

Nursing Workloads and Activity in Critical Care: A review of the Evidence.

Jane Greaves ^a, Deborah Goodall ^e, Andrea Berry ^b, Suman Shrestha ^c, Annette Richardson ^d, Pauline Pearson ^a

- a Faculty of Health and Life Sciences,
University of Northumbria,
Coach Lane Campus,
Benton,
Newcastle Upon Tyne,
NE7 7XA
- b C Floor, Brotherton Wing,
Leeds General Infirmary,
Great George Street,
Leeds,
LS1 3EX
- c Frimley Park Hospital,
Portsmouth Road,
Frimley,
GU16 7UJ
- d Freeman Hospital,
Freeman Road,
High Heaton,
Newcastle upon Tyne,
NE7 7DN
- e Deceased, formerly Northumbria University

Abstract:

Objectives: To review current methods for informing nurse workforce decisions in critical care. Many clinical outcomes are worse if staffing is inadequate. Workforce

planning is usually according to guidelines developed from the opinions of expert groups. Objective systems for planning and distributing staff have been developed but their value is unclear.

Design: A rapid review methodology was employed.

Review methods: The search included research studies, guidelines and surveys within and outside United Kingdom since 1995.

Findings: Thirty-two studies met eligibility criteria. Studies originated worldwide, with considerable work undertaken in the United Kingdom and Brazil. Two were large multicentre studies. Tools examined fell into three groups: those focused on the condition and needs of the patient, those focused on the number and time for nursing activities and those that also took account of psycho-social factors. Many tools were not used beyond their country of origin.

Conclusion: There is limited experience of using tools to determine nurse staffing. No one tool is likely to suit every application. More information is needed to clarify the practicalities of using the tools.

Key Words: critical care; workload; safety; systematic review

Implications for Practice

- The number and distribution of nurses in the intensive care unit is not usually decided on the basis of evidence.
- No tool has been adequately validated for determining staffing levels in the intensive care unit.
- No tool has been demonstrated to be superior to the professional judgement of an experienced nurse manager for staffing decisions.

Introduction

National and International guidelines for levels of qualified nursing staff in critical care are based on the opinions of expert groups. They have been produced in by a variety of nursing and medical professional bodies in many countries (RCN, 2003; BACCN, 2009; FICM/ICS, 2013 [United Kingdom]; EFCCN, 2007[Europe]; 2015, Kleinpell et al., 2014 [USA]; Chamberlain et al., 2017 [Australia]). The Oxford Centre for Evidence Based Medicine considers 'expert group opinion' to be the weakest form of evidence: Level 5 (Howick et al., 2012). Tools intended to allow more appropriate staffing decisions to be taken have, however, been developed. An evaluation of these tools is required to help decide whether they can inform a safe standard of nursing care, based on patients' individual requirements.

Background

Inadequate nurse staffing worsens patient outcomes in every area of care. There is evidence that an increased ratio of qualified nurses to patients improves patient outcomes (Aitken, 2014; McGahan et al., 2012). A study in England (Griffiths et al., 2016) and a multicentre study in the United Kingdom, Belgium, Finland, Spain, Switzerland and Ireland (Aiken, 2017) have found that higher levels of support-worker staffing are associated with higher hospital mortality rates. Kelly et al. (2014) found that each 10% increase in nurses with a bachelor's degree was associated with a 2% reduction in 30day mortality for mechanically ventilated older adults (Kelly et al., 2014). A literature review by Caryon and Gurses (2005) found that lower levels of staffing have been reported to be associated with: higher mortality (Cho and Yun,

2009; West et al., 2014; West et al., 2009); increased incidence of adverse events (Graf et al., 2005; West, et al., 2009); more healthcare associated infections (Daud-Gallotti et al., 2012; Stone et al., 2007; Venier et al., 2014); worse patient and relative satisfaction (Gerasimou-Angelidi et al., 2014; Johnson et al., 1998); more musculo-skeletal injury (Aiken et al., 2002; Frade Mera and García, 2009), and greater prevalence of pressure ulcers (Cremasco et al., 2013). An audit of an initiative rationing critical care nurse numbers in Swiss Hospitals found lower patient satisfaction; and increased nosocomial infection, medication errors, falls, critical incidents and pressure ulcers (Schubert et al., 2012).

Scott (2003) reviewed methods for guiding nurse workforce decisions and categorised approaches to workforce planning as top down, where factors such as historic levels of staffing and calculations of health need are used to develop guidelines; and bottom up, where factors such as patient need or nursing time are used. Hurst undertook a systematic review of the literature of methods for determining the size of nursing teams (Hurst, 2003) and described five planning systems (Table 1). Another review of the issues and difficulties of predicting the workload associated with nursing care is that of Adomat and Hewison (2004). They concluded that though patient dependency scoring systems for severity of illness are robust measures for predicting morbidity and mortality, they are not accurate for calculating nurse staffing ratios because they do not consider non-clinical nursing tasks.

(Table 1 here)

Optimal ratios of nurses to ICU patients have not been completely established. Although arbitrary thresholds have been set, these recommendations are based on experts' opinions rather than on scientific evidence. The European Federation of Critical Care Nurses issued a position-paper on nurse staffing in ICU the recommendations of which have been widely adopted in Europe

and beyond (EFCCN, 2007). Recommendations for levels of nurse staffing in critical care in the United Kingdom follow these guidelines and are mainly based on patient dependency (FICM/ICS, 2015). Critical care can be defined as care delivered in units where most patients are assessed as needing care at level 2 or 3 (FICM/ICS, 2015; Mackenzie, 2004). A minimum nurse/patient ratio of 1:2 is recommended for level 2 patients and 1:1 for level 3 patients (FICM/ICS, 2015). In Australian practice the same definitions are used and the staffing recommendations are the same (Chamberlain, 2017). In California the nurse/patient ratio is legally required to be 1:2, or lower, at all times (California Department of Health Services, 2003). Each state in the USA is able to set its own standards for staffing and in practice ratios of patients to bachelor's degree qualified nurses are generally at least 1:2 in critical care units.

Aim

This review was undertaken to answer the question, "Are there valid and reliable tools available for predicting nursing workload in Intensive Care Units to facilitate decisions about nurse staffing?"

Design

A rapid review (or rapid evidence appraisal) methodology was used in order to provide a timely answer. Rapid review provides an assessment of what is already known about a policy or practice issue. It differs from a comprehensive systematic review in that it is quicker, generally excludes hand searching, and review of grey literature, may include exclusion criteria and does not attempt meta-analysis of the data. (Civil Service, 2010; Grant and Booth, 2009).

Search Methods

A team including critical care experts (AR,SS,AB), an information specialist (DG) and two nursing academics (PP,JG) undertook the review. The scope of the search was agreed to include research studies, guidelines and surveys related to tools measuring patient related activity or nursing workload intensity, specifically in adult critical care and published during the last 20 years (1995-2016). The search was in accordance with the PRISMA framework (Liberati, 2009). The following search terms were used, singly and in combination: Critical care nursing, Nursing, Nurse staffing, Skill mix, Dependency, Adverse events, Health care assistants and critical care, Length of stay, Critical care and Intensive care. As the evaluation of papers progressed it became necessary to consider some important papers outside the 1995 limit.

The search encompassed subject specific electronic databases: CINAHL, Medline, Proquest Hospital Collection, Web of Knowledge, SCOPUS; evidence-based resources including: NHS Evidence, Cochrane Library; selected governmental, professional, academic and subject websites such as Kings Fund, Department of Health, RCN, and other sources identified within the team. Material searched for was in the English language; readily available in press or published in academic/peer-reviewed journals. The SPICE framework was used to help the review team to focus on key elements (Booth and Brice, 2004). References were collected and managed within EndNote™. Screening criteria at title/abstract level were developed iteratively, following initial searches and were discussed within the project team for approval.

Search outcome

Sixty-six records were initially identified through database searching using the terms above. Fifty-six additional records were identified through sources including NHS Evidence and the Cochrane Library, as well as selected governmental, professional, academic and subject websites. Team members excluded eighty-one records that

did not meet the inclusion criteria. Previous reviews and publications consisting only of opinion or discussion were excluded. Full text papers were obtained for the remaining forty-two records and ten more were found not to meet inclusion criteria. Thirty-two studies were thus included in the review. A diagram of the search is shown in Appendix 1.

Quality appraisal

Reviewing was shared between this paper's authors, with two individuals examining and commenting upon each paper. Reviewers used a form developed from SCIE systematic research review guidelines (SCIE, 2013).

