%			0	0%			3	3%		
	>=50	10	11%			2	2%			12	9%			3	2%			3	3%			3	3%		
	Unknown	8	9%			8	7%			3	2%			26	17%			5	5%			8	7%		
Type of nurse	Registered nurse	62	68%			70	65%			68	48%			85	56%			51	55%			41	37%		
	Student nurse	29	32%			37	35%			73	52%			66	44%			42	45%			70	63%		
Support management (range 1-5)				3,8	1,1			3,7	1,2			4,1	1,1			3,9	1,0			3,9	1,1			4,1	1,0
Support colleagues (range 1-5)				4,1	0,8			4,0	0,9			4,2	0,9			4,0	0,9			4,2	0,8			4,3	0,8

Not surprisingly, the vast majority of nurses are female (**Table 1**). Of the respondents of the baseline questionnaire, between 44% and 70 % were registered nurses; in the daily questionnaires this ranged between 37% and 68%. Gender and age category could not always be ascertained, for example for students who left the hospital or for temporary nursing staff. 36% to 68% of respondents were between 20 and 30 years old. The relatively high proportion of young nurses can be explained by the study setting: the research took place in an academic hospital, with specific training and educational tasks. On all wards, support of colleagues scored higher on average than support of management (4.0 to 4.3 and 3.7 to 4.1, respectively). Self-efficacy seems quite stable across wards, with average scores ranging between 3.5 and 3.7 and standard deviations between 0.4 and 0.5.

Modelled workload

One of the main practical concerns in the study hospital was whether the workload was divided equally across wards. In order to answer this question, modelled workload was analyzed per ward. **Figure 2** presents the average modelled workload per day shift, calculated retrospectively for the days of the work sampling period. Each line represents one ward. During the work sampling period, on two day shifts equipment failed on a ward and on one day the data download failed for one ward. This meant that not all the required data were available to calculate the modelled workload on those days, so three day shifts were excluded for all wards. Days 1, 3 and 5 are missing. Since these failures occurred randomly, it is expected that the missing data do not influence the outcomes.

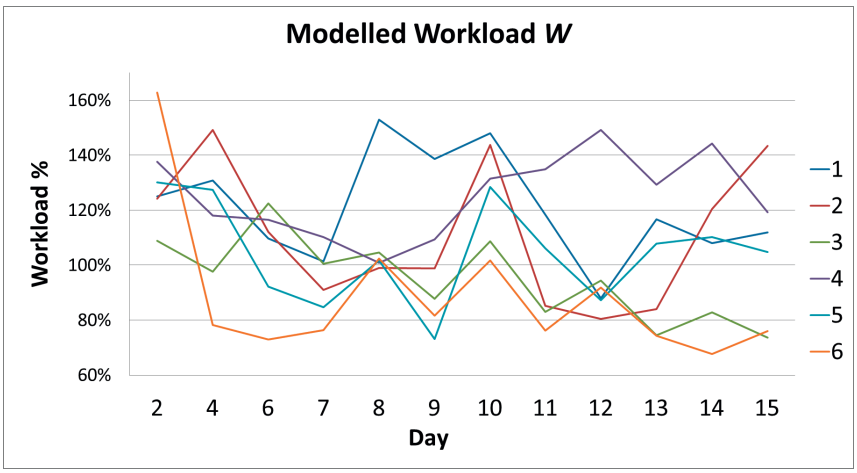

Figure 2: Average modelled workload per ward per day, calculated retrospectively for the work sampling period

The post hoc tests found that modelled workload on ward 6 was significantly lower than on wards 1 (estimated difference -32.3%, confidence interval -58.1% to -6.4%, p-value 0,001) and 4 (estimated difference -36.6%, confidence interval -62.4% to -10.7%, p-value <0,001), and workload on ward 3 was significantly lower than on ward 4 (estimated difference 30.2%, confidence interval -56.0% to -4.3%, p-value 0,002).

Perceived workload

For the perceived workload measures, data were available for all fifteen day shifts in the work sampling period.

Figure 3 presents the average perceived workload per ward per day shift, for each of the five perceived workload measures.

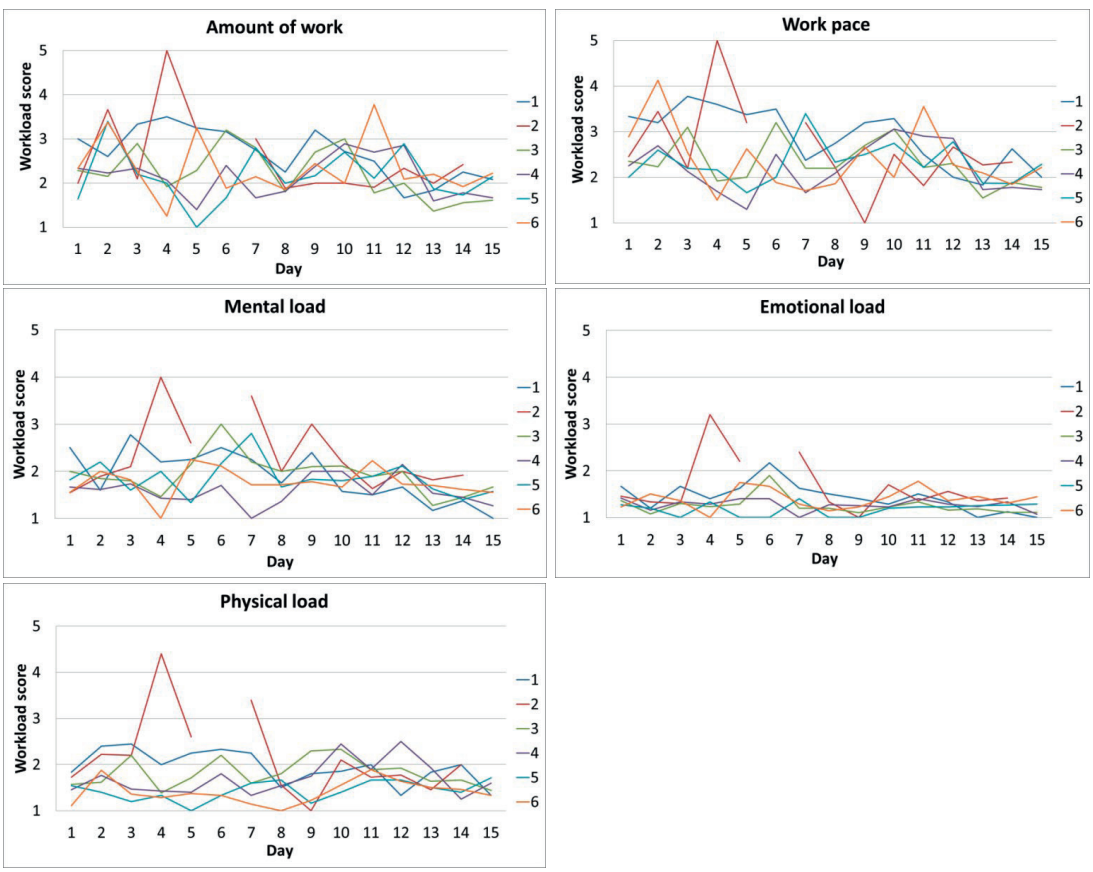

Figure 3: Five line graphs with average perceived workloads per ward per day for amount of work, work pace, mental load, emotional load and physical load

The graphs of amount of work and work pace are quite similar. The graph of emotional load is more stable and on average lower than the other measures. To a lesser extent, the same goes for the results on physical load. On day 4 on ward 2, workload was apparently perceived exceptionally high on all of the five outcomes measures. On day 9 on ward 2, all workloads were perceived to be relatively low, but mental load peaked.

Effects of personal resources, job resources and job demands

For all five perceived workload measures, the models with interactions did not perform better than the models without interactions, hence the interactions are not shown in Table 2.. This means that no moderation was found on the relation between modelled and perceived workload, all significant effects of variables were direct effects on perceived workload. Details on model fits can be found in **Appendix 1**.

For three outcome measures (mental load, emotional load and physical load), the models that included the job demands did not perform better than the models without the job demands. Therefore, no results are shown for the job demands for these three outcome measures.

Table 2: Effects of job demands, job resources and personal resources on five outcome measures of perceived workload (range 1 to 5)

		Perceived Work pace		Perceived Amount of work		Perceived Mental load		Perceived Emotional load		Perceived Physical load	
Type of variable	**Variable**	Estimated effect *	Standard error	Estimated effect *	Standard error	Estimated effect *	Standard error	Estimated effect *	Standard error	Estimated effect *	Standard error
Job demand	Modelled workload	**0.209**	**0.024**	**0.198**	**0.025**	**0.141**	**0.021**	**0.043**	**0.013**	**0.047**	**0.017**
Personal resource	Perceived self-efficacy	0.010	0.211	-0.03	0.248	-0.12	0.212	-0.08	0.147	-0.10	0.218
	Estimated nurse proficiency %	-0.00	0.039	-0.03	0.046	0.008	0.037	-0.00	0.026	-0.00	0.038
Job resource	Perceived support of management	-0.01	0.057	-0.05	0.061	-0.08	0.052	-0.02	0.032	-0.03	0.043
	Perceived support of colleagues	**-0.23**	**0.073**	**-0.30**	**0.079**	**-0.23**	**0.067**	**-0.11**	**0.042**	**-0.22**	**0.057**
	% of nurses on ward that is registered nurse	0.088	0.057	0.068	0.061	0.083	0.052	**0.085**	**0.032**	0.076	0.044
Job demand	% nursing time spent on direct patient care	**0.165**	**0.037**	**0.228**	**0.040**	.	.	.	.	.	.
	% nursing time spent on registration	-0.19	0.080	**-0.29**	**0.085**	.	.	.	.	.	.
	Perceived equality in work distribution	-0.10	0.171	-0.15	0.201	.	.	.	.	.	.
	Perceived interruptions	0.232	0.120	0.150	0.142	.	.	.	.	.	.

*For variables with ordinal scales (for example from "Never" to "Always", translated into 1 to 4 points), a rise of one full point results in the effect shown in Table 2. For ratio variables, a rise of 10% results in the effect shown in Table 2.
Significant effects are printed in bold.

The results indicate a positive correlation between all perceived workload measures and modelled workload. Every 10% increase in estimated workload (on a scale that ranges roughly between 70 and 170%) is associated with a 0.209 increase in perceived work pace (on a scale from 1 to 5 this is a 5.2% increase), 0.198 (5%) in perceived amount of work, 0.141 (3.5%) in perceived mental workload, 0.043 (1.1%) in perceived emotional workload and 0.047 (1.2%) in perceived physical load.

Neither of the personal resources were significantly related to any of the perceived workload measures. The scale for self-efficacy was tested for internal consistency by calculating Cronbach's alpha. Alpha was 0.657 and did not improve if items were deleted from the scale. Since this practical scale is used often by occupational health services, it was decided to keep the scale in the study and test whether it was of influence on perceived workload even though Cronbach's alpha was relatively low.

Support from management was not related to any of the perceived workload measures, whereas support from colleagues was negatively associated with all outcome measures. A 1-point increase (on an scale of 1 to 5) in experienced support from colleagues reduced the experienced work pace with 0.23 (5.8%), amount of work with 0.30 (7.5%), mental workload with 0.23 (5.8%), emotional workload with 0.11 (2.8%) and physical load with 0.22 (5.5%).

The percentage of registered nurses on the ward is correlated with the perceived emotional workload, but not the other subjective workload outcomes. Every 10% increase in proportion of registered nurses on a ward results in 0.085 (2.1%) increase in experienced emotional workload. The proportion of time spent on direct patient care and the proportion of time spent on registration were significantly related to perceived workload. For each 10% increase in time spent on direct patient care, there was a 0.165 (4.1%) point rise in perceived work pace and 0.228 (5.7%) point rise in perceived amount of work. Every 10% increase in proportion of time spent on registration gave a 0.29 (7.3%) decline in perceived amount of work. The other job demands were not significantly related to any of perceived workload measures.
Proportional effects for significant variables are summarized in **Table 3**.

Table 3: Proportional effects for variables with significant effect on perceived workload

			Perceived Work pace	**Perceived Amount of work**	**Perceived Mental load**	**Perceived Emotional load**	**Perceived Physical load**
Type of variable	**Variable**	**Increase**	Estimated proportional effect*	Estimated proportional effect*	Estimated proportional effect*	Estimated proportional effect*	Estimated proportional effect*
Job demand	Modelled workload	+10%	+5.2 %	+5 %	+3.5 %	+1.1 %	+1.2 %
Job resource	Perceived support of colleagues	+1 point	-5.8 %	-7.5 %	-5.8 %	-2.8 %	-5.5 %
	% of nurses on ward that is registered	+10%				+2.1 %	
Job demand	% nursing time spent on direct patient care	+10%	+4.1 %	+5.7 %			
	% nursing time spent on registration	+10%		-7.3 %			

*Estimated proportional effect on the outcome variable (expressed in % of rise in points on a 1-5 scale) for a rise of either 10% or 1 point in the independent variable

Discussion

Findings

The modelled workload is significantly different between wards 6 and 1, between 6 and 4 and between 3 and 4. The estimated differences are quite large; -32.3%, -36.6% and -30.2% respectively but so are the corresponding confidence intervals: -58.1% to -6.4%, -62.4% to -10.7% and -56.0% to -4.3% respectively.

