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Measuring perceived adequacy of staffing to incorporate nurses' judgement into hospital capacity management: a scoping review

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ABSTRACT

Background Matching demand and supply in nursing work continues to generate debate. Current approaches focus on objective measures, such as nurses per occupied bed or patient classification. However, staff numbers do not tell the whole staffing story. The subjective measure of nurses' perceived adequacy of staffing (PAS) has the potential to enhance nurse staffing methods in a way that goes beyond traditional workload measurement or workforce planning methods.

Objectives To detect outcomes associated with nurses' PAS and the factors that influence PAS and to review the psychometric properties of instruments used to measure PAS in a hospital setting.

Design and methods A scoping review was performed to identify outcomes associated with PAS, factors influencing PAS and instruments measuring PAS. A search of PubMed, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Business Source Complete and Embase databases identified 2609 potentially relevant articles. Data were independently extracted, analysed and synthesised. The quality of studies describing influencing factors or outcomes of PAS and psychometric properties of instruments measuring PAS were assessed following the National Institute for Health and Care Excellence quality appraisal checklist and the COnsensus-based Standards for the selection of health Measurement INstruments guidelines.

Results Sixty-three studies were included, describing 60 outcomes of PAS, 79 factors influencing PAS and 21 instruments measuring PAS. In general, positive PAS was related to positive outcomes for the patient, nurse and organisation, supporting the relevance of PAS as a staffing measure. We identified a variety of factors that influence PAS, including demand for care, nurse supply and organisation of care delivery. Associations between these factors and PAS were inconsistent. The quality of studies investigating the development and evaluation of instruments measuring PAS was moderate.

Conclusions Measuring the PAS may enhance nurse staffing methods in a hospital setting. Further work is needed to refine and psychometrically evaluate instruments for measuring PAS.

Strengths and limitations of this study

► This scoping review is the first to assess (1) the relationship between nurses' expert opinion of staffing adequacy and outcomes, (2) factors influencing nurses' perceived adequacy of staffing, and (3) the reliability and validity of instruments measuring perceived adequacy of staffing.

► The literature search was extensive, and designed and conducted with the help of a clinical librarian.

► Study selection, data extraction and quality appraisal of included studies and instruments were performed by two researchers.

► Limitations of this review include the potential that we have missed original literature on influencing factors or outcomes, because we excluded grey literature and qualitative studies.

INTRODUCTION

Since the early 1970s, both researchers and practitioners have been searching for the best way to match demand for nursing work with nursing supply. Societal developments have made adequate staffing more relevant today than ever. Driven by an ageing population and technological progress, demand for care is rising. At the same time, the WHO expects a worldwide shortage of over 7 million nurses and midwives by 2030,[1] putting continued pressure on staff. Previous research has indicated an association between nurse staffing levels and nurse-sensitive outcomes such as mortality, adverse events, fall rates, failure-to-rescue and missed care.[2–4] Inadequate staffing is also related to burn-out and job dissatisfaction among nurses.[5] Not only quantity but also quality in terms of skill mix matters; a higher proportion of registered nurses (RNs) is associated with better outcomes.[6 7] Inadequate staffing ultimately threatens safety, quality, affordability and accessibility of

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care. Therefore, a thorough understanding of staffing adequacy is needed.

The concept of adequacy of staffing can be divided into 'staffing' and 'adequacy'. 'Staffing' has been defined in multiple studies. Jelinek and Kavois[8] defined nurse staffing as the process of determining the appropriate number and mix of nursing resources necessary to meet workload demand for nursing care at the unit or departmental level. Burke et al[9] described hospital staffing as determining the number of personnel with the required skills to meet predicted requirements. Both of these definitions include balancing demand for nursing work with the adequate number and skill mix of nurses. Adding the word 'adequacy' to the concept of staffing, the meaning shifts from the process of staffing to a condition in which staffing is adequate. The American Nurse Association defined staffing adequacy as a match between RN expertise and recipient needs within the practice setting,[10] but details on what this match entails were omitted. Kramer and Schmalenberg[11] asked nurses if their staffing was adequate and received ambiguous answers: 'That depends – adequate for what? Safe care to all patients? (…) Quality care? (…) Or comprehensive care?' (p.194).

In the absence of an explicit clarification of what adequate staffing means,[12] nurses and managers continue to search for staffing measures that can objectify staffing requirements.[13] These measures need to facilitate different inter-related staffing decisions, for example, how many nurses to employ, staff-shift schedule, nurse roster and nurse-ward allocation.[14] Many workload and resource planning tools are available related to demand for nursing work, resource planning and workload evaluation.

Demand for nursing work
Demand for nursing work has been estimated by a volume-based approach, that is, patient counts multiplied by an administrative measure of work. This has been expressed as the nursing hours per patient day (HPPD),[15] nurse-to-patient ratios[2] and full-time equivalent numbers.[4] These have been criticised as measures for staffing decisions because different patient needs are ignored.[16] The workload-based approach takes different patient care requirements into account and is categorised into activity-based and dependency-based methods.[17] The activity-based method is based on how long nursing tasks take and the dependency-based method relies on patient classification of patients' needs based on indicators, based on which the amount of nursing time can be derived. Disadvantages of the workload-based approach include lack of reliability, validity and flexibility, and the need for time-consuming manual registration.[17–19]

Resource planning tools
Other resource planning tools indirectly measure adequacy of staffing by quantifying demand and supply. One example is the RAFAELA patient classification system.[20] It estimates optimum levels of nursing intensity by balancing demand for care with nursing resources available. The tool is used on a large scale in Finland, but preimplementation in the Netherlands encountered issues of validity and acceptability.[21]

Workload evaluation tools
Other workload tools evaluate nurses' workload. Tools to evaluate workload can be objective indirect measures of mental workload, such as brain activity and cardiac responses, or subjective tools such as the NASA Task Load Index and the Subjective Workload Assessment Technique.[22] These subjective instruments involve short questionnaires with items that reflect experiences (eg, mental demand, physical demand, temporal demand). Those type of measures are commonly used to evaluate workload or validate measures of staffing requirements,[13] reflecting on a broader definition than adequacy of staffing.

In 2010, Fasoli and Haddock[18] reported reliability and validity issues with the available workload measurement systems. Nine years later, another review[13] concluded that available systems were still highly uninformative. Scientists dispute whether nursing work can be accurately quantified. Hughes[23] states that 'it appears that nursing is more concerned with knowledge processing and nurses' intentions than just with the activities of caring' (p.317). Griffiths et al[13] describe that 'there is a limit to what can be achieved through measurement, both because of the fallible nature of the measures, but also because of the complex judgements that are required' (p.9). In the absence of applicable tools, professional judgement was identified as the nearest to a gold standard workload measurement.[13]

Professional judgement
The match between nurse demand and supply can be measured using the nurses' perceived adequacy of staffing (PAS). This measure relies on nurses' expert opinion in which nurses take the unquantifiable fluctuating patient needs and context and situation into account in assessing adequacy of staffing.[24] This direct approach to measuring adequacy of staffing contrasts traditional tools that measure staffing adequacy according to demand and supply. Nurses' perceptions have been accepted as a significant indicator of quality of care,[2] while nurse-perceived quality of care was highly associated with objectively measured nurse-sensitive outcomes, showing the validity of the measure.[25] Regarding nurse staffing tools, relying on nurses' perceptions is less common as most approaches attempt to objectify staffing needs.[13] However, a reliable and valid measure of PAS may be the optimal approach to helping head nurses and managers make nurse staffing decisions. A positive association of PAS with outcomes for patient, staff and organisation enables evidence-based staffing decision making. Staffing adequacy can potentially be predicted by associating structure and process factors of PAS. Data science techniques may minimise nurse effort by analysing these

factors in hospital information systems. However, these techniques have not been explored in nurse staffing literature.[26 27]

The concept of PAS potentially enhances nurse staffing methods, going beyond traditional workload measurement or workforce planning tools.

To explore this alternative to objective workload measurement tools, we conducted a scoping review to study the potential relevance of nurses' PAS in the setting of hospital wards. We asked the following research questions:

1. How is PAS associated with outcomes for the patient, nurse and organisation?
2. Which factors influence PAS?

If these findings show PAS to be a potentially relevant measure for a new staffing method, we will go on to answer the following research questions:

3. Which PAS measurement instruments are available in the literature?
4. What is the reliability and validity of those instruments?