Results

The reports of instruments for estimating nursing workload are shown in Table 2. The numbers used for the reviewed articles relate to the listing in this Table.

(Table 2 here)

Source of Studies

Studies came from a wide range of countries. There were three large, multicentre studies. One presenting data from twelve European countries (4) and two presenting data from a variety of countries worldwide (5, 29).

Methodology of the Studies

The studies included instrument developments (1-7), a description of software development (8), prospective studies of the use of specific tools (9-22), a retrospective analysis (23), observational studies (24-29) and reports of staffing models (30-32).

Tools Used to Measure the Probable Nursing Workload

The tools examined fell into three groups:

- Tools based on estimates of the condition of the patient. Measures such as APACHE scoring (Knaus et al., 1981) are primarily for establishing the severity of illness, in order to study and compare outcomes systematically. But on the assumption that sicker patients consume more resource, they are used to forecast nursing workload. (Table 3)
- Tools using measures of nursing activities and interventions. These are based on the actual work undertaken by nurses, much of which is not captured by scores focussed on the condition of the patient. (Table 4)
- Three measures in our search did not clearly fit either of the other categories, forming a grouping, drawing on psycho-social theories. These instruments have looked at factors such as patient risk, the complexity of tasks and the stress nurses suffer as a result of nursing activities. They depart from the use of both severity of illness and range of interventions as an index of nurse manpower requirement and have instead sought ways to quantify the unique nursing contribution to patient care. (Table 5)

(Table 3 Here)

(Table 4 Here)

(Table 5 here)

Outcomes

The reports used a variety of outcome measures. Some compared the predicted patient requirements with actual work done (14, 23). Some attempted to validate a tool by comparing its performance with other tools (8, 11, 12, 15, 16, 17, 20, 24) others compared tool performance with the decisions of the nurse making staff allocations (26, 27, 28, 29). Six studies used a metric to compare workloads in different units (10,13, 18, 22, 26, 30).

Outcomes fell into a range of areas:

- The first involves the relationship between patient dependence and staff workload. Studies making use of the tools focused on disease, diagnosis or physiological measures of health and illness, and patient dependency (APACHE II, III, SAPS II, DRGs (Diagnosis Related Groups) and SOFA (Sepsis Related Organ Failure Assessment) have tended to assume that the sicker the patient the more care they need. The TISS family of instruments including NAS (Nursing Activities Score) (5) are originally developed from TISS-76 (a severity of illness score) with the addition of nursing-activity related items. Adomet and Hicks (2003) used video recording to measure the real workload of intensive care. They concluded that current formulae overestimated the load of direct nursing tasks. They reported that patients identified as less dependent may in some cases require more input. Where patient sickness and dependency tools were compared with tools in the nursing activities and interventions group (9, 13, 18), the latter are reported as reflecting the workload better. Most studies that used patient dependence measures were using them to attempt to validate other, nurse-activity based tools.
- The second group of tools related to measuring what nurses needed to do. Altafin *et al* (9) found that the Nursing Activities Score (NAS) was able to capture a greater breadth of activities than TISS-28. eCastro *et al* (8) developed a computer-based version of NAS, demonstrating its effectiveness, particularly in data summary and display. Camuci *et al* (10) using NAS showed a high potential workload in a burns ICU compared to studies of other critical care units. Conishi *et al* (25) found that NAS performed better in 24-hour application than by shifts. Debergh *et al* (14) suggested that NAS was influenced by patient characteristics and by type of shift for example nights, weekends, daytime. Carmona-Monge *et al* (11) suggested that many items on the NAS scale are relatively subjective in use. Three reports evaluated the NEMS (Nine Equivalent of Nursing Manpower Score) against the NAS (12, 20,21) and indicated that the former's more focused

components led to a quicker completion time, and similar judgements of workload.

- The third group of outcomes related to factors that facilitate or impede the nursing contribution to critical care. Ball and McElligot (24) considered issues relating to risk, subsequently developing the Managing Risk Instrument (1). This was not found to be reliable, but the authors reported their rather mixed preliminary results because they believed that their concept was an important step forward in understanding the management of ITU manpower. The NASA Task Loading Index (NASA- TLX) (Hart and Staveland, 1988) explores a group of psychosocial factors: mental demand, physical demand, temporal demand, performance, effort and frustration level. Hoonakker, Carayon, et al, trialled it as a measure of nurse workload but the authors did not develop a useable tool (2). Neil and Davis developed a tool (6) using the subjective judgements of nurses about the patients care (SWAN – Subjective workload assessment for nurses).

Discussion

The issue of quantifying nursing workload is complicated by the variety of purposes for which instruments are intended. Many were originally developed for other applications such as manpower planning, cost-benefit analysis, skill-mix within critical care, severity of illness and to enable comparison between ICU's. Comparison of reports is further complicated by variations of staff titles and job responsibilities that exist between countries.

Many of the scoring systems have been developed by national organisations and are rarely used beyond their country of origin. Padilha et al. (29) investigated the use of the NAS in seven countries and found large variations in the average score between countries. This, and previous similar observations, indicate that national healthcare systems use critical care services in different ways and confirms that systems to determine staffing levels should depend on workload and dependency measures

specific to that system. The United Kingdom context in which this review began in early 2014 was one in which there were already national guidelines on critical care nurse staffing levels (FICM / ICS, 2013). The National Institute for Healthcare Excellence has published guidelines for staffing of acute wards (NICE, 2014), and revised guidelines for critical care nurse staffing in UK were published in 2015 (FICM/ICS, 2015). This plethora of guidance development sits alongside a situation where professionals and the public continue to grapple with understanding what is safe staffing in a context of austerity.

The Chief Nursing Officer for England (CNO) in a letter to healthcare organisations and their nurse directors (Cummings 2015) notes that 'healthcare is increasingly delivered by a multi-professional workforce', and getting the right skill-mix is important. One of the reviews mentioned above (Adomat and Hewitson 2004) demonstrates the difficulties in assessing skill-mix even within a nursing only team. Others, here reported, for example Altafin et al (9), incorporate a wider team in a very different organisational context. Cummings reminds her audience that staffing is also about how much time nurses spend with, or supporting patients, their families and carers, and what the outcomes for them. While time spent with patients is considered in some papers, consideration of patient and carer outcomes is largely absent in the tools examined with the exception of Ball and McElligot's exploratory study (24). The CNO also addressed the development of new models of care, and the consequent difficulty in identifying a one size fits all approach concluding that there will be no identikit approach to the mix of staff we need.

This review set out to identify which, if any, tools offered the most robust and inclusive method of identifying safe nurse staffing in critical care, or demonstrated potential for this. The range of tools explored fell into a number of potential groupings and sub-groupings, focused on nursing tasks and activities, therapeutic interventions, patient disease and dependency, and tools drawing on ideas of nurse effort and

patient risk. The diversity uncovered indicates that any one tool is unlikely to suit every application. This review suggests that for critical care there are relevant studies, including two large multicentre studies. The majority are prospective studies focusing on the use of one or more existing tool but there are few reports of long-term use in practice, and no reports of clinical outcomes or cost consequences.

Given the changing context and focus of nursing care, the shape and skill-mix of the workforce, rather than just the tasks undertaken, becomes extremely important. Skill-mix relates to the judgement of nursing competence and skills needed to meet the individual patient's problems and provide a good standard of safe care.

The study using the NASA index of task loading (2) and that using the SWAN tool (6) remind us that it is important to consider the psychological stresses on the nurse as well as the efficacy of care. Environmental and organisational contexts (for example the layout of the units concerned, and whether the organisation is public or private) should also be considered when planning safe levels of care.

The studies analysed in this review provided very little usable information on the practicalities of routine use of formal staffing tools in the clinical setting. Only NAS was developed as computer based form, piloted with a small cohort of patients. Data collection by a researcher was said to take 5 minutes per patient (8).

The early development of scoring systems concentrated largely on patient care in the form of interventions. Recent developments reflect increased self-confidence amongst critical care nurses, and are based on nursing considerations. In order to provide sustainable tools in practice for the future, more work is needed to understand which levels of staff might best complete tools, and what barriers might exist to their ongoing use.

Conclusions

It is essential to be clear about the purpose for which a scoring system will be used.

Only two papers reported using a workload prediction score to prospectively allocate staff and followed up with an assessment of the consequences (18, 23). Most reports are attempts to validate a scoring system against another metric or proxy for workload.

