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Determining acute nurse staffing, a hermeneutic review of an evolving science.

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3 **Title: Determining acute nurse staffing, a hermeneutic review of an evolving**
4 **science.**
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6 Authors: Alison Leary¹, Geoffrey Punshon¹
7

8 Corresponding author: Alison Leary London South Bank University, School of Health
9 and Social Care, 103 Borough Road, London UK SE1 0AA. Email:
10 alisonleary@yahoo.com Telephone/Fax: 0207 450 6064
11

12 ¹ London South Bank University, London, UK.
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Abstract

Objectives

Calculating nurse staffing in the acute hospital has become a key issue but solutions appear distant. Community, mental health and areas such as learning disability nursing have attracted less attention and remain intractable. This review aims to examine current approaches to the issue across many disciplines.

Design

The approach taken is iterative and in the form of a hermeneutic review. 769 pieces of evidence were reviewed from across disciplines such as nursing, medicine, engineering, statistics, population science, computer science and mathematics where nurse staffing was the subject of the study.

Results

A number of themes emerged. The first iteration showed the predominance of unit base approaches (e.g. nurse numbers, ratios, activity and workload) the second was the development of methodologies. Subsequent iterations examined issues such as demand, safety, nurse education, turnover, patient outcomes, patient or staff satisfaction, workload and activity. The majority of studies examined (n=767) demonstrated some association between staffing (units or type/skill) and various factors such as staff or patient satisfaction, working conditions, safety parameters, outcomes complexity of work achieved, work left undone or other factors. Many potential areas such as operational safety research were not utilised.

Conclusion

Although the relationship between staffing in acute care and factors such as units, safety or workload is complex, the evidence suggests an interdependent relationship on many levels which should only be dismissed with caution. The nature of these relationships should be further examined in order to determine nurse staffing.

Strengths and limitations of this study

- The study is a review of the existing literature across many fields and focuses on cross disciplinary approaches.
- The study encompasses many fields and breadth rather than depth limits the analysis.
- This study examines the issue of safe staffing from a wider operational safety perspective and suggests this could uncover additional insight and solutions.

- A limitation of the study is that the body of knowledge is large and complex yet appears to have little impact on policy.

Introduction

The question of registered nurses staffing hospitals to a level that is safe, high quality and cost effective has become a key issue worldwide. In terms of research it has also become something of a Gordian knot-one that attracts many attempts to solve but few solutions. Extending this question to community nursing and areas such as mental health or learning disability nursing demonstrate the complexity of the problem. Fundamental questions such as “How many nurses are needed?” “What kind of skill mix?” “Are staffing ratios the solution?” remain largely unanswered.

These issues present interesting theoretical problems but they have a very real world application as they underpin the safety of patients both in hospital and community. It could be argued that nursing is only visible by its absence such as those reported by Francis in the enquiry into the deaths at Mid Staffordshire NHS Foundation trust¹. Nursing is the largest part of the healthcare workforce² and attempts to curtail costs have seen radical workforce changes including reducing the number of registered nurses or replacing them with assistive personnel (Needleman 2016). It is of interest that there have been a number of coroners commenting on staffing levels under section 28 of the Coroners & Justice Act 2009³. This allows a Coroner in England to report circumstances where it may prevent further deaths. There are several examples of this for both the acute and care home sectors in recent years⁴.

Issues of staffing are further complicated by a lack of consensus within the profession around the levels of care that should be provided or calculated. Is there a difference between safe care and good care? Should all care be given by a registered nurse (RN)? Certainly, policy decisions in England are promoting the transfer of care to assistive personnel such as Nursing Associates⁵ for a variety of reasons such as shortage of RNs and increasing costs. Financial burden is a primary driver of workforce determinants. Investing in one aspect of staffing often means scaling back elsewhere, resulting in “trade-offs” for example using less educated staff or changing nurse patient ratios⁶.

Different countries within the UK are taking different policy positions on staffing which varies from guidance in England to legislation in Scotland and Wales⁷.

In order to make sense of the variation in published work a hermeneutic approach is taken. Such an approach is to question and to remain open to what might be revealed⁸. Different researchers have used different approaches to understand various aspects of this problem and the aim of this work to reveal a deeper understanding and understand more about the interrelational nature of the problem.

