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The Relationship between Understaffing of Nurses and Patient Safety in Hospitals— A Literature Review with Thematic Analysis

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Abstract

Introduction: Patient safety and the occurrence of adverse events in hospitals is a topic which has been widely addressed over the last decades. In that respect, there has been an increasing interest in the effect of working conditions on patient safety, and whether understaffing and adverse events are correlated. This paper therefore reports results from a study of understaffing of nurses understood as a lack of nurses available to conduct the tasks required of them. This implies that nurses are forced to ignore or postpone important tasks, thereby compromising patient safety. **Purpose:** The purpose of the study is to increase the knowledge of understaffing of hospital nurses, and the consequences that understaffing may have on patient safety. **Methods:** A literature search of the databases Chinal, Medline, Cochrane library, Isi Web of Science and Academic Search premiere was conducted in the period January 2014 to February, 2016. **Results:** Results are categorized into two main themes and four subthemes. The first main theme describes the direct relationship between understaffing and patient safety. Poor staffing increases the risk of mortality, and adverse conditions such as pressure ulcers, deep vein thrombosis and hospital-related infections. The second main theme relates to the indirect implications of understaffing for patient safety. These implications pertain to the lack of time that nurses could give each patient, limitations in the quality of nursing, and challenges in safe medication administration. **Conclusions:** The study documents the relationship between understaffing of nurses and adverse events in hospitals, revealingthat understaffing of nurses is a risk factor for hospitalized patients.

Keywords

Understaffing, Patient Safety, Adverse Events, Mortality, Patient Harm

1. Introduction

1.1. Incidence of Adverse Events

The incidence of patients experiencing adverse events while hospitalized has proven a major problem [1] [2] [3] [4]. Reports and research on the occurrences of adverse events shows that a great number of patients experience adverse events while receiving health care all over the world [4] [5] [6] [7]. An international study conducted in England, Germany and the USA, with focus on medication errors, found that the prevalence of adverse event related to drugs alone ranged from 3.22% to 5.64% of the patients hospitalized in 2006 [8]. There have been a greater media and research attention to patient safety and the effect of staffing on the occurrence of adverse events [9] [10] [11]. International media have previously described patients being exposed to adverse events with severe consequences, of which many are caused by poor staffing [12] [13]. There are several studies on this topic, but with varying foci such as mortality, adverse events related to specific patient groups and specific patient diagnosis, medication errors, patient satisfaction, work environment and economic perspectives [14] [15] [16] [17] [18]. Evidence in this area has also previously been synthesized in literature reviews [19] [20] [21], but no reviews have documented the direct and indirect relationship between understaffing of nurses and patient safety.

1.2. Patient Safety

The US Department of Health & Human Services defines *patient safety* as "the freedom of accidental or preventable injuries produced by medical care". Patient safety measures are defined as interventions or work intended to reduce the occurrence of preventable events [22]. Several different bodies ensure patient safety in hospitals. Health care providers have a responsibility to perform professionally appropriate health care. Each hospital must ensure that the health care providers work under conditions that promote safe practice, for example with appropriate equipment, adequate staffing and safe routines. Additionally, both health care workers and the health care system must comply with the law, professional standards and procedures to provide safe healthcare services [23].

1.3. Legislation

The requirement of professional responsibility is the most central demand in the legislation when it comes to safety practice in the healthcare service. The demand of professional responsibility is according to law, a shared responsibility, were the health workers are responsible for their own actions, and the healthcare system is responsible for the environment these actions are conducted in. Further on health workers, in this case nurses are obligated to perform safe healthcare through the nature of their public authorization, which is an arrangement built on common national and international demands in the nursing education and is a requirement to legally assess nursing tasks [23].

1.4. The Nurse's Role in Patient Safety

The International Council of Nursing states that nurses carry a responsibility to perform safe practice and to obtain the knowledge to do so. They are obligated to provide holistic patient care, which include giving the patients and families accurate information and education. Nurses are expected to participate in maintaining safe working conditions and safe practice [24].

1.5. Purpose of the Study

The purpose of this study is to increase the knowledge of understaffing amongst nurses in hospitals, and the possible consequences of understaffing for patient safety. More specifically the study examines understaffing as a risk factor for hospitalized patients. The following research question has guided the study: How can understaffing amongst nurses in hospitals affect patient safety?

1.6. Clarification of Terms

Understaffing is a term with numerous connotations and meanings. In the literature, *understaffing* is used, for instance, in reference to high patient-nurse ratios, heavy workload, large patient load, nursing hours per patient, and high bed occupancy. The common denominator of these definitions are that understaffing is a lack of personnel, in this case nurses, to conduct their required tasks. In this study, the term *understaffing* is defined as "a disparity between load of responsibilities/tasks and the possibility to conduct them in a professional manner".

A nurse is in this study, defined as a person with a bachelor education in nursing, having regular contact with patients admitted to a hospital ward.

2. Methods

A literature review was conducted using a systematic approach as described by Bettany-Saltikov [25]. Methods on thematically retrieving, synthesizing and analyzing the data was conducted following the method of Dixon-Woods *et al.* [26] and Pope [27]. The review was reported using PRISMA guidelines and the PRISMA float diagram [28].

2.1. Inclusion and Exclusion Criteria

To be included in the review, articles had to be written in English, they had to have a clear qualitative or quantitative design, and they had to have been published between1997 and 2016. Eligible studies had to be concerned with nurses with patient contact, working in hospitals, some form of understaffing (excessive workload, high patient-to-nurse ratio, number of working hours per patient) and patient safety.

2.2. Identification of Studies

The search strategy was developed in accordance with Bettany-Saltikov [25] methodology for literature reviews in nursing. Literature searches were con-

ducted in the Cinahl, Medline, Isi Web of Science, Cochrane Library and Academic Search Premiere databases between early February and the end of January 2016. All databases focus on health and social science. In addition, secondary searches were made based on the reference lists of included articles, and a manual search was conducted in selected journals of specific interests such as *BMC Health Services Research* [29]. The terms used when searching the databases included *understaffing, nurse, patient safety, lack of nurses, staffing levels, manning levels, downsizing, short-staffed, short-handed, inadequate staffing, insufficient staffing, workload, patient outcome, patient security, patient mortality* and *adverse events*. Terms which disclosed understaffing (lack of nurses, staffing levels, manning levels) were combined with terms disclosing nurses (healthcare worker, RN, trained nurse) and hospital (healthcare facility, Hospital ward, medical institution) in a systematic manner which included all possible combinations of these words. (A comprehensive list of the searches done in each database can be found in Attachment 1)

2.3. Quality Assessment of Studies

All included studies were of quantitative study design, and underwent a quality assessment according to the Cochrane Quality Assessment Tool for Quantitative Studies [30]. This assessment tool was developed for use in public health, and is suitable for quality assessment in most areas of public health [30]. The quality assessment involves grading six areas in each study (selection bias, study design, confounders, blinding, data collecting methods, withdrawals and drop-outs). Each domain is given points (1 - 3 points) based on relevant questions. Based on the total ranking score, each study was graded as having strong, moderate or weak quality. Studies graded "moderate" or "strong" were included in the review. (Attachment 2 gives a full overview of the quality assessment.)

2.4. Data Extraction

We used a predesigned form for data extraction according to Dixon-Woods *et al.* [26], describing the study design, quality, objectives, data material/participants, main findings, and the location of the study. First author retracted data from all included studies under detailed supervision from the research group. Recognition of themes was made through "identification of prominent or recurrent results in the articles analyzed, to produce an account of evidence" [26].

2.5. Selection of Studies

The database searches identified 2847 records. Six articles were found through secondary searches and recommendations from researchers in the field of patient safety. Of the 2609 articles screened, 2495 were excluded. The remaining 114 articles were read and evaluated in full text (see Figure 1, The PRISMA 2009 Flow diagram if article selection process). Following the full text evaluation, 43 articles were included based on the inclusion and exclusion criteria. 10 of these
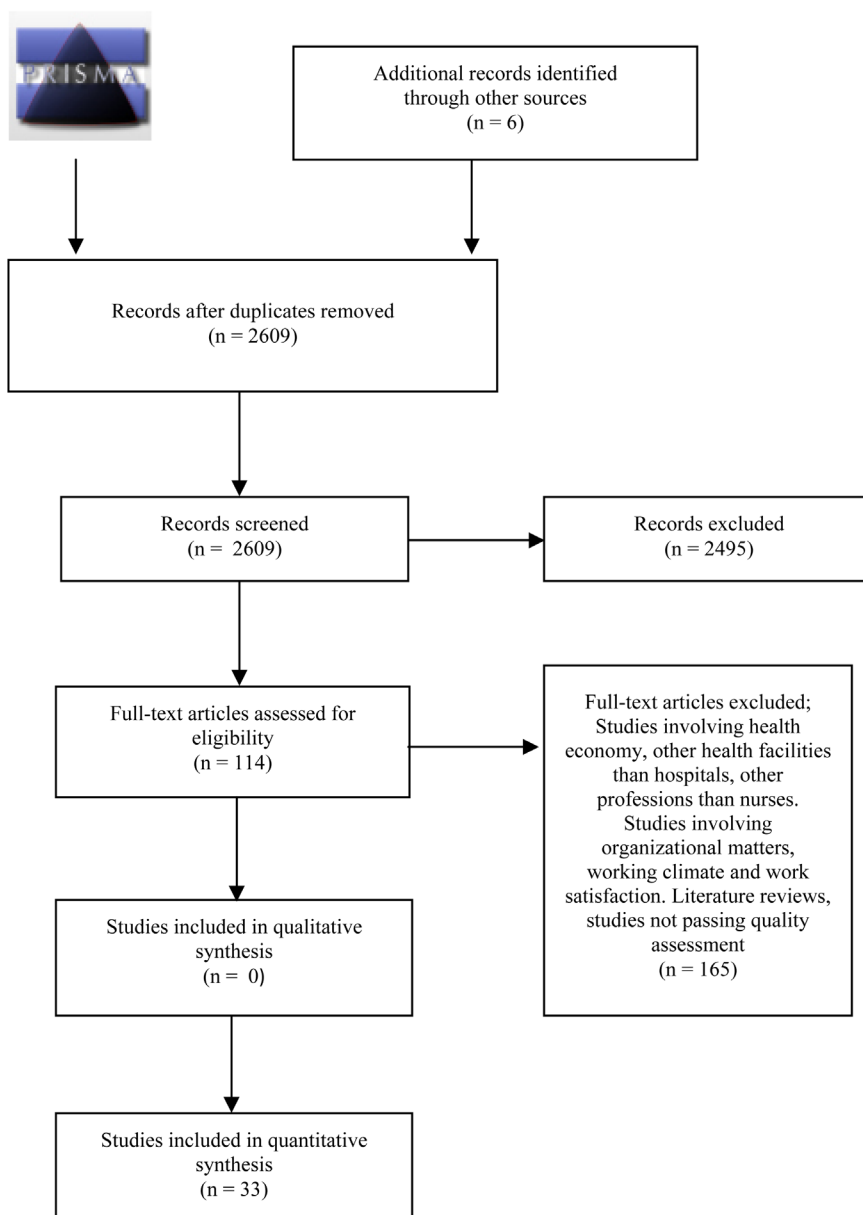
Figure 1. The PRISMA 2009 Flow diagram of article selection process.

studies did not pass the quality assessment, and were excluded, resulting in a total of 33 quantitative studies being included in the current review. First author performed the searches and undertook the screening of titles and abstracts against inclusion criteria, with supervision from the research group. First researcher then undertook the read-through of selected full-text articles. Where there was question of inclusion eligibility, the research group was consulted independently to assess full-text item suitability.