METHODS

We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses—Extension for Scoping Reviews checklist and guidelines to ensure our review was robust and replicable.[28] We did not publish a protocol for this review.

Search strategy

PubMed, CINAHL, Business Source Complete (through EBSCOhost) and Embase were searched from inception to November 2019. The following free-text and database subject headings were combined to search for peer-reviewed articles: *nursing staff, nurses, nurse, staffing adequacy, inadequate staffing, staffing inadequacy, adequate staffing, requirements for nursing resources, attitude of health personnel, perception* and *perceive*, and truncation symbols, for example, nurs*, were used if suitable. Additionally, we screened reference lists of included studies and reviews on nurse staffing for other relevant studies. No limits regarding publication status, date or language were imposed. The complete search strategy for each database is presented in online supplemental appendix 1. The search was designed and conducted with the help of a clinical librarian.

Study selection

References from the databases were combined and downloaded into a reference manager, and duplicates were removed. Articles were screened in two phases. First, two reviewers (CM and CO) independently screened all titles and abstracts and selected articles that met the inclusion criteria (table 1). For the measurement instruments that were applied, the primary development and evaluation study was included. The screening resulted in a Cohen's κ of 0.80. Disagreements about inclusion of studies between the two reviewers (CM and CO) were resolved by discussion. Next, full-text versions were independently screened by the two reviewers and excluded if articles did not meet the inclusion criteria (table 1). Authors were contacted for irretrievable articles.

Data extraction

Data were independently extracted by two reviewers (CM and CO) using a predefined, structured data abstraction form. The form included the author, year of publication, country, journal, aim, research design, population, test setting, sample size, staffing measures, instruments (including subscales), measurement type, validity, reliability, associations between PAS and outcomes, and associations between influencing factors and PAS. Full details of associations were documented and expressed as correlation coefficients (r), β-coefficients (β) derived from linear regression analysis or ORs derived from logistic regression analysis, including their p values and 95% CIs. We also documented whether the associations were corrected for other factors by multivariate analysis.

Quality assessment

Quality of the study outcomes associated with PAS and the factors influencing PAS were evaluated according to the National Institute for Health and Care Excellence quality appraisal checklist for quantitative studies reporting correlations and associations,[29] adapted from Griffiths *et al*.[3] The checklist assesses bias across four categories—population, confounding factors, measures and analyses—using five response options (++, +, -, not reported, not applicable). The resulting score indicates whether the external validity (ie, the generalisability) and the internal validity (ie, the validity of the associations) are strong, moderate or weak.

The methodological quality of the included PAS instruments was appraised using the COnsensus-based

Table 1	Inclusion and exclusion criteria for primary screening	
Inclusion	**Exclusion**
Studies including front-line nurses in hospitals	Systematic reviews, qualitative studies, columns, newspaper or opinion articles, conference abstracts
Studies using PAS to evaluate nurse staffing	
Studies developing or evaluating an instrument for measuring PAS	

PAS, perceived adequacy of staffing.

Standards for the selection of health Measurement INstruments (COSMIN) Risk of Bias checklist.[30 31] This checklist, which has been developed to assess the methodological quality of patient-reported outcome measure studies, is suitable for assessing the risk of bias of PAS instruments. Instrument development, structural validity, internal consistency and other measurement properties in the included studies were assessed. Quality was judged as very good, adequate, doubtful or inadequate, and the overall quality was the lowest item rating in the COSMIN boxes.[31] Measurement properties were rated sufficient (+), insufficient (-) or indeterminate (?) following the criteria for good measurement properties.[31]

Quality was appraised by one reviewer (CM) and cross-checked by a second reviewer (CO). Disagreements between reviewers were solved by consensus.

Data analysis

Outcomes for each research question were summarised. With regard to the influencing factors and outcome studies, variables analysed by t-tests, (multivariate) analysis of variance ((M)ANOVA), χ^2, correlation or regression were judged significant if the value of p was <0.05 or their CI did not enclose the value of 0 or 1. We judged the structural validity and internal consistency of measurement instruments based on the original development study.

Data synthesis

Data for outcomes/influencing factors and measurement instruments were structured separately. The structure-process-outcome model[32] was used to structure the influencing factors and outcomes. Influencing factors are factors related to (1) Structure, that is, the physical and organisational context of care delivery, and (2) Process, that is, the technical and interpersonal process of care delivery. Outcomes reflect the impact of those factors demonstrating the result of structure and process. Following the patient care delivery model,[33] the influencing factors and outcomes of PAS were clustered into patient, staff and organisation categories. Models including PAS as a dependent variable are described separately.

Both single-item and multi-item measurement instruments were included.

Patient and public involvement

No patient was involved.

RESULTS
Study selection and characteristics

The search identified 3120 studies. After removing duplicates and screening titles and abstracts, 135 eligible studies were included for full-text review, including 6 studies that were identified in the reference lists of included studies. Full-text review excluded a further 59 studies. The main reasons for exclusion were no instrument development

or associations with influencing factors or outcomes (24/59), no measurement of PAS (10/59) and staffing measures that were not PAS (8/59). For 13 studies, the full text was not available and the authors did not respond to our request for the full text. In total, 63 studies were included in the analysis (figure 1).

The included studies (tables 2 and 3) were published between 1975 and 2019 worldwide. Most studies (28/63) were carried out in North America,[11 24 34–59] 25 studies were conducted in Europe,[60–84] 5 in Asia,[85–89] 4 in Oceania[90–93] and 1 in multiple continents.[94]

Fifty-two studies included outcomes influenced by PAS or factors that influence PAS.[24 35 37 39 40 42–47 49 52–54 56–60 62 63 65–94] Twenty-one studies described the development and evaluation of PAS instruments.[11 34 36 38 41 43 44 46 48 50 51 54–56 58 61 64 82 86 87 91] Forty-nine studies used a cross-sectional research design,[24 35 37 39 40 42–47 52–54 56 57 59 60 62 63 65–76 78–94] two studies used a longitudinal research design[49 77] and one study used a cross-sectional and longitudinal design.[58] Complete extracted outcomes and influencing factors are provided in online supplemental appendix 2.

Quality assessment of studies investigating influencing factors and outcomes

The methodological quality of most studies was moderate to good (table 4). We revealed serious methodological flaws (weak internal and external validity) in six studies. The risk of bias was increased by cross-sectional research designs, omitting confounding factors, and the lack of multilevel studies and objective measures. External validity was weak because the source population was not clearly described and because of the use of single sites. An overview of the compete quality appraisal is presented in online supplemental appendix 3.

Outcomes influenced by PAS

Our first research question was to explore the associations between PAS and outcomes for the patient, nurse and organisation. Sixty outcomes were found to be influenced by PAS—27 of these were patient-related, 26 were nurse-related and 7 were organisation-related (table 2). Job satisfaction was investigated in nine studies,[39 46 47 52 66 72 75 78 86] quality of care in eight studies,[35 47 66 72 75 85 86 94] safety in four studies,[71 73 75 77] and missed care,[40 62 87] emotional exhaustion,[66 68 75] and occupation dissatisfaction[39 52 75] in three studies. Forty-nine outcomes were investigated in two or fewer studies. Most outcomes were positively associated with PAS.