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3 This paper reviews the approaches that have been used to investigate the idea of
4 safe staffing, the knowledge elicited and explores direction this area of research
5 might take in the future.
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8 9 **Method**

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11 Hermeneutic reviews⁹ utilise a process of searching and interpretation as
12 interrelational activity (Figure 1). This is because the focus is on the understanding
13 and interpretation of the materials. In a subject with a high volume of literature, this
14 approach allows the integration of interpretation and analysis of the literature and the
15 development of searching as part of the review. A hermeneutic framework describes
16 the literature review process as fundamentally a process of developing
17 understanding that is iterative in nature⁹. This has allowed a much wider perspective
18 incorporating a wider search and analysis than for example a systematic review
19 utilising methods such as PRISMA¹⁰. This body of evidence uses an extremely
20 diverse set of methodologies ranging from inductive studies reliant on qualitative
21 data to areas of computational mathematics. This would make approaches such as
22 meta-analysis almost impossible.
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27 ***Insert Figure 1 here***

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29 Initial reading indicated that the work on this topic was not limited to the nursing
30 literature and so the first iteration was to expand the search to areas such as
31 computer science, maths and engineering. A search of the common databases was
32 undertaken including those in informatics and computational mathematics (PubMed,
33 CINAHL, arXiv, CiteSeerX, IEEEExplore) using search terms “nursing” (for computer
34 science, maths and engineering only as this is a minority term) “nurse staffing”
35 “nurse workload” “hospital staffing” “nursing ratios” “safe staffing” “staffing” AND
36 “patient safety” in the past 15 years (2003-2018). All terms were in English. A
37 successive fractions approach was used to refine this search⁹. Systematic reviews
38 were included where primary research is available.
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42 This generated 7323 items. A significant proportion of work in the area of nurse
43 staffing has taken the form of editorials and various types of commentary or opinion
44 pieces rather than empirical studies. After elimination of opinion pieces and
45 professional non peer reviewed literature there remained in excess of 700 papers
46 (n=769) across the different disciplines. These were reviewed and have broadly
47 been themed to gain insight into the different approaches and relational research
48 used to examine the issue of staffing within a wider context of safety.
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Ethical Considerations

This is a review of the literature. Ethical permission was not sought.

Patient and Public Involvement

There was no patient and public involvement in this review.

Results

In terms of analysis specific themes started to emerge which were anchored around methodology and different lens through which the issue of nurse staffing is seen. Approaches to the question framed as “how many do we need?” are commonly approached as units, for example, numbers of workforce, ratios (nurse to patient or nurse to furniture) unit/ward levels of activity, job (different types of nursing such as paediatric, theatres or intensive care) or contextually/situationally. It is interesting to note that some situational perspectives originated from systems engineering approaches such as Caryaon & Gurses¹¹ and their systems engineering approach in intensive care units.

After examining the literature iteratively a number of themes emerge. Any of these themes would merit study in their own right but a broad overview of the different approaches and their application is given here. What is striking is the range of approaches used. These range from descriptive studies to the development of operational mathematical models.

Nursing as units, workload or activity.

The literature on the development of a ratio or the effect of nurse to patient ratios is a common theme in the nursing. A meta-analysis by Driscoll¹² draws on 35 studies which show an association between nurse staffing ratios and patient outcomes. These studies use large administrative data sets and found that higher staffing levels were associated with reduced mortality, reduced medication errors, reduction in incidence of pressure ulcers, reduced use of restraint, reduction in infections such as hospital acquired pneumonia, higher aspirin use and a greater number of patients receiving treatment. It is interesting to note that all of these studies are either cross sectional or point prevalence studies. When examining this section of the literature, cross sectional studies dominate.

Shindul-Rothschild et al¹³ notes how workload impacts on efficiency in emergency departments. Using regression in trauma centres, the time to a diagnostic evaluation significantly increased when nurses care for a higher number of patients. Aikens

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3 work on RN 4Cast¹⁴ shows that an increase in a nurses' workload by one patient
4 increased the likelihood of an inpatient dying within 30 days of admission by 7% and
5 every 10% increase in bachelor's degree nurses was associated with a decrease in
6 this likelihood by 7%. These associations imply that patients in hospitals in which
7 60% of nurses had bachelor's degrees and nurses cared for an average of six
8 patients would have almost 30% lower mortality than patients in hospitals in which
9 only 30% of nurses had bachelor's degrees and nurses cared for an average of eight
10 patients. Skillmix is also a feature of this body of work. Graduate RNs are associated
11 with better outcomes while higher registered nurse to patient ratios or support worker
12 to registered nurse ratios are associated with poorer outcomes¹⁵. Diane Boyle's
13 study¹⁶ found that higher Registered Nurse Hours Per Patient Day (RNHPPD) was
14 associated with improvements in total fall rates over time. This finding was not
15 unique with various studies exposing the same association for example Staggs and
16 Dunton¹⁷ found that skillmix of a higher rate of assistive personnel was associated
17 with an increase in falls but there was variation. On acute medical units there was a
18 weak association between decrease in falls and increase in RN staffing, but in step
19 down and medical units the authors concluded that increasing non RN staffing was
20 ineffective for decreasing falls. Increasing RN staffing did have a positive impact but
21 this varied by unit type. White et al¹⁸ in another cross-sectional study (N=353,333)
22 examined a historical dataset using thirty-day mortality and failure to rescue as
23 endpoints and found that each 10% increase in the proportion of graduate nurses
24 was associated with 4% lower odds of death in the older population 10% lower odds
25 of death for those with dementia. This was associated with better odds of rescue
26 where graduate nurses are deployed.