Instruments such as APACHE II, III or SAPS are the most reliable way to stratify severity of illness in critical care but did not perform well as measures of nursing workload. NAS is the most extensively examined workload tool, with generally reliable results. It is also a system that focuses on the whole of the critical care nurse's workload. It is probably the most suitable instrument for evaluating overall staffing levels. NEMS is easier to complete and provides broadly similar results - but deals mostly with patient factors. For skill-mix issues the risk based model developed by Ball and McElligot (24) provides a means of determining nurse allocation on the basis of risk rather than workload, or patient dependency, but did not enable assessors to clearly discriminate the levels of nursing experience required. The human factors approach of Neill and Davis (6) is similarly intended to assist in skill mix decisions.

Further work is needed to examine and develop these tools for use before any unequivocal recommendation can be made. None of the instruments here reported are sufficiently developed for routine use. This is reflected in this review by the almost complete absence of reports of using a workforce-planning tool for the day-to-day allocation of staff within individual critical care units. We need to consider whether a complex tool can be as efficient or effective as the opinion of an experienced critical care nurse when making staffing decisions. The reports comparing the predictions of tools with the judgement of nurses are generally taken

as evidence of their validity, but can be interpreted as showing that the judgement of the nursing professionals is at least as good. They understand the nature and mix of their available staff and the complexity of their patients. They understand the capability of the individuals. They have experience of the demands upon their unit and should understand what problems are prone to occur and how to pre-empt them. Nevertheless, It seems likely that experienced critical care nurses will value the development of effective tools to help them provide safe patient care.

Weaknesses of this review

- National variations in the way critical care services are staffed and delivered make it difficult to compare outcomes.
- The demography of patients in critical care units is variable and depends on both the guidelines in operation and local factors such as case-mix and the pressure on beds.

Acknowledgements

Dr Deborah Goodall contributed to much of the work involved and to writing and commenting on earlier drafts, but sadly died during the late stages of preparation. We are grateful for her significant contribution, and wish to acknowledge her authorship.

References

- AACN. Synergy Model. American Association of Critical-Care Nurses; 2014. <https://www.aacn.org/nursing-excellence/aacn-standards/synergy-model> Accessed 2nd May 2016
- Adomat R, Hewison A. Assessing patient category/dependence systems for determining the nurse/patient ratio in ICU and HDU: a review of approaches. *Journal of nursing management*. 2004;12:299-308.
- Adomat R, Hicks C. Measuring nursing workload in intensive care: an observational study using closed circuit video cameras. *J Adv Nurs*. 2003;42:402-12.
- Aiken LH, Clarke SP, Sloane DM, Sochalski J, Silber JH. Hospital nurse staffing and patient mortality, nurse burnout, and job dissatisfaction. *JAMA*. 2002;288:1987-93.
- Aiken LH, Sloane D, Griffiths P, Rafferty AM, Bruyneel L, McHugh M, et al. Nursing skill mix in European hospitals: cross-sectional study of the association with mortality, patient ratings, and quality of care. *BMJ Qual Saf*. 2017;26:559-68.
- Aiken LH, Sloane DM, Bruyneel L, Van den Heede K, Griffiths P, Busse R, et al. Nurse staffing and education and hospital mortality in nine European countries: a retrospective observational study. *The Lancet*. 2014;383:1824-30.
- Altafin JA, Grion CM, Tanita MT, Festti J, Cardoso LT, Veiga CF, et al. Nursing Activities Score and workload in the intensive care unit of a university hospital. *Rev Bras Ter Intensiva*. 2014;26:292-8.
- BACCN. Standards for Nurse Staffing in Critical Care. British Association of Critical Care Nurses: London; 2009.
- Ball C, McElligott M. Realising the potential of critical care nurses': an exploratory study of the factors that affect and comprise the nursing contribution to the recovery of critically ill patients. *Intensive Crit Care Nurs*. 2003;19:226-38.
- Ball C, Walker G, Harper P, Sanders D, McElligott M. Moving on from 'patient dependency' and 'nursing workload' to managing risk in critical care. *Intensive Crit Care Nurs*. 2004;20:62-8.
- Booth A, Brice A. Evidence-based practice for information professionals: A handbook: Facet publishing; 2004.
- Brana Marcos B, Del Campo Ugidos RM, Fernandez Mendez E, de la Villa Santovena M. [Proposal of a new assessment scale of work load and nursing times (VACTE)]. 2007; *Enferm Intensiva*, 18(3), 115-125.
- California Department of Health Services. (2003). Staffing regulations, R-37-01. Retrieved from http://www.cdph.ca.gov/services/DPOPP/regs/Documents/R-37-01_Regulation_Text.pdf. Accessed 10th Feb 2018.
- Camuci MB, Martins JT, Cardeli AA, Robazzi ML. Nursing Activities Score: nursing work load in a burns Intensive Care Unit. *Rev Lat Am Enfermagem*. 2014;22:325-31.
- Cantarelli M. Il modello delle prestazioni infermieristiche: Elsevier srl; 2003.
- Carayon P, Gurses AP. A human factors engineering conceptual framework of nursing workload and patient safety in intensive care units. *Intensive Crit Care Nurs*. 2005;21:284-301.
- Carmona-Monge F, Rollán Rodríguez GM, Quirós Herranz C, García Gómez S, Marín-Morales D. Evaluation of the nursing workload through the nine equivalents for

- nursing manpower use scale and the nursing activities score: A prospective correlation study. *Intensive Crit Care Nurs.* 2013a;29:228-33.
- Carmona-Monge FJ, Uranga IU, Gomez SG, Herranz CQ, Bengoetxea MB, Unanue GE, et al. [Usage analysis of the Nursing Activities Score in two Spanish ICUS]. *Rev Esc Enferm USP.* 2013b;47:1108-16.
- Chamberlain D, Pollock W, Fulbrook P. ACCCN Workforce Standards Development Group. ACCCN Workforce Standards for Intensive Care Nursing: Systematic and evidence review, development, and appraisal. *Aust Crit Care*; 2017 (in press) <https://doi.org/10.1016/j.aucc.2017.08.007> Accessed 2nd March 2018
- Cho S-H, Yun S-C. Bed-to-nurse ratios, provision of basic nursing care, and in-hospital and 30-day mortality among acute stroke patients admitted to an intensive care unit: cross-sectional analysis of survey and administrative data. *International journal of nursing studies.* 2009;46:1092-101.
- Civil Service. Rapid Evidence Assessment. London: Civil Service,; 2010.
- Clini E, Vitacca M, Ambrosino N. Dependence nursing scale: a new method to assess the effect of nursing work load in a respiratory intermediate intensive care unit. *Respiratory Care* 1999;44:29-37.
- Conishi RMY, Gaidzinski RR. Evaluation of the Nursing Activities Score (NAS) as a nursing workload measurement tool in an adult ICU. *Revista da Escola de Enfermagem da USP.* 2007;41:346-54.
- Cremasco MF, Wenzel F, Zanei SS, Whitaker IY. Pressure ulcers in the intensive care unit: the relationship between nursing workload, illness severity and pressure ulcer risk. *Journal of clinical nursing.* 2013;22:2183-91.
- Critical Care Medicine.* 2014; 42 (5):1291–1292.
- Cummings J Gateway reference: 03587. Ensuring the NHS is safely staffed. Gateway reference: 03587 ed2015. Available at Accessed 1st Jan 2018
- Daud-Gallotti RM, Costa SF, Guimaraes T, Padilha KG, Inoue EN, Vasconcelos TN, et al. Nursing workload as a risk factor for healthcare associated infections in ICU: a prospective study. *PLoS One.* 2012;7:e52342.
- Debergh DP, Myny D, Van Herzeele I, Van Maele G, Reis Miranda D, Colardyn F. Measuring the nursing workload per shift in the ICU. *Intensive Care Med.* 2012;38:1438-44.
- Ducci AJ , Zanei SSV , Whitaker IY. Nursing workload to verify nurse/patient ratio at a cardiology ICU, *Rev Esc Enferm USP.* 2008; 42(4): 672-8.
- Ducci AJ, Padilha KG. Nursing Activities Score: a comparative study about retrospective and prospective applications in intensive care units. *Acta Paulista de Enfermagem.* 2008;21:581-7.
- e Castro MCN, Dell'Acquall MCQ, Corrente JED, Zornoff CM, Arantes F. Computer application with the nursing activities score: An intensive care management instrument. *Texto e Contexto Enfermagem* 2009;18:577-85.
- EFCCN. Position statement on workforce requirements within European critical care nursing. European Federation of Critical Care Nursing Associations: Available at: <http://www.efccna.org/> Accessed 13 Jan 2018.
- FICM/ICS. Core Standards for Critical Care Units. London. The Faculty of Intensive Care Medicine / The Intensive Care Society: London; 2013