Associations with PAS were found for the patient outcomes pain,[84] pressure ulcers[24] and patient-centred care.[60] Williams and Murphy[44] asked nurses to rate 10 aspects of care, (including basic hygiene, feeding and medication) from poor to good in six units. Scores for each category were generally higher when staffing was adequate, but results were inconsistent within individual units. Patient safety associated positively with PAS in all studies[71 73 77] except for one,[75] which reported mixed
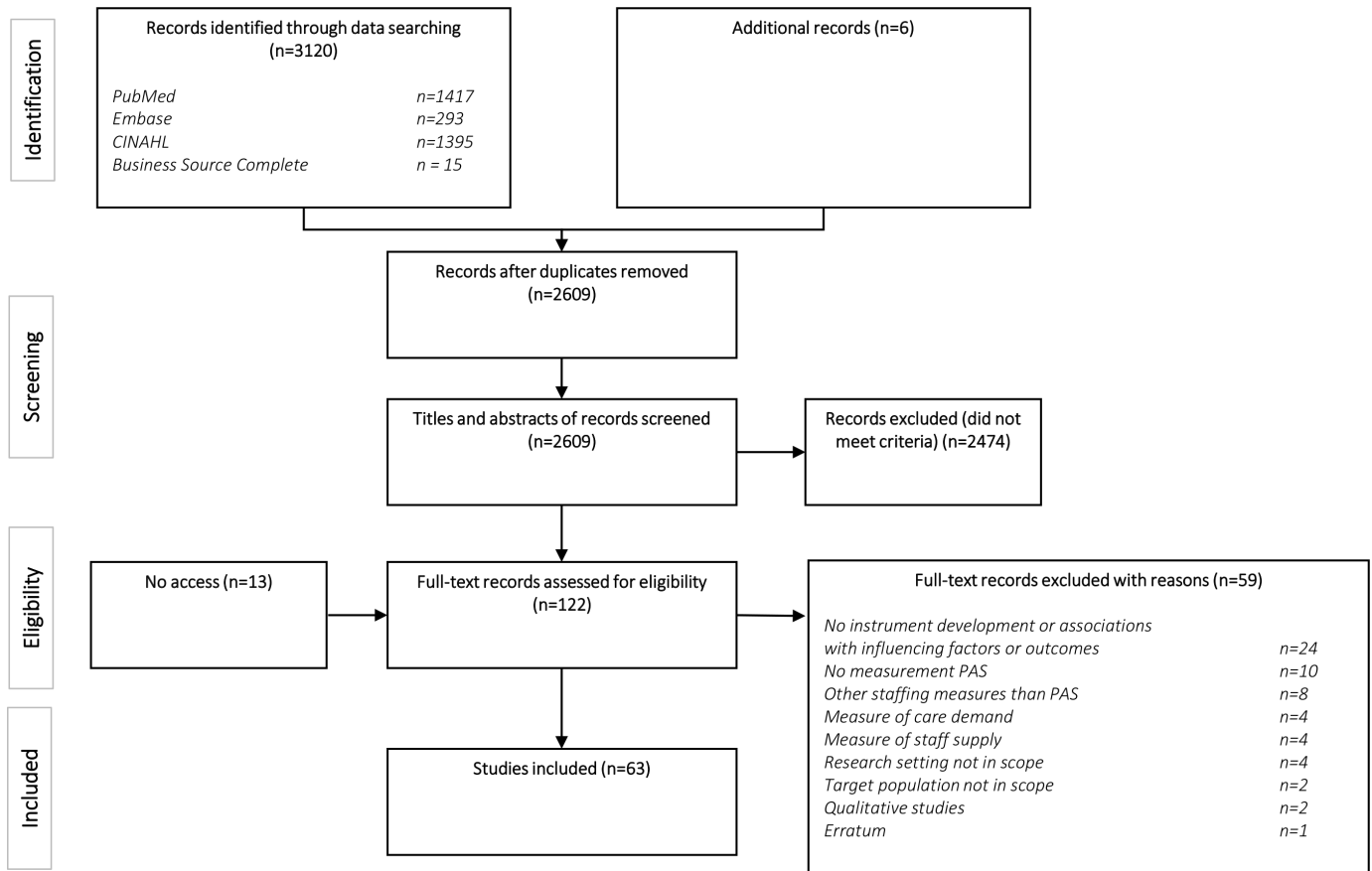
Figure 1 Flow diagram of the search and selection process.

results. Associations with PAS were also mixed for adverse events,[87] infections,[49 74] survival,[73] patients' ability to manage care after discharge,[76] communication with nurses[44 87] and missed care.[40 45 62 70 87] Cho et al[87] found that missed communication and basic care mediate the association between patient-perceived staffing and adverse events and communication with nurses.

PAS had a personal effect on nurses. It affected job satisfaction,[39 46 47 52 66 72 75 78 86] burn-out,[78 86] effort-reward imbalance,[67] depersonalisation, personal accomplishment,[68] feelings of being a safe practitioner and workplace cognitive failure,[77] psychosocial attention,[75] and change efficacy.[81] The reported effects of satisfaction with the occupation,[39 52 75] intention to leave the occupation,[76] intention to leave employment,[80 86 89 94] emotional exhaustion,[66 68 75] depressive symptoms,[67] pain,[53] blood pressure and total cholesterol level[82] were inconsistent. Pain in the neck, shoulder, arm, lower extremities and musculoskeletal system[53] as well as low-density lipoprotein cholesterol levels[82] and change commitment[81] were not influenced by PAS.

PAS affected organisational outcomes, including nurses' turnover,[42 47] absenteeism,[45] quality of nursing[73] and quality improved within the last year.[75] Mixed results were reported for quality of care.[35 47 66 72 75 85 86 94] Patients' hospital rating was associated with patient-perceived staffing adequacy but not with nurse-perceived staffing

adequacy.[87] Anzai et al[85] found no association between PAS and nurses' ability to provide quality nursing care.

Influencing factors of PAS

For the second research question, we identified the structural and process factors that influence PAS.

Structural factors

Fifty-two structural factors that influence PAS were identified. These were categorised into demand for care (11 factors), nurse supply (30 factors) and organisation of care delivery (11 factors). The setting type was investigated in seven studies[44 47 75 83 84 91 92] and patients-per-nurse in three studies.[24 59 87] The remaining 50 factors were investigated in two or fewer studies. Associations were mainly positive, that is, higher scores on structural factors led to more positive PAS.

With regard to demand for care, no consistent results were found for factors associated with PAS. Inconsistent results were found for census,[43 44] number of maximum care patients[43] and patient classification category.[43 58 69] New admissions, transfers, discharges, postoperative patients, specialised nursing procedures[43] and crowding scores in the emergency department[54] were not related to PAS.

Nurse supply factors influencing PAS were full-time equivalent RNs per patient day,[58] HPPD,[24] nursing hours,[43]

Table 2 Influencing factors and outcomes of PAS

Outcome	#
Patient	1
Adverse events	
Communication with nurses	2
Basic feeding and toileting	1
Basic hygiene	1
Implementation of new orders without undue delay	1
Implicit rationing of nursing care	1
Medications, IVs	1
Missed care	3
Missed communication	1
Mobility	1
Observation	1
Occurrence of central line-associated bloodstream infection	
Overall survival	1
Patients ability to manage care after discharge	
Pain	1
Patient care interventions omitted or delayed	1
Patient-centred care	1
Rounds with or assist MD	1
Safety	4
Special procedures	1
Surgical site infection after total hip arthroplasty	1

Continued

Table 2 Continued

Continued

Column headers (study references):
- Anzai, Douglas, and Bonner[85]
- Astar, Kapucu, Kose, Kurt, and Ersoy[83]
- Bachnick, Ausserhofer, Baernholt, and Simon[60]
- Bae, Brewer, Kelly, and Spencer[49]
- Bragadóttir, Kalisch, and Tryggvadóttir[92]
- Bragadóttir, Kalisch, and Tryggvadóttir[79]
- Bruyneel, Van den Heede, Diya, Aiken, and Sermeus[78]
- Burmeister et al[94]
- Cho et al[96]
- Cho et al[97]
- Choi and Staggs[54]
- De Groot, Burke, and George[47]
- Desmedt, De Geest, Schubert, Schwendimann, and Ausserhofer[69]
- Ducharme, Bernhardt, Padula, and Adams[36]
- Escobar-Aguilar et al[84]
- Fuentelsaz-Gallego, Moreno-Casbas, Gomez-Garcia, and Gonzalez-María[86]
- Gunnarsdóttir, Clarke, Rafferty, and Nutbeam[88]
- Hegney et al[91]
- Heinen et al[76]
- Jafree, Zakar, Zakar, and Fischer[98]
- Jolivet et al[87]
- Kalisch and Lee[37]
- Kalisch, Lee, and Rochman[39]
- Kalisch, Tschannen, and Lee[52]
- Kalisch, Tschannen, Lee, and Friese[90]
- Kalisch, Friese, Choi and Rochman[99]
- Kim et al[95]
- Leineweber et al[89]
- Lin, Chiang, and Chen[80]
- Louch, O'Hara, Gardner and O'Connor[77]
- Mark, Salyer and Harless[59]
- Nelson-Brantley, Park, Bergquist-Beringer[82]
- O'Brien-Pallas et al[45]
- Pineau, Laschinger, Regan, and Wong[46]
- Rauhala and Fagerström[56]
- Reeder, Burleson, and Garrison[54]
- Roche and Duffield[92]
- Roche, Duffield, and White[93]
- Rochon, Heale, Hunt, and Parent[57]
- Sasso et al[90]
- Schubert, Glass Clarke, Schaffert-Witvliet, and De Geest[70]
- Sharma et al[81]
- Smeds, Tishelman, Runesdotter, and Lindqvist[71]
- Spence et al[90]
- Spence Laschinger[90]
- Stalpers, Van Der Linden, Kaljouw, and Schuurmans[72]
- Triveldi and Hancock[43]
- Tvedt, Sjetne, Helgeland, and Bukholm[73]
- Tvedt, Sjetne, Helgeland, Lower, and Bukholm[74]
- Weigl, Schmuck, Heiden, Angerer, and Müller[58]
- Williams and Murphy[44]
- Zander, Dobler, and Busse[75]