2.6. Analysis

The results of the included studies were analyzed through *Thematic analysis* which involve finding prominent or recurrent themes in included articles, and

gather the themes under suitable headings [26]. The predesigned form was used to organize the main results of the included studies, allowing the researcher to detect patterns or recurring subjects in the literature. The recurring subjects were then organized in to sub-themes and themes.

2.7. Consent

Data represented in this study emerged from already published peer reviewed articles. Data collection did not involve human subjects, and a written informed consent has therefore not been obtained.

2.8. Availability of Data and Materials

All the data supporting the conclusions can be found in Table 1 with information on the included studies. Information on the search words, combinations and results, can be found in the supplementary file 2 *Database search report.*

3. Results

This literature review synthesizes evidence about the effects of the understaffing of nurses on patient safety in hospitals. Thirty-three studies of moderate-to-strong quality were included, from which two main themes and four subthemes emerged.

Twenty-three studies [14] [16] [18] [31]-[50] found a direct relationship between understaffing and patient safety. Eight of these studies focused on mortality in patients admitted to a hospital. Fourteen studies described how patients were directly harmed as a consequence of understaffing in the form of infections, pressure ulcers and other adverse hospital events. One study described the relationship between nurse staffing and length of hospital stays.

Six studies [51]-[56] found an indirect relationship between understaffing and patient safety, focusing on important nursing tasks that were left undone due to nurses lack of time to carry them out. Two of these studies showed how understaffing affected the administration of medication.

One study [17] investigated both direct and indirect consequences, and three studies [57] [58] [59] found weak or no association between understaffing and patient safety.

3.1. Study Characteristics

Of the thirty-three studies included, there are nine cohort studies, thirteen cross-sectional studies, two correlation studies, one case control study, three retrospective observational studies, two retrospective longitudinal studies and one with a four-stage sampling design. It was not possible to categorize the methods used in two of the studies. (Table 1 lists the articles and study characteristics). All of the studies investigated the relationship between understaffing of nurses working in hospitals and patient safety.

Table 1. Overview of included articles.

Author study design quality country	Aim	Informants/data material	Main findings	Themes
Aiken *et al.* (2014) [31] Retrospective observational study Moderate Belgium, England, Finland, **Ireland, The** Netherlands, Norway, Spain, Sweden, Switzerland	To determine whether differences in patient to nurse ratio and nurses educational qualifications were associated with hospital mortality after common surgical procedures.	Discharge data from 422.730 patients 50 years or older, who underwent surgery and survey of 26.516 Nurses	Each increase of one patient per nurse is associated with a 7% increase in the likelihood of a surgical patient dying within 30 days of admission, whereas each 10% increase in the percent of bachelor degree nurses in hospital is associated with a 7% decrease in this likelihood.	Direct consequences: mortality
Aiken *et al.* (2002) [14] Cross-sectional analyses Moderate USA, California	To determine the association between the patient-to-nurse ratio and patient mortality, failure to rescue among surgical patients, and factors related to nurse retention	Data from 10.184 staff nurses surveyed, 232.342 general, orthopedic and vascular surgery patients and administrative data from 168 general hospitals	Each additional patient per nurse was associated with a 7% increase in the likelihood of dying within 30 days of admission and a 7% increase in the odds of failure to rescue (Patient and hospital characteristics were adjusted).	Direct consequences: mortality
Al-Kandari & Thomas (2009) [51] Cross-sectional survey Moderate Kuwait	To identify the perceived adverse patient outcomes related to nurse' workload	780 registered nurses working in medical and surgical wards of five governmental hospitals in Kuwait.	Five major perceived adverse patient outcomes: 1) complaints from patient and their families, 2) patient received a late dose or missed a dose of medication, 3) discovering pressure ulcer, 4) wound infection and 5) infection on the site of IV cannula.	Indirect consequences: Poor basic quality of care
Amarvadi *et al.* (2000) [32] Observational cohort study Moderate USA	To determine if having a 1:2 rather than a 1:3 or more night-time nurse-to-patient ratio (NNPR) in the intensive care unit affected hospital mortality	Adult patients who had esophageal resection in Maryland 1994 to 1998 (366 patients)	There were no significant difference in the risk of in-hospital mortality between patients with a NNRP > 1:2 (Night time nurse-to-patient ratio > one nurse caring for one or two patients) and those with a NNRP < 1:2 (Nurse caring for three or more patients) Patients with a NNPR < 1:2 had an increased risk of reintubation, pneumonia and sepsis	Direct consequences: Patient harm
Carthon *et al.* (2012) [33] Cross-sectional survey Moderate USA, Pennsylvania	To determine the association between nurse staffing and postsurgical outcomes for older black adults, including 30-day mortality and failure to rescue.	548.397 patients ages 65 and older, undergoing general, orthopedic or vascular surgery	One additional patient in the average nurse's workload was associated with higher odds of 30 day mortality for all patients. Odds of failure to rescue were higher for patient in settings with poorer nursing staffing	Direct consequences: Mortality
Cho *et al.* (2015) [52] Cross sectional study Moderate South Korea	To examine the relationship of nurse staffing levels and work environment with patient adverse events	4864 nurses Data from 58 hospitals Discharge data from 113,426 Patients	A large number of patients per nurse were significantly associated with a greater incidence of administration of wrong medication or dose, pressure ulcers and patient falls with injury.	Indirect consequences: medication errors and patient harm.

Continued

Cho *et al.* (2003) [16] can't tell Moderate USA	Examine the effects of nurse staffing on adverse events, morbidity, mortality and medical costs	Existing databases from 232 acute care hospitals and 124,204 patients in 20 surgical diagnosis-related groups. 857 patients with hemorrhagic and ischemic stroke who were admitted to ICUs of 185 Korean hospitals	An increase of one hour worked by registered nurses per patient per day was associated with an 8.9% decrease in the odds of pneumonia. Hospitals with higher ICU staffing were more likely to fully provide basic care. Better staffing were associated with lower in-hospital and 30-day mortality. 30-day mortality had a more distinct decrease with lower staffing rates	Direct consequence: Patient harm
Cho & Yun (2009) [34] Cross-sectional design including a survey Moderate Korea	To examine differences in provision of basic nursing care and in-hospital and 30-day mortality by nurse staffing of ICUs and general wards among acute stroke patients	ICUs of 185 Korean hospitals	Better staffing was associated with lower in-hospital and 30-day mortality. 30-day mortality had a more distinct decrease with lower staffing rates.	Direct consequences: Mortality
Cimotti *et al.* (2006) [35] Prospective cohort study Strong Canada	To examine the association between registered nurse staffing and healthcare associated bloodstream infections in infants in neonatal intensive care units.	2675 infants admitted to the NICUs for more than 48 hours and all registered nurse who worked in the same NICUs during the study	A greater number of hours of care provided by RNs in NICU 2 were associated with decreased risk of bloodstream infections. Number of hours of care provided by RNs in NICU 1 was not associated with bloodstream infections.	Direct consequences: Patient harm
de Cordova *et al.* (2014) [37] Longitudinal study Moderate USA	Examine the association between night nurse staffing and work force characteristics and length of stay (LOS)	Monthly observations of administrative data from 138 acute care hospitals (N = 8243)	Higher night staffing and higher skill mix were associated with reduced LOS	Direct consequences: Patient harm
Daud-Gallotti *et al.* (2012) [36] Prospective cohort study Strong Brazil	Evaluate the role of nursing workload in the occurrence of HAI in medical intensive care units.	195 ICU-Patients	22% developed HAI (healthcare-associated infection). Average NAS (Nursing activity score) and average proportion of non-compliance with NPC (Non-compliance to the nurse's patient-care plans) were significantly higher in HAI patients. Only excessive nursing workload and severity of the patient's clinical condition remained as risk factors to HAI.	Direct consequences: Patient harm
Duffield *et al.* (2011) [17] Longitudinal, Retrospective study combined with a cross-sectional study Moderate Australia	Examine the relationship of nurse staffing and workload, in the context of the work environment, to patient outcomes.	Data from the public hospital system. Five years of data for 80 public hospitals	Increased RN staff were associated with significantly decreased rates of pressure ulcer, pneumonia, and sepsis, GI bleeding, physiological/metabolic derangement, pulmonary failure, sepsis and shock. There were several nursing-tasks left undone or postponed as a consequence of heavy workload.	Direct and indirect consequences: Poor basic care quality and patient harm