- FICM/ICS. Guidelines for the Provision of Intensive Care Services. Faculty of Intensive Care Medicine/Intensive Care Society; London; 2015.
- Frade Mera M, García Z. Burnout syndrome in different intensive care units. *Enfermería intensiva*. 2009;20:131-40.
- Galimberti S, Reborá P, Di Mauro S, D'Illio I, Vigano R, Moiset C, et al. The SIPI for measuring complexity in nursing care: evaluation study. *Int J Nurs Stud*. 2012;49:320-6.
- Garfield M, Jeffrey R, Ridley S. An assessment of the staffing level required for a high-dependency unit. *Anaesthesia*. 2000;55:137-43.
- Gerasimou-Angelidi S, Myrianthefs P, Chovas A, Baltopoulos G, Komnos A. Nursing Activities Score as a predictor of family satisfaction in an adult intensive care unit in Greece. *Journal of nursing management*. 2014;22:151-8.
- GIRTI. Time oriented score system (toss): a method for direct and quantitative assessment of nursing workload for icu patients. Italian multicenter group of icu research (GIRTI). *Intensive care med*. 1991;17:340-5.
- Goncalves LA, Padilha KG, Cardoso Sousa RM. Nursing activities score (NAS): A proposal for practical application in intensive care units. *Intensive and Critical Care Nursing*. 2007; 23(6): 355-361.
- Graf J, Von den Driesch A, Koch KC, Janssens U. Identification and characterization of errors and incidents in a medical intensive care unit. *Acta anaesthesiologica Scandinavica*. 2005;49:930-9.
- Grant MJ, Booth A. A typology of reviews: an analysis of 14 review types and associated methodologies. *Health Info Libr J*. 2009;26:91-108.
- Griffiths P, Ball J, Murrells T, Jones S, Rafferty AM. Registered nurse, healthcare support worker, medical staffing levels and mortality in English hospital trusts: a cross-sectional study. *BMJ open*. 2016;6:e008751.
- Hart SG, Staveland LE. Development of NASA-TLX (Task Load Index): Results of empirical and theoretical research. *Advances in psychology*. 1988;52:139-83.
- Hoonakker P, Carayon P, Gurses A, Brown R, McGuire K, Khunlertkit A, et al. Measuring Workload of Icu Nurses with a Questionnaire Survey: The Nasa Task Load Index (Tlx). *IIE Trans Healthc Syst Eng*. 2011;1:131-43.
- Howick J, Chalmers i, Glasziou P, Greenhalgh T, et al. "The 2011 Oxford CEBM Evidence Levels of Evidence (Introductory Document)". Oxford Centre for Evidence-Based Medicine. <http://www.cebm.net/index.aspx?o=5653> Accessed 12th March 2016
- Hurst K. Developing and Validating the AUKUH's WP&D System. Commissioned by AUKUH Directors of Nursing. 2005.
- Hurst, K. Selecting and Applying Methods for Estimating the Size and Mix of Nursing Teams - A Systematic Review commissioned by the Department of Health. 2003 Leeds: Nuffield Institute for Health.
- Johnson D, Wilson M, Cavanaugh B, Bryden C, Gudmundson D, Moodley O. Measuring the ability to meet family needs in an intensive care unit. *Critical care medicine*. 1998;26:266-71.
- Kaplan, RS. Analysis and control of nurse staffing. *Health services research*. 1975;10 (3): 278.

- Kelly, DM, Kutney-Lee A, McHugh MD, et al. Impact of Critical Care Nursing on 30-Day Mortality of Mechanically Ventilated Older Adults *Critical Care Medicine*. 2014. 42(5) :1089-1095
- Kleinpell RM. ICU workforce: revisiting nurse staffing. *Critical care medicine*. 2014 May 1;42(5):1291-2.
- Knaus WA, Zimmerman JE, Wagner DP, Draper EA, Lawrence DE. APACHE- acute physiology and chronic health evaluation: a physiologically based classification system. *Critical Care Medicine*. 1981; 9 (8):591-597.
- Kohr L, [PA Hickey](#), MAQ Curley. Building a nursing productivity measure based on the synergy model: first steps. *American Journal Of Critical Care*. 2012;21:420-30.
- Kroh M, Hurlock-Chorostecki C. A shared staffing model for two critical care environments. *Can Nurse*. 2009;105:23-5.
- Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gøtzsche PC, et al. The PRISMA Statement for Reporting Systematic Reviews and Meta-Analyses of Studies That Evaluate Health Care Interventions: Explanation and Elaboration. *BMJ* 2009;339:b2700, doi: 10.1136/bmj.b2700
- Lucchini A, De Felippis C, Elli S, Schifano L, Rolla F, Pegoraro F, et al. Nursing Activities Score (NAS): 5 years of experience in the intensive care units of an Italian University hospital. *Intensive Crit Care Nurs*. 2014;30:152-8.
- Mackenzie S. The Organisation of Critical Care Services. *Anaesthesia & Intensive Care Medicine*. 2004;5:23-5.
- McGahan M, Kucharski G, Coyer F, Paper WABNR. Nurse staffing levels and the incidence of mortality and morbidity in the adult intensive care unit: a literature review. *Australian Critical Care*. 2012;25:64-77.
- Meyer, D. (1978) GRASP. Workload management system ensures stable nurse-patient ratios, *Hospitals*, 52, 5, pp.81-85.
- Miranda DR, Nap R, de Rijk A, Schaufeli W, Iapichino G. Nursing activities score. *Crit Care Med*. 2003;31:374-82.
- Miranda DR, Ryan DW, Schaufeli W, Fidler V. *Organisation and Management of Intensive Care: A Prospective Study in 12 European Countries*. New York: Springer; 1998.
- Moiset C, Vanzetta M, Vallicella F. *Misurare l'assistenza: un modello si sistema informativo della performance infermieristica*: McGraw-Hill; 2003.
- Neill D, Davis GC. Development of a Subjective Workload Assessment for Nurses: A Human Factors Approach. *J Nurs Meas*. 2015;23:452-73.
- NICE. *Safe staffing for nursing in adult inpatient wards in acute hospitals*. London: National Institute for Healthcare Excellence; 2014.
- Norrie P. Nurses' time management in intensive care. *Nurs Crit Care*. 1997;2:121-5.
- Padilha KG, de Sousa RM, Queijo AF, Mendes AM, Reis Miranda D. Nursing Activities Score in the intensive care unit: analysis of the related factors. *Intensive Crit Care Nurs*. 2008;24:197-204.
- Padilha KG, Stafseth S, Solms D, Hoogendoorn M, Monge FJ, Gomaa OH, et al. Nursing Activities Score: an updated guideline for its application in the Intensive Care Unit. *Rev Esc Enferm USP*. 2015;49 Spec No:131-7.