Outcome	#
Surgical site infection after total hip arthroplasty for non-elective patients	1
Survival after acute myocardial infarction	1
Therapeutic interventions omitted or delayed	1
Unit-acquired pressure ulcers	1
Ventilator-associated pneumonia	1
Vital signs	1

Nurse

Outcome	#
Any musculoskeletal pain	1
Arm pain	1
Burn-out	2
Blood pressure	1
Change commitment	1
Change efficacy	1
Depersonalisation	1
Depressive symptoms	1
Effort-reward imbalance	1
Emotional exhaustion	3
Intention to leave	3
Intention to leave and stay in nursing	1
Intention to leave nursing	1
Intention to stay in employment	1
Job satisfaction	9

Table 2 Continued

	Anzal, Douglas, and Bonner[38]	Astet, Kapucu, Kose, Kurt, and Ersoy[83]	Bachnick, Aussethofer, Baernholt, and Simon[80]	Bae, Brewer, Kelly, and Spencer[29]	Bragadottir, Kalisch, and Tryggvadottir[82]	Bragadottir, Kalisch, and Tryggvadottir[79]	Bruyneel, Van den Heede, Diya, Aiken, and Sermeus[78]	Burmeister et al[76]	Cho et al[95]	Cho et al[97]	Choi and Staggs[34]	De Groot, Burke, and George[47]	Desmedt, De Geest, Schubert, Schwendimann, and Aussethofer[93]	Duchanne, Bernhardt, Padula, and Adams[35]	Escobar-Aguilar et al[94]	Fuentelsaz-Gallego, Moreno-Casbas, Gomez-Garcia, and Gonzalez-Maria[85]	Gunnarsdottir, Clarke, Rafferty, and Nutbeam[86]	Hegney et al[81]	Heinen et al[75]	Jafree, Zakar, and Fischer[88]	Jolivet et al[87]	Kalisch and Lee[37]	Kalisch, Lee, and Rochman[99]	Kalisch, Tschannen, and Lee[62]	Kalisch, Tschannen, Lee, and Friese[60]	Kalisch, Friese, Choi and Rochman[59]	Kim et al[53]	Leineweber et al[89]	Lin, Chiang, and Chen[96]	Louch, O'Hara, Gardner and O'Connor[77]	Mark, Salyer and Harless[58]	Nelson-Brantley, Park, Bergquist-Beringer[42]	O'Brien-Pallas et al[45]	Pineau, Laschinger, Regan, and Wong[46]	Rauhala and Fagerström[49]	Reeder, Burleson, and Garrison[64]	Roche and Duffield[92]	Roche, Duffield, and White[90]	Rochon, Heale, Hunt, and Parent[57]	Sasso et al[90]	Schubert, Glass Clarke, Schaffert-Witvliet, and De Geest[70]	Sharma et al[91]	Smeds, Tishelman, Runesdotter, and Lindqvist[71]	Spence et al[60]	Spence Laschinger[56]	Stalpers, Van Der Linden, Kaljouw, and Schuurmans[72]	Trivedi and Hancock[43]	Tvedt, Sjetne, Helgeland, and Bukholm[73]	Tvedt, Sjetne, Helgeland, Lower, and Bukholm[74]	Weigl, Schmuck, Heiden, Angerer, and Müller[92]	Williams and Murphy[44]	Zander, Dobler, and Busse[75]	#
LDL cholesterol level																											x																							x			1
Low back pain																											x																									1
Lower extremity pain																											x																									1
Neck/shoulder pain																											x																									1
Number of areas in pain																											x																									1
Occupation dissatisfaction																							x*	x*																												x	3
Personal accomplishment																																																				
Psychosocial attention																												x*																						x			1
Safe practitioner																														x*																					x*	1
Total cholesterol level																														x*																						1
Workplace cognitive failure																																																	x			1
Organisation																																																				
Ability to provide quality nursing care	x																																																			
Absenteeism																																	x*																				1
Overall hospital rating									x																																											1
Quality of care							x*	x	x*			x*		x			x*																													x*						x*	8
Quality improved within the last year																																																				x*	1
Quality of nursing																																																x*					1
Turnover												x*																				x*																				2
Demand for care																																																				
Census																																															x				x		2
Crowding (ED)																																				x																	1
Discharges																																															x						1
New admissions																																															x						1
Number of maximum care patients																																																			x		1
OPCQ																																			x																		1

Table 2 Continued

Continued

The table is a wide matrix (rotated on the page) listing studies (columns) against variables (rows). The column headings (author citations), from right to left, are:

Zander, Dobler, and Busse[75]; Williams and Murphy[74]; Weigl, Schmuck, Heiden, Angerer, and Müller[82]; Tvedt, Sjetne, Helgeland, Lower, and Bukholm[74]; Tvedt, Sjetne, Helgeland, and Bukholm[73]; Trivedi and Hancock[49]; Stalpers, Van Der Linden, Kaljouw, and Schuurmans[72]; Spence Laschinger[56]; Spence et al[90]; Smeds, Tishelman, Runesdotter, and Lindqvist[71]; Sharma et al[81]; Schubert, Glass Clarke, Schaffert-Witvliet, and De Geest[70]; Sasso et al[80]; Rochon, Heale, Hunt, and Parent[57]; Roche, Duffield, and White[93]; Roche and Duffield[92]; Reeder, Burleson, and Garrison[54]; Rauhala and Fagerström[89]; Pineau, Laschinger, Regan, and Wong[96]; O'Brien-Pallas et al[95]; Nelson-Brantley, Park, Bergquist-Beringer[47]; Mark, Salyer and Harless[58]; Louch, O'Hara, Gardner and O'Connor[77]; Lin, Chiang, and Chen[88]; Leineweber et al[83]; Kim et al[93]; Kalisch, Friese, Choi and Rochman[99]; Kalisch, Tschannen, Lee, and Friese[60]; Kalisch, Tschannen, and Lee[52]; Kalisch, Lee, and Rochman[59]; Kalisch and Lee[37]; Jolivet et al[87]; Jafree, Zakar, Zakar, and Fischer[98]; Heinen et al[76]; Hegney et al[91]; Gunnarsdottir, Clarke, Rafferty, and Nutbeam[86]; Fuentelsaz-Gallego, Moreno-Casbas, Gomez-Garcia, and Gonzalez-María[85]; Escobar-Aguilar et al[84]; Duchame, Bernhardt, Padula, and Adams[35]; Desmedt, De Geest, Schubert, Schwendimann, and Ausserhofer[53]; De Groot, Burke, and George[97]; Choi and Staggs[24]; Cho et al[67]; Cho et al[66]; Burmeister et al; Bruyneel, Van den Heede, Diya, Aiken, and Sermeus[78]; Bragadóttir, Kalisch, and Tryggvadóttir[79]; Bragadóttir, Kalisch, and Tryggvadóttir[92]; Bae, Brewer, Kelly, and Spencer[69]; Bachnick, Ausserhofer, Baernholt, and Simon[50]; Asiret, Kapucu, Kose, Kurt, and Ersoy[63]; Anzai, Douglas, and Bonner[65].