Continued

Hugonnet et al. (2007) [18] Prospective observational cohort study Moderate Switzerland	To determine whether low nurse-to-patient ratio increases risk for VAP and whether this effect is similar for early-onset and late-onset VAP.	2470 ICU patients. Variable such as number of patients and nurses on duty, patient characteristics, nurse training levels	262 VAP episodes were diagnosed in 22.3% of the patients who underwent mechanical ventilation The median daily nurse-to-patient ratio was 1.9 over the study period. High nurse-to-patient ratio was associated with a decreased risk for late-onset VAP, but there was no association with early-onset VAP	Direct consequences: patient harm
Holden et al. (2011) [53] Cross-sectional survey Moderate. USA	To measure each of the three types of workload experienced by nurses and to assess whether and which measures of workload were related to three important outcomes.	99 nurses from two hospitals	The task level measure of mental workload related to interruptions, divided intention, and being rushed was associated with burnout and medication error. Workload was not significantly associated with any other outcomes	Indirect consequences: Medication errors
Kiekkas et al. (2008) [38] Observational prospective study (cohort study) Moderate Greece	Investigate differences in mortality of intensive care unit (ICU) patient according to the ratio between total patient care demands and nurse staffing	396 patients admitted in the general ICU of an academic, tertiary care, Greek Hospital from October 2005 to September 2006	Mortality on all patients increased from 22% in the low-exposure group (<21.9) Therapeutic Intervention Scoring System (TISS-28) point per nurse-workload measurement) to 25.0% in the medium exposure group (21.9 - 25.8 TISS-28 point per nurse) and reached up to 28.8% in the high-exposure group (>25.8 TISS-28 score per nurse) Despite these increases, differences in adjusted ICU mortality among groups did not reach statistical significance	Direct consequences patient mortality
Kovner et al. (2002) [50] Cross-sectional descriptive study Moderate USA	To examine the impact of nurse staffing on selected adverse events hypothesized to be sensitive to nursing care	Nurse staffing data from 1990-1996 from the American hospital association annual survey of hospitals. Includes 530 - 570 hospitals for each of the years from 1990-1996, with 187 hospitals having data for all seven years.	Registered nurse (RN) hours per patient per day were inversely related to all adverse events, but was significant ($P < 0.05$) only for pneumonia	Direct consequences: Patient harm
Liang et al. (2012) [39] Longitudinal, cross-sectional Study Strong Taiwan	To explore the effects of nurse staffing ratios on patient mortality in acute care hospitals.	108 hospital nursing units in 32 of Taiwan's 441 accredited Western medicine district/regional hospitals and medical centers. Data from a survey on hospital nurse staffing levels and patient outcomes.	The risk of incidence of death seemed to be higher in high patient-nurse ratio groups than in low patient-nurse ratio groups. The risk of incidence of death in high healthcare workforce-bed ratio groups was much lower than in low healthcare workforce-bed ratio groups.	Direct consequences: Patient harm

Continued

Needleman *et al.* (2002) [40] Cohort study Strong USA	Not reported	Administrative data from 1997 for 799 hospitals in 11 states, covering 5,075,969 discharges of medical patients and 1,104,659 surgical patients	A higher proportion of hours of care per day provided by registered nurses and a greater number of hours of care provided per day were associated with a shorter length of stay and lower rates of urinary tract infections and upper gastrointestinal bleeding. A higher hour of care provided by RNs was associated with a lower rate of pneumonia, shock or cardiac arrest, and "failure to rescue".	Direct consequences: Patient harm
Person *et al.* (2004) [41] Cross-sectional analysis Moderate USA	Assess the association of nurse staffing with in-hospital mortality for patients with acute myocardial infarction.	118,940 patients admitted with AMI in 6668 hospitals in the US	Patients treated in environments with higher RN staffing were less likely to die in-hospital. Patients treated in environments with higher LPN (licensed practical nurse) staffing were more likely to die in-hospital. (The data was adjusted with patient demographic, clinical characteristics, treatment, hospital volume, technology index teaching and urban status)	Direct consequences: Mortality
Potter *et al.* (2003) [54] Moderate Prospective, correlation study USA	To determine baseline values of patient outcome measures and the relationship of nurse staffing to patient outcomes.	32 acute inpatient care units 3418 patients	The percentage of RN hours was negatively correlated with patient pain and self-care ability, and positive correlated with patient health status and five out of seven measures of post-discharge patient satisfaction.	Indirect consequences: Poor quality of basic care
Rogowski *et al.* (2013) [42] Retrospective cohort study Strong USA	To study the adequacy of Neo Natal Intensive Care Unit (NICU) nurse staffing in the United States using national guidelines and analyze its association with infant outcomes	newborn very low-birth-weight infants discharged from the NICUs in 2008 (n = 5771) and 2009 (n = 5630) All registered nurses with infant assignments.	The percentage of Very Low Birth Weight (VLBW) infants with hospital associated infections were 16.4% in 2008 and 13.9% in 2009. Relative to the guidelines, on average, hospitals understaffed 47% of all NICU infants in 2008 and 31% in 2009. A 1 standard deviation increase in the amount of a nurse per infant to meet the guidelines was associated with higher odds of infection in 2008 and 2009	Direct consequences: Patient harm
Sasicbay-Akkadecbanunt *et al.* (2003) [43] cross-sectional study Moderate UK	To examine the association between in-hospital mortality and four nurse staffing variables.	Data of 2531 patients admitted to seven medical units and 10 surgical units of a 2300 bed university hospital.	The nurse-to-patient ratio was statistically correlated with in-hospital mortality. Nurse-to-patient ratio had an individual effect on in-hospital mortality. The ratio of total staff to patients was the best predictor of in hospital mortality among four staffing variables. There was not a significant relationship between in hospital mortality and the proportion of RNs to total nursing staff, the mean years of RN experience and the percentage of bachelor degree prepared nurses.	Direct consequences: Mortality

Continued

Schreuders et al. (2014) [57] Retrospective longitudinal study Moderate Australia	To compare characteristics of hospitalizations with and without complications and examine the impact of nurse staffing on inpatient complications	Administrative data from Western Australian Department of Health (2001-2008)	Nurse staffing levels were not associated with decreased patient complication risks.	No significant relationship
Seynaeve et al. (2011) [56] Cross-sectional survey. Moderate USA, Antwerp	To examine the association between in-hospital mortality and four nurse staffing variables.	Data of 2531 patients admitted to seven medical units and 10 surgical units of a 2300 bed university hospital.	Statistically correlated with in-hospital mortality. Nurse-to-patient ratio had an individual effect on in-hospital mortality. The ratio of total staff to patients was the best predictor of in hospital mortality among four staffing variables. There was not a significant relationship between in hospital mortality and the proportion of RNs to total nursing staff, the mean years of RN experience and the percentage of bachelor degree prepared nurses.	Direct consequences: Mortality
Shuldham et al. (2008) [58] Retrospective case control study Strong UK	To explore the relationship between nurse staffing characteristics and patient outcomes.	All patients, included day cases, who were admitted at two hospitals as an in-patient over 12 months	Weak association between nurse staffing and the majority of the outcomes in the lower dependency category wards. The Incidence Rate Ratio (IRR) for falls, GI bleeds, sepsis and Deep Vein Thrombosis (DVT) were reduced where nursing hour per patient day increased, but the numbers were not statistical significant. When adding bank hours (extra staff from the hospital), in addition to the permanent staff, only the result of pressure sores and DVT reached statistical significance.	No statistical significance. Indirect consequences: Patient harm
Stone et al. (2007) [44] Observational study Moderate USA	To examine effects of a comprehensive set of working condition on elderly patient safety outcome in intensive care units.	To examine effects of a comprehensive set of working condition on elderly patient safety outcome in intensive care units.	Units with higher staffing levels had lower incidence of CLBSI (central line blood stream infections), ventilator-associated pneumonia, 30-day mortality and pressure ulcer.	Direct consequences: Patient harm.
Tarnow-Mordi et al. (2000) [45] Retrospective observational analyses Strong UK	Not reported	1050 admissions in the ICU	Adjusted mortality were more than two times higher in patients exposed to low ICU workload. After exclusion of measures of nursing requirement, adjusted mortality increased with the ratio of occupied to appropriately staffed beds during each patient's stay.	Direct consequence: Mortality

Continued

Twigg *et al.* (2011) [47] Retrospective cohort study and Time-series study Strong Australia	To determine the impact of implementing the NHPPD (Nursing hours per patient day) staffing method on 14 nursing-sensitive outcomes	236,453 patients from three adult hospital wards. Changes in nursing-sensitive outcomes were examined comparing the pre NHPPD-implementation-stage 0 and the post implementation-stage 2.	Significant decreases in the rates of nine out of fourteen nursing-sensitive outcomes when examining hospital-level data following implementation of NHPPD: Mortality, central nervous system complications, pressure ulcers, deep vein thrombosis, sepsis, ulcer/gastritis/upper gastrointestinal bleed, shock/cardiac arrest, pneumonia and average length of stay.	Direct consequences: Patient harm and patient mortality
Unruh (2003) [48] Cohort study Moderate USA	To examine the changes in licensed nursing staff and assess the relationship of nursing staff with patient adverse events in hospitals	A convenience sample of all Pennsylvania, acute-care, hospitals, 1991 to 1997	Greater incidence of nearly all adverse events occurred in hospitals with fewer licensed nurses. There were a higher incidence of pressure ulcer and pneumonia in hospitals with a lower proportion of licensed nurses	Direct consequences: Patient harm
Van den Heede *et al.* (2009) [59] Cross-sectional analysis Moderate Belgium	Examine the association between nurse staffing levels and 10 different patient outcomes potentially sensitive to nursing care	Data from 115 Belgian acute hospitals for the year 2003.	No significant relationship between acuity adjusted NHPPD (Nursing hours per patient day), proportions of registered nurses with at least a Bachelors' degree and 10 patient outcomes.	No significant relationship
Weissman *et al.* (2007) [49] Can't tell Moderate USA	To determine the relationship between peak hospital workload and rates of adverse events.	A random sample of 24,676 patients discharged from the medical/surgical services at 4 US hospitals	Admissions and patients per nurse were significantly related to the likelihood of an adverse event. For example 0.1% increase in the patient-to-nurse ratio led to a 28% increase in the adverse event rate in one urban teaching hospital with high occupancy. These results were only significant for this hospital. There were no significant results in the other three hospitals in the study.	Direct consequences patient harm
Yang (2003) [46] Correlation study Moderate Taiwan	To examine the effect of nurse staffing variables-daily average hours of care, ratio of RNs to average patients' census, workload, and skill mix on patient outcomes as measured by five adverse occurrences	Data from hospital statistics. Sample composed of 347 FTE (fulltime equivalent) RNs distributed in 21 units with 793 beds ranging from 34 to 48 with a mean of 37.76 beds, as well as 29,424 inpatients.	Significantly positive correlation between daily average hours of care and urinary tract infections ($r = 0.523$, $p < 0.05$) and patient falls ($r = 0.456$, $p < 0.05$). Ratio of RNs to patient census negatively correlated to patient falls, urinary tract infections and complaints. Positive and significant relationship between workload and respiratory tract infections, patients' complaints and their acuity level.	Direct consequences: Patient harm
Zhu *et al.* (2012) [55] Four stage sampling design Moderate China	To examine the relationship between nurse staffing and patient outcomes in hospitals in mainland China.	7802 nurses and 5430 patients	Higher levels of nurses per patient had a statistically significant positive effect on the conduct of important nurse related tasks, and therefore on patient outcomes.	Indirect consequences: poor quality of basic care.