The first hypothesis was accepted, since there is a linear correlation between the modelled workload and all five perceived outcome measures. Every 10% increase in modelled workload results in a 0.209 (5.2%) increase in perceived work pace, 0.198 (5%) in perceived amount of work, 0.141 (3.5%) in perceived mental workload but only 0.043 (1.1%) in perceived emotional workload and 0.047 (1.2%) in perceived physical load. Apparently, modelled workload *W* has the biggest effect on work pace, amount of work and mental workload. This makes sense, considering that the modelled workload *W* is based on comparing required and allocated care time only, and does not give any insight in emotional and physical requirements. Having to work fast due to a lack of balance between required and allocated resources may result in an experienced higher mental load because tasks that need focus and concentration need to be done under time pressure. Modelled workload, as found in this study, varies roughly between 70% and 170%; a range of 100%. With every 10% increase of the modelled workload, the perceived work pace increases with 5.2% and the perceived amount of work with 5.0%. It seems that perceived workload does not rise to the same extent as modelled workload. However, we need to consider that the answer range that was provided for all perceived workload measures ranges from 1 to 5 on an ordinal scale, which is quite a narrow range. Respondents therefore had limited options to express their perceptions of workload. In future research, a broader range of response may be of value to get a more detailed insight on the extent to which modelled workload influences perceptions.

Of the perceived workload measures, work pace and amount of work show a similar pattern. In the QEEW [46] these two are brought together in one construct: work pressure. In our study, we made the decision to separate the two in order to see whether the covariates may have different effects on each measure. Indeed this turned out to be the case; percentage of time spent on registration was correlated with perceived amount of work but not with work pace. Apparently, researching these two measures as separate constructs pays off. The graph of emotional load is most stable and on average reports a lower workload than the other measures. To a lesser extent, the same goes for the results on physical load. There were two peak days for ward 2 (days 4 and 9), we could not retrieve what would have been the reason for this. Especially the peak in mental

workload on day 9 is puzzling, since all other workloads measures on that ward on that day were relatively low.

Personal resources self-efficacy and proficiency were not related to any of the outcome measures. As for self-efficacy, this is not in line with findings in other studies, such as those of Spence Laschinger [40] and Martens [42], where positive correlations were found between (occupational coping) self-efficacy and workload and stress of staff shortages. Our findings do correspond with Schmidt's[31], who did find an effect of self-efficacy on job strain but not on perceived workload. However, the internal consistency of the scales for self-efficacy used in our study turned out to be low. The questions in the scale are insufficiently correlated to be seen as one construct, so no definite conclusion can be drawn about the effect of self-efficacy on perceived workload. It is recommended that in further research, validated scales for self-efficacy. A study on nurse risk assessment decisions [48], showed that under conditions without time pressure, nurses with clinical expertise (i.e. more proficient nurses) performed better than novice nurses; the positive effects of clinical expertise, however, were negated when time pressure was introduced to clinical simulations. Since proficiency of nurses was not significantly related to workload in our study and in addition the workload estimate *W* was higher than 100% in 4 out of 6 wards, which indicates understaffing, possibly, this effect also occurred in our study setting. There was no evidence that the personal resources are related to the perceived workload measures; no direct effects or moderation were found, so hypothesis two was rejected.

Of the job demands other than workload, only the proportions of direct patient care and registration were of significance. An increased proportion of direct patient care results in increased perceptions of work pace and amount of work. This may be explained by the fact that time spent with the patient is regarded as more demanding; possibly patient related tasks are considered more urgent than other tasks and add to perceived work pressures. In line with this finding, an increase in proportion of time spent on registration gave a decline in perceived amount of work. Registration might be regarded as a less demanding task which may influence the perception of the work pressure. More research is needed on this, but the results may be explained by the fact that registration takes place in a quiet environment, away from the patient and thus away from potential pressures of patients and relatives or other caregivers. Possibly administrative work can form a stable, quiet moment in the working day where nurses can focus on this one task, whilst sitting down at a desk, instead of having to hurry along between tasks in different patient rooms. Also, unexpectedly, perceived work interruptions seemed irrelevant to perceived workload. Based on the available literature [26, 28], which shows a negative correlation between interruptions and patient safety, for example when performing complicated tasks such as

medication preparation, a positive correlation between interruptions and perceived workload was expected, at least with outcome measure perceived mental load. Perceived equality in work distribution was also not proven to be correlated to any of the workload outcome measures. To our knowledge there is no available literature on the effects of equal work distribution in the day shift on perceived workload. There are studies on distributive organizational justice (which reflects the perceived fairness in decision outcomes, such as work scheduling), and these suggest a negative correlation between distributive justice and intention to leave [49] and a positive correlation between distributive justice and quality of work life (for example psychological well-being, workload and work satisfaction)[50]. Assuming that equal work distribution would be also perceived as a fair distribution, a positive correlation between equal work distribution and perceived workload was expected but not proven. However, upon studying the different model fits for all outcome measures, there was a notable finding. For outcome measure perceived mental workload, two models scored almost similar on the BIC (see **Appendix 1**, **Table 3**): the model with all personal and job resources and all job demands (BIC=1061.9) and the model that also included interactions (BIC=1062.1). The model with interactions showed a significant moderation on the relation between modelled and perceived workload, for job demands work interruptions and equality of work distribution.

The job resources support from colleagues and proportion of registered nurses were significantly related to perceived workload. Support from colleagues proved to be an important factor in workload perception, since it was negatively correlated to all outcome measures. This is in line with findings of other studies [17, 33, 34], where teamwork was shown to offset negative effects of high workload. The fact that the effect of teamwork was found to be less strong on outcome measure perceived emotional workload was unexpected; apparently support from colleagues is more important in handling workload in the cognitive and physical domain than when coping with emotional challenges. The percentage of registered nurses on the ward is positively correlated with the perceived emotional workload, although not very strong. It was expected that registered nurses would be better equipped to handle emotional stressors than student nurses, but apparently, there is more to this. Possibly, registered nurses feel more responsible for their work than student nurses, which may increase emotional load. Or maybe registered nurses are more likely to be given the more emotionally challenging tasks than student nurses. More research is needed to explain this effect. Perceived support from management did not turn out to be significantly related to any of the outcome measures. A study by MacPhee [8] did show that support of unit-level management in managing workload could have positive effects on perceived quality of care and job outcomes, but this study did not test the direct relation between support

of management and perceived workload. In the present study, the relation between support from management and workload was tested, but could not be proven. When considering which support is more important to nurses, apparently sticking together as a team is more important to how workload is perceived than getting support from ward leadership. This suggests that ward leadership should consider their role in enhancing teamwork and teambuilding on the ward.
For all outcome measures, the models without the interactions showed a better fit than the models with interactions. This means that there is only evidence for direct effects, there is no moderation, which means that hypotheses three and four must be rejected. More research is recommended on the effects of perceived interruptions and perceived equality of work distribution on perceived mental workload, because the model that included moderation was almost as good as the model without.

Strengths and limitations

This was a longitudinal, multilevel study, which is rare in this field of research. The fact that an objective (modelled) and subjective (perceived) workload measures were combined in one study is unique.
Another strong feature of this study was that nurses were in the lead and had complete freedom in determining a set of patient characteristics that they believed influence care time the most. This resulted in a new set of characteristics, several of which have not been studied before, such as a patient's bodily proportions and one-on-one care. The effects of the patient characteristics on care time were quantified by work sampling over a relatively long study period of 15 day shifts.
Nurses involved in the study stressed the importance of nurse proficiency in workload calculations and suggested a new way of defining nurse proficiency. Data were corrected for this newly defined nurse proficiency, which has not been done before and proved to be an important factor to include in the analysis. The proportion of students is relatively high in our study, since the study setting is an academic hospital and two of the wards in the study are also specific learning wards which have a higher proportion of students than usual. Correcting for nurse proficiency is especially relevant in a teaching hospital setting.
A new concept 'baseline care time' was defined and quantified by deriving estimated marginal means from the mixed model, which has not been described in literature before.
The combination of a modelled workload measure and five perceived workload measures in one study is unique. Also, testing for moderation of job demands and job resources on the relation between the modelled and perceived workloads has not been done before.
The overall response rates on the baseline measure questionnaire and the daily questionnaire that

was used during the work sampling period were 65% and 70% respectively, which is considered to be quite good [51].

There are several limitations that need to be addressed. This study was set in an academic hospital, which makes it uncertain whether the study results can be readily applied to different settings, such as general hospitals. Nurses' activities and the patient mix in general hospitals are likely to be different than in academic hospitals, if this study is to be applied in such a setting, the framework can be the same, but it is recommended to review the list of patient characteristics and to repeat the work sampling.

The confidence intervals for the estimated differences of modelled workload between wards were relatively high. For future research, a larger sample size is recommended in order to make a more accurate estimate of differences between wards.

The scales used to measure self-efficacy were chosen for practical reasons and were not validated by means of international publications. The items on the scale proved not to be internally consistent; future research should include validated scales of self-efficacy. Since the items do not represent one construct, no conclusion can be drawn about the effect of self-efficacy on perceived workload.

Perceived equality of work distribution and perceived interruptions were both measured by one question. Possibly, the use of more extensive measures would have influenced results. More research is recommended on this.

In this study, proficiency was estimated by a mini-Delphi study among head nurses. Another way to measure the proficiency of nurses would be to keep track of the actual exact time spent on each activity, calculate an estimate per activity per type of nurse and derive the proficiency percentage from these estimates. However, since there were 6 types of nurses and 24 activity groups in the study, this approach would have required a much larger sample size and a more accurate measurement of time spent on an activity than work sampling every ten minutes. For practical reasons (costs, registration), this was not possible, and the choice was made to estimate nurse proficiency instead.

Concluding remarks

The study presents a method to calculate an objective measure for workload of nurses, which is positively associated with the perceived workload. This modelled workload can be used to detect differences in workload between wards, which may be useful to more evenly distribute workload in order prevent issues in the domain of e.g. organizational justice. When sufficient historical data are collected, an average patient characteristics profile per admission day can be composed for

treatments such as operations. This way, an indication of workload of nurses on surgical hospital wards can be predicted based on operating room schedules. Besides the modelled workload, job resources support of colleagues and job demands time spent on direct patient care and time spent on registration had the biggest significant effects on perceived workload. In times when workload is high, extra effort in teambuilding is likely to have a positive effect on perceived workload. In these circumstances, unit-level management should consider focusing their attention on facilitating the nursing team to work together smoothly and on enhancing team spirit. Since time spent on direct patient care is positively associated with perceived workload and time spent on registration is negatively associated with perceived workload, a good balance between time spent on direct patient care and registration may also benefit perceptions of workload.

The findings of this research can help nurse management in allocating resources and directing their attention to the most relevant factors so workload of nurses is better balanced, which in turn leads to a higher quality of care, keeping nurses healthy and the prevention of additional costs for overstaffing, absenteeism or high turnover of nurses.

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Appendix 1 (1 of 5)

Outcome: Work pace Mixed models: daily experience workload vs. calculated workload according to model. Fixed effects & fit statistics for 5 models.

			Model 1			Model 2			Model 3			**Model 4**			Model 5		
Obs	*Effect*	*Ward*	*est1*	*stderr1*	*pval1*	*est2*	*stderr2*	*pval2*	*est3*	*stderr3*	*pval3*	***est4***	***stderr4***	***pval4***	*est5*	*stderr5*	*pval5*
1	Ward	1	-0.6122	0.4028	0.1319	-0.6133	0.4022	0.1307	-0.8856	0.3948	0.0273	**-10.798**	**0.3862**	**0.0063**	-11.115	0.3987	0.0065
2	Ward	2	-0.5622	0.3978	0.1609	-0.5753	0.4002	0.1539	-0.8919	0.3936	0.0258	**-11.540**	**0.3857**	**0.0036**	-12.070	0.4006	0.0034
3	Ward	3	-0.6170	0.3940	0.1208	-0.6221	0.3952	0.1189	-0.8007	0.3852	0.0405	**-0.9145**	**0.3723**	**0.0160**	-0.9455	0.3804	0.0148
4	Ward	4	-13.632	0.3931	0.0008	-13.403	0.3985	0.0011	-16.053	0.3901	<.0001	**-17.432**	**0.3783**	**<.0001**	-17.570	0.3891	<.0001
5	Ward	6	-0.3060	0.4020	0.4486	-0.2588	0.4120	0.5314	-0.2733	0.4086	0.5053	**-0.2099**	**0.3985**	**0.5996**	-0.3188	0.4126	0.4419
6	Ward	5	0	.	.	0	.	.	0	.	.	**0**	.	.	0	.	.
7	DPC10		.	.	.	.	.	.	.	.	.	**0.1650**	**0.03780**	**<.0001**	0.04612	0.1886	0.8070
8	Intercept		0.9046	0.4099	0.0298	0.8983	0.9016	0.3217	14.355	0.9994	0.1543	**0.9567**	**10.195**	**0.3506**	49.119	24.030	0.0439
9	Proficiency10		.	.	.	0.01998	0.03955	0.6138	0.007830	0.03851	0.8390	**-0.00743**	**0.03948**	**0.8509**	-0.01344	0.04040	0.7397
10	registr10		.	.	.	.	.	.	.	.	.	**-0.1918**	**0.08086**	**0.0184**	-0.5026	0.3663	0.1712
11	Workdistr0		.	.	.	.	.	.	.	.	.	**-0.1031**	**0.1713**	**0.5478**	0.4425	0.5758	0.4429
12	selfeffic0		.	.	.	-0.04542	0.2250	0.8401	0.03022	0.2181	0.8899	**0.01051**	**0.2110**	**0.9603**	0.03876	0.2157	0.8575
13	pctRN10		.	.	.	.	.	.	0.09011	0.05898	0.1276	**0.08882**	**0.05789**	**0.1260**	-0.2671	0.2449	0.2764
14	supportcoll		.	.	.	.	.	.	-0.2641	0.07467	0.0005	**-0.2376**	**0.07332**	**0.0013**	-0.6399	0.3186	0.0455
15	supportmgt		.	.	.	.	.	.	-0.00353	0.05873	0.9521	**-0.01400**	**0.05743**	**0.8076**	-0.1463	0.2601	0.5743
16	interruption0		.	.	.	.	.	.	.	.	.	**0.2322**	**0.1206**	**0.0552**	0.5670	0.3871	0.1441
17	wlmod1_10		0.2168	0.02471	<.0001	0.2159	0.02478	<.0001	0.2218	0.02434	<.0001	**0.2091**	**0.02409**	**<.0001**	-0.1426	0.1938	0.4626
18	wlmod1_10*DPC10		.	.	.	.	.	.	.	.	.	.	.	.	0.01139	0.01654	0.4915
19	wlmod1_10*registr10		.	.	.	.	.	.	.	.	.	.	.	.	0.02493	0.02970	0.4020
20	wlmod1_10*workdistr		.	.	.	.	.	.	.	.	.	.	.	.	-0.05165	0.04931	0.2958
21	wlmod1_10*pctRN10		.	.	.	.	.	.	.	.	.	.	.	.	0.03051	0.02101	0.1476
22	wlmod1_10*supportcoll		.	.	.	.	.	.	.	.	.	.	.	.	0.03730	0.02827	0.1881
23	wlmod1_10*supportmgt		.	.	.	.	.	.	.	.	.	.	.	.	0.01221	0.02306	0.5968
24	wlmod1_10*interruption		.	.	.	.	.	.	.	.	.	.	.	.	-0.03042	0.03352	0.3649