- Pirret AM. Utilizing TISS to differentiate between intensive care and high-dependency patients and to identify nursing skill requirements. *Intensive Crit Care Nurs.* 2002;18:19-26.
- RCN. Guidance for nurse staffing in critical care. London: Royal College of Nursing; 2003.
- Schubert M, Clarke SP, Aiken LH, De Geest S. Associations between rationing of nursing care and inpatient mortality in Swiss hospitals. *International Journal for Quality in Health Care.* 2012;24:230-8.
- SCIE. SCIE systematic research reviews guidelines 2nd edition. Social Care Institute for Excellence; 2013.
- Scott C. Setting safe nurse staffing levels. London: RCN Institute. 2003.
- Stafseth SK, Solms D, Bredal IS. The characterisation of workloads and nursing staff allocation in intensive care units: A descriptive study using the Nursing Activities Score for the first time in Norway. *Intensive Crit Care Nurs.* 2011;27:290-4.
- Stone PW, Mooney-Kane C, Larson EL, Horan T, Glance LG, Zwanziger J, et al. Nurse working conditions and patient safety outcomes. *Medical care.* 2007;45:571-8.
- Telford WA. Determining nursing establishments. *Health Service Manpower Review* 1979; 5 (4): 11-17.
- Venier A-G, Leroyer C, Slekovec C, Talon D, Bertrand X, Parer S, et al. Risk factors for *Pseudomonas aeruginosa* acquisition in intensive care units: a prospective multicentre study. *Journal of Hospital Infection.* 2014;88:103-8.
- Walther SM, Jonasson U, Karlsson S, Nordlund P, Johansson A, Malstam J, et al. Multicentre study of validity and interrater reliability of the modified Nursing Care Recording System (NCR11) for assessment of workload in the ICU. *Acta Anaesthesiol Scand.* 2004;48:690-6.
- West E, Barron DN, Harrison D, Rafferty AM, Rowan K, Sanderson C. Nurse staffing, medical staffing and mortality in intensive care: an observational study. *International journal of nursing studies.* 2014;51:781-94.
- West E, Mays N, Rafferty AM, Rowan K, Sanderson C. Nursing resources and patient outcomes in intensive care: a systematic review of the literature. *Int J Nurs Stud.* 2009;46:993-1011.
- Wilson-Barnett J. A Review of Patient-nurse Dependency Studies. DHSS/ Nursing Dept, 1978 London.
- Wysokinski M, Ksykiewicz-Dorota A, Fidecki W. Demand for nursing care for patients in intensive care units in southeast Poland. *American Journal of Critical Care.* 2010;19:149-55.

Appendix 1

Prisma Search flow diagram

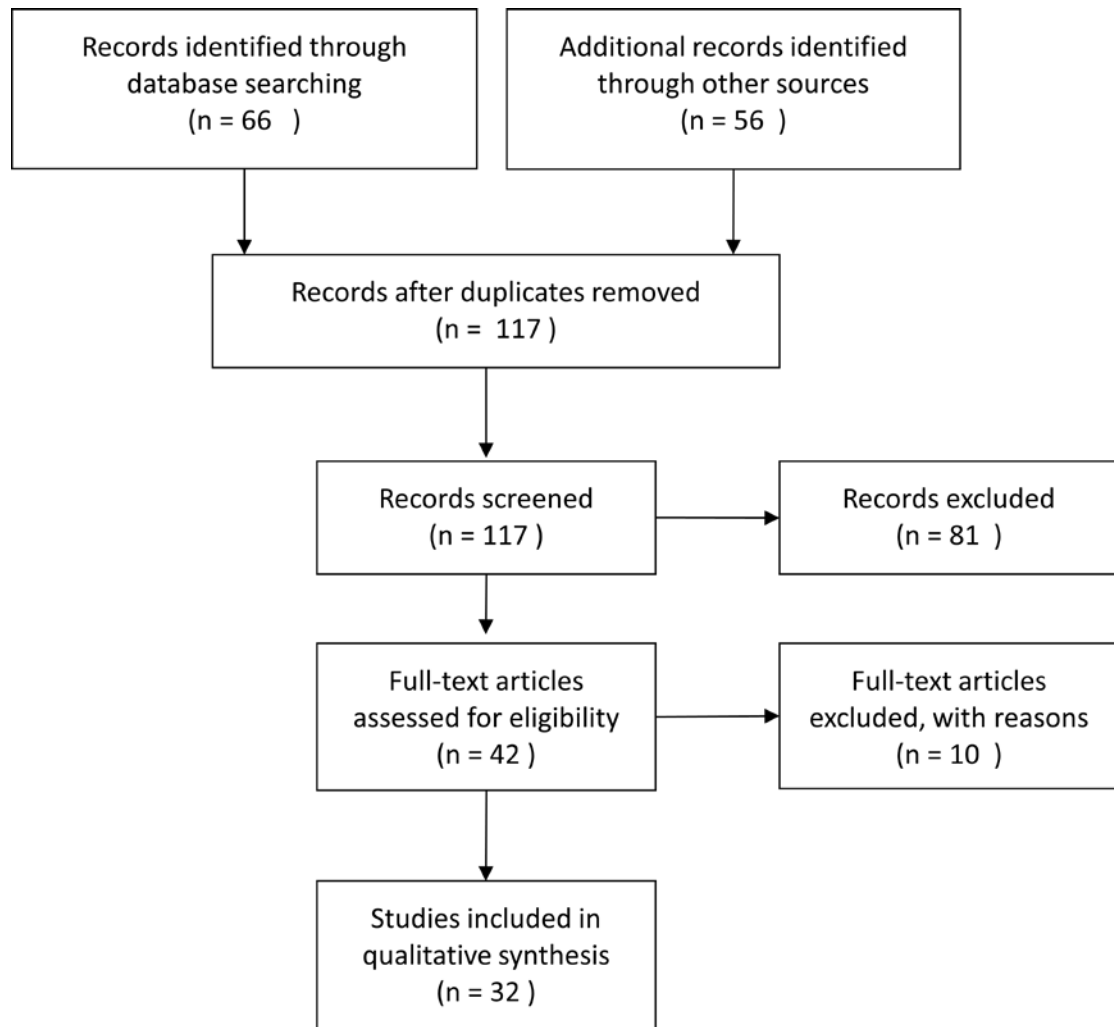


Table 1 Systems commonly used for planning nurse workforce (Hurst 2003)	
Professional Judgement (Telford, 1979)	Quick and easy and can be applied in any ward or specialty. The standard with which most other systems are compared.
Nurses per occupied bed method (NPOB) (Wilson-Barnett 1978)	The use of professional guidelines – numbers of nurses per occupied bed
Acuity-quality method (Fawcett 1985)	Safer Nursing Care Toolkit (Hurst 2005)
Timed-task/activity approaches	Instruments such as GRASP (Meyer 1978, Anderson 1997) and the Aberdeen method (Crompton et al 1976)
Regression based systems (Kaplan, 1975)	Developed because demand side planning did not provide a suitable staffing formula. Uses bed occupancy, theatre sessions, number admissions etc. to predict staffing needs.

Studies Reporting Instrument Development			
	References	Design and sample	Outcomes
1	<p>Ball C, Walker G, Harper P, Sanders D, McElligott M. Moving on from 'patient dependency' and 'nursing workload' to managing risk in critical care. <i>Intensive Crit Care Nurs.</i> 2004;20:62-8.</p> <p>Brazil</p> <p>Tools: Allocation according to 'risk'.</p>	<ul style="list-style-type: none"> • To develop a preliminary instrument to appraise risk and associate this with the level of nurse required to reduce risk. • To correlate this with the level of nurse available. • To undertake preliminary validation of the instrument on one critical care unit (20 bedded ICU in a large teaching hospital). <p>The tool was based on 4 topic areas: Patient centred, Proactive, Vigilance, Emotional support.</p> <p>The tool was used to determine risk and map to the correct level of competence of ICU nurses using two matrices.</p>	<p>The results of the pilot indicated the tool was valid but reliability has not yet been demonstrated. There was not always agreement on how to categorise staff using the categories: Novice, Advanced beginner, Competent, Proficient. The lack of reliability precluded any firm conclusions. However it does provide a view of determining nurse allocation around risk as opposed to workload or patient dependency.</p>
2	<p>Hoonakker P, Carayon P, Gurses A, Brown R, McGuire K, Khunlertkit A, et al. Measuring Workload of Icu Nurses with a Questionnaire Survey: The Nasa Task Load Index (TLX). <i>IIE Trans Healthc Syst Eng.</i> 2011;1:131-43.</p> <p>USA</p> <p>Tools: NASA-TLX; SYNERGY model</p>	<p>To confirm construct validity of NASA-TX for nursing workload. Secondary data analysis for two multisite cross sectional studies to assess construct validity of NASA-TLX in healthcare and ICU nurses workload. Involved 757 nurses completed the NASA-TX questionnaire in relation to their workload</p>	<p>A psycho-social approach.</p> <p>May be useful as a management tool or developing a model to identify the overall nursing resource required. Not relevant to day-to-day workloads.</p>
3	<p>Kohr L, et al Building a nursing productivity measure based on the synergy model: first steps. <i>American Journal Of Critical Care.</i> 2012;21:420-30.</p> <p>USA</p> <p>Tools: American Association of Critical-Care Nurses (AACN) Synergy Model for Patient Care (AACN, 2014).</p>	<p>Set in paediatric ICU. Nurse focus groups, a survey (x3), and visual analogue scales used to explore the feasibility of using the American Association of Critical-Care Nurses (AACN) Synergy Model for Patient Care as a system that describes nursing work on the basis of the needs of the patient and their family members.</p>	<p>Staff nurse participants differentiated workload types in 6 of the 8 dimensions of the Synergy Model. The most important were found to be:</p> <ul style="list-style-type: none"> • <i>Patients' stability</i> • <i>Complexity</i> • <i>Predictability</i>
4	<p>Miranda D, Ryan DW, Schaufeli W, Fidler V. <i>Organisation and Management of Intensive Care: A Prospective Study in 12 European Countries.</i> New York: Springer; 1998.</p> <p>Study published as a book.</p> <p>12 European countries</p> <p>Tools: TISS-28 (Simplified Intervention Scoring System) and NEMS (Nine Equivalent of Nursing Manpower Score)</p>	<p>Developing NEMS from TISS-28. To develop a tool for determining nursing workload.</p> <ol style="list-style-type: none"> 1. Retrospective statistical analysis to develop NEMS 2. A prospective multicentre study. <p>Units were requested to score all patients on the unit on a visit day using TISS- 28.</p> <p>NEMS scoring was then done by an independent rater (blinded) and handed to the project lead.</p> <p>453 TISS – 28 scores were collected.</p>	<p>In comparison to TISS-28 the reduction of 28 items to 9 items strongly reduces the discriminative power of the new scoring system to quantify workload at the patient level. Its quality, together with its extreme simplicity, makes NEMS most suitable for multicentre studies. Despite the above, the authors suggest that NEMS will readily provide ICU managers with a prediction of workload and nursing requirements in relation to any given patient.</p>