3.2. Thematic Analysis

The thematic analysis [26] [60] generated two main themes and two subthemes concerning understaffing and consequences for patient safety.

Theme 1: Direct consequences

Twenty-three studies reported that understaffing had direct and severe consequences for patients.

1A) Patient harm

Sixteen of the twenty-three studies examined several adverse events as a direct consequence of understaffing among nurses working in hospitals [16] [17] [18] [32] [35] [36] [37] [40] [42] [44] [46] [47] [48] [49] [50] [58]. Several studies found that understaffing increased the patient's risk of contracting pneumonia, urinary tract infections or other hospital-related infections [16] [17] [35] [36] [40] [42] [44] [47] [48] [49] [50]. Cho and colleagues [16] found that one extra hour of work by registered nurses per patient per day was associated with a 8.9% decrease in the odds of the patients getting pneumonia. Cimiotti *et al.* [35] also found a negative association between number of hours of care provided by registered nurses and the risk of bloodstream infections in infants receiving neonatal care, but only in one of the two neonatal intensive care units (NICU) investigated. The authors attribute these differences in results to variation in the hospitals' and infants' characteristics.

Along with hospital-related infections, the incidence of pressure wounds was also a problem that, according to the literature, increased in proportion to understaffing [17] [44] [47] [48] [52]. Twigg *et al.* [47] reported that surgical patients experienced significant lower pressure wounds rates in all three hospitals investigated, after those hospitals adopted a new staffing method called Nursing Hour Per Patient Day (NHPPD). This staffing method significantly increased the staffing levels. In other words, increased staffing levels led to decreased rates of pressure wounds. A lower proportion of licensed nurses working was associated with a higher incidence of pressure wounds in the hospital investigated by Unruh [48]. Van den Heede *et al.* [59] in contrast, did not find any significant relationship between acuity adjusted nursing hours per patient day and pressure wounds. Kovner *et al.* [60] also investigated the direct consequences of understaffing but did not find any significance between registered nurses (RNs) hour per patient per day and three types of adverse events: pulmonary compromise, urinary tract infection, and thrombosis. Other studies, however, found a significant relationship between understaffing and both thrombosis and shock/cardiac arrest [17] [40] [47]. Schreuders *et al.* [57] found an inconsistency in the relationship between understaffing and patient complications such as urinary tract infections and surgical wound infections related to patient characteristics such as age, gender and health status. The direction of the association between nurse staffing and inpatient complications was not consistent for different patient complications.

Lastly, one study found that higher night staffing reduced the prevalence of

extended hospital stays [37].

2B) Patient mortality

Nine studies found understaffing to affect mortality in hospitalized patients. Both surgical and medical patients were investigated [14] [31] [33] [34] [38] [39] [41] [43] [45].

In one observational study from 2014 and one cross-sectional analysis from 2002 Aiken and colleagues found that after adjusting for patient and hospital characteristics, each additional patient per nurse was associated with a 7% increase in the likelihood of dying within 30 days after admission. Carthon *et al.* [33] reported similar results, finding that an increase of one patient in the nurse's patient load increased the occurrence of deaths in hospitalized patients. They also found that older surgical patients were affected more by understaffing than other groups of patients. Older surgical patients had a poorer post-surgical course when their nurses had a heavier workload, including a higher chance of death and failed resuscitation [33]. One study investigated mortality in the form of failure to rescue (from an adverse health-related event), finding that understaffing had a negative effect also in this area [33].

In two studies, no correlation between mortality and understaffing were found [38] [68]. Amarvadi and colleagues [32] investigated the understaffing-mortality problem by taking a closer look at the night shift. They used the night time nurse-to-patient ratio to calculate staffing, and found no increased risk of dying in hospital whether one night nurse cared for one or two patients or for three or more. Kiekkas *et al.* [38] found that an increased workload among the nurses did affect hospital mortality, but these numbers did not reach statistical significance.

Theme 2: Indirect consequences

Six studies found understaffing to affect patient safety, not by causing the patient direct harm but by increasing the risk for direct harm later on.

2A) Poor quality of basic care.

Four studies concluded that understaffing led to poor quality of care [15] [17] [54] [69]. Several nursing tasks, such as patient communication, skin care, oral hygiene, documentation, responding to patient alarms and mobilization were left undone, postponed or not prioritized due to lack of time, as a consequence of understaffing of nurses [17] [55]. Zhu and colleagues [55] found that 30.39% of nurses reported that the care that they delivered was of moderate or poor quality. Duffield *et al.* [17] found in their longitudinal study that patient communication was not prioritized in as many as 39.5% of the shifts. Skin care and back rubs (24.0%) and oral hygiene (19.3%) were also frequently reported undone. Patients' ability for self-care and patient satisfaction was also negatively associated with understaffing [15] [54].

2B) Errors in administration of medication.

Two studies focused on understaffing and medication errors [53] [56], reporting that heavy nursing workload, interruptions and being rushed increased the risk of adverse events in conjunction with the administration of medication. Several other studies found an association between understaffing and medication

errors, even when this was not their focus [15] [17] [52]. These findings showed that understaffing led to missed or late doses of medication, poor pain management resulting from difficulties in administering needed pain medication, and medication errors in general [15] [17].

4. Discussion

The results of the literature review indicate that understaffing of nurses have a negative effect on patient safety. The negative effect is reflected through various consequences for the patient's wellbeing, health, and outcome of hospitalization. Even though the results of this study are divided into themes and subthemes, all four themes are interrelated. The literature review shows that the indirect consequences of understaffing (lack of managing important nursing task such as measuring vital signs, patient mobilization and responding to patient alarms) may cause severe and direct consequences (thrombosis, patient falls and mortality) later in the course of treatment.

A relationship between the themes can for example be seen in relation to pressure wounds; hygiene measures, skincare, and mobilization are measures intended to prevent pressure wounds [61], and were not always undertaken by the nurses due to understaffing [17] [55]. Pressure wounds will, according to the literature, increase the patient's risk of contracting wound infections that prove fatal [61]. Further, poor quality of care may also prevent nurses from discovering other severe conditions like thrombosis, pneumonia and wound infections.

Failure to provide basic care as a consequence of understaffing affects patients in ways that might not always be apparent. Tasks that do not seem as important as other tasks are constantly postponed or left undone, placing the patient at risk of severe harm.

As previously stated, the results of the studies reviewed here indicate that understaffing affects patient safety in numerous negative ways. However, several other aspects must be taken in consideration before formulating conclusions.

Many of the studies of mortality were conducted in intensive care units (ICU) [16] [32] [34] [36]. Considering that a patient admitted to an ICU in most cases will be in an acute phase of the disease [62], will mean they are in greater risk of any adverse event regardless of staffing. At the same time, these patients may be more vulnerable to lack of surveillance, medication errors, and lack of basic care as described in Theme 2-Indirect consequences. Hence, these patients might actually be more affected by staffing levels than others.

Several of the studies describe surgical patients in conjunction with both patient mortality and patient harm [14] [31] [33]. Surgical procedures are associated with certain risks like pneumonia, infections, pressure ulcers, and even mortality. These are adverse events described in Theme 1—Direct consequences, that may occur regardless of understaffing [63]. Since these studies are limited to surgical patients, this needs to be considered when interpreting the results. The same applies to studies of elderly patients, who are also at an increased risk of

being affected by adverse events of both Theme 1—Direct consequences, and Theme 2-Indirect consequences. As Carthon *et al.* [33] argue studies of the elderly are valuable in this setting, having found that elderly patients are even more affected by understaffing than other patient groups.

Furthermore, the data used in most of the included studies were based singularly on administrative data (hospital statistics, discharge data, staffing data) and/or surveys. This type of data brings a few challenges. There will always be a chance of underreporting of adverse events, which may lead to unreliable results [48] [49]. ICD Codes (international identification of disease) are in most health facilities used to register diseases and health issues [64]. Errors in these coding's, or lack of accuracy in coding, may affect the results, especially if the errors are systematic [68]. In some cases patient characteristics may be limited because of lack of clinical information in administrative databases [16] [46]. The same is true for staffing characteristics [50]. On the other hand, this type of data material will provide a great deal of information and include a larger sample of patient and nurses, which is important to create a wide picture of the problem understaffing and patient safety.

Another important aspect is that most of the studies are conducted in high income countries all over the world. There is one study from Brazil [61] and two studies from Taiwan [39] [46] which are countries that are borderline in form of developed and developing countries. This must be taken in consideration when reading the results. Even though the remaining studies were conducted in high income countries such as USA, Australia, UK, and Belgium it is important to keep in mind that staffing levels, hospital characteristics, and nurse characteristics will vary. Nurses' responsibilities may also differ, and therefore workload may differ in both quantity and type, which may make direct comparisons of the result of these studies difficult.

Lastly, the health personnel in this study include Registered Nurses (RNs), even though some of the studies also included data regarding other health personnel, the results of this study do not consider the effect of other health personnel on patient safety. It is known that for example nursing assistants and licensed practical nurses (LPN) are huge contributors to the basic care given in hospital wards. Further, there are also research results showing that wards with low RN-rates in the skill mix compared with other groups such as LPNs has less fortune outcomes when it comes to adverse events [31] [37]. Another factor included in some of the understaffing research, which have not been included in this study, is work environment, which has also shown to affect patient safety [14] [52].

Kane and colleagues systematic literature review from 2007 [19] also showed an association between understaffing of nurses and several adverse events (mortality and nurse sensitive patient outcomes). This study included factors such as the effect of LPNs, nurses' experience, education and staffing policy. Other literature reviews have concentrated on specific adverse advents such as medication

errors [20], mortality [65] or healthcare associated infections [21] or special settings like critical or intensive care [66] [67]. The effect poor quality care such as absence of skincare, mobilization or oral hygiene (indirect consequences) may have on patient outcomes in form of direct consequences (infections, pressure wounds, mortality) have not been explored in previous literature reviews.