Obs	*Descr*	*Mod1*	*Mod2*	*Mod3*	*Mod4*	*Mod5*
1	-2 Log Likelihood	1108.0	1107.7	1086.9	1063.3	1052.7
2	AIC (Smaller is Better)	1126.0	1129.7	1114.9	1099.3	1102.7
3	AICC (Smaller is Better)	1126.4	1130.4	1116.0	1101.1	1106.2
4	BIC (Smaller is Better)	1149.3	1158.2	1151.2	**1146.0**	1167.6

Appendix 1 (2 of 5)

Outcome: Amount of work Mixed models: daily experience workload vs. calculated workload according to model. Fixed effects & fit statistics for 5 models.

			Model 1			Model 2			Model 3			**Model 4**			Model 5		
Obs	*Effect*	*Ward*	*est1*	*stderr1*	*pval1*	*est2*	*stderr2*	*pval2*	*est3*	*stderr3*	*pval3*	***est4***	***stderr4***	***pval4***	*est5*	*stderr5*	*pval5*
1	Ward	1	0.006347	0.4861	0.9896	0.02167	0.4864	0.9646	-0.2782	0.4675	0.5533	**-0.5389**	**0.4492**	**0.2334**	-0.4845	0.4596	0.2947
2	Ward	2	0.1634	0.4786	0.7336	0.1965	0.4829	0.6850	-0.1666	0.4650	0.7210	**-0.4538**	**0.4478**	**0.3136**	-0.5152	0.4607	0.2665
3	Ward	3	0.1023	0.4762	0.8304	0.1296	0.4787	0.7872	-0.08651	0.4576	0.8505	**-0.2168**	**0.4352**	**0.6197**	-0.1831	0.4418	0.6795
4	Ward	4	-0.6290	0.4731	0.1869	-0.5992	0.4805	0.2156	-0.9075	0.4610	0.0520	**-10.896**	**0.4399**	**0.0151**	-11.464	0.4488	0.0123
5	Ward	6	0.4948	0.4862	0.3114	0.5043	0.4999	0.3157	0.4434	0.4846	0.3626	**0.4555**	**0.4653**	**0.3302**	0.3464	0.4775	0.4700
6	Ward	5	0	.	.	0	.	.	0	.	.	**0**	**.**	**.**	0	.	.
7	DPC10			.	.		.	.		.	.	**0.2285**	**0.04020**	**<.0001**	0.3203	0.1965	0.1043
8	Intercept		0.1311	0.4783	0.7847	0.5927	10.916	0.5885	16.348	11.664	0.1644	**13.424**	**11.671**	**0.2531**	80.082	25.605	0.0024
9	Proficiency10		.	.	.	-0.01252	0.04859	0.7968	-0.02828	0.04636	0.5423	**-0.03215**	**0.04669**	**0.4917**	-0.03334	0.04754	0.4837
10	registr10		.	.	.	.	.	.	.	.	.	**-0.2994**	**0.08588**	**0.0006**	-0.5244	0.3800	0.1686
11	Workdistr0		.	.	.	.	.	.	.	.	.	**-0.1512**	**0.2019**	**0.4547**	13.623	0.6143	0.0274
12	selfeffic0		.	.	.	-0.1057	0.2747	0.7008	-0.01366	0.2612	0.9583	**-0.03939**	**0.2488**	**0.8743**	0.06586	0.2530	0.7948
13	pctRN10		.	.	.	.	.	.	0.07600	0.06389	0.2352	**0.06865**	**0.06175**	**0.2672**	-0.5868	0.2545	0.0219
14	supportcoll		.	.	.	.	.	.	-0.3357	0.08210	<.0001	**-0.3009**	**0.07945**	**0.0002**	-0.6886	0.3336	0.0399
15	supportmgt		.	.	.	.	.	.	-0.03181	0.06361	0.6174	**-0.05112**	**0.06124**	**0.4045**	-0.5542	0.2715	0.0422
16	interruption0		.	.	.	.	.	.	.	.	.	**0.1509**	**0.1421**	**0.2892**	-0.2952	0.4139	0.4764
17	wlmod1_10		0.2147	0.02680	<.0001	0.2148	0.02685	<.0001	0.2188	0.02621	<.0001	**0.1982**	**0.02557**	**<.0001**	-0.4245	0.2034	0.0378
18	wlmod1_10*DPC10		.	.	.	.	.	.	.	.	.	**.**	**.**	**.**	-0.00849	0.01728	0.6234
19	wlmod1_10*registr10		.	.	.	.	.	.	.	.	.	**.**	**.**	**.**	0.01843	0.03084	0.5506
20	wlmod1_10*workdistr		.	.	.	.	.	.	.	.	.	**.**	**.**	**.**	-0.1385	0.05209	0.0083
21	wlmod1_10*pctRN10		.	.	.	.	.	.	.	.	.	**.**	**.**	**.**	0.05607	0.02181	0.0107
22	wlmod1_10*supportcoll		.	.	.	.	.	.	.	.	.	**.**	**.**	**.**	0.03770	0.02961	0.2040
23	wlmod1_10*supportmgt		.	.	.	.	.	.	.	.	.	**.**	**.**	**.**	0.04526	0.02408	0.0611
24	wlmod1_10*interruption		.	.	.	.	.	.	.	.	.	**.**	**.**	**.**	0.04119	0.03554	0.2475

Obs	*Descr*	*Mod1*	*Mod2*	*Mod3*	*Mod4*	*Mod5*
1	-2 Log Likelihood	1183.7	1183.4	1155.9	1119.7	1095.3
2	AIC (Smaller is Better)	1201.7	1205.4	1183.9	1155.7	1145.3
3	AICC (Smaller is Better)	1202.1	1206.1	1184.9	1157.5	1148.8
4	BIC (Smaller is Better)	1225.0	1234.0	1220.2	**1202.4**	1210.2

Appendix 1 (3 of 5)

Outcome: Mental load Mixed models: daily experience workload vs. calculated workload according to model. Fixed effects & fit statistics for 5 models.

			Model 1			Model 2			**Model 3**			Model 4			Model 5		
Obs	*Effect*	*Ward*	*est1*	*stderr1*	*pval1*	*est2*	*stderr2*	*pval2*	***est3***	***stderr3***	***pval3***	*est4*	*stderr4*	*pval4*	*est5*	*stderr5*	*pval5*
1	Ward	1	-0.5101	0.3929	0.1974	-0.4965	0.3905	0.2067	**-0.7406**	**0.3814**	**0.0552**	-0.8059	0.3873	0.0403	-0.7342	0.3944	0.0659
2	Ward	2	-0.02854	0.3871	0.9414	-0.01867	0.3879	0.9617	**-0.3471**	**0.3794**	**0.3627**	-0.4399	0.3860	0.2575	-0.4256	0.3950	0.2842
3	Ward	3	-0.1199	0.3848	0.7561	-0.1033	0.3842	0.7886	**-0.2718**	**0.3732**	**0.4683**	-0.3160	0.3756	0.4025	-0.2280	0.3801	0.5502
4	Ward	4	-0.9515	0.3826	0.0147	-0.8775	0.3860	0.0253	**-11.402**	**0.3761**	**0.0032**	-12.112	0.3793	0.0019	-11.600	0.3852	0.0034
5	Ward	6	-0.1995	0.3928	0.6128	-0.09227	0.4010	0.8185	**-0.1146**	**0.3952**	**0.7725**	-0.1445	0.4015	0.7198	-0.2718	0.4103	0.5093
6	Ward	5	0	.	.	0	.	.	**0**	.	.	0	.	.	0	.	.
7	DPC10		.	.	.	.	.	.	.	.	.	0.07731	0.03404	0.0238	-0.05323	0.1624	0.7434
8	Intercept		0.7742	0.3893	0.0497	12.562	0.8761	0.1550	**20.547**	**0.9524**	**0.0336**	21.862	10.031	0.0319	55.360	21.346	0.0111
9	Proficiency10		.	.	.	0.02696	0.03886	0.4884	**0.008953**	**0.03777**	**0.8128**	0.004113	0.04037	0.9189	0.01304	0.04105	0.7510
10	registr10		.	.	.	.	.	.	.	.	.	-0.1868	0.07268	0.0106	0.01453	0.3136	0.9631
11	Workdistr0		.	.	.	.	.	.	.	.	.	-0.05222	0.1745	0.7650	15.868	0.5121	0.0021
12	selfeffic0		.	.	.	-0.2058	0.2200	0.3504	**-0.1258**	**0.2129**	**0.5550**	-0.1501	0.2150	0.4857	-0.05340	0.2182	0.8069
13	pctRN10		.	.	.	.	.	.	**0.08333**	**0.05245**	**0.1132**	0.07326	0.05231	0.1624	-0.4732	0.2102	0.0251
14	supportcoll		.	.	.	.	.	.	**-0.2383**	**0.06734**	**0.0005**	-0.2347	0.06748	0.0006	-0.1703	0.2761	0.5378
15	supportmgt		.	.	.	.	.	.	**-0.08150**	**0.05222**	**0.1197**	-0.08573	0.05187	0.0994	0.09928	0.2245	0.6587
16	interruption0		.	.	.	.	.	.	.	.	.	0.06297	0.1228	0.6085	-10.060	0.3453	0.0039
17	wlmod1_10		0.1370	0.02218	<.0001	0.1354	0.02222	<.0001	**0.1411**	**0.02152**	**<.0001**	0.1363	0.02164	<.0001	-0.1996	0.1685	0.2370
18	wlmod1_10*DPC10		.	.	.	.	.	.	.	.	.	.	.	.	0.01198	0.01429	0.4028
19	wlmod1_10*registr10		.	.	.	.	.	.	.	.	.	.	.	.	-0.01203	0.02546	0.6369
20	wlmod1_10*workdistr		.	.	.	.	.	.	.	.	.	.	.	.	-0.1439	0.04323	0.0010
21	wlmod1_10*pctRN10		.	.	.	.	.	.	.	.	.	.	.	.	0.04267	0.01801	0.0185
22	wlmod1_10*supportcoll		.	.	.	.	.	.	.	.	.	.	.	.	-0.00399	0.02451	0.8708
23	wlmod1_10*supportmgt		.	.	.	.	.	.	.	.	.	.	.	.	-0.01592	0.01991	0.4246
24	wlmod1_10*interruption		.	.	.	.	.	.	.	.	.	.	.	.	0.09891	0.02954	0.0009

Obs	*Descr*	*Mod1*	*Mod2*	*Mod3*	*Mod4*	*Mod5*
1	-2 Log Likelihood	1029.7	1028.5	997.5	988.2	947.2
2	AIC (Smaller is Better)	1047.7	1050.5	1025.5	1024.2	997.2
3	AICC (Smaller is Better)	1048.2	1051.2	1026.6	1026.0	1000.7
4	BIC (Smaller is Better)	1071.1	1079.0	**1061.9**	1070.9	1062.1

Appendix 1 (4 of 5)

Outcome: Emotional load Mixed models: daily experience workload vs. calculated workload according to model. Fixed effects & fit statistics for 5 models.