Variables (rows) and their totals (# column):

Category	Variable	#
	Patient classification	1
	Patient technology	1
	Postoperative patients	1
	Specialised nursing procedures	1
	Transfers	1
Nurse supply	Age	2
	Assistive personnel	1
	Educational level	1
	Emotional stability	1
	FTE RNs per patient day	1
	Gender	2
	Hours per patient day	1
	Level of agreeableness	1
	Level of conscientiousness	1
	Life orientation	1
	Mental stress	2
	Non-RN hours per patient day	1
	Nurse hours per patient day	1
	Nursing hours	1
	Nursing role	2
	Part time	1
	Patients per nurse	3
	Psychological capital	1
Structure	RN temporary nursing care hours per patient day	1
	Skill mix	2

Table 2 Continued

			Anzai, Douglas, and Bonner[85]	Asiret, Kapucu, Kose, Kurt, and Ersoy[83]	Bachnick, Ausserhofer, Baernholdt, and Simon[60]	Bae, Brewer, Kelly, and Spencer[49]	Bragadóttir, Kalisch, and Tryggvadóttir[62]	Bragadóttir, Kalisch, and Tryggvadóttir[79]	Bruyneel, Van den Heede, Diya, Aiken, and Sermeus[78]	Burmeister *et al*[94]	Cho *et al*[86]	Cho *et al*[87]	Choi and Staggs[24]	De Groot, Burke, and George[47]	Desmedt, De Geest, Schubert, Schwendimann, and Ausserhofer[63]	Ducharme, Bernhardt, Padula, and Adams[35]	Escobar-Aguilar *et al*[84]	Fuentelsaz-Gallego, Moreno-Casbas, Gomez-Garcia, and Gonzalez-Maria[65]	Gunnarsdóttir, Clarke, Rafferty, and Nutbeam[66]	Hegney *et al*[91]	Heinen *et al*[76]	Jafree, Zakar, Zakar, and Fischer[88]	Jolivet *et al*[67]	Kalisch and Lee[37]	Kalisch, Lee, and Rochman[39]	Kalisch, Tschannen, and Lee[52]	Kalisch, Tschannen, Lee, and Friese[40]	Kalisch, Friese, Choi and Rochman[59]	Kim *et al*[53]	Leineweber *et al*[68]	Lin, Chiang, and Chen[89]	Louch, O'Hara, Gardner and O'Connor[77]	Mark, Salyer and Harless[58]	Nelson-Brantley, Park, Bergquist-Beringer[42]	O'Brien-Pallas *et al*[45]	Pineau, Laschinger, Regan, and Wong[46]	Rauhala and Fagerström[69]	Reeder, Burleson, and Garrison[54]	Roche and Duffield[92]	Roche, Duffield, and White[93]	Rochon, Heale, Hunt, and Parent[57]	Sasso *et al*[80]	Schubert, Glass Clarke, Schaffert-Witvliet, and De Geest[70]	Sharma *et al*[81]	Smeds, Tishelman, Runesdotter, and Lindqvist[71]	Spence *et al*[90]	Spence Laschinger[56]	Stalpers, Van Der Linden, Kaljouw, and Schuurmans[72]	Trivedi and Hancock[43]	Tvedt, Sjetne, Helgeland, and Bukholm[73]	Tvedt, Sjetne, Helgeland, Løwer, and Bukholm[74]	Weigl, Schmuck, Heiden, Angerer, and Müller[82]	Williams and Murphy[44]	Zander, Dobler, and Busse[75]	#
		Staff hours																																																			x'		1
		Staff hours per maximum care patient																																																			x'		1
		Staff hours per patient																																																			x'		1
		Students																																			x									x'									2
		Total temporary nursing care hours per patient day				x																																																	1
		Use of causal staff																																												x*									1
		Use of relief staff																																												x*									1
		Work capacity																																			x									x*									2
		Work experience																																												x*								x	2
		Working duration in unit		x																																																			1
	Organisation of care delivery	Case mix index																									x					x*																							2
		Managerial planning and organisation of the work																																			x																		1
		Meetings/training during shift																																			x*									x'									2
		Number of beds on the unit																														x*																							1
		Number of high technology services																														x*																							1
		Organisation of manager																																												x*									1
		Planning of the shift schedule																																												x*									1
		Planning of the work rota																																			x																		1
		Setting		x											x°*			x*		x*																			x*														x°	x'	7
		Substitute resources																																			x																		1
		Unit size																														x*																							1
Process		Backup						x*																x*																													2

Continued

Table 2 Continued

	Anzai, Douglas, and Bonner[58]	Asiret, Kapucu, Kose, Kurt, and Ersoy[59]	Bachnick, Aussenhofer, Baernholdt, and Simon[60]	Bae, Brewer, Kelly, and Spencer[48]	Bragadóttir, Kalisch, and Tryggvadóttir[62]	Bragadóttir, Kalisch, and Tryggvadóttir[61]	Bruyneel, Van den Heede, Diya, Aiken, and Sermeus[75]	Burmeister et al[63]	Cho et al[66]	Cho et al[67]	Choi and Staggs[54]	De Groot, Burke, and George[47]	Desmedt, De Geest, Schubert, Schwendimann, and Aussenhofer[53]	Ducharme, Bernhardt, Padula, and Adams[35]	Escobar-Aguilar et al[64]	Fuentelsaz-Gallego, Moreno-Casbas, Gomez-Garcia, and Gonzalez-María[65]	Gunnarsdóttir, Clarke, Rafferty, and Nutbeam[96]	Hegney et al[81]	Heinen et al[76]	Jafree, Zakar, and Fischer[82]	Jollet et al[37]	Kalisch and Lee[37]	Kalisch, Lee, and Rochman[59]	Kalisch, Tschannen, and Lee[52]	Kalisch, Tschannen, Lee, and Friese[60]	Kalisch, Friese, Choi and Rochman[59]	Kim et al[83]	Leineweber et al[82]	Lin, Chiang, and Chen[98]	Louch, O'Hara, Gardner and O'Connor[77]	Mark, Salyer and Harless[56]	Nelson-Brantley, Park, Bergquist-Beringer[42]	O'Brien-Pallas et al[45]	Pineau, Laschinger, Regan, and Wong[46]	Rauhala and Fagerström[96]	Reeder, Burleson, and Garrison[84]	Roche and Duffield[2]	Roche, Duffield, and White[90]	Rochon, Heale, Hunt, and Parent[57]	Sasso et al[80]	Schubert, Glass Clarke, Schaffert-Witvliet, and De Geest[70]	Sharma et al[81]	Smeds, Tishelman, Runesdotter, and Lindqvist[71]	Spence et al[90]	Spence Laschinger[36]	Stalpers, Van Der Linden, Kaljouw, and Schuurmans[72]	Trivedi and Hancock[49]	Tvedt, Sjetne, Helgeland, and Bukholm[73]	Tvedt, Sjetne, Helgeland, Lower, and Bukholm[74]	Weigl, Schmuck, Heiden, Angerer, and Müller[92]	Williams and Murphy[44]	Zander, Dobler, and Busse[75]	#
Cooperation/coordination with other staff																				x															x*																		1
Cooperation in your own group																				x															x																		1
Cooperation with doctors																				x															x*							x*											2
Cooperation within the organisation																				x															x																		1
Cooperation with peer nurses																																																					1
Error reporting culture																																																					1
Governance																																																					1
Nurse co-worker relations																																																					1
Nurse foundations for quality care																																																					1
Nurse leaders' perceived influence																																																					1
Nurse manager ability, leadership and support														x																																							1
Nurse participation in hospital affairs																																																					1
Nurses' feeling of respect																																																					1
Organisational commitment												x																																									1
Patient-perceived staffing										x																																											1
Professional commitment												x																																									1
Professional practice climate												x																																									1
Role support																						x																															1
Shared mental models							x																															x																2
Structural empowerment																																		x*																			1

Continued

Table 2 Continued

Factor	#	Anzai, Douglas, and Bonner[85]	Bragadóttir, Kalisch, and Tryggvadóttir[79]	Kalisch and Lee[81]	Kalisch, Lee, and Rochman[59]	Kalisch, Friese, Choi and Rochman[59]	Rochon, Heale, Hunt, and Parent[57]
Team leadership scores	2		×*	×*			
Team orientation	2		×*		×*		
Teamwork	3		×*		×*		×
Trust	2		×*	×*			
Unexpected rise in patient volume and/or acuity	1					×*	
Ward morale	1	×*					

Table 3 Instruments for measuring perceived adequacy of staffing (PAS), including characteristics and psychometric properties