As showed, there may be characteristics about the patient, the hospital, and the ward, that affect the results of the studies included in our literature review. Understaffing may be one of the contributing factors that affect patient safety, but other factors may most likely also be contributing

Methodological Limitations

There are possible limitations in our literature review and several confounders need to be addressed when reviewing the results. Manual searches could have been conducted in other additional journals, by using citation tracking, and by assessing unpublished literature to increase chances of finding further relevant items. To test for additional findings, we tested new search terms and search words, without identifying new items meeting our inclusion criteria. The study was conducted according to strict methodological guidelines for literature reviews [68] and we believe that the majority of publications of relevance for our topic and research question are identified, although relevant publications could be missed by traditional database searches due to not being indexed in such a way as to allow identification within the parameters of such a search [69].

Secondly we excluded studies of other health facilities than hospitals, and other health personnel than nurses, and also publications on discharge outcomes, in accordance with the exclusion criteria. This may have led to the loss of valuable information about understaffing and patient safety.

Thirdly, the thematic analysis method used in this review is more commonly used in studies with singularly qualitative designs, or with mixed methods [27]. Yet, early in the search process, this method proved to be the right one, as the themes emerged from the data. Meta-analysis, and so-called pooling of data—more commonly used in reviews of quantitative data—could not be used because of the wide range of results and study designs [27].

Finally, some general risks of bias will always be present in literature reviews. Studies with valuable results, but not written in English, are excluded because of the exclusion criteria [25]. Furthermore, if the method of identifying relevant studies is not sensitive enough, there is always a risk of relevant studies being overlooked [70]. Bias may also occur during data retraction, if the same data is not retracted from each study [70]. Dixon-Woods *et al.* [26] mention some weaknesses with the use of thematic analysis. There can be a lack of transparency in the decisions made during the analysis process. To compensate, we have described the process in detail, showed examples in the tables to illustrate the findings, and demonstrated how the research group collaborated during the review process.

5. Conclusion

The literature review documents that understaffing of nurses can affect patient safety negatively in both direct—(pressure wounds, infections, mortality) and indirect ways (poor documentation, failure to mobilize patients, lack of proper surveillance). The type of ward, hospital, patient group, and country in the included studies vary, but all studies show that too few nurses at the hospital wards give too little time to perform important nursing tasks, which may have consequences of varying degrees of severity for the patient. The current results show that numerous characteristics and factors (e.g. type of hospital, ward, and patient characteristics) are important when investigating the relationship between understaffing and patient safety. All of these characteristics and factors must be considered when reading the results of this and other studies. More research on the topic is needed, as the articles included in this study mention the lack of research, especially in the Nordic countries. Lastly, no clear and direct causal relationship between understaffing and patient safety is found, but the findings leads us to the conclusion that understaffing of nurses constitutes a risk factor for hospitalized patients and could be one threat to patient safety.

Availability of Data and Materials

All the data supporting the conclusions can be found in Table 1 with information on the included studies. Information on the search words, combinations and results, can be found in the supplementary file *Database search report.*

Ethics

The results of this systematic review emerged from analysis of data extracted from already published peer reviewed articles. The study does not involve any data collection involving human subjects and does not require any consent or ethical approval.

Competing Interests

None.

Author's Contributions

All members of the research group participated in the conception and design of the study as well as in analysis and interpretation of data. The first researcher undertook acquisition of data and the drafting of the manuscript. All authors were involved in critically revising the manuscript for important intellectual content and all read and approved the final manuscript.

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Attachment 1: Database Search Report

Search words:

1) Understaffing

2) Lack of nurses

3) Staffing levels

4) Under manning

5) Manning levels

6) Downsizing

7) Short-staffed

8) Short-handed

9) Inadequate in number of workers

10) Inadequate staffing

11) Insufficient number of personnel

12) Workload

13) Nurses

14) Health worker

15) RN (registered nurse)

16) Employee

17) Trained nurse

18) Patient safety

19) Patient

20) Outcome

21) Patient security

22) Patient mortality

23) Adverseevents

24) Hospital

25) Health care facilities

26) Hospital ward

27) Medical institution

Searches done in Chinal 04.02.14-

Word combination	Results	First Exclusion	Closer look
1 + 13 + 18 + 24	10	Missedcriteria 2:4	10 studies
1 + 13 + 18	42	Missed criteria 1:4 Missed criteria 2:20 Missed criteria 3:3	5 Studies
2 + 14 + 19 + 25	No results		0
3 + 15 + 21 + 26	No results		0
1 + 13 + 20	4	Misses criteria 1:2 Missedcriteria 2:2	0
1 + 13 + 21	No results		0
1 + 13 + 22	1	Alreadyfound	0
1 + 15 + 18	11	Missed criteria 1:1 Missed criteria 2:1 Already found: 8	1 study
1 + 15 + 20	2	Missedcriteria 2:2	0
1 + 15 + 21	No results		0
1 + 15 + 22	No results		0
1 + 25 + 28	No results		0
1 + 15 + 23	1	Already found	0
1 + 15 + 28	No results		0
1 + 15 + 23	1	Already found	0
2 + 18 + 24	8	Missed criteria 1:7 Missed criteria 2:1	0
2 + 20 + 24	1	Missed criteria 1	0
2 + 21 + 24	No results		0
2 + 22 + 24	No results		0
2 + 23 + 24	3	Missed criteria 1:3	0
2 + 28 + 24	1	Missed criteria 1	0
3 + 13 + 18	32	Missed criteria 1:3 Missed criteria 2:19 Already found: 4	7 studies
3 + 13 + 20	4	Missed criteria 1:2	2 studies
3 + 13 + 21	No results		0
3 + 13 + 22	1		1 study
3 + 13 + 23	5	Already found: 3	2 studies
3 + 13 + 28	No results		0
4 + 13 + 28*	No results		0
5 + 13 + 18**	No results		0

Continued

6 + 13 + 20***	No results		0
7 + 13 + 18	1	Missed criteria 1	0
7 + 13 + 20	No results		0
7 + 13 + 21	No results		0
7 + 13 + 22	No results		0
7 + 13 + 23	No results		0
7 + 13 + 28	No results		0
8 + 13 + 18****	No results		0
10 + 13 + 18	6	Criteria 1:1 Criteria 2:1 Already found: 2	2 studies
10 + 13 + 20	3	Already found: 3	0
10 + 13 + 21	No results		0
10 + 13 + 22	No results		
10 + 13 + 23	1	Already found	0
10 + 13 + 28	No results		0
11 + 13 + 18	3	Missed criteria 1:1 Missed criteria 2:1 Already found: 1	0
11 + 13 + 20	3	Criteria 1:1 Already found: 1	1 study
11 + 13 + 21	1	Already found	0
11 + 13 + 23	2	Criteria 1:1 Already found: 2	0
12 + 13 + 28	No results		0
12 + 13 + 18	71	Criteria 1:35 Criteria 2:19 Already found: 8	10
12 + 13 + 20	50	Criteria 1:41 Criteria 2:1 Already found: 4	4
12 + 13 + 21	1	Criteria 1	0
12 + 13 + 22	3	Criteria 1:1 Criteria 2:2	1
12 + 13 + 23	9	Criteria 1:1 Criteria 2:1 Already found: 6	1
Summary:	289 studies		47 studies

*Search word 4 (undermanning) didn't give any results in any combinations. **Search word 5 (Manning levels) didn't give any results in any combinations. ***Search word 6 (Downsizing) didn't give any results in any combinations. ****Search word 8 (short-handed) didn't give any results in any combinations.

Searches done in Medline—15.02.14

Word combination	Results	First Exclusion	Closer look.
1 + 13 + 18	2	Missed criteria 1:1 Already found: 1	0
1 + 13 + 20	2	Criteria 1:2	0
1 + 13 + 21	No results		0
1 + 13 + 22	No results		0
1 + 13 + 23	3	Missed criteria 1:2	1
2 + 8 + 24	7	Missed criteria 1:7	0
2 + 20 + 24	No results		0
2 + 21 + 24	No results		0
2 + 22 + 24	No results		0
2 + 23 + 24	1	Missed criteria 1:1	0
3 + 13 + 18	14	Missed criteria 1:6 Missed criteria 2:1 Already found: 5	1
3 + 13 + 20	28	Missed criteria 1:16 Missed criteria 2:5 Already found: 5	2
3 + 13 + 21	No results		0
3 + 13 + 22	2	Missed criteria 2:1	1
3 + 13 + 23	7	Missed criteria 1:1 Already found: 5	1
6 + 13 + 18	No results		0
6 + 13 + 20	No results		0
6 + 13 + 21	No results		0
6 + 13 + 22	No results		0
6 + 13 + 23	No results		0
7 + 13 + 18	No results		0
7 + 13 + 20	No results		0
7 + 13 + 21	No results		0
7 + 13 + 22	No results		0
7 + 13 + 23	No results		0
10 + 13 + 18	4	Already found: 3	1
10 + 13 + 20	4	Missed criteria 1:1 Missed criteria 2:1 Already found: 2	0
10 + 13 + 21	No results		0
10 + 13 + 22	No results		0
10 + 13 + 23	1	Already found: 1	0
11 + 13 + 18	2	Missed criteria 1:1 Already found: 1	0
11 + 13 + 20	3	Criteria 1:2 Already found: 1	0
11 + 13 + 22	1	Already found: 1	0
11 + 13 + 23	2	Already found: 2	0

Continued

		Missed criteria 1:30 Missed criteria 2:5 Already found: 14	
12 + 13 + 18	53	Missed criteria 1:30 Missed criteria 2:5 Already found: 14	4
12 + 13 + 20	67	Missed criteria 1:49 Missed criteria 2:3 Already found: 10	5
12 + 13 + 21	No results		0
12 + 13 + 22	5	Missed criteria 1:4 Already found: 1	0
12 + 13 + 23	23	Missed criteria 1:18 Already found: 4	1
Summary:	263		17