			Model 1			Model 2			**Model 3**			Model 4			Model 5		
Obs	*Effect*	*Ward*	*est1*	*stderr1*	*pval1*	*est2*	*stderr2*	*pval2*	***est3***	***stderr3***	***pval3***	*est4*	*stderr4*	*pval4*	*est5*	*stderr5*	*pval5*
1	Ward	1	-0.07633	0.2585	0.7684	-0.06649	0.2580	0.7972	**-0.2152**	**0.2617**	**0.4130**	-0.1848	0.2652	0.4876	-0.1821	0.2621	0.4889
2	Ward	2	0.2829	0.2544	0.2690	0.2976	0.2560	0.2480	**0.1109**	**0.2599**	**0.6705**	0.1050	0.2640	0.6917	0.06380	0.2623	0.8084
3	Ward	3	-0.2096	0.2534	0.4103	-0.1932	0.2541	0.4490	**-0.2721**	**0.2569**	**0.2923**	-0.2781	0.2583	0.2845	-0.2601	0.2531	0.3068
4	Ward	4	-0.2066	0.2515	0.4134	-0.1649	0.2546	0.5189	**-0.3038**	**0.2577**	**0.2415**	-0.3167	0.2597	0.2258	-0.3294	0.2561	0.2016
5	Ward	6	0.1254	0.2588	0.6291	0.1753	0.2655	0.5107	**0.2258**	**0.2718**	**0.4083**	0.1969	0.2759	0.4774	0.1657	0.2729	0.5454
6	Ward	5	0	.	.	0	.	.	**0**	.	.	0	.	.	0	.	.
7	DPC10		.	.		.	.	.	.	.	.	0.008247	0.02124	0.6981	0.08683	0.1046	0.4070
8	Intercept		0.9977	0.2516	0.0001	13.807	0.5792	0.0192	**14.365**	**0.6443**	**0.0282**	17.140	0.6764	0.0130	21.804	13.844	0.1188
9	Proficiency10		.	.		0.007205	0.02589	0.7810	**-0.00229**	**0.02628**	**0.9306**	-0.01064	0.02800	0.7041	-0.00856	0.02741	0.7552
10	registr10		.	.	.	.	.	.	.	.	.	-0.1186	0.04528	0.0092	-0.1381	0.2016	0.4938
11	Workdistr0		.	.	.	.	.	.	.	.	.	-0.02904	0.1206	0.8099	0.6937	0.3320	0.0375
12	selfeffic0		.	.	.	-0.1298	0.1461	0.3749	**-0.08491**	**0.1476**	**0.5654**	-0.1100	0.1487	0.4603	-0.07297	0.1456	0.6167
13	pctRN10		.	.	.	.	.	.	**0.08584**	**0.03272**	**0.0092**	0.07492	0.03272	0.0227	-0.1981	0.1352	0.1441
14	supportcoll		.	.	.	.	.	.	**-0.1197**	**0.04253**	**0.0052**	-0.1303	0.04270	0.0025	-0.02897	0.1779	0.8707
15	supportmgt		.	.	.	.	.	.	**-0.02090**	**0.03255**	**0.5214**	-0.01800	0.03240	0.5790	0.1190	0.1446	0.4111
16	interruption0		.	.	.	.	.	.	.	.	.	0.05384	0.08495	0.5267	-0.2800	0.2241	0.2124
17	wlmod1_10		0.03952	0.01370	0.0042	0.03906	0.01372	0.0047	**0.04301**	**0.01335**	**0.0014**	0.04449	0.01347	0.0011	-0.01364	0.1086	0.9001
18	wlmod1_10*DPC10		.	.	.	.	.	.	.	.	.	.	.	.	-0.00679	0.009209	0.4616
19	wlmod1_10*registr10		.	.	.	.	.	.	.	.	.	.	.	.	0.004399	0.01637	0.7884
20	wlmod1_10*workdistr		.	.	.	.	.	.	.	.	.	.	.	.	-0.06397	0.02792	0.0227
21	wlmod1_10*pctRN10		.	.	.	.	.	.	.	.	.	.	.	.	0.02274	0.01158	0.0505
22	wlmod1_10*supportcoll		.	.	.	.	.	.	.	.	.	.	.	.	-0.00855	0.01580	0.5887
23	wlmod1_10*supportmgt		.	.	.	.	.	.	.	.	.	.	.	.	-0.01165	0.01282	0.3642
24	wlmod1_10*interruption		.	.	.	.	.	.	.	.	.	.	.	.	0.03136	0.01909	0.1016

Obs	*Descr*	*Mod1*	*Mod2*	*Mod3*	*Mod4*	*Mod5*
1	-2 Log Likelihood	651.6	650.8	628.1	620.9	598.6
2	AIC (Smaller is Better)	669.6	672.8	656.1	656.9	648.6
3	AICC (Smaller is Better)	670.0	673.4	657.2	658.7	652.1
4	BIC (Smaller is Better)	692.9	701.3	**692.4**	703.6	713.5

Appendix 1 (5 of 5)

Outcome: Physical load Mixed models: daily experience workload vs. calculated workload according to model. Fixed effects & fit statistics for 5 models.

			Model 1			Model 2			**Model 3**			Model 4			Model 5		
Obs	*Effect*	*Ward*	*est1*	*stderr1*	*pval1*	*est2*	*stderr2*	*pval2*	***est3***	***stderr3***	***pval3***	*est4*	*stderr4*	*pval4*	*est5*	*stderr5*	*pval5*
1	Ward	1	0.7192	0.3986	0.0744	0.7311	0.3975	0.0691	**0.5150**	**0.3839**	**0.1830**	0.4031	0.3880	0.3016	0.3260	0.3876	0.4025
2	Ward	2	0.9822	0.3913	0.0138	10.028	0.3938	0.0125	**0.7390**	**0.3807**	**0.0553**	0.6127	0.3860	0.1159	0.5128	0.3872	0.1887
3	Ward	3	0.4593	0.3916	0.2439	0.4804	0.3923	0.2239	**0.3376**	**0.3777**	**0.3738**	0.2861	0.3793	0.4526	0.2658	0.3764	0.4819
4	Ward	4	0.05986	0.3871	0.8774	0.1151	0.3915	0.7695	**-0.1025**	**0.3776**	**0.7867**	-0.1298	0.3799	0.7334	-0.1504	0.3790	0.6925
5	Ward	6	-0.02429	0.4004	0.9518	0.04291	0.4108	0.9170	**0.03846**	**0.3993**	**0.9235**	0.1007	0.4050	0.8042	-0.07100	0.4050	0.8612
6	Ward	5	0	.	.	0	.	.	**0**	**.**	**.**	0	.	.	0	.	.
7	DPC10		.	.	.	.	.	.	.	.	.	0.09237	0.02858	0.0014	0.2167	0.1391	0.1202
8	Intercept		10.474	0.3752	0.0064	15.621	0.8936	0.0838	**21.502**	**0.9348**	**0.0237**	17.627	0.9764	0.0744	65.533	18.875	0.0008
9	Proficiency10		.	.	.	0.009633	0.04046	0.8120	**-0.00359**	**0.03894**	**0.9266**	-0.00593	0.04138	0.8861	-0.00734	0.04110	0.8585
10	registr10		.	.	.	.	.	.	.	.	.	-0.1090	0.06129	0.0764	-0.5341	0.2670	0.0464
11	Workdistr0		.	.	.	.	.	.	.	.	.	0.1455	0.1779	0.4140	0.2578	0.4515	0.5685
12	selfeffic0		.	.	.	-0.1745	0.2271	0.4429	**-0.1053**	**0.2180**	**0.6293**	-0.1197	0.2195	0.5858	-0.07773	0.2179	0.7215
13	pctRN10		.	.	.	.	.	.	**0.07629**	**0.04405**	**0.0843**	0.07767	0.04366	0.0763	-0.6043	0.1792	0.0008
14	supportcoll		.	.	.	.	.	.	**-0.2248**	**0.05772**	**0.0001**	-0.2141	0.05754	0.0002	-0.2011	0.2366	0.3959
15	supportmgt		.	.	.	.	.	.	**-0.03337**	**0.04387**	**0.4475**	-0.04139	0.04330	0.3399	-0.1148	0.1921	0.5507
16	interruption0		.	.	.	.	.	.	.	.	.	0.1195	0.1257	0.3423	-0.1988	0.3055	0.5158
17	wlmod1_10		0.04404	0.01834	0.0169	0.04353	0.01837	0.0184	**0.04746**	**0.01784**	**0.0082**	0.03762	0.01787	0.0362	-0.3951	0.1450	0.0068
18	wlmod1_10*DPC10		.	.	.	.	.	.	.	.	.	.	.	.	-0.01056	0.01231	0.3914
19	wlmod1_10*registr10		.	.	.	.	.	.	.	.	.	.	.	.	0.04026	0.02178	0.0656
20	wlmod1_10*workdistr		.	.	.	.	.	.	.	.	.	.	.	.	-0.01087	0.03740	0.7716
21	wlmod1_10*pctRN10		.	.	.	.	.	.	.	.	.	.	.	.	0.05807	0.01532	0.0002
22	wlmod1_10*supportcoll		.	.	.	.	.	.	.	.	.	.	.	.	-0.00103	0.02102	0.9609
23	wlmod1_10*supportmgt		.	.	.	.	.	.	.	.	.	.	.	.	0.007278	0.01707	0.6701
24	wlmod1_10*interruption		.	.	.	.	.	.	.	.	.	.	.	.	0.03027	0.02567	0.2394

Obs	*Descr*	*Mod1*	*Mod2*	*Mod3*	*Mod4*	*Mod5*
1	-2 Log Likelihood	896.3	895.7	866.0	853.6	832.2
2	AIC (Smaller is Better)	914.3	917.7	894.0	889.6	882.2
3	AICC (Smaller is Better)	914.7	918.4	895.1	891.5	885.8
4	BIC (Smaller is Better)	937.6	946.2	**930.3**	936.3	947.1

Chapter 7

General Discussion

General Discussion

Although workload of nurses has been a much-studied topic for years, there is not yet consensus on how to objectively assess whether nursing capacity is optimally matched to patient needs. A fair and sensible distribution of nursing staff across wards is desirable in order to keep nurses healthy and motivated, ensure quality of care, and efficiently staff wards. Since workload of nurses seems to be increasing and can have a profound effect on both patient and nurse outcomes, many researchers have studied an extensive array of variables related to workload. A wide range of existing research discusses how specific variables influence or predict nurses' workload: patient characteristics (for example age, body mass index), consequences of treatment (such as pressure ulcers or amount of complications), nursing diagnoses (for instance impaired mobility or acute confusion), nurse practice environment (amongst others hospital and unit level management, nurse-physician relationship), ward-specific characteristics (for example ward layout), the nursing team (including perceptions of teamwork) and individual nurse characteristics (such as working experience or perceived self-efficacy). This field is well researched but includes few studies on predicting objective measures of workload and even less longitudinal research. We contributed to this field of study by developing a workload management method based on an objective measure of workload that can be used to assess and give an indication of workload levels on hospital wards and evaluate differences in workload and operational effectiveness between wards. In addition to this, we also examined the relation of this objective workload measure with five dimensions of perceived workload and considered the impact of specific personal resources, job demands and job resources on this relation. Research data were collected on six wards, over a period of 15 consecutive working days: this multi-level, longitudinal character of the study helps understand the differences between wards and reduces the effects of unknown confounders.

In this general discussion, first the main research findings presented in this thesis are summarized per chapter. This is followed by a reflection on the practical implications of these findings for managing nurses' workload in hospital wards, including an overview of the challenges that remain, strengths and limitations of the study and recommendations for further research. The discussion ends with the overall conclusions of the thesis.

Designing a method to balance nurses' workload

The second chapter of this thesis unfolded the development of a new workload management method for nurses on hospital wards. In this workload management method, required nursing time for direct patient care and non-(direct) patient related activities were estimated based on objective measurements, and offset to the total allocated nursing time. The ratio of required and allocated nursing time gives a modelled estimate of workload of nurses. Estimating this ratio is not new; however, the approach we used to calculate the required and allocated nursing times is. In our study design, we planned the following steps in developing the workload management method. First, expert nurses were to compose a set of patient characteristics that they expected to have the biggest impact on care time. We would give the experts complete freedom to choose the characteristics that they felt mattered most. Next, a work sampling study was to be done on the six wards involved in the study, where nurses were observed during fifteen consecutive dayshifts. Trained observers would register all nurses' activities and in case the activity was patient-related, the relevant patient identification number was to be recorded as well. During the work sampling period, nurses would also register on a daily basis the characteristics that applied to each patient on the ward. Results of the work sampling study and the registration of patient characteristics were to be combined to calculate additional care time per patient characteristic. Since we would be dealing with multi-level, longitudinal data, linear mixed effects models should be used to analyze the data. The work sampling study would also yield an estimate of a baseline care time: this is time that is spent on patients regardless of the patient characteristics. Nursing time needed for non-patient related activities would also be derived from the work sampling study results. Required care time for a day on a ward would be estimated by adding up the patient related care times for all patients admitted to the ward and adding required nursing time for non-patient related activities for all nurses on duty on the ward. Allocated care time was to be estimated by adding up all nurses assigned to a shift, multiplying this by the shift duration and correcting the result for nurse proficiency. Nurse proficiency was to be expressed as a percentage and estimated by ward management of the wards involved in this study. Six types of nurses were distinguished, based on the level of education and working experience. A fully qualified, registered nurse with more than one year of experience was considered the standard and was set to 100%. The other types of nurses were offset to this standard, based on the expert opinion of the ward management.

Following implementation of the patient characteristics registration in our standard working procedures, we expected that after a certain period of time historic data on patient characteristics could be used to compose patient characteristics profiles. For example, for each patient who has

undergone a certain type of operation, historic data could tell us which patient characteristics are likely to apply on each day of admission. In this way, we would be able to predict nurses' workload based on the schedule of planned operations and align the schedule in such a way that nurses' workload is optimal.