Title—author	Country	Measurement aim	Items, formats, subscale	Measurement type	Quality of instrument/ subscale development	Sample size	Structural validity Meth. Quality	Rating	Internal consistency Meth. Quality	Rating	Other measurement properties Yes/ no	Specification	Meth. Quality	Rating
Adequate staff for care—Spence Laschinger[56]	Canada	To measure nurses' perceptions of adequate staffing to provide high quality of nursing care.	Single item, item not reported	Possible score range 1–5	Inadequate	NR	NA	NA	NA	NA	No	NA	NA	NA
American Association of Critical-Care Nurses Healthy Work Environment (AACN-HWE) Assessment Tool[50]	USA	To assess the health of the work environment.	Subscale Appropriate staffing, 3 items: 1. Administrators and nurse managers work with nurses and other staff to make sure there are enough staff to maintain patient safety 2. Administrators and nurse managers make sure there is the right mix of nurses and other staff to ensure optimal outcomes 3. Support services are provided at a level that allows nurses and other staff to spend their time on the priorities and requirements of patient and family care	5-point Likert Scale (strongly disagree– strongly agree)	Inadequate	500	Inadequate	NR	Very good	+ α>0.80	Yes	Hypothesis testing	Inadequate	NR OOM
Assessment of real-time demand for the emergency department (ED)— Reeder, Burleson, and Garrison[54]	USA	To assess the current real-time demands for the ED	Single item; Are the demands on current resources significantly greater than your available resources?	Exceeded/not exceeded	Inadequate	NR	NA	NA	NA	NA	No	NA	NA	NA
Head nurse questionnaire – Trivedi and Hancock[43]	USA	To measure and predict workload on nursing units using perceptions of head nurses	Nursing workload, 6 items: (Q1) If one additional person was available to you on your unit for today's shift: How would you express the need for that person if that person was an (1) RN (2) LPN (3) aide? (Q3) If one person had been withdrawn from your unit for staffing elsewhere: With what degree of difficulty could you have released that person if that person was an (4) RN (5) LPN (6) aide?	5-point Likert Scale (no need–very great need) 5-point Likert Scale (very great difficulty– no difficulty)	Doubtful	For the day shift, the head nurse of five study units completed the questionnaire for a 7-week period	NA	NA	NA	NA	No	NA	NA	NA

Continued

Table 3 Continued

Title—author	Country	Measurement aim	Items, formats, subscale	Measurement type	Quality of instrument/ subscale development	Sample size	Structural validity	Internal consistency	Other measurement properties
Hospital Survey on Patient Safety Culture (HSOPS)—Sorra & Nieva[55]	USA	To assess the culture of patient safety in healthcare organisations	Subscale Staffing, 4 items; (A2) We have enough staff to handle the workload (A5) Staff in this unit work longer hours than is best for patient care (negatively worded) (A7) We use more agency/temporary staff than is best for patient care (negatively worded) (A14) We work in 'crisis mode' trying to do too much, too quickly (negatively worded)	5-point Likert Scale (strongly disagree–strongly agree)	Doubtful	1437	Very good / +EFA and CFA loadings NR, CFI≥0.90, RMSEA 0.04	Very good / - α 0.63 / Yes	Hypothesis testing / Hypothesis testing / Doubtful / Doubtful / +OOM ? KG
MISSCARE Survey—Kalisch and Williams[38]	USA	MISSCARE Survey: to measure missed nursing care	Single item, part of unit and staff characteristics; % of the time perceived staffing adequacy in the unit	5-point Likert Scale 100% of the time (1), 75% of the time (2), 50% of the time (3), 25% of the time (4), 0% of the time (5)	Inadequate	NR	NA / NA	NA / NA / No	NA / NA / NA
New graduates' perception of adequate staffing—Pineau Stam et al[46]	Canada	To measure new graduates' perceptions of adequate staffing for the successful provision of care	Single item; In the last month how often has short staffing affected your ability to meet your patient/clients' needs?	5-point Likert Scale (1=never, 2=monthly, 3=weekly, 4=several times a week, 5=daily)	Inadequate	NR	NA / NA	NA / NA / No	NA / NA / NA
Nurse-perceived staffing adequacy—Cho et al[87]	South Korea	To measure nurse-perceived staffing adequacy	Single item; Was there a sufficient number of nurses to provide quality nursing care on the unit?	4-point Likert Scale (very insufficient–very sufficient)	Inadequate	NR	NA / NA	NA / NA / No	NA / NA / NA
Nursing Teamwork Survey—Kalisch et al[48]	USA	To measure levels of nursing teamwork in acute care settings	Single item, part of unit and staff characteristics; % of the time perceived staffing adequacy in the unit	5-point Likert Scale 100% of the time (1), 75% of the time (2), 50% of the time (3), 25% of the time (4), 0% of the time (5)	Inadequate	NR	NA / NA	NA / NA / No	NA / NA / NA
Nursing Work Index - Extended Organisation (NWI-EO)—Bonneterre et al[61]	France	To assess perceived levels of stress caused by psychosocial and organisational work factors	Subscale Staffing inadequacy to perform duties, 2 items: 1. Enough registered nurses on staff to provide quality patient care 2. Enough staff to get the work done	4-point Likert Scale (strongly agree–strongly disagree)	Doubtful	4085	Adequate / -EFA loadings NR	Very good / +α 0.89 / Yes	Reliability / Hypothesis testing / Doubtful / Doubtful / - Spearman's r 0.61 ? KG
Nursing Work Index - Revised (NWI-R)—Aiken and Patrician[34]	USA	To measure characteristics of professional nursing practice environments	No staffing subscale derived in original study[34]	4-point Likert Scale (strongly agree–strongly disagree)	NA	NA	NA / NA	NA / NA / NA	NA / NA / NA

Continued

Table 3 Continued

Title—author	Country	Measurement aim	Items, formats, subscale	Measurement type	Quality of instrument/subscale development	Sample size	Structural validity		Internal consistency			Other measurement properties		
PAS Scale (part of essentials of magnetism II)—Kramer and Schmalenberg[11]	USA	To measure perceived adequacy of staffing as a process variable	Subscale Perceived adequacy of staffing, 6 items; 1. Adequate to give quality patient care 2. Adequacy varies with/is affected by type of delivery system 3. Inadequate even if all budgeted positions are filled 4. Adequate for safe patient care 5. Cohesiveness and teamwork help 6. Positively affects job satisfaction	4-point Likert Scale	Adequate	729	Adequate	−EFA loadings 0.549–0.711	Very good	+α 0.873	Yes	Hypothesis testing	Adequate	+KG
Perceived Nursing Work Environment (PNWE)—Choi et al[61]	USA	To measure the perceived work environment for critical care practice	Subscale Staffing and resources adequacy, 5 items; 1. Enough staff to get the work done 2. Enough RNs to provide quality patient care 3. Adequate support services allow me to spend time with my patients 4. Enough time and opportunity to discuss patient care problems with nurse 5. A satisfactory salary	4-point Likert Scale (strongly agree–strongly disagree)	Doubtful	2324	Adequate	−EFA loadings 0.47–0.80	Very good	+α 0.83	Yes	Hypothesis testing Hypothesis testing	Doubtful Adequate	+OOM −KG
Perception of staffing adequacy—Cho et al[66]	Korea	To measure perceptions of staffing adequacy	Single item; Enough nurses to provide high-quality nursing care	4-point Likert Scale (strongly agree–strongly disagree)	Inadequate	NR	NA	NA	NA	NA	No	NA	NA	NA
Perception of work conditions—Gerolamo[36]	USA	To measure nurses' perceptions of the working conditions on their unit	Single item of perceived adequacy of staffing; We had enough staff this shift to handle the workload	5-point Likert Scale (strongly agree–strongly disagree)	Inadequate	NR	NA	NA	NA	NA	No	NA	NA	NA
Perceptions of adequacy of staffing—Mark, Salyer, and Harless[58]	USA	To measure perceptions of staffing adequacy	Single item; Evaluate the adequacy of staffing on your unit	5-point Likert Scale (very much above average–very much below average)	Inadequate	NR	NA	NA	NA	NA	No	NA	NA	NA
Perceptions of understaffing— Weigl, Schmuck, Heiden, Angerer, and Müller[32]	Germany	To measure perceived staffing level on the ward or hospital unit	Single item; Staffing level is sufficient in this unit/ward	5-point Likert Scale (no, not at all, yes, to a very great extent)	Inadequate	NR	NA	NA	NA	NA	No	NA	NA	NA