Searches done in ISI Web of science 31.03.14-

Word combination	Results	First exclusion	Closer look
1 + 13 + 18	14	Missed criteria 1:10 Already found: 2	2
2 + 13 + 18	373*	Missed criteria 1:7	0
3 + 13 + 18	426**	Missed criteria 1:268 Missed criteria 2:3 Already found: 5	4
4 + 13 + 18	1	Missed criteria 1:1	0
5 + 13 + 18	3	Missed criteria 1:3	
6 + 13 + 18	9	Missed criteria 1:9	0
7 + 13 + 18	64***	Missed criteria 1:24 Already found: 9	1
6 + 13 + 18	0		0
9 + 13 + 18	1	Missed criteria 1:1	0
10 + 13 + 18	60****	Missed criteria 1:24 Already found: 9	3
11 + 13 + 18	3	Missed criteria 1:3	0
12 + 13 + 18	282*****	Missed criteria 1:5	0
1 + 13 + 20	18	Missed criteria 1:10 Already found: 5	3
1 + 13 + 21	1	Missed criteria 1:1	0
1 + 13 + 22	8	Missed criteria 1:3 Already found: 5	0
1 + 13 + 23	7	Missed criteria 1:3 Already found: 4	0
2 + 13 + 20	10	Missed criteria 1:10	0
3 + 13 + 20	6	Missed criteria 1:3 Already found: 1	2
4 + 13 + 20	0	0	0
5 + 13 + 20	0	0	0
6 + 13 + 20	1	Missed criteria 1:1	0
7 + 13 + 20	0	0	0
8 + 13 + 20	0	0	0
9 + 13 + 20	0	0	0

Continued

10 + 13 + 20	0	0	0
11 + 13 + 20	0	0	0
12 + 13 + 20	16	Missed criteria 1:11 Already found: 2	3
2 + 13 + 21	0	0	0
3 + 13 + 21	0	0	0
4 + 13 + 21	0	0	0
5 + 12 + 21	0	0	0
6 + 13 + 21	0	0	0
7 + 13 + 21	0	0	0
8 + 13 + 21	0	0	0
9 + 13 + 21	0	0	0
10 + 13 + 21	0	0	0
11 + 13 + 21	0	0	0
12 + 13 + 21	0	0	0
2 + 13 + 22	0	0	0
3 + 13 + 22	24	Missed criteria 1:17 Already found: 6	1
4 + 13 + 22	0	0	0
4 + 13 + 22	0	0	0
6 + 13 + 22	2	Missed criteria 1:1 Already found: 1	0
7 + 13 + 22	0	0	0
8 + 13 + 22	0	0	0
9 + 13 + 22	0	0	0
10 + 13 + 22	2	Missed criteria 1:2	2
11 + 13 + 22	0	0	0
12 + 13 + 22	18	Missed criteria 1:7 Missed criteria 2:2 Already found: 7	2
2 + 13 + 23	0	0	0
3 + 13 + 23	24	Missed criteria 1:16 Already found: 6	2
4 + 13 + 23	0	0	0
5 + 13 + 23	0	0	0
6 + 13 + 23	1	Missed criteria 1:1	0
7 + 13 + 23	0	0	0
8 + 13 + 23	0	0	0
9 + 13 + 23	0	0	0
10 + 13 + 23	2	Missed criteria 1:2	0
11 + 13 + 23	0	0	0
12 + 13 + 23	37	Missed criteria 1:31 Missed criteria 2:1 Already found: 5	0
Summary	579		25

*Reduced the result to 7 hits, by checking of nursing and excluding case report, meeting and editorial. **Reduced the result to 280 hits, by checking of English, nursing and excluding Editorial, meeting and case report. ***Reduced the result to 34 hits by checking of nursing and English. ****Reduced the result to 36 hits by checking of nursing and English and excluding case report. *****Reduced the result to 5 by checking of nursing, English an exclude newsletter, editorial, reference material and case report.

Searches done in Cohrane library 29.04.14-

Word combination	Results	First exclusion	Closer look
1 + 13 + 18	0	0	0
1 + 13 + 20	1	Missed criteria 1:1	0
1 + 13 + 21	0	0	0
1 + 13 + 22	0	0	0
1 + 13 + 23	0	0	0
2 + 13 + 18	65	Missed criteria 1:23 Missed criteria 2:42	0
2 + 13 + 20	0	0	0
2 + 13 + 21	0	0	0
2 + 13 + 22	0	0	0
2 + 13 + 23	0	0	0
3 + 13 + 18	17	Missed criteria 1:17	0
3 + 13 + 20	12	Missed criteria 1:12	0
3 + 13 + 21	1	Missed criteria 1:1	0
3 + 13 + 22	17	Missed criteria 1:17	0
5 + 13 + 18	7	Missed criteria 1:7	0
5 + 13 + 20	1	Missed criteria 1:1	0
5 + 13 + 21	1	Missed criteria 1:1	0
5 + 13 + 22	1	Missed criteria 1:1	0
5 + 13 + 23	9	Missed criteria 1:9	0
6 + 13 + 18	0	0	0
6 + 13 + 20	1	Missed criteria 1:1	0
6 + 13 + 21	0	0	0
6 + 13 + 22	0	0	0
6 + 13 + 23	0	0	0
7 + 13 + 18	1	Missed criteria 1:1	0
7 + 13 + 20	1	Missed criteria 1:1	0
7 + 13 + 21	0	0	0
7 + 13 + 22	0	0	0
7 + 13 + 23	0	0	0
8 + 13 + 18	0	0	0
8 + 13 + 20	0	0	0
8 + 13 + 21	0	0	0
8 + 13 + 22	0	0	0
8 + 13 + 23	0	0	0
10 + 13 + 18	3	Missed criteria 1:3	0

Continued

10 + 13 + 20	6	Missed criteria 1:6	0
10 + 13 + 21	0	0	0
10 + 13 + 22	3	Missed criteria 1:3	0
10 + 13 + 23	2	Missed criteria 1:2	2
11 + 13 + 18	0	0	0
11 + 13 + 20	1	Missed criteria 1:1	0
11 + 13 + 21	0	0	0
11 + 13 + 22	0	0	0
11 + 13 + 23	0	0	0
12 + 13 + 18	11	Missed criteria 1:11	0
12 + 13 + 20	39	Missed criteria 1:39	0
12 + 13 + 21	0	0	0
12 + 12 + 22	6	Missed criteria 1:6	0
12 + 13 + 23	7	Missed criteria 1:7	0
Summary	327		2

Searches done in Academic search premiere 31.04.14-

Word combination	Results	First exclusion	Closer look
1 + 13 + 18	16	Missed criteria 1:4 Missed criteria 2:12	0
1 + 13 + 20	6	Missed criteria 1:4 Missed criteria 2:2	0
1 + 13 + 21	0	0	0
1 + 13 + 22	1	Already found: 1	0
1 + 13 + 23	2	Missed criteria 1:1 Already found: 1	0
2 + 13 + 18	68	Missed criteria 1:52 Missed criteria 2:14 Already found: 1	0
2 + 13 + 20	1	Missed criteria 2:1	0
2 + 13 + 21	2	Missed criteria 1:1 Missed criteria 2:1	0
2 + 13 + 22	0	0	0
2 + 13 + 23	1	Missed criteria 2:1	0
3 + 13 + 18	60	Missed criteria 1:25 Missed criteria 2:15 Already found: 20	0
3 + 13 + 20	50	Missed criteria 1:23 Missed criteria 2:20 Already found: 7	0

Continued

3 + 13 + 21	1	Missed criteria 1:1	0
3 + 13 + 22	6	Missed criteria 2:4 Already found: 2	0
3 + 13 + 23	10	Missed criteria 1:5 Missed criteria 2:4 Already found: 1	0
5 + 13 + 18	0	0	0
5 + 13 + 20	1	Missed criteria 1:1	0
5 + 13 + 21	0	0	0
5 + 13 + 22	0	0	0
5 + 13 + 23	0	0	0
6 + 13 + 18	0	0	0
6 + 13 + 20	2	Missed criteria 1:2	0
6 + 13 + 21	0	0	0
6 + 13 + 22	0	0	0
6 + 13 + 23	0	0	0
7 + 13 + 18	0	0	0
7 + 13 + 20	0	0	0
7 + 13 + 21	0	0	0
7 + 13 + 22	0	0	0
7 + 13 + 23	0	0	0
8 + 13 + 18	0	0	0
8 + 13 + 20	0	0	0
8 + 13 + 21	0	0	0
8 + 13 + 22	0	0	0
8 + 13 + 23	0	0	0
10 + 13 + 18	8	Missed criteria 1:2 Missed criteria 2:5 Already found: 1	0
10 + 13 + 20	2	Missed criteria 1:1 Already found: 1	
10 + 13 + 21	0	0	0
10 + 13 + 22	0	0	0
10 + 13 + 23	2	Missed criteria 1:1 Already found: 1	0
11 + 13 + 18	2	Missed criteria 1:1 Missed criteria 2:1	0
11 + 13 + 20	2	Missed criteria 1:2	0
11 + 13 + 21	0	0	0
11 + 13 + 22	0	0	0
11 + 13 + 23	1	Missed criteria 1:1	0
Summary	965		0

Searches done in Chinal December 2015-February 2016 (Year 2014-2015)

Word combination	Results	First exclusion	Closer look
1 + 13 + 18 + 24	0		0
2 + 13 + 18 + 24	0		0
3 + 13 + 18 + 24	0		0
4 + 13 + 18 + 24	0		0
5 + 13 + 18 + 24	0		0
6 + 13 + 18 + 24	0		0
7 + 13 + 18 + 24	0		0
8 + 13 + 18 + 24	0		0
9 + 13 + 18 + 24	0		0
10 + 13 + 18 + 24	0		0
11 + 13 + 18 + 24	0		0
12 + 13 + 18 + 24	11	Missed criteria 1:8 Missed criteria 2:1 Already found: 1	1
1 + 13 + 18 + 24	10	Missedcriteria 1:10	0
1 + 14 + 18 + 24	4	Missed criteria 1:2 Missed criteria 3:1	1
1 + 15 + 18 + 24	2	Missed criteria 3:2	0
1 + 16 + 18 + 24	4	Missed criteria 3:4	0
1 + 17 + 18 + 24	0		0
1 + 13 + 19 + 24	1	Already found: 1	0
1 + 14 + 19 + 24	1	Missed criteria 1:1	0
1 + 15 + 19 + 24	0		0
1 + 16 + 19 + 24	1	Missed criteria 1:1	0
1 + 17 + 19 + 24	0		0
1 + 13 + 20 + 24	0		0
1 + 14 + 20 + 24	0		0
1 + 15 + 20 + 24	0		0
1 + 16 + 20 + 24	0		0
1 + 17 + 20 + 24	0		0
1 + 13 + 21 + 24	0		0
1 + 14 + 21 + 24	0		0
1 + 15 + 21 + 24	0		0
1 + 16 + 21 + 24	0		0
1 + 17 + 21 + 24	0		0
1 + 13 + 22 + 24	0		0
1 + 14 + 22 + 24	0		0