In the initial study design, we described correcting the allocated care time for nurse proficiency, since a fully qualified, experienced registered nurse is likely to be able to handle more work than a student nurse. Further along in the research we realized that in order to be consistent, the required care time should also be corrected for nurse proficiency, since qualified and experienced nurses are also likely to perform tasks faster than student nurses. So, both sides of the workload equation needed to take nurse proficiency into account. This was not planned in the original study design but was included as the study progressed.
There is one more deviation from the plan that needs to be mentioned. In the original study design, we planned to study the relation between the modelled workload and the perceived workload. Other factors that may influence perceived workload such as job resources and personal resources were initially not in scope of the study. However, during the course of the research, only focusing on the effect of modelled workload on the perceived workload seemed too narrow a scope. In order to avoid missing an opportunity, several job demands, job resources and personal resources were included in the study. The following variables were included: perceived interruptions, equal work distribution, proportion of time spent on registration, proportion of time spent on direct patient care (all regarded as job demands), proportion of registered nurses on a ward, support from management, support from colleagues (job resources), self-efficacy and individual nurse proficiency (personal resources). These variables were tested for their effect on the relation between modelled workload and perceived workload and on direct effects on the outcome measures.

Defining patient characteristics

We chose to develop a workload management method that was partly based on calculating the effect of the presence of certain patient characteristics on nurses' workload. Measuring the effect of patient characteristics on care time is rare in this field of research; classification of patients in classes of varying nursing intensity is more common. Several studies [1-3] classify patients by asking nurses to award points or a score to areas of nursing need or care areas. Scores are added up and patients are classified in one of four (or in some studies more) classes. Each class corresponds with a level of nursing intensity and overall scores can be used assess nursing intensity on a ward, for example by offsetting scores to a predefined optimum level. The classes

usually range from minimal care to intensive care; if only four classes are used, each represents a broad range of required care. In our study, we aimed to be more specific and quantify the required care time per patient, based on a baseline care time that is always needed for any patient that is admitted to a ward and an additional required care time per patient based on the presence of certain patient characteristics. The third chapter of this thesis describes how we defined a new set of patient characteristics that can be used to predict required care time. Expert nurses from all six wards involved in the study had complete freedom in determining a list of patient characteristics that they believed to have the biggest influence on care time provided by nurses. A four phase Delphi study was set up, and fifteen expert nurses (all senior nurses or team leaders) were involved in this study. In the different phases of the Delphi study, a list of patient characteristics was drafted, reviewed, tested and reviewed again. This resulted in a set of fifteen patient characteristics that were expected to be most relevant to care time: 'partial assistance bathing/mobilization', 'full assistance bathing/mobilization or care for incontinent patient', 'full assistance meals, providing drip feed (portioned or by triple lumen) or TPN (Total Parenteral Nutrition)', 'two or more IV/drip/drain', 'inspection or minor activity every 1 or 2 hours', 'inspection or minor activity several times an hour', 'exceptional bodily proportions', 'emergency admittance, complex discharge procedure, external transfers or extensive health education', 'other specialty/complex co-morbidity', 'unstable', 'psychosocial support', 'extensive wound/fistula and/or VAC (Vacuum Assisted Closure) bandages', 'new stoma', 'isolation measures', 'one on one care'. The set includes both personal patient characteristics (bodily proportions, psychosocial condition) and consequences of disease or treatment (isolation measures, number of IV or drains, assistance with meals). Content validity was ensured by the repeated Delphi procedure with expert nurses. When the nurses were asked to prioritize the characteristics, results showed that characteristics related to disease or treatment were expected to have the biggest influence on care time.

Several other studies have also examined characteristics that influence care time. Our findings correspond with previous studies in many ways; we found characteristics that roughly match results from other studies, although we chose a different clustering for certain patient characteristics. We also found characteristics that were not described in literature before.
For example other studies separated monitoring of vital signs and clinical signs, but we chose to combine these and also included small nursing activities in the characteristic 'inspection or minor activity every 1 or 2 hours' and 'inspection or minor activity several times an hour'. We separated these characteristics based on the frequency of these smaller activities and not on the type of

activity. We made this decision because defining these smaller activities separately would have made the checklist of patient characteristics longer. Furthermore, these activities do not often occur simultaneously for one patient on one shift and if they do, nurses tend to combine these activities in one visit to the patient in order to save time. If in that case all would be registered separately, the measurements may give the wrong indication of required time.
We also clustered emotional support and care for disoriented patients in one characteristic, psychosocial support, and this is combined with amongst others retardation and language barriers. Where possible we combined characteristics, especially when characteristics were in the same domain (for example psycho-social care) and it was expected that the chances of them occurring simultaneously were small.

Our study included several characteristics that had not been studied before for their relation to care time or nurses' workload, for example characteristic 'unusual bodily proportions of the patient'. In other studies, body mass index is mostly used. However, assisting a very tall (and thus heavy) patient with bathing can require quite some time, even when the patient's body mass index is normal.
One-on-one care is also a new characteristic. This had not been mentioned or described in previous studies. One-on-one care is technically not a patient characteristic, but was included as a way to register that one nurse was busy caring for one specific patient during an entire shift. This characteristic was added after practical testing of a draft patient characteristics checklist. In the test period, we found that for some very complex patients, registering only the separate patient characteristics did not reflect the actual amount of care that was required. Hence we introduced this new characteristic, which can be used when the total amount of required care exceeds the sum of required care related to the separate characteristics.

Studying nurses' activities

In chapter four, we discuss the results of an observational study on nurses' activities. We measured how much time nurses spent on different activities, by performing a work sampling study. During this work sampling study, all nurses in the dayshift were observed approximately every ten minutes; observation times were computer generated and randomized with an average of ten minutes between observations. Independent observers were selected and carefully trained. Observers registered three items with each observation: the name of the nurse; the activity the nurse was performing; and in case the activity was patient-related, the patient identification number. The study examined all activities of nurses on the wards: direct patient care (care attributed to an individual patient), collective patient care (patient related tasks but not

attributable to individual patients, e.g. meal distribution), general tasks (other activities that were not directly patient related such as general administration, meetings, education) and other tasks (breaks and personal time) [4].

We found that nurses spent between 40.1 % and 55.8 % of their time on direct patient care. We also analyzed data per ward and found significant differences between wards for 10 of the 21 activity groups. Activity groups "Education/guidance" and "Medication preparation" showed the biggest differences between wards, followed by activity groups "Assistance meals/excretion", "Communication patient/family", "Personal care" and "Meetings". The differences in the last category would be especially interesting to examine further.

Duffield developed a list of activity groups that is widely used [5]. Our list is similar, however there is one important difference. This list contains categories called "Direct care" and "Indirect care" that both concern patient related activities. Activities for specific patients are classified as direct or indirect, based on the location of the nurse (with the patient or away from the patient). One of our study aims was to determine how much time nurses spend on patients with specific characteristics. We defined activity categories "Direct patient care" and "Collective patient care", where "Direct patient care" only includes activities that can be linked to one specific patient. For example "Handover" is not classified as direct patient care but as collective patient care, because during a handover, each patient is discussed only for a short time. If during a work sampling study, a handover meeting would be observed and the full 10 minutes were attributed to the patient being discussed at that moment, it would be an unfair allocation of time to that one patient. For this reason, we cannot directly compare our categories to Duffield's categories. It is possible though to compare the sum of these two categories.
Rasmussen [6] presents an overview of studies, where the sum of direct care plus indirect care varies between 59.7% to 67.6%. Our study showed an average of 60.9% for the equivalent of these two categories, which is relatively low in comparison. This may be explained by the fact that our research was done in an academic hospital, with a workforce that contains more than one third nursing students. We found that the wards that spent the most time on educational activities also spent the least time on direct patient care.

Relating patient characteristics to care time

In chapter five, we tested whether or not the items in the newly developed list of patient characteristics influence care time and if so, to what extent. We were also interested in whether there were differences between wards in care time for patients with a specific profile. For this

purpose, the results of the work sampling study were combined with the daily registration of patient characteristics during the work sampling period. A mixed effects model was used to test significance and estimate additional care time associated with each patient characteristic. Means were derived from the model to estimate average care time for a patient with an average patient characteristic profile and for a patient with a profile where none of the characteristics apply. The care time associated with the latter profile was considered to be the baseline care time; this is the time that nurses spend on patients regardless of the presence of any of the patient characteristics.

We corrected both the numerator and denominator of the workload ratio (required care time and allocated care time) for nurse proficiency. By means of a mini-Delphi study, six types of nurses were distinguished based on education and level of experience. Corresponding nurse proficiencies were estimated for each type of nurse. The Delphi group consisted of nurse management of all six wards involved in the study; all nurses with fifteen years of working experience or more. Proficiency is expressed as a percentage and ranges between 0-100%, where 100% is the standard for a fully qualified registered nurse with a minimum of one-year experience. The source data of the work sampling study were corrected for nurse proficiency by multiplying observed care times with the proficiency percentage of the nurse that provided the care.

The model found 9 patient characteristics that were significantly related to care time. These characteristics concerned requiring 'partial assistance bathing, mobilization', 'full assistance bathing, mobilization, care for incontinent patient', 'full assistance meals, drip feed, TPN, 'psychosocial support', 'extensive wound care, fistula, VAC bandages', 'new stoma', 'isolation measures' or 'one-on-one care' . Most characteristics required on average an additional 18 to 35 minutes of care time, with the exception of 'two or more IV/drip/drain' (8 minutes) and 'one-on-one care' (156 minutes). The mean daily care time for patients with a profile where none of the characteristics apply (the baseline care time) was found to be between 44 and 57 minutes. Mean daily care time for patients with an average patient profile (of the patient characteristics in our study) was between 75 and 88 minutes. Variation between wards was due to proficiency of nurses, patients, and day-to-day variation within patients. The model explained more variance (R^2) between patients than within patients, 36% and 22% respectively, which is relatively low. This was unexpected, considering the fact that expert nurses were given complete freedom to select those characteristics that they thought to be most relevant to care time. Some relevant factors may have been left out because they were less obviously related to care time for the expert

nurses. The work sampling study might give some clues. Results indicated that 26% of direct patient care consists of administration and reporting and 12% of communication with patients or their families. This is quite a substantial portion of direct patient care. Certain medical or patient conditions may require additional registration, for example risk assessments on malnutrition or falling. Or additional consultation is required, for example if the patient is in a critical condition. These factors were not included in this study. However, the unexplained variance may also be related to more subjective variables such as the personality of the patient or the nurse. Certain patients may claim or be given more care time than others, regardless of their condition. Whether or not a patient and a nurse connect on an personal level may be of importance. Previous studies also identified variables such as the number of work interruptions [7, 8] patient turnover [7, 9, 10], ward related factors such as available support staff or logistic workers and ward layout [7] as factors of importance, however these were not included in this study. There is evidence that comforting and talking to patients is the task most often left undone [9]. Depending on workload, there may or may not be time for this, which may explain part of the variation. Another explanation that we considered is the academic setting. In this setting, many patients require multidisciplinary care; caregivers of many different specialties may be involved in the treatment process. This makes care harder to coordinate and possibly not optimally organized. For example, doctors of different specialties may need to visit the patient and they may not be all available at the same time. That means that activities such as wound inspection might have to be done more than once on a day and consequently care time of nurses may be higher than necessary. The way that care is organized can therefore also impact care time of nurses; further research in that area is recommended.

One-on-one care is a new patient characteristic, that indicates that one nurse was dedicated to only one patient during the entire shift. Chapter 4 showed that nurses spent 40 to 56% of their working day on direct patient care. On the wards where one-on-one care was most often registered (wards 2, 5 and 6) this was between 192 and 227 minutes of direct care time per nurse in a day shift. Subtracting the average baseline care time results in a range of 140-175 minutes of direct care time available per nurse on the dayshift. The average care time of one-on-one care was 156 minutes, which confirms that indeed a nurse then spends the entire shift on one patient. The characteristic concerning small inspections/activities turned out not to be significantly related to care time. These activities may be done when nurses are in the room with the patient anyway for other, more time-consuming, activities. There were only 17 observations for the characteristic

regarding exceptional bodily proportions of the patient, which may be an explanation as to why this characteristic was not significant to care time.
The baseline care time was found to be between roughly 45 minutes and an hour. That is quite a lot of time that is not explained by the patient characteristics. This can concern time related to medication, reporting, meals, or just having an informal chat with the patient or their family. More research is needed on the elements that make up the baseline care time, in order to better understand if relevant patient characteristics may have been missed.

When correcting data for nurse proficiency, we found a remarkable difference in the estimated means. In the means of the model with the original source data, ward 6 stood out; more time was spent for the same type of patient on this ward than on any of the other wards. However, after correcting for nurse proficiency, there was no longer a difference. The workforce of ward 6 contains more student nurses than the workforce on the other wards, and because of this, correcting for nurse proficiency eliminated the difference in care time.

We have shown that correcting for nurse proficiency is essential; leaving it out can lead to distorted results and make wards appear less efficient than they really are. If proficiency is not taken into account, hospital or unit level management may draw incorrect conclusions, which may lead to an unfair distribution of nursing staff between wards.