5	Miranda DR, Nap R, de Rijk A, Schaufeli W, Iapichino G. (TISS Working Group) Nursing activities score. Crit Care Med. 2003;31:374-82. 15 countries Tools: TISS-28, NAS (Nursing Activities Score)	Reports tool development using expert group consensus to determine the nursing activities that best describe workload in ICU and to weight these to describe time consumption rather than severity of illness. Expert panel asked to identify items not included in TISS-28. Random moment analysis of nurse activity for 2105 patients in 99 ICUs used to weight activity.	Only 30% of activity on high tech. High use of time on new activities. Capable of measuring nursing workload. NAS is now widely used and the benchmark for planning ICU work studies. It can be criticised as averaging out national variations – these are significant because of different staffing patterns and grades of worker in ICU. Suggests the necessity for adjusted weightings in national studies or planning manpower.
6	Neill D, Davis GC. Development of a Subjective Workload Assessment for Nurses: A Human Factors Approach. J Nurs Meas. 2015;23:452-73. USA Tools: SWAN (Subjective Workload Assessment for Nurses)	A tool was devised that took into account the nurses subjective assessment of the workload associated with a task	A psycho-social approach. Found to be internally consistent but needs further development to be a useful tool. A psychometric/human factors approach.
7	Norrie P. Nurses' time management in intensive care. Nurs Crit Care. 1997;2:121-5. UK Tools: None – Nurse judgement	To investigate, quantify and categorise the workload of nurses in a UK ICU, and to pilot a simple tool. Then to measure time spent on each nursing activity. A descriptive approach was used.	Five categories developed: 1. Direct nursing care, 2. Clerical nursing duties, 3. Patient assessment, 4. Non-nursing duties 5. Time out (of unit). 41% time in direct nursing care; 22% on patient assessment; 19% clerical nursing duties; 7% non-nursing duties; 11% time out.
Paper Reporting Software Development			
8	eCastro, M. C. N., et al (2009). "Computer application with the nursing activities score: An intensive care management instrument." Texto e Contexto Enfermagem 18(3): 577-585. Brazil Tools: NAS based computer software	To demonstrate a computer programme for NAS data entry. Piloted with 12 patients, compared with manual form, and then used for 90 consecutive days.	Effective means of collecting data and provides the ability to transfer and visualise it in chart form.
Prospective Studies			
9	Altafin JA, Grion CM, Tanita MT, Festti J, Cardoso LT, Veiga CF, et al. Nursing Activities Score and workload in the intensive care unit of a university hospital. Rev Bras Ter Intensiva. 2014;26:292-8. Brazil Tools: NAS, APACHE II, SOFA and TISS-28.	To compare four possible tools which could potentially be used to inform nurse staffing in ICU. Longitudinal prospective study of patients admitted to an ICU . 437 patients were evaluated.	The results of the study demonstrated the NAS tool had a greater breadth of activities included which was better able to capture nursing activities. Rationale for excluding patients staying < 24 hours is unclear, as may have contributed considerable work.
10	Camuci MB, Martins JT, Cardeli AA, Robazzi ML. Nursing Activities Score: nursing work load in a burns Intensive Care Unit. Rev Lat Am Enfermagem. 2014;22:325-31. Brazil Tools: NAS.	An exploratory, descriptive cross-sectional study to evaluate the nursing workload in a 6 bedded burns Intensive Care Unit according to the Nursing Activities Score (NAS). 1,221 measurements were obtained about 50 patients aged over 18 and in the unit >24 hours from their hospital records	The study showed a high mean workload in the burns ICU.

11	<p>Carmona-Monge FJ, Uranga IU, Gomez SG, Herranz CQ, Bengoetxea MB, Unanue GE, et al. [Usage analysis of the Nursing Activities Score in two Spanish ICUS]. Rev Esc Enferm USP. 2013b;47:1108-16.</p> <p>Spain Tools: NAS</p>	<p>Prospective comparative study to analyse differences in NAS scoring in two Spanish critical care units. Data from 103 patients.</p>	<p>Statistically significant differences were found in a number of items. Using standardised instruments is important to be able to compare different ICUs. Authors comment that many items on the NAS scale are relatively subjective.</p>
12	<p>Carmona-Monge F, Rollán Rodríguez GM, Quirós Herranz C, García Gómez S, Marín-Morales D. Evaluation of the nursing workload through the nine equivalents for nursing manpower use scale and the nursing activities score: A prospective correlation study. Intensive Crit Care Nurs. 2013a;29:228-33.</p> <p>Spain Tools: NAS, NEMS</p>	<p>A descriptive prospective correlational design to compare NAS and NEMS. Nursing workload data collected daily for each of 730 hospitalised patients, using the NAS and NEMS scales</p>	<p>Correlation for individual measurements 0.672, as well as for the total workload measurement in the unit, evaluated through both instruments 0.932. NEMS scale is completed much faster than the NAS, due to its fewer components</p>
13	<p>Clini E, Vitacca M, Ambrosino N. Dependence nursing scale: a new method to assess the effect of nursing work load in a respiratory intermediate intensive care unit. Respiratory Care 1999;44:29-37.</p> <p>Italy Tools: The Dependence Nursing Scale (DNS), APACHE II, NEMS, and clinical outcome.</p>	<p>Comparison of DNS with NEMS and APACHE II in predicting nursing workload. Over 1 year, 111 consecutively admitted patients who required mechanical ventilation, prolonged weaning from mechanical ventilation (33 patients, or cardiopulmonary monitoring, were admitted to the study. At admission, demographic data, severity of disease (APACHE II), nursing work load (NEMS), and maximal inspiratory pressure were recorded. The DNS score was determined at admission and at discharge.</p>	<p>At admission, the DNS score and the NEMS were significantly higher for patients in Group 2 than for patients in Groups 1 and 3. At admission, the DNS score was significantly better correlated with the NEMS (r 0.70) than with the APACHE II score, maximal inspiratory pressure, or the number of days spent in the RIICU. Compared with scores for clinical illness severity and inspiratory muscle function, the DNS score can better predict the dependence level of patients and better reflect the nursing work load required for patients admitted to an RIICU.</p>
14	<p>Debergh DP, Myny D, Van Herzeele I, Van Maele G, Reis Miranda D, Colardyn F. Measuring the nursing workload per shift in the ICU. Intensive Care Med. 2012;38:1438-44.</p> <p>Belgium Tools: NAS, NEMS</p>	<p>A prospective, observational study to evaluate whether differences in nursing workload between consecutive shifts can be identified using a nursing workload measurement tool. The tool was used for each patient for every shift over a 4-week period in 2.</p>	<p>The NAS was influenced by patient characteristics and the type of shift. Scores were lower during night shifts, at weekends and in medical ICU patients.</p>
15	<p>Ducci AJ, Padilha KG. Nursing Activities Score: a comparative study about retrospective and prospective applications in intensive care units. Acta Paulista de Enfermagem. 2008;21:581-7.</p> <p>Brazil Tools: NAS</p>	<p>A comparative study to record and compare retrospective and prospective applications of NAS in intensive care units. Reviewed 104 consecutive patients in ICU >24 hours. To compare NAS prediction of workload with the prospective estimate of the nurse and the data at the end of that data retrospectively</p>	<p>Very high levels of agreement between prospective and retrospective scores. Neither unit had previously used NAS, and many scores were decided upon after discussion between researcher and nurse. The protocol is flawed by the retrospective workload being calculated by a researcher who is not blind to the prospective result. This seems like a fatal flaw in the design.</p>