Continued

Table 3 Continued

Title—author	Country	Measurement aim	Items, formats, subscale	Measurement type	Quality of instrument/subscale development	Sample size	Structural validity	Internal consistency			Other measurement properties		
Practice Environment Scale of the Nursing Work Index (PES-NWI)—Lake[41]	USA	To measure the hospital nursing practice environment	Subscale Staffing and resource adequacy, 4 items: 1. Enough staff to get the work done 2. Enough RNs to provide quality patient care 3. Adequate support services allow me to spend time with my patients 4. Enough time and opportunity to discuss patient care problems with other nurses	4-point Likert Scale	Adequate	2299	Adequate; ? EFA loading 0.47–0.73	Very good	+α 0.80	Yes	Reliability Hypothesis testing	Adequate Very good	+ICC 0.96 +KG
Professional Assessment of Optimal Nursing Care Intensity Level (PAONCIL)—Fagerström and Rainio[64]	Finland	To assess the nursing care intensity of a ward, that is, the degree to which personnel resources are in balance with the patients' care needs	Professional estimate of the nursing care intensity, single item; Assess the nursing intensity of the patients you nursed during your shift	7-point scale from −3 (very low) to +3 (very high) The estimate can be made with an accuracy of 0.25 points	Inadequate	169	NA	NA	NA	Yes	Hypothesis testing	Adequate	+OOM
Unit staffing/care evaluation form — Williams and Murphy[44]	USA	To obtain charge nurses' evaluations of staffing adequacy and levels of direct care provided	Single item; In general, did you feel that staffing for this shift was:	4-point Likert Scale (more than adequate–inadequate)	Inadequate	NR	NA	NA	NA	No	NA	NA	NA
Workload Perceptions Survey—Hegney et al[61]	Australia	To measure adequacy of staffing to meet patient needs	Relevant questions; (Q20) Were sufficient staff employed in your work unit to meet patient/client/resident needs? (Q21) Was the skill mix of nursing/midwifery staff employed in your work unit adequate to meet the daily needs of patients/clients/relatives?	5-point Likert Scale (never or very seldom–always or nearly always)	Inadequate	NR	NA	NA	NA	No	NA	NA	NA

CFA, confirmative factor analysis; CFI, Comparative Fit Index; EFA, exploratory factor analysis; ICC, intraclass correlation coefficient; KG, known groups; LPN, licensed practical nurse; NA, not applicable; NR, not reported; OOM, other outcome measurement; RMSEA, root mean square error of approximation; RN, registered nurse.

Table 4 NICE quality appraisal checklist[29] adapted from Griffiths et al[3]

Criteria	Weak		Moderate		Strong	
Section 1: Population						
1.1 Is the source population or source area well described?	15%	(8)	42%	(22)	42%	(22)
1.2 Is the eligible population or area representative of the source population or area?	19%	(10)	44%	(23)	37%	(19)
1.3 Do the selected participants or areas represent the eligible population or area?	8%	(4)	50%	(26)	42%	(22)
Section 2: Confounding factors						
2.1 How well were likely confounding factors identified and controlled?	38%	(20)	19%	(10)	42%	(22)
Section 3: Measures						
3.1 Were the main measures and procedures reliable?	2%	(1)	85%	(44)	13%	(7)
3.2 Were the outcome measurements complete?	0%	(0)	50%	(26)	50%	(26)
Section 4: Analyses						
4.0 Study design and analyses	92%	(48)	8%	(4)	0%	(0)
4.1 Was the study sufficiently powered to detect an effect (if one exists)?	8%	(4)	23%	(12)	69%	(36)
4.2 Were the analytical methods appropriate?	37%	(19)	46%	(24)	17%	(9)
4.3 Was the precision of association given or calculable? Is association meaningful?	8%	(4)	19%	(10)	73%	(38)
Section 5: Summary						
5.1 Are the study results internally valid (ie, unbiased)?	27%	(14)	40%	(21)	33%	(17)
5.2 Are the findings generalisable to the source population (ie, externally valid)?	15%	(8)	37%	(19)	48%	(25)

NICE, National Institute for Health and Care Excellence.

patients-per-nurse,[24 59 86] (RN) skill mix,[24 58] educational level,[83] assistive personnel,[59] causal/relief staff,[90] mental stress,[69 90] nurses' psychological capital[46] and life orientation.[47] Mixed results were reported for staff hours available,[44] presence of students,[69 90] nursing role,[67 85] gender,[75 85] work experience[75 83 90] and nurses' work capacity.[69 90] Nursing HPPD, non-RN HPPD, temporary nursing-care HPPD,[49] age[75 83] and part-time nurses[75] were not related to PAS. Louch et al[77] found that levels of agreeableness and conscientiousness moderated the association between PAS and whether nurses feel they can act as a safe practitioner, and that emotional stability moderated the association between PAS and patient safety.

Organisation of care delivery factors unit size, number of beds and number of high-technology hospital services[58] affect PAS. Spence et al[90] reported that organisation of the clinical manager's work and the shift schedules was the most important of nine factors that increase workload. In contrast, Rauhala and Fagerström[69] found no relationship between managerial planning, work organisation, work rota planning and Professional Assessment of Optimal Nursing Care Intensity Level (PAONCIL) Scores. Mixed results were found for the setting,[44 47 75 83 84 91 92] case mix index,[58 59] and meetings and training during shifts.[69 90] Substitute resources did not correlate with PAONCIL Scores.[69]

Process factors

Twenty-seven process factors were investigated in relation to PAS. Most process factors were positively associated

with PAS, that is, higher process factor values were related to more positive PAS.

Teamwork was investigated in three studies, and other factors were examined in two or fewer studies. Ward morale,[85] error reporting culture, governance, nurse participation in hospital affairs, nurse manager ability, leadership and support, foundations for quality nursing care,[88] trust, shared mental models, team leadership, backup,[37 79] structural empowerment,[46] nurses' feeling of respect,[56] organisational and professional commitment, professional practice climate,[47] and unexpected rise in patient volume or acuity,[59] all influenced PAS. An increase in positive patient perceptions of staffing was related to an increase in positive perceptions of nurse staffing.[87] Intraprofessional and interprofessional cooperation[69 88 90] and teamwork[37 57 79] showed inconsistent associations with PAS. The perceived influence of nurse leaders was associated with PAS in four out of six leadership domains.[35] PAS was not associated with role support.[93]

Models

Three studies explained PAS using regression models. Kalisch et al[59] reported four different models with variables HPPD, case mix index, nursing education, unexpected rise in patient volume and acuity, and inadequate number of assistive personnel. The model including all variables explained most variance in PAS (33.8%). Mark et al[58] studied three models explaining between 33% and 51% of the variance in PAS. Patient technology, number of beds, growing admissions, and case mix index were relevant in all three models. Rauhala and Fagerström[69]

built models for 22 wards including patient classification and non-patient questions as independent variables. The median variance explained by patient factors alone was 45%. Adding non-patient factors increased the median variance to 55%, indicating that patient factors contributed to PAS more strongly than non-patient factors did.

Measurement instruments of PAS

The third research question investigated instruments used to measure the PAS. We found 21 studies that described PAS measurement instruments (table 3),[11 34 36 38 41 43 44 46 48 50 51 54–56 58 61 64 82 86 87 91 91] 20 of which were found in the development studies. Most instruments were developed in the last two decades, except for two that were developed in the 1970s.[43 44] Most instruments (12/19) were developed in the USA.[11 34 36 38 41 43 44 48 51 54 55 58]

The measurement aim, items and response options of the different instruments varied considerably. Instruments with a direct practical purpose of balancing nurse demand and supply were the head nurse questionnaire,[43] PAONCIL,[64] assessment of real-time demand for the emergency department[54] and the unit staffing/care evaluation form.[44] These instruments are used on a daily basis.