Modelling workload

We assumed that we could influence the perceived workload by balancing the modelled workload. In chapter six, first we determined and discussed the modelled workload and the five measures of perceived workload, and then we analyzed the relation between the modelled and the perceived workload measures. We also included the effects of specific job demands (proportion direct patient care, proportion registration, interruptions, equality of work distribution, job resources (support colleagues, support management, proportion registered nurses) and personal resources (self efficacy, proficiency) on this relation.

The modelled workload is the ratio of required care time and allocated care time and is expressed as a percentage. A modelled workload of 100% represents a perfect fit, higher than 100% means that a department is understaffed and lower indicates overstaffing. In our study, the average workload per ward per day ranges roughly between 70% and 170%. Significant differences were found between wards 6 and 1, 6 and 4 and 3 and 4. The estimated differences between these wards were substantial, over 30%, but so were the corresponding confidence intervals. For future

research, a larger sample size is recommended in order to make a more accurate estimate of differences between wards.
When studying the average results of perceived workload measures per ward per day, perceived work pace and perceived amount of work showed a similar pattern. In the Questionnaire on the Experience and Evaluation of Work (QEEW) [11] these two measures are part of the same construct: work pressure. We decided to consider these separately. Perhaps one or more of the covariates would have a different effect on perceived work pace than on perceived amount of work. This happened to be the case because percentage of time spent on registration was correlated with perceived amount of work but not with work pace. In future research, studying these two as separate constructs may be useful. Emotional load did not appear to depend on modelled workload, and was on average lower than the other measures. Outcome measure physical load showed the same, although to a lesser extent.

The first hypothesis was confirmed, since we found a positive correlation between the modelled workload and all five perceived outcome measures. Modelled workload had the biggest effect on work pace, amount of work and mental workload. Since modelled workload in our study is the ratio between required and allocated care time, it is logical that it relates to work amount and pace and not to emotional and physical requirements. The effect on mental load can be explained by the fact that when the ward is not adequately staffed, tasks that require focus and concentration need to be done under time pressure. Modelled workload varied roughly between 70% and 170% and every 10% increase of the modelled workload resulted in a maximum increase of 7.5 % of the perceived workload. It seemed that perceived workload did not rise to the same extent as modelled workload. However, the answer range for all perceived workload measures was 1 to 5, so respondents did not have an extensive range to express their perceptions of workload. A broader range of response options might have yielded different results.

Personal resources self-efficacy and proficiency were not significantly related to any of the outcome measures, so there was no evidence to support hypothesis two. The internal consistency of the items that were used to measure self-efficacy was low however, so we recommended that future research uses other, validated scales for self-efficacy.
There is evidence [12] that shows that under conditions without time pressure, nurses with clinical expertise (i.e. more proficient nurses) performed better than novice nurses; but this was not the case for conditions with time pressure. In our study, proficiency of nurses was not significantly related to workload. The average modelled workload was higher than 100% in most

wards, which indicates understaffing. This might explain why no significant relation between proficiency and perceived workload was found.

We found that an increase in job demand proportion of direct patient care results in increased perceptions of work pace and amount of work. Possibly, time spent with the patient is regarded as more demanding; patient related tasks may be considered to be more pressing than other tasks. An increase in proportion of time spent on registration resulted in a decline in perceived amount of work. Registration might be regarded as a less demanding task because it usually takes place in a more quiet environment, away from the patient and potential corresponding pressures of patients and relatives.
Unexpectedly, perceived work interruptions seemed irrelevant to perceived workload. Because available literature [8, 13] reported a negative correlation between interruptions and patient safety, a positive correlation between interruptions and perceived workload was expected, at least with outcome measure perceived mental load. Perceived equality in work distribution was also not proven to be correlated to any of the workload outcome measures. To our knowledge there is no available literature on the effects of equal work distribution in the day shift on perceived workload. There are studies on distributive organizational justice (which reflects the perceived fairness in decision outcomes, such as work scheduling), and these suggest a negative correlation between distributive justice and intention to leave [14] and a positive correlation between distributive justice and quality of work life (for example psychological well-being, workload and work satisfaction)[15]. Assuming that equal work distribution would be also perceived as a fair distribution, a positive correlation between equal work distribution and perceived workload was expected but not found. However, upon studying the different model fits for all outcome measures, there was a notable finding. For outcome measure perceived mental workload, two models scored similarly on the measure of model fit: the model with all personal and job resources and all job demands, and the model that also included interactions. The model with interactions indicated a significant moderation on the relation between modelled and perceived workload for the job demands work interruptions and equality of work distribution.

The job resources support from colleagues and proportion of registered nurses were significantly related to perceived workload. Support from colleagues proved to be an important factor in workload perception, since it was negatively correlated to all outcome measures. This is in line with findings of other studies [16-18], where teamwork was shown to offset negative effects of high workload. That the effect of teamwork was found to be less strong on the outcome

perceived emotional workload was unexpected; apparently support from colleagues was more important in handling workload in the cognitive and physical domain than in coping with emotional challenges.

The percentage of registered nurses on the ward was positively correlated with the perceived emotional workload, although not very strongly. We expected that registered nurses would be better equipped to handle emotional stressors than student nurses but that appears to be too simplistic. Possibly, registered nurses feel more responsible for their work than student nurses, which may increase emotional load. Or perhaps registered nurses are more likely to be given the more emotionally challenging tasks than student nurses. More research is needed to explain this effect.

Perceived support from management did not turn out to be significantly related to any of the outcome measures. A study by MacPhee [19] did show that support of unit-level management in managing workload could have positive effects on perceived quality of care and job outcomes, but this study did not test the direct relation between support of management and perceived workload. In the present study, the relation between support from management and workload was tested, but could not be proven. When considering which support is more important to nurses, apparently sticking together as a team is more important to how workload is perceived than feeling supported by ward leadership. When balancing workload, ward leadership can help by enhancing teamwork and teambuilding on the ward.

For all outcome measures, the models without the interactions fit better than the models with interactions. This means that we only found evidence for direct effects and insufficient evidence for moderation. More research is recommended on the effects of perceived interruptions and perceived equality of work distribution on perceived mental workload, because the model that included moderation was almost as good as the model without.

From burned out to balanced (practical implications)

This study has interesting implications both from an operational excellence and a organizational psychology perspective. In our context, operational excellence concerns the process of focusing on the patients' needs, keeping the employees positive and empowered, and continually improving the current activities in the workplace. Balancing workload optimally will prevent inefficiencies related to overstaffing wards, and will also help ensure high levels of quality of care and contribute to retaining scarce nursing staff. It should prevent absenteeism and health issues such as emotional exhaustion and burnout.

Our research suggests a new way of determining workload in an objective manner and exhibits a positive correlation between this modelled workload and workload as perceived by nurses. This indicates that the modelled workload is a valid instrument to measure changes in perceived workload. When sufficient historical data have been collected, an average patient characteristics profile per admission day can be composed for treatments such as operations. With this, an indication of nurses' workload on surgical hospital wards can be predicted based on operating room schedules. This information can help in decision making around allocating staff across wards.

However, it is important to keep in mind that the modelled workload is not an accurate measure of objective workload: since the set of patient characteristics explained a maximum 36% of variation in care time and the confidence intervals for estimates of each characteristic were quite broad, predictions of absolute workload levels based on these patient characteristics can only give an indication of objective workload.

The set of relevant patient characteristics that we determined is short, easy to use, and gives an indication of which patient characteristics are most relevant to care time and to what extent. Calculating the estimated means per ward for a certain patient profile gives additional information on the differences in care time between wards for the same type of patients. This method has not been described in literature before and is a unique objective way of determining whether there are significant differences between wards in the amount of time that nurses spend on the same type of patients. Results can be a starting point for a discussion on the efficiency of different ways of working and learning from each other.

From testing the relationship between modelled and perceived workload, we learned that several job demands and resources are relevant in the context of balancing workload. **Figure 1** shows all job demands and resources in our study that were significantly related to perceived workload.

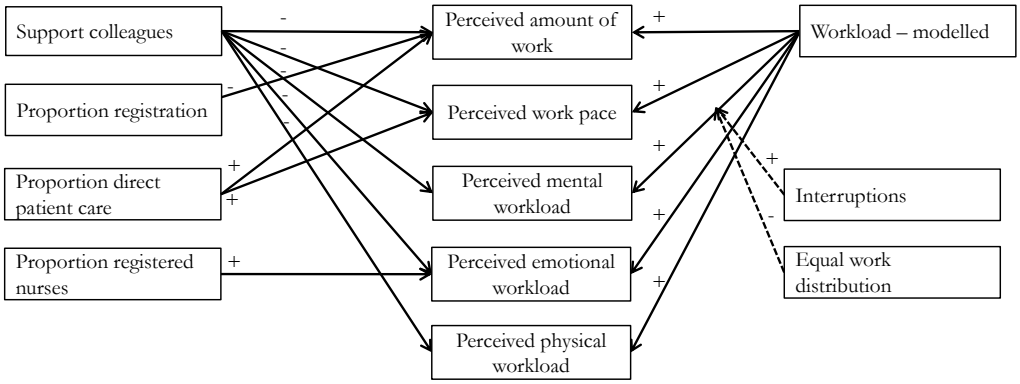

Figure 1: Variables with significant effects on perceived workload of nurses. The dotted lines represent possible moderation of job demands perceived interruptions and perceived equal work distribution on the relation between modelled workload and perceived mental workload. Lines marked with a + represent a positive correlation, lines marked with a – represent a negative correlation.

In addition to modelled workload, job resource support of colleagues and job demands time spent on direct patient care and time spent on registration had the largest effects on perceived workload. In times when workload is high, unit-level management can contribute to containing perceived workload by stimulating cooperation between ward nurses and promoting team spirit. Nurses involved in the study indicated that they were sometimes swamped with paperwork and mandatory registrations and did not get around to spending enough time with their patients. Because of this, we initially expected a negative correlation between the amount of time spent on direct patient care and perceived workload and a positive correlation between time spent on registration and workload. Results showed that the opposite is more likely to be true. However we do not assume that this means the more time spent on registration the better, but that the balance between time spent on registration and direct patient care is important to consider. More research is needed to understand the mechanisms around this. Future research should also include the effects of perceived interruptions and equality of work distribution on workload, because the model that found a significant moderating effect for these variables was almost as good as the model without moderation.

In the time study, we found significant differences between wards in how nurses spend their time. Especially the variation found in time spent on meetings is interesting to explore further, since there is no obvious reason that justifies this difference.

In future research, it could also be worthwhile to include measures of patient experiences and quality of care as perceived by patients, to see if the differences in time spent on direct patient care are associated with the patient experiences. To date, research primarily examines nurse reported quality of care; it would be valuable to include the experiences of the recipient of care as well.

Strengths and limitations

This thesis entails a longitudinal, multilevel study, which is rare in this field of research. The fact that objective (modelled) and subjective (perceived) workload measures were combined in one study is unique. Another strong feature of this study was that it was set up in close cooperation with nurses and nurse management; this strong involvement of the stakeholders led to a different approach in defining relevant patient characteristics and new views on how to include nurses' skills and experience in the workload equation. Nurses were in the lead and had complete freedom in determining a set of patient characteristics that they believed influenced care time the most. This resulted in a new set of characteristics, several of which had not been studied before, such as a patient's bodily proportions and one-on-one care. The effects of the patient characteristics on care time were quantified by work sampling over a relatively long study period of fifteen dayshifts.

In the work sampling study, trained, independent observers registered activities of nurses at random times, on average every ten minutes. Using independent observers, as opposed to self-reporting, reduced the risk of bias, for example by allocating too much or too little time to a task based on perceptions. The random time intervals helped prevent missing or overestimating times for certain standardized tasks. For instance if nurses had been observed at fixed time intervals, then too much or too little time might have been attributed to activities that take place on specific times, such as lunch breaks or handover meetings. Making pairwise comparisons between wards yielded valuable indications for possible differences in efficiency.

Nurses involved in the study stressed the importance of nurse proficiency in workload calculations and suggested a new way of defining nurse proficiency. Data were corrected for this newly defined nurse proficiency, which had not been done before and proved to be an important factor to include in the analyses. The proportion of students is relatively high in our study, since the study setting is an academic hospital and two of the wards in the study are also teaching wards with a high proportion of students. Correcting for nurse proficiency is especially relevant in such a setting.

A new concept 'baseline care time' was defined and quantified by estimating means from the mixed model, which has not been described in literature before.

The combination of a modelled workload measure and five perceived workload measures in one study is also new. Also, testing for moderation of job demands and job resources on the relation between the modelled and perceived workloads has not been done yet.
The overall response rates on the baseline measure questionnaire and the daily questionnaire that was used during the work sampling period were 65% and 70% respectively, which is considered to be quite good [20].