Continued

1 + 15 + 22 + 24	0		0
1 + 16 + 22 + 24	0		0
1 + 17 + 22 + 24	0		0
2 + 13 + 18 + 24	8	Missed criteria 1:7 Missed criteria 2:1	0
2 + 14 + 18 + 24	17	Missed criteria 1:17	0
2 + 15 + 18 + 24	9	Missed criteria 1:5 Missed criteria 2:3	1
2 + 16 + 18 + 24	4	Missed criteria 1:2 Missed criteria 2:2	0
2 + 17 + 18 + 24	5	Missed criteria 1:3 Missed criteria 3:2	0
2 + 13 + 19 + 24	47	Missed criteria 1:42 Missed criteria 3:2 Already found: 1	2
2 + 14 + 19 + 24	4	Missed criteria 1:4	0
2 + 15 + 19 + 24	2	Missed criteria 2:2	0
2 + 16 + 19 + 24	4	Missed criteria 1:3 Missed criteria 2:1	0
2 + 17 + 19 + 24	5	Missed criteria 1:5	0
2 + 13 + 20 + 24	1	Missed criteria 1:1	0
2 + 14 + 20 + 24	1	Missed criteria 1:1	0
2 + 15 + 20 + 24	1	Missed criteria 1:1	0
2 + 16 + 20 + 24	4	Missed criteria 1:3 Missed criteria 2:1	0
2 + 17 + 20 + 24	2	Missed criteria 1:2	0
2 + 13 + 21 + 24	9	Missed criteria 1:8 Already found: 1	0
2 + 14 + 21 + 24	1	Missed criteria 1:1	0
2 + 15 + 21 + 24	1	Missed criteria 1:1	0
2 + 16 + 21 + 24	0		0
2 + 17 + 21 + 24	4	Missed criteria 1:4	0
2 + 13 + 22 + 24	5	Missed criteria 1:5	0
2 + 14 + 22 + 24	0		0
2 + 15 + 22 + 24	1	Missed criteria 1:1	0
2 + 16 + 22 + 24	0		0
2 + 17 + 22 + 24	5	Missed criteria 1:5	0
3 + 13 + 18 + 24	31	Missed criteria 1:25 Missed criteria 2:1 Missed criteria 3:2 Already found: 1	2

Continued

3 + 14 + 18 + 24	1	Missed criteria 1:1	0
3 + 15 + 18 + 24	2	Missed criteria 1:2	0
3 + 16 + 18 + 24	3	Missed criteria 1:3	0
3 + 17 + 18 + 24	1	Missed criteria 1:1	0
3 + 13 + 19 + 24	4	Missed criteria 1:4	0
3 + 14 + 19 + 24	0		0
3 + 15 + 19 + 24	0		0
3 + 16 + 19 + 24	0		0
3 + 17 + 19 + 24	1	Missed criteria 1:1	0
3 + 13 + 20 + 24	0		0
3 + 14 + 20 + 24	0		0
3 + 15 + 20 + 24	0		0
3 + 16 + 20 + 24	0		0
3 + 17 + 20 + 24	0		0
3 + 13 + 21 + 24	0		0
3 + 14 + 21 + 24	0		0
3 + 15 + 21 + 24	0		0
3 + 16 + 21 + 24	0		0
3 + 17 + 21 + 24	0		0
3 + 13 + 22 + 24	3	Missed criteria 1:2	1
3 + 14 + 22 + 24	0		0
3 + 15 + 22 + 24	0		0
3 + 16 + 22 + 24	0		0
3 + 17 + 22 + 24	0		0
4 + 13 + 18 + 24	0		0
4 + 14 + 18 + 24	0		0
4 + 15 + 18 + 24	0		0
4 + 16 + 18 + 24	0		0
4 + 17 + 18 + 24	0		0
4 + 13 + 19 + 24	0		0
4 + 14 + 19 + 24	0		0
4 + 15 + 19 + 24	0		0
4 + 16 + 19 + 24	0		0
4 + 17 + 19 + 24	0		0
4 + 13 + 20 + 24	0		0
4 + 14 + 20 + 24	0		0
4 + 15 + 20 + 24	0		0

Continued

4 + 16 + 20 + 24	0		0
4 + 17 + 20 + 24	0		0
4 + 13 + 21 + 24	0		0
4 + 14 + 21 + 24	0		0
4 + 15 + 21 + 24	0		0
4 + 16 + 21 + 24	0		0
4 + 17 + 21 + 24	0		0
4 + 13 + 22 + 24	0		0
4 + 14 + 22 + 24	0		0
4 + 15 + 22 + 24	0		0
4 + 16 + 22 + 24	0		0
4 + 17 + 22 + 24	0		0
5 + 13 + 18 + 24	0		0
5 + 14 + 18 + 24	0		0
5 + 15 + 18 + 24	0		0
5 + 16 + 18 + 24	0		0
5 + 17 + 18 + 24	2	Missed criteria 1:2	0
5 + 13 + 19 + 24	0		0
5 + 14 + 19 + 24	0		0
5 + 15 + 19 + 24	0		0
5 + 16 + 19 + 24	0		0
5 + 17 + 19 + 24	3	Missed criteria 1:3	0
5 + 13 + 20 + 24	0		0
5 + 14 + 20 + 24	0		0
5 + 15 + 20 + 24	0		0
5 + 16 + 20 + 24	0		0
5 + 17 + 20 + 24	0		0
5 + 13 + 21 + 24	0		0
5 + 14 + 21 + 24	0		0
5 + 15 + 21 + 24	0		0
5 + 16 + 21 + 24	0		0
5 + 17 + 21 + 24	0		0
5 + 13 + 22 + 24	0		0
5 + 14 + 22 + 24	0		0
5 + 15 + 22 + 24	0		0
5 + 16 + 22 + 24	0		
5 + 17 + 22 + 24	9	Missed criteria 1:9	0

Continued

6 + 13 + 18 + 24	2	Missed criteria 3:2	0
6 + 14 + 18 + 24	0		0
6 + 15 + 18 + 24	0		0
6 + 16 + 18 + 24	1	Missed criteria 3:1	0
6 + 17 + 18 + 24	0		0
6 + 13 + 19 + 24	2	Missed criteria 1:2	0
6 + 14 + 19 + 24	2	Missed criteria 1:1	1
6 + 15 + 20 + 24	0		0
6 + 16 + 20 + 24	0		0
6 + 17 + 20 + 24	0		0
6 + 13 + 21 + 24	2	Missed criteria 1:1 Missed criteria 2:1	0
6 + 14 + 21 + 24	0		0
6 + 15 + 21 + 24	0		0
6 + 16 + 21 + 24	0		0
6 + 17 + 21 + 24	0		0
6 + 13 + 22 + 24	2	Missed criteria 2:2	2
6 + 14 + 22 + 24	2	Alreadu found: 2	0
6 + 15 + 22 + 24	0		0
6 + 16 + 22 + 24	0		0
6 + 17 + 22 + 24	0		0
6 + 13 + 22 + 24	0		
6 + 14 + 22 + 24	1		1
6 + 15 + 22 + 24	0		0
6 + 16 + 22 + 24	0		0
6 + 17 + 22 + 24	0		0
7 + 13 + 23 + 24	0		0
7 + 14 + 23 + 24	0		0
7 + 15 + 23 + 24	0		0
7 + 16 + 23 + 24	0		0
7 + 17 + 23 + 24	0		0
7 + 13 + 18 + 24	0		0
7 + 14 + 18 + 24	1	Missed criteria 1:1	0
7 + 15 + 18 + 24	0		0
7 + 16 + 18 + 24	0		0
7 + 17 + 18 + 24	0		0
7 + 13 + 19 + 24	0		0
7 + 14 + 19 + 24	0		0

Continued

7 + 15 + 19 + 24	0		0
7 + 16 + 19 + 24	0		0
7 + 17 + 19 + 24	0		0
7 + 13 + 20 + 24	0		0
7 + 14 + 20 + 24	0		0
7 + 15 + 20 + 24	0		0
7 + 16 + 20 + 24	0		0
7 + 17 + 20 + 24	0		0
7 + 13 + 21 + 24	2	Missed criteria 1:2	0
7 + 14 + 21 + 24	1	Missed criteria 1:1	0
7 + 15 + 21 + 24	0		0
7 + 16 + 21 + 24	0		0
7 + 17 + 21 + 24	0		0
8 + 13 + 18 + 24	0		0
8 + 14 + 18 + 24	0		0
8 + 15 + 18 + 24	0		0
8 + 16 + 18 + 24	0		0
8 + 17 + 18 + 24	0		0
8 + 13 + 19 + 24	0		0
8 + 14 + 19 + 24	0		0
8 + 15 + 19 + 24	0		0
8 + 16 + 19 + 24	0		0
8 + 17 + 19 + 24	0		0
8 + 13 + 20 + 24	0		0
8 + 14 + 20 + 24	0		0
8 + 15 + 20 + 24	0		0
8 + 16 + 20 + 24	0		0
8 + 17 + 20 + 24	0		0
8 + 13 + 21 + 24	0		0
8 + 14 + 21 + 24	0		0
8 + 15 + 21 + 24	0		0
8 + 16 + 21 + 24	0		0
8 + 17 + 21 + 24	0		0
8 + 13 + 22 + 24	0		0
8 + 14 + 22 + 24	0		0
8 + 15 + 22 + 24	0		0
8 + 16 + 22 + 24	0		0
8 + 17 + 22 + 24	0		0