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28 Relationships between staffing factors and outcomes are complex^{19,20,21} as the
29 causal relationship is not fully understood. However we know from other studies that
30 there is a deficit in care. For example, in a study by Ball et al²² nurses (86%)
31 reported that one or more care activity had been left undone due to lack of time on
32 their last shift. Most care frequently left undone were: comforting or talking with
33 patients (66%), educating patients (52%) and developing/updating nursing care
34 plans (47%). The odds of care being left undone halved when nurses had six or less
35 patients to care for. The work left undone has become a more specific area of
36 enquiry with more authors coming to essentially the same conclusions²³. Missed
37 care appears to be common and perhaps even predictable. The work of Bragadottir
38 et al²⁴ examined the correlates and predictors of missed nursing care in hospitals
39 using regression. Such approaches may contribute to future demand based models.

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41 A substantial body of evidence has been built which uses the approach of nurses,
42 nursing care or patients as units of work activity.

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44 Many factors contribute to workload and the relationship with safety is frequently
45 investigated. Adequate staffing and resources, administrative support, and
46 collaborative workplace relationships have been shown to improve patient safety,
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3 and factors such as low job satisfaction, staff turnover, and high workload increase
4 risk to patient safety^{25,26}.

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6 Nursing workload is subjected to “measurement” using a plethora of measurement
7 tools which numerate tasks. Most of these tools tend to view nursing workload as
8 countable tasks, which is likely to be an oversimplification of complex work. Such
9 tools do not recognise the ‘other’ work which nurses do related to workplace culture
10 and climate²⁷. Fasoli & Haddock²⁸ after an extensive review of nurse workload
11 classification systems, reported there was no gold standard system for doing this
12 and current measures were not sensitive enough. This is reflected in findings that the
13 data collected routinely by nurses is not of sufficient quality to perform such complex
14 modelling^{17,29,30}.

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18 There has been a preoccupation with “time and motion” studies but these are of
19 limited use in complex work^{31,32} as a result this method cannot handle relational
20 work³³ and is therefore likely to underestimate nursing workload.

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23 There are measures which consider the complexity of the work³⁴ and workload
24 emerged as a theme including systematic reviews of the effect of workload on
25 patient safety^{35,11}. Several inductive subgroups emerged including the role of
26 workload and subsequent delegation of tasks which leads to delegation of safety
27 critical activity such as vital signs monitoring for example how local modifications to
28 track and trigger systems can reduce accuracy the of predictive algorithms³⁶ or the
29 workplace environment as a factor of workload³⁷.

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32 There has been some examination of redistribution of workload³⁸ in which there has
33 been some measurable increase in clinical time by workload redistribution. Although
34 this review does not consider the costs of staffing there are some interesting papers
35 on this. Perhaps one of the most interesting is Newbold’s 2008 model³⁹ which used
36 Aiken’s 2003⁴⁰ study, looked at nurse levels of education and patient mortality in
37 terms of a trade-off: what would a cost/mortality look like. Other researchers have
38 also utilised the cross sectional work to iterate mathematical models with some
39 success.
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45 **Workforce**

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47 Levels of workforce skill and education also feature in the literature. Much of the
48 work linking staffing (units or education) to outcomes looks at specific aspects of
49 care or harm. Boyle et al¹⁶ found an association between speciality nursing
50 education (post registration certification) and improvement in the rates of falls using
51 a longitudinal model (903 hospitals over 6 years) which echoed the findings of
52 Kendall-Gallagher & Blegen⁴¹, Lange et al⁴² and Boltz et al⁴³. For example, the Lang
53 paper found that units staffed with two or more geriatric-certified nurses had
54 significantly lower fall rates than units with one or no geriatric-certified nurses⁴².
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3 There appears to be a body of evidence supporting a higher skilled educated
4 workforce as associated with less harm although it is interesting to note that Magnet
5 hospitals were associated with higher rates of falls⁴⁴. There are numerous papers
6 linking RN staffing with patient outcomes/harm but fewer on education. One
7 interesting single centre study looked at the consequences of outlying patients to
8 non-specialist wards which was associated with an increase in mortality⁴⁵.