There are several limitations that need to be addressed. This study was set in an academic hospital, which makes it uncertain whether the study results can be readily applied to different settings, such as general hospitals. Nurses' activities and the patient mix in general hospitals are likely to be different than in academic hospitals. If this study were to be applied in such a setting, the framework could be the same, but the list of patient characteristics should be reviewed and the work sampling repeated.
The study is based on a random sample of nurses' activities, which gives an estimate of true care time. Activities were sampled approximately every ten minutes, which may not properly reflect reality, although overall there were a large number of observations in the study.
The number of observations per patient characteristic is limited for some characteristics, leading to uncertain estimates. During the time study 21% of the observation lists on patient characteristics were not filled in. The missing lists were randomly distributed across the time study days, patients and departments, so it is assumed that the missing data did not affect the study results.
Our model does not explain all variation in care time; at the start of the research we expected to explain a higher percentage of variation of care time with the new list of patient characteristics, since we gave expert nurses complete freedom to determine what they felt was most relevant to care time.
The confidence intervals for the estimated differences of modelled workload between wards were relatively high. For future research, a larger sample size is recommended in order to make a more accurate estimate of differences between wards.
The scales used to measure self-efficacy were chosen for practical reasons and were not validated by means of international publications. The scales proved not to be internally consistent; future research should include validated scales of self-efficacy. Since the scales do not sufficiently reflect the construct, no conclusion can be drawn about the effect of self-efficacy on perceived workload.
Perceived equality of work distribution and perceived interruptions were both measured once in

the baseline measurement, by one question. If more extensive or daily measures had been used, results might have been different. More research is recommended on this.
In this study, proficiency was estimated by a mini-Delphi study among head nurses. Another way to measure the proficiency of nurses would be to keep track of the actual exact time spent on each activity, calculate an estimate per activity per type of nurse and derive the proficiency percentage from these estimates. However, since there were 6 types of nurses and 24 activity groups in the study, this approach would have required a much larger sample size and a more accurate measurement of time spent on an activity than work sampling every ten minutes. For practical reasons (costs, registration), this was not possible, and the choice was made to estimate nurse proficiency instead.

Conclusions

This thesis presents a new method to calculate an objective measure for workload of nurses, which includes all activities of nurses (also non-patient related activities), requires limited additional registration and is easy to use. This modelled workload can be used to detect differences in workload between wards, which may be useful to more evenly distribute workload in order prevent issues in the domain of e.g. organizational justice. Our method also includes a way to identify differences in care time between wards for the same type of patients, which may help evaluate ward efficiency. When linked to operating room scheduling, the modelled workload can also predict an indication of expected workload on a ward and this can contribute to timely aligning nurses' working schedules to anticipated patient needs.
We demonstrated that nurse proficiency is an important factor to take into account when considering workload, since ignoring it may lead to incorrect conclusions and a suboptimal allocation of nursing staff.
One of the main reasons to start this research was that nurses indicated that they perceived differences in workload between wards: the grass always seemed to be greener on the other side, where other nurses seemed to be less busy. Our research contributes to objectively testing whether that perception is true and supports nurse management in decision making and allocating resources. Nurse management can be made aware of possible disparities in workload or efficiency between wards.
In times when workload is high, nurse leadership should consider interventions regarding team building and balancing time spent on direct patient care and time spent on registration.

In practice, workload of nurses is often still managed based on outdated standards, experience or gut-feeling/emotion. We recommend giving more attention to evidence-based methods to

balance workload, so we can keep workload at an acceptable level. Nurses have a profound effect on the experiences of everyone who is in the vulnerable position of being a hospitalized patient. We need to support nurses in doing what they do best, which is delivering top-quality care; this is only possible when workload is contained. Hospital management and healthcare decision makers have an important responsibility in facilitating the right working environment for nurses. As New Zealand nurses put it in their protest rallies against high workload: let's be fair to those who care.

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Addendum

Samenvatting

In het huidige zorglandschap staan ziekenhuizen voor de grote uitdaging om met een groeiende vraag naar zorg en een steeds beperkter wordend budget toch hoge kwaliteit van zorg te bieden. Mensen worden gemiddeld steeds ouder en hebben meer chronische ziekten. Technologische ontwikkelingen maken dat er meer behandelmogelijkheden zijn, maar kunnen daarmee ook de kosten opdrijven. Een substantieel gedeelte van het budget van ziekenhuizen wordt op dit moment besteed aan personeelskosten. Verpleegkundigen vormen de grootste beroepsgroep in het ziekenhuis; een aanmerkelijk deel van het ziekenhuisbudget is daarom te relateren aan verpleegkundige zorg. Verpleegkundigen spelen een belangrijke rol in de zorgverlening; zij hebben een grote invloed op de kwaliteit van zorg en op de ervaringen van patiënten. Er is daarnaast ook sprake van een oplopend tekort aan verpleegkundigen, waardoor het steeds lastiger wordt om voldoende personeel te vinden om aan de vraag naar zorg tegemoet te komen. Onder deze omstandigheden is er een risico dat de werkbelasting van verpleegkundigen te hoog is, wat onder andere tot gevolg kan hebben dat de kwaliteit van zorg achteruit gaat. Verder kunnen de verpleegkundigen minder werkplezier ervaren, gezondheidsklachten ontwikkelen en vaker verzuimen of zelfs het beroep verlaten. Over de hele wereld zijn er de afgelopen jaren protesten geweest van zorgverleners tegen de hoge werkbelasting. In onder andere Canada, Nieuw-Zeeland en Nederland zijn artsen en verpleegkundigen de straat op gegaan om te demonstreren voor betere arbeidsomstandigheden en hebben er stakingen plaatsgevonden. Dit geeft aan dat de noodzaak steeds hoger wordt om aandacht te besteden aan de werkbelasting van de verpleegkundige.

Er is veel onderzoek gedaan naar de effecten van hoge werkbelasting op verpleegkundigen. Het is duidelijk dat een hoge werkbelasting veel nadelige effecten kent, zowel voor de patiënt als voor de verpleegkundige zelf, maar er is nog onvoldoende bekend over hoe je ervoor kunt zorgen dat de werkbelasting niet teveel oploopt. Wat is werkbelasting eigenlijk? Werkbelasting wordt niet eenduidig gedefinieerd. Werkbelasting kan bijvoorbeeld gaan over de balans tussen de behoeften van de patiënten en de hoeveelheid beschikbare medewerkers om hieraan tegemoet te komen, maar ook over de complexiteit van het werk, de hoeveelheid werk, de emotionele kant van het werk of wat er fysiek of mentaal van de medewerker gevraagd wordt. In veel studies worden één of twee van deze dimensies van werkbelasting gekozen en meestal gemeten door middel van vragenlijsten. Er is evenwel weinig onderzoek wat zicht richt op hoe je de werkbelasting op een

objectieve manier kunt bepalen, en bij voorkeur ook kunt voorspellen. Meer achtergrond over dit onderwerp staat beschreven in hoofdstuk 1.

In dit proefschrift beschrijven we hoe wij bijdragen aan het onderzoeksgebied door een nieuwe, objectieve maat voor werkbelasting te ontwikkelen en deze te vergelijken met vijf dimensies van ervaren werkbelasting. Het hoofddoel van het onderzoek is om een gebruiksvriendelijke, eenvoudige methode te ontwikkelen waarmee werkbelasting van verpleegkundigen gemeten kan worden en die ook bruikbaar is om werkbelasting te voorspellen. We verwachten dat we hiermee de werkbelasting beter tussen de verpleegkundigen en de afdelingen kunnen verdelen en de inzet van de verpleegkundigen beter kunnen afstemmen op de behoeften van de patiënten. Daarnaast heeft het onderzoek tot doel om te toetsen hoe deze gemodelleerde werkbelasting in relatie staat tot de daadwerkelijk ervaren werkbelasting en welke andere factoren van invloed zijn op deze relatie, bijvoorbeeld werkeisen en energiebronnen. Het onderzoek heeft plaats gevonden op zes chirurgische verpleegafdelingen van een academisch ziekenhuis in Nederland en spitste zich toe op werkbelasting van verpleegkundigen in de dagdienst.

In het tweede hoofdstuk beschrijven we het plan van aanpak waarmee we onze doelen willen bereiken: het studie ontwerp. De basis van onze methode om werkbelasting te bepalen ligt in het identificeren van patiëntkenmerken die van invloed zijn op de tijd die verpleegkundigen besteden aan patiënten. Met behulp van een tijdstudie wordt bepaald of deze kenmerken ook daadwerkelijk effect hebben op de zorgtijd en zo ja, in welke mate. Vervolgens wordt vastgesteld hoeveel tijd verpleegkundigen aan patiënten besteden ongeacht de aanwezigheid van patiëntkenmerken: de basis zorgtijd. Ook wordt bekeken hoeveel tijd nodig is voor niet-patiëntgebonden taken. Het totaal van deze tijden vormt de benodigde zorgtijd en kan per dagdienst per afdeling bepaald worden. De benodigde zorgtijd wordt vervolgens afgezet tegen de toegewezen zorgtijd: het aantal ingeroosterde verpleegkundigen per dienst, vermenigvuldigd met het aantal uren in de dienst. De ratio van benodigde en toegewezen zorgtijd geeft de schatting van werkbelasting. Zowel de benodigde als de toegewezen zorgtijd wordt gecorrigeerd voor inzetbaarheid van de verpleegkundigen. Niet alle verpleegkundigen zijn namelijk in dezelfde mate inzetbaar: studenten of jonggediplomeerde verpleegkundigen kunnen nog niet alle taken zelfstandig uitvoeren en hebben mogelijk meer tijd nodig om taken uit te voeren dan een ervaren gediplomeerde verpleegkundige. De gemodelleerde werkbelasting wordt vergeleken n met vijf verschillende dimensies van ervaren werkbelasting om zo vast te stellen of de gemodelleerde werkbelasting een goede voorspeller is van ervaren werkbelasting.

Vervolgens wordt in het proefschrift per hoofdstuk dieper ingegaan op de verschillende stappen die in het studie ontwerp staan beschreven. Het derde hoofdstuk beschrijft het proces van vaststellen van de lijst van patiëntkenmerken die naar verwachting een effect hebben op de zorgtijd. Hiertoe is een Delphi studie uitgevoerd onder in totaal vijftien senior verpleegkundigen van de betrokken afdelingen en zijn concept lijsten met patiëntkenmerken uitgebreid in de praktijk getest. De studie resulteerde in vijftien kenmerken waarvan de verpleegkundigen verwachtten dat ze de grootste impact hebben op de tijd die zij aan patiënten besteden: hulp bij voeding, hulp bij baden, mobiliseren en incontinentie, verzorging van drains, lijnen en infusen, frequente controles en kleine handelingen, stabiliteit van de patiënt, complexe co-morbiditeit of patiënt van een ander specialisme, psychosociale zorg, wondverzorging, isolatie maatregelen, spoedopnames en bijzondere ontslagprocedures, stomazorg en bijzondere lichamelijke afmetingen (bv. qua gewicht of lengte). Daarnaast bevat de lijst ook een kenmerk dat betrekking heeft op de bijzondere situatie dat een verpleegkundige gedurende een dienst volledig ten dienste staat van één patiënt: één op één zorg. Dit kenmerk en het kenmerk met betrekking tot bijzondere afmetingen van de patiënt zijn nog niet eerder onderzocht in relatie tot zorgtijd.

De volgende stap in het onderzoek (hoofdstuk 4) is een tijdstudie naar de activiteiten van verpleegkundigen. Gedurende een periode van vijftien opeenvolgende dagdiensten, worden alle aanwezige verpleegkundigen van alle zes de deelnemende afdelingen gevolgd. Getrainde observatoren noteren gemiddeld elke tien minuten voor elke verpleegkundige met welke activiteit zij op dat moment bezig zijn en indien van toepassing, voor welke patiënt. Er zijn vier activiteiten categorieën gedefinieerd: 1) directe patiëntenzorg; zorg die is te relateren aan één specifieke patiënt, zoals het aanleggen van een infuus, 2) collectieve patiëntenzorg; patiënt gerelateerde zorg maar niet toe te wijzen aan één specifieke patiënt, zoals overdracht, 3) algemene taken, zoals bevoorrading en 4) overige taken, zoals pauze. Deze vier categorieën vallen uiteen in 21 activiteitengroepen. Gedurende deze tijdstudie wordt door de verpleegkundigen ook dagelijks genoteerd welke patiëntkenmerken op die dag van toepassing zijn, voor elke patiënt die opgenomen is gedurende de dagdienst. De tijdstudie, een Multi Moment Opname, geeft inzicht in hoe verpleegkundigen hun tijd besteden en waar er verschillen zitten tussen afdelingen. We zien dat verpleegkundigen tussen de 52% en 68% van hun tijd besteden aan patiëntgebonden taken (direct en collectief), tussen 15% en 30% aan algemene taken en tussen 15% en 17% aan overige taken. Door gebruik te maken van MANOVA, ANOVA en post-hoc analyses zijn verschillen tussen afdelingen gevonden voor bijvoorbeeld tijdsbesteding aan onderwijs, medicatie bereiden en hulp bieden bij voeding of communicatie. De meeste van deze verschillen kunnen

verklaard worden door de verhouding tussen studenten en gediplomeerd verpleegkundigen op de afdeling, het type aandoening waar de patiënt aan lijdt en in welk deel van het lichaam de patiënt een ingreep heeft ondergaan. Er zijn ook onverklaarde verschillen gevonden, bijvoorbeeld in de tijd die besteed is aan vergaderen. Deze resultaten dragen bij aan het starten van het gesprek over de effectiviteit van de werkprocessen op een afdeling.