16	Galimberti S, Rebora P, Di Mauro S, D'Ilio I, Vigano R, Moiset C, et al. The SIPI for measuring complexity in nursing care: evaluation study. <i>Int J Nurs Stud</i> . 2012;49:320-6. Italy Tools: SIPI – Sistema-Informativo della Performance Infermieristica (<i>Nursing Performance Information System</i>).	Validation of SIPI score compared to nurse estimates of complexity of clinical care. A group of trained nurses were asked to indicate their own perception of the level of nursing day-care complexity provided to each patient and then to complete the SIPI. A multi-centre study involving 25 Italian hospitals; a convenience sample of wards;	Nursing complexity, as expressed both by nurse judgment and by the SIPI score, was very similar in the three classes of wards at standard, medium and elevated clinical intensity of care, as classified by health authorities. This suggests that the diagnosis, which determines the intensity of care on the clinical side, does not determine per se the level of complexity in nursing care
17	Garfield M, Jeffrey R, Ridley S. An assessment of the staffing level required for a high-dependency unit. <i>Anaesthesia</i> . 2000;55:137-43. UK Tools: TISS-28 and DNS	To compare nursing workloads as predicted by TISS-28 and DNS. Prospective design, over 7 months (407 HDU admissions > 12 hours)	Authors found a weak correlation between the DNS and the TISS-28 score. In HDU only.
18	Padilha KG, de Sousa RM, Queijo AF, Mendes AM, Reis Miranda D. Nursing Activities Score in the intensive care unit: analysis of the related factors. <i>Intensive Crit Care Nurs</i> . 2008;24:197-204. Brazil Tools: NAS, SAPS II and TISS-28, APACHE	Exploratory, descriptive, prospective study. To explore the association between NAS and patient variables such as gender, age, length of stay, discharge, SAPS II and TISS-28.	Patient with a higher NAS remained on average longer in the ICU (5.5 days) compared to patients with low NAS (3.8 days). Highest mortality was found among patients obtaining highest NAS. For patients who died, the probability of a higher NAS score rose to 2.65 times patients who survived. APACHE score was not fit to measure patient dependency
19	Pirret AM. Utilizing TISS to differentiate between intensive care and high-dependency patients and to identify nursing skill requirements. <i>Intensive Crit Care Nurs</i> . 2002;18:19-26. New Zealand Tools: TISS	To differentiate between intensive care and high dependency patients using the TISS tool with a view to identify nursing skills requirements. All patients admitted to the unit over a 23 month period (n=450)	The results were used to look at the types of interventions required for patients in the sample group, this was then used to discuss what was missing from the tool, followed by the implications for staffing and skill mix.
20	Stafseth SK, Solms D, Bredal IS. The characterisation of workloads and nursing staff allocation in intensive care units: A descriptive study using the Nursing Activities Score for the first time in Norway. <i>Intensive Crit Care Nurs</i> . 2011;27:290-4 Norway Tools: NEMS, NAS.	Exploratory descriptive study. That compares NEMS and NAS in terms of characterising the nursing workload by calculating the per nurse NAS% over a 24 hour period.	NAS found nursing workload at about 75-90%. This is compared to the literature where one nurse accomplishes a NAS of 100%. In some units the correlation between NAS and NEMS was poor. In others it was moderate. The authors discuss why Norwegian results might differ from Spain and Brazil in particular, including different work demands.
21	Walther SM, Jonasson U, Karlsson S, Nordlund P, Johansson A, Malstam J, et al. Multicentre study of validity and interrater reliability of the modified Nursing Care Recording System (NCR11) for assessment of workload in the ICU. <i>Acta Anaesthesiol Scand</i> . 2004;48:690-6. Sweden Tools: The Nursing Care Recording System (NCR11, TISS, NEMS	To compare the Nursing Care Recording System (NCR11) scoring with TISS and NEMS, and to examine the inter-rater reliability of NCR11 scoring	NCR11 does not measure the same aspects of ICU workload as TISS and NEMS. Inter-rater reliability of NCR11 is good, showing little variation in scoring across nurses. The authors suggest that NCR11 could be a tool for comparison of nursing workload between shifts, time periods, disease categories and units.

22	Wysokinski M, Ksykiewicz-Dorota A, Fidecki W. Demand for nursing care for patients in intensive care units in southeast Poland. American Journal of Critical Care. 2010;19:149-Poland Tools: TISS-28	To compare the nursing intensity in 3 types of hospital: those providing basic services, those providing additional subspecialist services and those providing wide ranging and national services.	This small study found that the diagnostic category and level of medical specialism did not significantly alter the nursing workload.
Retrospective Study			
23	Lucchini A, De Felippis C, Elli S, Schifano L, Rolla F, Pegoraro F, et al. Nursing Activities Score (NAS): 5 years of experience in the intensive care units of an Italian University hospital. Intensive Crit Care Nurs. 2014;30:152-8. Italy Tools: NAS, SAPS	Retrospective analysis of the application of the Nursing Activities Score (NAS). Records of 5856 patients in three – general, Neuro and cardiothoracic –ICUs. NAS compared to measures of patient severity: SAPS (Simplified Acute Physiology Score), RASS (Richmond Agitation Sedation Scale) and Braden	The study showed that overall there had been an allocation of nursing resources proportionate to the complexity of patient to be cared for. NAS is a relatively simple tool to calculate nursing staff requirements. It appears reliable in identifying staffing needs when linked to the analysis of other scoring systems.
Observational Studies			
24	Ball C, McElligott M. Realising the potential of critical care nurses': an exploratory study of the factors that affect and comprise the nursing contribution to the recovery of critically ill patients. Intensive Crit Care Nurs. 2003;19:226-38. UK Tools: No tools used.	An exploration of the nursing related factors that contribute to outcome in critical care. Ten critical care units participated. Data consisted of nurse interviews, patient-relative interviews and periods of observation.	Led to the concept of staff allocation by competence and numbers to reduce patient risk. Analysis demonstrated that the geographical layout, unit activity, case mix and skill mix of nurses, had a major effect on the ability of nurses to contribute to the recovery of the critically ill. A model was constructed that identified the central tenets upon which nursing care can be optimised.
25	Conishi RMY, Gaidzinski RR. Evaluation of the Nursing Activities Score (NAS) as a nursing workload measurement tool in an adult ICU. Revista da Escola de Enfermagem da USP. 2007;41:346-54. Summary only in English Brazil Tools: NAS	Comparison of actual nurse activity with NAS prediction. An exploratory, descriptive, prospective field study which aimed to evaluate the NAS as a tool for measuring nursing workload, its use in measuring shifts, and how it relates to the number of nursing staff.	NAS scoring was performed and compared with the actual 'shift' or daily nursing requirement as determined by existing nurse allocation systems.
26	Ducci AJ, Zanei SSV, Whitaker IY. Nursing workload to verify nurse/patient ratio at a cardiology ICU, Rev Esc Enferm USP. 2008; 42(4):672-8. Brazil Tools: NAS, TISS-28, NEMS	A descriptive study comparing the nursing workload in a postoperative heart surgery unit using NAS, TISS-28 and NEMS, and verifying both the observed and recommended nursing staff-to-patient ratio according to the workload indexes used.	The daily number of nursing staff in each shift was obtained through the daily schedule, for those who provided direct care to the patient (nurses /residents/nursing auxiliaries and technicians). These data, referring to each work shift, were The average number of nursing professionals was higher in the morning shift than in other periods. The average workload of the nursing team as measured by NAS (73.7%) was statistically higher than TISS-28 (62.2%), which in turn was higher than NEMS (59.7%). The staff-to-patient ratio estimated by all tools was lower than the ratio actually observed at the.