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11 In a recent systematic review⁴⁶ eighteen studies were examined which gave
12 subjective reports of missed care. 75% or more nurses reported omitting some care.
13 Fourteen of these studies found low nurse staffing levels were significantly
14 associated with higher reports of missed care. There was little evidence that adding
15 support workers to the team reduced this. The authors note that the extent to which
16 the relationships observed link to outcomes has yet to be investigated.

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19 Other work suggests that adding assistive nursing personnel without professional
20 nurse qualifications may contribute to preventable deaths, erode quality and safety of
21 hospital care¹⁴. Where studies have explored the impact of second level nurses,
22 similar to enrolled nurse qualification, the evidence is not supportive of the role⁴⁷.

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25 Satisfaction with work and other factors such as environmental, workload, working
26 hours and effect of skill mix. In some cases there is evidence of an association
27 between shift length, staff satisfaction and patient outcomes⁴⁸ which associated
28 longer shifts with more care left undone. These studies usually take the form of cross
29 sectional surveys as there appears to be no routine data collection of these data.
30 Unlike the concepts of staffing, there is much more consistency in the reporting of
31 issues related to workload such as moral distress, burn out and compromise of both
32 personal and professional values including the erosion of identity⁴⁹. The corollary of
33 this also occurs in that papers describing moral distress also cite inadequate staffing
34 as a causative attribute⁵⁰.

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38 Staffing and turnover is also occasionally reported in terms of outcomes for example
39 turnover and patient outcomes. In 2014 Park et al⁵¹ examined episodic unit-level
40 data from 2008 to 2010. This study examined 10,935 unit-quarter observations
41 (2,294 units, 465 hospitals) using multilevel regression. They found that the effect of
42 RN turnover on unit-acquired pressure ulcers was significant and “lagged” in terms of
43 time. For every 10 percentage-point increase in RN turnover in a quarter, the odds of
44 a patient having a pressure ulcer increased by 4 percent in the next quarter. Higher
45 RN turnover in a quarter was associated with lower RN staffing in the current and
46 subsequent quarters. Higher RN staffing was associated with lower pressure ulcer
47 rates, but it did not mediate the relationship between turnover and pressure ulcers.

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51 There appears to be a growing body of literature which examines resilience. The
52 emotional labour of nursing involves managing the emotional demands of nursing
53 work. An integrative review by Delgado et al²⁶ identifies the difficult nature of not only
54 the work but the opportunities to build personal resilience.

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3 Alves et al⁵² found that RNs nurses with greater autonomy, good working
4 relationships and control over their work environment had lower levels of emotional
5 exhaustion, higher job satisfaction, less intention of leaving. Although they do not
6 associate findings with patient outcomes these and other authors do find positive
7 associations with autonomy and rescue rates and mortality-and they are more likely
8 to experience this in small and non-teaching hospitals⁵³. This a consistent theme in
9 the literature reflected in a scoping review of twelve studies⁵⁴ which concludes that
10 structural empowerment effects the quality of care and patient safety in hospital. This
11 is also reflected in perceptions of safety culture and outcomes. When adequate
12 resource is allocated in terms of staffing the perception of safety and patient
13 satisfaction improves⁵⁵.

19 **Understanding the complex relationship**

21 There were a number of studies that used various aspects of data science. These
22 ranged from Bayesian approaches⁵⁶, to systems thinking, modelling, computational
23 mathematics and approaches such as machine learning. Many of these papers
24 appeared outside of the nursing literature and were located via databases that serve
25 the physical sciences, engineering and mathematics.

28 This includes work such as Aickelin et al⁵⁷ who developed a memetic evolutionary
29 algorithm to achieve explicit learning in rule-based nurse rostering, which involves
30 applying a set of heuristic rules for each nurse's assignment. This uses a set of
31 building blocks in terms of data and rules to build an Estimation of Distribution
32 Algorithm (EDA). As the authors point out, although this performs well in some "real
33 world" situations it is limited by its ability to learn-one of the solutions is to add more
34 nurses to the model without understanding that this might be a constraint.