In hoofdstuk vijf worden de resultaten van de tijdstudie gecombineerd met de registratie van de patiëntkenmerken. In verband met het longitudinale karakter van de studie en gezien het feit dat onze studie meerdere niveaus van data bevat, hebben we ervoor gekozen om de gegevens met behulp van linear mixed effects modellen te analyseren. We hebben twee modellen gemaakt: een model met de originele brondata en een model waarin we hebben gecorrigeerd voor inzetbaarheid van de verpleegkundigen. Deze inzetbaarheid is meegenomen in het onderzoek omdat betrokken verpleegkundigen aangaven dat het bij het bepalen van werkbelasting uitmaakt welk type verpleegkundigen er op de afdeling zijn. Een mini-Delphi ronde onder de managers zorgeenheid van alle betrokken afdelingen (allen verpleegkundigen met meer dan vijftien jaar ervaring) resulteert in zes typen verpleegkundigen, waarbij het onderscheid gemaakt wordt op basis van opleidingsniveau en werkervaring. Een volledig gediplomeerd verpleegkundige met meer dan een jaar ervaring op de betreffende afdeling is als de standaard genomen, met een bijbehorende inzetbaarheid van 100%. Voor elk ander type verpleegkundige is door de Delphi groep een gemiddelde inzetbaarheid geschat, met een maximum van 100%. De resultaten van de linear mixed effects modellen laten zien dat negen patiëntkenmerken een significante relatie hebben met zorgtijd. Verder vinden we ook bewijs dat het meenemen van inzetbaarheid in het model van toegevoegde waarde is. Daarom is er verder gewerkt met het model dat gecorrigeerd is voor inzetbaarheid. Aanwezigheid van een van de negen significante patiëntkenmerken zorgt gemiddeld voor 18 tot 35 minuten extra zorgtijd per patiënt per dagdienst, met uitzondering van het kenmerk verzorging van drains, lijnen en infusen (gemiddeld 8 minuten) en het kenmerk één op één zorg (gemiddeld 156 minuten). Ook vinden we dat voor een patiënten profiel waarbij geen van de kenmerken uit onze studie van toepassing is, gemiddeld tussen de 44 en 57 minuten zorgtijd nodig is: dit is tijd die je ongeacht de patiëntkenmerken aan een patiënt besteedt en deze beschouwen we als basis zorgtijd. Voor een patiënt met een gemiddeld profiel van patiëntkenmerken (zoals geobserveerd in onze studie) vinden we dat ongeveer 30 minuten extra zorgtijd nodig is, bovenop de basis zorgtijd. Een relatief klein deel van de variantie in zorgtijd wordt verklaard door patiëntkenmerken. Het model dat gecorrigeerd is voor inzetbaarheid verklaart meer variantie in zorgtijd tussen patiënten (R2=36%) dan binnen patiënten (R2=22%).

We kunnen niet verklaren waarom dit zo is. We verwachten op beide domeinen een hogere verklaarde variantie, omdat het model is gebaseerd op een lijst van patiëntkenmerken die door ervaringsdeskundigen is opgesteld. Blijkbaar zijn er nog andere factoren die een grote invloed hebben op zorgtijd. Het kan interessant zijn om de invloed van factoren zoals verplichte registratie of de mate van verstoringen in het werkproces, maar ook variabelen zoals de persoonlijke klik tussen patiënt en verpleegkundige, verschillen in verwachtingen voor wat betreft zorg vanuit patiënten en naasten, en de organisatie van de zorg verder te onderzoeken.

In het zesde hoofdstuk beschrijven we hoe we een model hebben gemaakt om zorgtijd te voorspellen. Dit model is gebaseerd op de uitkomsten van de voorgaande analyses. De benodigde zorgtijd per afdeling wordt berekend door de basis zorgtijd, de extra zorgtijd die gerelateerd is aan patiëntkenmerken en de tijd die nodig is voor niet-patiënt gebonden taken op te tellen. Vervolgens wordt deze benodigde zorgtijd vergeleken met de toegewezen zorgtijd, die gebaseerd is op het aantal en type beschikbare verpleegkundigen op de afdeling op die dag. De ratio van de benodigde en de toegewezen zorgtijd geeft een indicatie van de werkbelasting: 100% is een goede balans, alles onder 100% betekent overbezetting en alles boven 100% wijst op een onderbezetting. Omdat de verklaarde variantie van de patiëntkenmerken relatief laag is, heeft het model een beperkte voorspellende waarde en is het met name geschikt om werkbelasting indicatief te voorspellen, bijvoorbeeld om een indruk te krijgen of werkbelasting naar verwachting zal toenemen of afnemen en of er verschillen zijn tussen afdelingen. We hebben de gemodelleerde objectieve werkbelasting vergeleken met de werkbelasting zoals die is ervaren door verpleegkundigen. Daarbij hebben we vijf soorten ervaren (subjectieve) werkbelasting gemeten: hoeveelheid werk, werk tempo, mentale werkbelasting, emotionele belasting en fysieke inspanning. De gemodelleerde werkbelasting blijkt positief gecorreleerd te zijn met alle vijf de maten voor subjectieve werkbelasting, waarbij de gemodelleerde werkbelasting het sterkst geassocieerd is met de ervaren hoeveelheid werk en het ervaren werktempo. Dit past bij de verwachting, omdat de gemodelleerde werkbelasting gaat over de hoeveelheid tijd die nodig is ten opzichte van de hoeveelheid tijd die ingezet wordt: dit zegt nog weinig over de inhoud van het werk. Aanvullend hebben we ook vier werkeisen (ervaren mate van verstoringen, ervaren gelijkmatige werkverdeling, gemeten tijd besteed aan directe patiëntenzorg, gemeten tijd besteed aan registratie), drie energiebronnen (ervaren steun van collega's, ervaren steun van leidinggevenden, gemeten percentage gediplomeerd verpleegkundigen op de afdeling) en twee persoonlijke hulpbronnen (ervaren geloof in eigen kunnen, geschatte inzetbaarheid) in de studie meegenomen. Voor wat betreft de persoonlijke hulpbronnen hebben we onderzocht of er een

directe relatie is met de ervaren werkbelasting en voor de werkeisen en energiebronnen hebben we bestudeerd of deze een effect hebben op de relatie tussen de gemodelleerde en ervaren werkbelasting. Er is geen bewijs voor een verband tussen de persoonlijke hulpbronnen en de ervaren werkbelasting. Er is ook onvoldoende bewijs voor een modererend effect van de energiebronnen en eisen in het werk op de relatie tussen de gemodelleerde ('objectieve') en ervaren ('subjectieve') werkbelasting. Er is wel bewijs gevonden voor directe verbanden tussen energiebronnen en ervaren werkbelasting en tussen werkeisen en ervaren werkbelasting. Ervaren steun van collega's is negatief gecorreleerd met alle vijf de maten van ervaren werkbelasting, wat betekent dat steun van collega's de ervaren werkbelasting vermindert. Het percentage gediplomeerde verpleegkundigen op de afdeling is positief gecorreleerd met de ervaren emotionele belasting. Wellicht worden gediplomeerd verpleegkundigen vaker ingezet bij patiënten die meer emotionele belasting met zich meebrengen, bv. patiënten die stervende zijn, of voelen zij een grotere verantwoordelijkheid voor de patiënten en de afdeling dan verpleegkundig studenten. De tijd besteed aan directe patiëntenzorg is positief gecorreleerd met de ervaren hoeveelheid werk en het ervaren werktempo, terwijl de tijd besteed aan registratie negatief gecorreleerd is met de ervaren hoeveelheid werk. De literatuur beschrijft dat verpleegkundigen bij hoge werkbelasting, onder andere veroorzaakt door toenemende verplichte registraties, kunnen ervaren dat zij tijd tekort komen om aan directe patiëntenzorg te besteden. In het licht van deze literatuur hadden we de richting van de correlaties rond de werkeis tijd besteed aan registratie omgekeerd verwacht. Wellicht wordt de druk die de zorgvraag vanuit de patiënt met zich meebrengt als urgenter of groter ervaren, dan de druk die voortkomt uit registratie. Een andere verklaring kan zijn dat er mogelijk meer registratie wordt gedaan op dagen dat er tijd over is en de werkbelasting als lager wordt ervaren.

De bevindingen van dit onderzoek dragen bij aan een beter begrip en beheersing van de werkbelasting van verpleegkundigen en daarmee aan de kwaliteit van zorg, de gezondheid en het welbevinden van de verpleegkundigen, en mogelijk ook de binding van de verpleegkundigen aan het ziekenhuis. Onze gemodelleerde werkbelasting geeft een indicatie van de te verwachten ervaren werkbelasting en kan helpen bij het gelijkmatiger verdelen van de werkbelasting tussen afdelingen en het beter afstemmen van het rooster van de verpleegkundigen op de verwachte behoeftes van patiënten. Leidinggevenden in de zorg zijn geholpen met de wetenschap dat ervaren steun van collega's een invloedrijke energiebron is. Er is meer onderzoek nodig naar interventies die deze energiebron bevorderen, omdat deze energiebron de ervaren werkbelasting kan verminderen.

In dit tijdperk van toenemende vraag naar zorg, afnemende budgetten en schaarste op de arbeidsmarkt, vormt het beheersen van de werkbelasting van verpleegkundigen een grote uitdaging. Toch worden besluiten over inzet van verpleegkundigen in de praktijk nog veel op basis van verouderde standaarden, ervaring of gevoel genomen.

We hebben op basis van de meest actuele kennis en ontwikkelingen van modellen over werkbelasting, een studie gedaan naar objectieve en subjectieve werkbelasting van verpleegkundigen op de verpleegafdeling. Daarbij zijn de volgende resultaten naar voren gekomen. De objectieve maat voor werkbelasting, die op basis van de patiëntkenmerken wordt berekend, is positief gecorreleerd met de ervaren werkbelasting. Deze objectieve maat is geschikt om een indicatie te geven van verwachte ervaren werkbelasting, hiermee kan rekening gehouden worden bij de roostering van verpleegkundigen. Ook kan deze indicatie gebruikt worden om werkbelasting tussen afdelingen te vergelijken. Verder toonden we aan dat het van belang is om bij het berekenen van werkbelasting ook de inzetbaarheid van de verschillende typen verpleegkundigen mee te nemen. Daarnaast vonden we dat als verpleegkundigen zich gesteund voelen door collega's, dat een positief effect heeft op zowel ervaren hoeveelheid werk en werktempo, als in mindere mate ook op mentale, emotionele en fysieke werkbelasting. We vonden geen bewijs dat ervaren steun van leidinggevenden effect heeft op ervaren werkbelasting. Voor wat betreft werkbelasting, is het zinvol als leidinggevenden inzetten op maatregelen die teamgevoel en samenwerking stimuleren. Gediplomeerd verpleegkundigen ervaren een hogere emotionele belasting dan studenten. Hoe meer tijd besteed wordt aan directe patiëntenzorg, hoe hoger verpleegkundigen de hoeveelheid werk en het werktempo ervaren. Daarentegen bleek ook dat als er meer tijd besteed wordt aan registratie, de hoeveelheid werk als minder wordt ervaren. Het creëren van een goede balans tussen tijd besteed aan registratie en aan directe patiëntenzorg kan helpen om de ervaren werkbelasting te beheersen.
Deze bevindingen kunnen beleidsmakers en leidinggevenden helpen bij het optimaal ondersteunen van verpleegkundigen bij het verlenen van professionele en persoonlijke verpleegkundige zorg van hoge kwaliteit.

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List of publications

1. Oetelaar van den WFJM, Stel van HJ, Rhenen van W, Stellato RK, Grolman W: **Balancing nurses' workload in hospital wards: study protocol of developing a method to manage workload**. *BMJ Open* 2016, **6**(11).
2. Oetelaar van den WFJM, Stel van HJ, Stellato RK, van Rhenen W, Grolman W: **Mapping nurses' activities in surgical hospital wards: a time study**. *PLOS ONE* 2017.
3. Oetelaar van den WFJM, van Rhenen W, Stellato RK, Grolman W: **Balancing workload of nurses: Linear mixed effects modelling to estimate required nursing time on surgical wards**. *Nursing Open* 2019.

In preparation:

4. Oetelaar van den WFJM, Roelen, CAM, Grolman W, Stellato RK, van Rhenen W: **Exploring the relation between modelled workload and perceived workload of nurses and related job demands, job resources and personal resources, a longitudinal study**. *Submitted and under review* 2019.

Curriculum Vitae

Miranda van den Oetelaar was born on the 7th of January 1974 in Oirschot, the Netherlands. After finishing secondary school at Jacob-Roelandslyceum in Boxtel in 1992, she attended Eindhoven University of Technology to study Industrial Engineering. An internship with the University of San Carlos in Cebu City, the Philippines, sparked a love for travel and far away cultures. In 1998, she graduated and started a position as sales and operations planner at ICI Polyurethanes Ltd. (later Huntsman Holland B.V.). After five years of working at Huntsman as sales and operations planner, project manager, supply chain team manager and two sabbaticals where she travelled the world, Miranda left Huntsman to move to West Papua, Indonesia. She helped run an eco-touristic scuba diving resort in the remote Raja Ampat island group and participated in wildlife conservation and humanitarian aid projects. In 2004, Miranda transferred to Bali where she became Total Asia order manager for high-end jewelry company PT Karya Tangan Indah (John Hardy), where she was responsible for the alignment of sales orders, inventory and production. After three years abroad, she decided that she saw the long term future in the Netherlands and returned. However, she made a conscious decision not to return to commercial industries, but to join a non-profit organization. Miranda accepted a job as process manager at the University Medical Center in Utrecht and spent the following years optimizing patient logistics and working processes in several divisions of the hospital. In 2012, one of these process improvement projects lead to the start of the study described in this thesis. In 2013, she was given the opportunity to change to a different field of work and started a position as program manager housing projects for the UMC Utrecht Cancer Center. Three years later, she joined the Poli 3.0 program as project manager of processes and organization, a position that she still holds today.