27	Fugulin FMT (2012), Nursing care time in the Intensive Care Unit: evaluation of the parameters proposed in COFEN Resolution N° 293/04, Rev. Latino-Am. Enfermagem Mar.-Apr.;20(2):325-32. Brazil Tools: COFEN staffing requirements	The actual staffing of ICU was compared with that calculated from the recommendation of the Brazilian Federal Nursing Council (COFEN).	The actual staffing was lower than that recommended by COFEN. The COFEN recommendations are particular to Brazil and difficult to compare with other similar instruments.
28	Ksykiewicz-Dorota, A. and Wysokiński, M. (2001). Special characteristics of nursing staff scheduling in intensive care units. Annales Universitatis Mariae Curie-Skłodowska. Sectio D: Medicina 56: 313-318. Poland Tools: None stated	Comparing staffing allocated in the ICU with actual time used in a study of 63 patients.	The time allocated by the self-observation method was significantly less than the time taken.
29	Padilha KG, et al. Nursing Activities Score: an updated guideline for its application in the Intensive Care Unit. Rev Esc Enferm USP. 2015; 49 Spec No:131-7. Norway, the Netherlands, Spain, Poland, Egypt, Greece and Brazil Tools: NAS	A one day survey of ITU patients in nineteen ITUs in 7 countries.	It was unclear whether this is principally due to differences in the patients, the culture of caring or of understanding the NAS items. The NAS varied from 44.5% in Spain to 101.8% in Norway. Demonstrates the large variations in services between countries
Description of Experience With Staffing Formulae			
30	Brack S, Sandford M. Partnerships in intensive care unit (ICU): a new model of nursing care delivery. Aust Crit Care. 2011;24:101-9. Australia Tools: Top down management tool altering skill mix.	A new 'economical' staffing method was trialled in part in ICU. Instead of using 100% ICU nurses a mix of ICU trained nurses and ENs were deployed. Enrolled Nurse (EN) is a diploma level qualified nurse in Australia.	The experiment failed. Managing the pilot consumed too much managerial activity. The staff did not want to continue the pilot. Narrative study that does not really explain the rationale for the chosen staffing method.
31	Goncalves, L. A., Padilha KG, . Cardoso Sousa RM Nursing activities score (NAS): A proposal for practical application in intensive care units. Intensive and Critical Care Nursing. 2007; 23(6): 355-361. Brazil Tools: NAS	Description of the adoption of the NAS into everyday use in ICU and highlights the challenges of standardisation of operational definitions, training requirements and accurate completion of documentation when using the tool.	NAS use was feasible and provided relevant information on nursing workload. The authors showed that it was possible to gather empirical data in order to express the reality of a particular unit, and adapt the tool to provide appropriate guidance for adequate staffing in a different shift context from that originally envisaged.
32	Kroh M, Hurlock-Chorostecki C. A shared staffing model for two critical care environments. Can Nurse. 2009;105:23-5. (Kroh and Hurlock-Chorostecki, 2009) Canada Tools: None	Descriptive of new staffing rota Implementation study - action research – modifications after feedback from survey to determine levels of satisfaction with the staffing model. Nursing staff rotate through two units MSICU and CSRU – two teams of 14 nurses with a charge nurse	Professional development; Teamwork: rotating between units did not hinder team functioning. Patient- and family-centred care: They believed that helping patients and families remained the central focus. Job satisfaction. Rated as “acceptable” to “very good.”

Table 3. Patient Illness Focused Scores Also Used for Workload Calculations (acuity-quality methods)

<p>Therapeutic Intervention Scoring System. TISS 76 (Cullen et al., 1974) TISS-28 (Miranda et al.,1996)</p>	<p>A severity of illness scoring methods based on therapeutic interventions. Original 76 items reduced to 28. Was superseded by APACHE and SAPS as the standard severity score and subsequently mostly used for estimation of nurse workload (4, 5, 9, 17,18,19,21, 22, 26,)</p>
<p>APACHE, II, III - Acute Physiological and Chronic Health Evaluation severity of disease classification (Knaus et al., 1981)</p>	<p>Commonly used severity of illness score that includes scores for chronic health. Scoring systems for workforce have often been compared with these scores on the basis that sicker patients occupy more nursing time (9,13,18)</p>
<p>SAPS II - Simplified Acute Physiology Score (Le Gall, 1984)</p>	<p>A simplified scoring system using only 14 patient observations of patient physiological status (18, 23)</p>
<p>DRGs - Diagnostic Related Groups (Fetter et al., 1980)</p>	<p>A health economics metric. Based on mutually exclusive medical and surgical categories by diagnosis. Mostly used to determine case mix and compare ICUs. (Goldfield et al 2010)</p>
<p>SOFA - Sequential Organ Failure Assessment (Vincent et al., 1996)</p>	<p>An organ dysfunction score used in sepsis to characterize patient severity (9)</p>

Table 4. Workload Scores That Focus Primarily on Nursing Interventions (Task Activity and Professional Judgement Methods)

<p>Nursing Activities Score (NAS) (Miranda <i>et al.</i>, 2003)</p>	<p>A task activity-method. Uses data on activities undertaken by the nursing team. Work sampling was used to define the relative times spent on each activity and an expert group was used to find categories of nursing activity missing from TISS. Each activity is scored according to percentage of time used on this in a 24-hour period. Scores run between 23 and 170: if the score is 100 a 1:1 nurse ratio is recommended (5, 8, 9, 10, 11, 12, 14, 15, 18, 23, 25, 26, 29, 31)</p>
<p>Dependence Nursing Scale (DNS) (Clini <i>et al.</i>, 1999)</p>	<p>A task activity-method. This score is concerned with nursing activities and was developed by measuring the time spent on these (13,17).</p>
<p>Nursing Interventions Classification NIC (Butcher <i>et al.</i>, 2013)</p>	<p>A professional judgement method. The Nursing Interventions Classification (NIC) is a classification of nursing treatments in all healthcare settings. Developed by literature review, focus groups and expert consultation (not timings). The NIC includes 433 interventions in the recently published second edition.</p>
<p>NEMS Nine Equivalents of nursing Manpower Use (Reis-Miranda <i>et al.</i>, 1997)</p>	<p>A professional judgement method derived from an acuity-quality framework. Derived from TISS-28 framework by regression analysis of contribution of each item to overall score. Categorises nursing activities in nine categories and allocates a weighting to each intervention (4, 12, 13, 14, 20, 21)</p>
<p>American Association of Critical (AACN) Synergy Model for Patient Care (ACCN, 2012)</p>	<p>A professional judgement method was used to develop weightings for a scoring system that incorporates judgements by the patient and relatives as well as objective data. Allocation guidelines also include the competence level of individual staff (2, 3).</p>
<p>SIPI (Sistema Informativo della Performance Infermieristica) (Moiset <i>et al.</i>, 2003)</p>	<p>A professional judgement method. The SIPI is a grid-based survey tool derived from the care needs expressed by the patients and carers and refers to the conceptual model of nursing care of Marisa Cantarelli (Cantarelli, 2003), the same model adopted by ICA (16).</p>
<p>System of Patient Related Activities - SoPRA</p>	<p>A professional judgement method. SoPRA was developed by ICNARC The Intensive Care National Audit and Research Centre in the UK as a scoring system based upon Patient Related Activities.</p>
<p>Time Oriented Scoring System (TOSS)</p>	<p>A task-activity method. Each nursing activity has been timed in and the results averaged. Nursing acts were grouped in different categories. No publication in the search period (GIRTI, 1991)</p>
<p>Valoracion de Cargas de Trabajo y Tiempos de Enfermeria (VACTE) (<i>Evaluation of Workloads and Nursing Times</i>) (Brana Marcos <i>et al.</i>,</p>	<p>A task-activity method. Timing of nursing activities were analysed for their contribution to an activity score. Brana Marcos compared VACTE with NEMS and APACHE II and found good correlation (Spanish – abstract in English). No other reports of this metric in English. Included here for completeness.</p>

2007)	
-------	--

Table 5. Workload Scores That Focus Primarily on Nursing’s Psycho-social elements

NASA Task Loading Index (NASA- TLX)	A scale that is used to estimate the ‘load’ on an individual. Consists of six scales: mental demand, physical demand, temporal demand, performance, effort and frustration level. (Hoonaker et al., 2005) (2)
‘Managing Risk’ instrument -(Ball et al., 2003).	Items fell into four categories: Patient centred; Proactive; Vigilance; Emotional support. Used to allocate nursing staff according to levels of competence in order to respond to perceived risk.(1)
Subjective Workload Assessment for Nurses – SWAN (Neill and Davis, 2015).	This instrument seeks to capture nurses’ subjective experiences. (6)