PAS is measured in the different questionnaires by single items,[36 38 44 46 48 54 56 58 64 82 86 87] multiple items[43 91] and multi-item subscales to evaluate safety culture[55] and nursing work environment.[11 34 41 50 51 61] Some items assess the adequacy of staffing numbers (eg, 'Enough staff to get the work done'),[36 41 43 46 51 55 61 82 86 87 91] and some assess the skill mix (eg, 'Enough registered nurses on staff to provide quality patient care').[41 43 50 51 61 91] Some instruments attempt to specify the purpose of adequate staffing (eg, adequate 'for quality care',[11 41 51 56 61 86 87] 'to handle the workload',[36 55] 'to meet your patient/clients' needs',[46 91] 'to get the work done'[41 51 61] and 'to maintain patient safety'[50]) while other instruments just measure adequacy of staffing without specifying what this entails.[38 44 48 58 82]

The target respondents of all instruments are nurses in general, head nurses,[43] critical care nurses,[50 51] charge nurses[44] or new graduates.[46] One study asked both nurses and patients to assess PAS.[87] Most instruments used a 4-point or 5-point Likert Scale.[11 34 36 38 41 43 44 46 48 50 51 55 56 58 61 82 86 87 91] Real-time demand for the emergency department[54] was assessed using a dichotomous scale: exceed or not exceed. The PAONCIL includes a 7-point scale, and estimates can be made with an accuracy of 0.25 points.[64]

Reliability and validity

The fourth research question assessed the reliability and validity of PAS measurement instruments. We found methodological flaws in most studies. With regard to the single-item instruments, construct validity of PAONCIL was tested by hypothesising a correlation between PAONCIL scores and patient classification scores.[64] No other studies of single-item or multi-item measures reported reliability or validity testing. The Nursing Work Index - Revised

development study did not use a staffing subscale,[34] so we could not assess psychometric properties. For the remaining six subscales,[11 41 50 51 55 61] the methodological quality of structural validity and internal consistency were adequate, except for structural validity of the American Association of Critical-Care Nurses Healthy Work Environment. However, while internal consistency was sufficient in most studies, structural validity was sufficient in only one study.

DISCUSSION

Our scoping review found that mostly positive perceptions of staffing adequacy (measured using the PAS) are related to positive outcomes for patient, nurse and organisation, confirming the importance of the measure. We identified many factors that influence PAS, but the associations were inconsistent. Twenty-one instruments were identified that measure PAS, and these different instruments had different measurement aims.

Most studies reported that positive perceptions of staffing adequacy are related to positive outcomes for the patient, nurse and organisation. Effects on patient outcomes were inconsistent, mainly because of severe methodological flaws in one study.[44] The positive relationship between staffing and outcomes was confirmed by different staffing measures, such as nurse-to-patient ratios.[13 95] However, studies explained more of the variation in patient outcomes of PAS than staffing measures such as nurse-to-patient ratios and HPPD,[24 60] indicating the informative value. Kalisch et al[59] found moderate correlations between nurse-reported staffing adequacy, nurse-to-patient ratios and nursing HPPD, clarifying that these measures 'may capture different elements of the unit context to explain nurse staffing' (p.775). It seems that adequate staffing depends on more than just staff numbers and skill mix elements, and that nurses take these additional factors into account when assessing PAS.[24 96] In agreement with this, we identified many factors that influence PAS in the present study, including demand for care, nurse staffing, and organisation and process factors. Whether outcomes are improved by objective measurement of workload on a daily basis is unclear.[12] The RAFAELA system has provided some evidence that patient safety and mortality are associated with workload level.[97] Our finding that measuring the PAS is associated with positive outcomes indicates that measuring the PAS will strengthen nurse staffing tools, which will in turn improve staffing decisions. Measuring the PAS was also found to be relevant in research areas other than nurse staffing. For example, PAS was one of the eight essential factors of magnetism. Magnetism refers to elements that are essential for a work environment that can attract and retain nurses while providing a high level of job satisfaction and quality of care.[98]

We identified a variety of factors that influence PAS, but were unable to define a valid set of factors that were relevant to nurse staffing. Most factors were investigated in

one study and results were inconsistent between studies. There appear to be many factors affecting PAS, including patient-related and nurse-related factors and how care delivery is organised. Factors related to the work environment were also important, such as cooperation, leadership and teamwork. This is in agreement with other studies of factors that influence demand for care.[99–102] Hence, patient, nurse and organisation factors were recommended to consider in a staffing model.[101] Nurses have disputed traditional instruments for measuring workload because they involve time-consuming manual registration and cannot forecast staffing adequacy.[17–19 96 100 103] Including influencing factors in a staffing model can solve these issues, enabling decision makers to align nursing resources in a timely fashion. The study by Trivedi and Warner[104] was one of the first attempts to predict staffing adequacy using data. They designed a multivariate regression model that predicted head nurse perceptions of staffing adequacy and used this model to allocate float nurses at the beginning of the shift. Nowadays, more advanced techniques are available. Machine learning and artificial intelligence can be used to analyse hospital data and potentially explain and forecast PAS, supporting staffing decisions. These methods are a prerequisite for reliable and valid measurement of PAS.

Most of the PAS measurement instruments we found were single items, and they did not include psychometric testing. However, multiple psychometric tests can be performed on single items, including tests for content validity, inter-rater variability and responsiveness.[105] Although a single item is suitable in some situations,[106] multiple items are more reliable. Multiple items should be used for complex constructs as they define the meaning of the construct for the rater.[105] Kramer and Schmalenberg found that multiple items are needed to measure PAS.[107] However, the downside of administrative burdens have been shown to inhibit successful implementation.[21] Most relevant shortcomings of multiple-item instruments of PAS are a lack of information on subscale development, omitting to fully determine structural validity by confirmative factor analysis and confirm other psychometric properties such as reliability, criterion validity, hypothesis testing, measurement error and responsiveness.

Overall, development and evaluation of PAS instruments has been moderate; this reflects the varying use of the measure. There is no established definition of staffing adequacy. Most instruments reflect the adequacy of staff numbers, and some include skill mix (which is becoming increasingly relevant).[3 108] In addition, the measurement aims differ between instruments. For some measurements such as safety[55] and work environment,[34 41] it is sufficient to grade adequacy of staffing, while for nurse staffing decision making understaffing or overstaffing need to be graded. Moreover, instruments measure PAS by referring to the adequacy of full-time equivalent numbers[11] or team composition.[41] This tactical/strategic decision level of staffing differs from instruments on operational decision levels of capacity management, where decisions involve the staff schedule of a specific

shift. Just as for workload measurement tools,[12] the decisions supported by the PAS instrument are mostly unspecified. As a result, there are a variety of available instruments, so practical use of PAS in the nurse staffing process is still limited. Decision makers continue to search for objective staffing measures and rely only moderately on nurses' opinions, so there is still a significant gap between managers and nurses in daily operations.

Strengths and limitations

The strengths of our review includes that our review was set up systematically and assessed the quality of included studies, something which is not mandatory for a scoping review.[109] But, there are some limitations to our study. First, we were unable to assess the full text of some studies (0.5%) because of no access and failing requests to researchers. However, because of the small amount of inaccessible studies we consider these studies of minimum impact on our results and conclusions. Second, we searched for studies that developed and validated PAS instruments, which could have affected our results as other publications discussing psychometric properties of included instruments were not included. Finally, we excluded qualitative studies and grey literature, which may have included potential influencing factors or outcomes. Because these studies are often followed up by quantitative studies to determine influencing factors,[102] it is likely that these factors and outcomes already are included in the quantitative studies included in this review. Nevertheless, in future research qualitative data should be explored as an extension of the results reported in this review.

Practical implications

Adequate staffing is essential for the patient, nurse and organisation.[110] In an ideal situation, PAS would be evaluated daily on the hospital ward to identify inadequate staffing either at the beginning of a shift or in upcoming shifts. Using existing patient and nurse data avoids additional administrative work and incorporating nurses' judgement potentially generates valid and reliable information acceptable to nursing staff. Measuring PAS in this way is in accordance with existing design principles.[101] The information is input for a mutual dialogue and decision making on a team, ward or cross-departmental level. Nursing managers should recognise that staff numbers do not tell the whole staffing story and avoid investing in traditional patient classification systems. Machine learning and artificial intelligence will provide new opportunities for measuring adequacy of staffing in the near future. For adequate and practical measurement of PAS, a balance should be found between using multiple items for reliability and limiting the effort needed to use them. For this to work, practitioners need to be involved in developing adequate PAS measures.

CONCLUSIONS

This scoping review found that PAS is positively associated with outcomes for patient, nurse and organisation, supporting the relevance of PAS as a measure for

nurse staffing decisions. Many factors were identified that influence PAS, but associations were inconsistent. Instruments used to measure PAS were found to have moderate reliability and validity. Measuring PAS could enhance nurse staffing methods by predicting staffing adequacy based on existing patient and nurse data using machine learning and artificial intelligence techniques. This approach goes beyond traditional workload measurement or workforce planning methods. Further work is needed to refine and psychometrically evaluate instruments measuring PAS.

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