Continued

9 + 13 + 18 + 24	0		0
9 + 14 + 18 + 24	1	Missed criteria 1:1	0
9 + 15 + 18 + 24	0		0
9 + 16 + 18 + 24	0		0
9 + 17 + 18 + 24	0		0
9 + 13 + 19 + 24	1	Already found: 1	0
9 + 14 + 19 + 24	0		0
9 + 15 + 19 + 24	0		0
9 + 16 + 19 + 24	1	Missed criteria 1:1	0
9 + 17 + 19 + 24	0		0
9 + 13 + 20 + 24	0		0
9 + 14 + 20 + 24	0		0
9 + 15 + 20 + 24	0		0
9 + 16 + 20 + 24	0		0
9 + 17 + 20 + 24	0		0
9 + 13 + 21 + 24	0		0
9 + 14 + 21 + 24	0		0
9 + 15 + 21 + 24	0		0
9 + 16 + 21 + 24	0		0
9 + 17 + 21 + 24	0		0
9 + 13 + 22 + 24	4	Missed criteria 1:2 Already found: 2	0
9 + 14 + 22 + 24	0		0
9 + 15 + 22 + 24	0		0
9 + 16 + 22 + 24	0		0
9 + 17 + 22 + 24	0		0
10 + 13 + 18 + 24	4	Missed criteria 1:3 Already found: 1	0
10 + 14 + 18 + 24	0		0
10 + 15 + 18 + 24	0		0
10 + 16 + 18 + 24	0		0
10 + 17 + 18 + 24	0		0
10 + 13 + 19 + 24	4	Missed criteria 1:2 Already found: 2	2
10 + 14 + 19 + 24	1	Missed criteria 1:1	0
10 + 15 + 19 + 24	2	Missed criteria 1:1 Already found: 1	0
10 + 16 + 19 + 24	1	Missed criteria 1:1	1
10 + 17 + 19 + 24	0	0	0

Continued

10 + 13 + 21 + 24	0		0
10 + 14 + 21 + 24	0		0
10 + 15 + 21 + 24	0		0
10 + 16 + 21 + 24	0		0
10 + 17 + 21 + 24	0		0
10 + 13 + 22 + 24	1	Missed criteria 1:1	1
10 + 14 + 22 + 24	0		0
10 + 15 + 22 + 24	2	Missed criteria 1:1 Already found: 1	0
10 + 16 + 22 + 24	0		0
10 + 17 + 22 + 24	0		0
11 + 13 + 18 + 24	1	Already found: 1	0
11 + 14 + 18 + 24	0		0
11 + 15 + 18 + 24	1	Already found: 1	0
11 + 16 + 18 + 24	0		0
11 + 17 + 18 + 24	0		0
11 + 13 + 19 + 24	1	Missed criteria 1:1	0
11 + 14 + 19 + 24	0		0
11 + 15 + 19 + 24	0		0
11 + 16 + 19 + 24	1	Missed criteria 1:1	0
11 + 17 + 19 + 24	0		0
11 + 13 + 20 + 24	2	Missed criteria 1:2	0
11 + 14 + 20 + 24	1	Missed criteria 1:1	0
11 + 15 + 20 + 24	0		0
11 + 16 + 20 + 24	2	Missed criteria 1:1 Missed criteria 3:1	0
11 + 17 + 20 + 24	0		0
11 + 13 + 21 + 24	0		0
11 + 14 + 21 + 24	0		0
11 + 15 + 21 + 24	0		0
11 + 16 + 21 + 24	1	Missed criteria 3:1	0
11 + 17 + 21 + 24	1	Missed criteria 1:1	1
11 + 13 + 22 + 24	0		0
11 + 14 + 22 + 24	0		0
11 + 15 + 22 + 24	0		0

Continued

11 + 16 + 22 + 24	0		0
11 + 17 + 22 + 24	0		0
12 + 13 + 18 + 24	0		0
12 + 14 + 18 + 24	0		0
12 + 15 + 18 + 24	0		0
12 + 16 + 18 + 24	1	Missed criteria 1:1	0
12 + 17 + 18 + 24	0		0
12 + 13 + 19 + 24	50	Missed criteria 1:37 Missed criteria 3:6 Already found: 3	4
12 + 14 + 19 + 24	2	Missed criteria 1:1	1
12 + 15 + 19 + 24	2	Missed criteria 1:2	0
12 + 16 + 19 + 24	3	Missed criteria 1:2 Missed criteria 3:1	0
12 + 17 + 19 + 24	3	Missed criteria 1:2	0
12 + 13 + 20 + 24	44	Missed criteria 1:36 Missed criteria 2:4 Already found: 3	1
12 + 14 + 20 + 24	5	Missed criteria 1:5	0
12 + 15 + 20 + 24	4	Missed criteria 1:4	0
12 + 16 + 20 + 24	2	Missed criteria 1:2	0
12 + 17 + 20 + 24	1	Missed criteria 1:1	0
12 + 13 + 21 + 24	1	Missed criteria 1:1	0
12 + 14 + 21 + 24	0		0
12 + 15 + 21 + 24	0		0
12 + 16 + 21 + 24	0		0
12 + 17 + 21 + 24	0		0
12 + 13 + 22 + 24	14	Missed criteria 1:6 Missed criteria 3:3 Already found: 5	0
12 + 14 + 22 + 24	0		0
12 + 15 + 22 + 24	1	Missed criteria 1:1	0
12 + 16 + 22 + 24	0		0
12 + 17 + 22 + 24	0		0
Summary	424		23
12 + 13 + 18	70	Missed criteria 1:26 Missed criteria 2:40 Already found: 4	0
Summary:	326		0

Attachment 2: Quality Assessment of Included Studies

Fulltext Quality Assesement tool for quantitative
studies: http://www.ephpp.ca/PDF/Quality%20Assessment%20Tool_2010_2.pdf
Fulltext Quality Assessment tool for quantitative studies dictionary:
http://www.ephpp.ca/PDF/QADictionary_dec2009.pdf

Ratings Author(s)	A. Selction bias	B. Study design	C. confounders	D. Blinding	E. Data collection method	F. Withdrawals and dropouts	Rating
Aiken *et al.* (2014)	strong	strong	Strong	moderate	strong	weak	Moderate
Aiken *et al.* (2002)	Strong	Weak	Strong	Moderate	Strong	Moderate	Moderate
Aiken *et al.* (2001)	Moderate	Weak	Weak	Moderate	Weak	Strong	Weak
Al-Kandari & Thomas (2008)	Strong	Weak	Moderate	Moderate	Strong	Moderate	Moderate
Amaravadi *et al.* (2000)	Strong	Strong	Strong	Moderate	Strong	Weak	Moderate
Ball *et al.* (2013)	Moderate	Weak	Strong	Moderate	strong	Moderate	Moderate
Carthon *et al.* (2012)	Moderate	Weak	Strong	Moderate	Moderate	Moderate	Moderate
Cho *et al.* (2003)	Moderate	Weak	Strong	Moderate	Strong	Moderate	Moderate
Cho *et al.* (2015)	Strong	Weak	Strong	Moderate	Strong	Moderate	Moderate
Cho & Yun (2008)	Moderate	Weak	Strong	Moderate	Strong	Moderate	Moderate
Cimotti *et al.* (2006)	Moderate	Moderate	Strong	Moderate	Strong	Strong	Strong
Cordova *et al.* (2014)	Moderate	Moderate	Moderate	Moderate	Strong	Weak	Moderate
Daud-Gallotti *et al.* (2012)	Moderate	Moderate	Moderate	Strong	Moderate	Moderate	Strong
Duffield *et al.* (2011)	Moderate	Weak	Moderate	Moderate	Strong	Moderate	Moderate
Glance *et al.* (2012)	Strong	Weak	Strong	Moderate	Strong	Moderate	Moderate
Halm *et al.* (2005)	Weak	Weak	Moderate	Moderate	Strong	Moderate	Weak
Hayes & Ball (2012)	Weak	Weak	Weak	Moderate	Weak	Weak	Weak
Hugonnet *et al.* (2007)	Moderate	Moderate	Weak	Moderate	Strong	Moderate	Moderate
Hinno *et al.* (2011)	Weak	Weak	Strong	Moderate	Strong	Moderate	Weak
Holden *et al.* (2009)	Moderate	Weak	Strong	Moderate	Strong	Strong	Moderate
Jones (2014)	Weak	Weak	Strong	Moderate	Strong	Weak	Weak
Kiekkas *et al.* (2008)	Moderate	Weak	Strong	Moderate	Strong	Strong	Moderate
Kovner *et al.* (2002)	Moderate	Weak	Strong	Moderate	Strong	Moderate	Moderate
Liang *et al.* (2011)	Moderate	Moderate	Strong	Moderate	Strong	Moderate	Strong
Needleman *et al.* (2002)	Moderate	Moderate	Strong	Moderate	Strong	Moderate	Strong
Pearson *et al.* (2004)	Moderate	Weak	Strong	Moderate	Strong	Moderate	Moderate
Potter *et al.* (2003)	Moderate	Weak	Moderate	Moderate	Strong	Moderate	Moderate
Rogowski *et al.* (2013)	Moderate	Moderate	Strong	Moderate	Strong	Moderate	Strong
Sasicbay-Akkadecbanunt *et al.* (2003)	Moderate	Weak	Strong	Moderate	Strong	Moderate	Moderate
Screuders *et al.* (2015)	Moderate	Weak	Moderate	Moderate	Strong	Moderate	Moderate

Continued

Seynaeve *et al.* (2011)	Moderate	Weak	Strong	Moderate	Strong	Moderate	Moderate
Shuldham *et al.* (2008)	Moderate	Moderate	Moderate	Moderate	Strong	Moderate	Strong
Tarnow-Mordi *et al.* (2000)	Moderate	Moderate	Moderate	Moderate	Strong	Moderate	Strong
Tervo-Heikkinen *et al.* (2008)	Weak	Weak	Strong	Moderate	Moderate	Moderate	Weak
Twigg *et al.* (2010)	Moderate	Moderate	Strong	Moderate	Strong	Moderate	Strong
Unruh (2002)	Moderate	Weak	Strong	Moderate	Strong	Moderate	Moderate
Van den Heede *et al.* (2009)	Moderate	Weak	Strong	Moderate	Strong	Moderate	Moderate
Volpe *et al.* (2014)	Moderate	Weak	Weak	Moderate	Strong	Strong	Weak
Stegenga *et al.* (2002)	Moderate	Weak	Weak	Moderate	Strong	Moderate	Weak
Stone *et al.* (2007)	Moderate	Weak	Strong	Moderate	Strong	Moderate	Moderate
Thomas-Hawkins *et al.* (2008)	Weak	Weak	Strong	Moderate	Strong	Moderate	Weak
Wissman *et al.* (2007)	Moderate	Weak	Strong	Moderate	Moderate	Moderate	Moderate
Yang (2003)	Moderate	Weak	Moderate	Moderate	Strong	Moderate	Moderate
Zhu *et al.* (2012)	Strong	Weak	Strong	Moderate	Strong	Moderate	Moderate