38 Pitkaaho et al⁵⁸ used Finnish data from over 35,000 episodes of care to determine
39 relationships between nurse staffing and patients' length of stay in acute care units
40 and to determine whether non-linear relationships exist between variables using a
41 Bayesian approach. They found that acuity was the overriding factor that connected
42 all eleven variables in the dependency network of nurse staffing and short length of
43 stay. Non-linear associations were found between short length of stay and the
44 proportion of RNs. Skill mix consisting of an average proportion of Registered
45 Nurses (65–80%) was conducive to a short length of stay and predicted a 66%
46 likelihood of short length of stay. Lower percentages of RN predicted lower likelihood
47 of short length of stay.

51 An overriding theme in these approaches are challenges in the real world. Well-
52 constructed approaches to calculating staffing needing more work than authors
53 anticipated when tested in reality. This is not unusual-these approaches tend to be
54 iterative, however it is interesting to note that a number of these approaches

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3 concluded that previous staffing models had underestimated ratios and staffing
4 requirements in areas examined such as recovery⁵⁹.

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6 Other authors such as Park⁶⁰ are now building more optimized models based on
7 operational mathematical approaches and are likely to yield a more comprehensive
8 approach to the problem of computing staffing and outcomes as they accommodate
9 complexity.

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11 Data science approaches were the only ones to consider knowledge stock or
12 knowledge flow in the early part of the 21st century but little consideration was given
13 to this after this time⁶¹.

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15 The advent of data science offers many opportunities however nursing may not be
16 placed to capitalise on them⁶². Lack of high quality data is a recurring issue in terms
17 of both unit based approaches and approaches using data science to examine
18 complexity. Nursing data is generally episodic and lacks sensitivity to the activity that
19 nurses perform. In the studies, most informatics systems use taxonomies or lists of
20 tasks which are limited and show no apparent relationship with time taken. Another
21 issue is the dominance of supply side (nurse units of time for example) and not the
22 demand from patients which is rarely looked at.
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29 **Refining and leaving the hermeneutic circle**

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31 A key facet of Gadamer's⁸ approach is not to leave the hermeneutic circle due to its
32 inescapability and as such the review has focussed on the search. However the
33 author is from a positivist paradigm and so has broken the circle at this juncture. This
34 method is an inductive one and as such recognises that the iterations of searching
35 and analysis could be infinite. The themes that emerge here across the literature are
36 not exhaustive but provide a break in the cycle of searching and analysis. The
37 exploration of these themes can be further built up. The papers reviewed offered
38 many directions in which to expand this area of enquiry and these are shown in
39 Figure 2.
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43 *Insert Figure 2 here*

44 **Discussion**

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46 Although the evidence in the nursing literature appears to offer no firm guidance on
47 staffing models or absolute solutions, this could be seen as reassurance because it
48 also demonstrates the complexity of the problem. The literature describes different
49 associations between various factors such as outcomes and staffing numbers/skill
50 mix. Each piece of work gives a slightly different perspective but an overarching
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3 emerging theme is that a relationship does exist between different factors even if
4 these relationships are not fully understood, there is an apparent effect.
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6 The conceptual difficulty safety presented in the context of staffing was an emerging
7 theme. How is safe differentiated from unsafe, what is optimal staffing and where
8 should trade off occur. These studies help with clarification of the problem but there
9 is little consistency in this body of work in terms of a solution.
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11 One of the themes herein was the repeated association with not only numbers of
12 RNs but the educational level in the workplace. This appeared to show an overall
13 benefit in employing RNs and also RNs with a degree level qualification. Some
14 authors note this in the employment marketplace-that employers are acting on these
15 findings and recording a downward trend in using assistive roles in the USA⁶³.
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18 It is interesting that only one paper mentioned knowledge stock and knowledge flow.
19 None of the papers reviewed examined nurse staffing in terms of being a knowledge
20 intense occupation which is a factor in modelling workforces in other safety critical
21 industries or in other fields where operations are highly reliant on professional
22 knowledge such information technology⁶⁴. This might be because the approach to
23 workforce modelling in nursing is focussed on linear, deterministic approaches such
24 as time and motion or time filled with tasks. This is more akin to workforce modelling
25 in the service industries⁶⁵.
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29 There is narrative which focusses on a fixed ratio as staffing model in nursing. Ratios
30 are common in other safety critical industries or area such as mass gatherings
31 however it is often used as a failsafe rather than a staffing model⁶⁶ which might be a
32 more practical option for nursing.
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35 The literature is supportive of a relationship between staffing, skillmix and education
36 and this has been reviewed before⁶⁷ however circling out beyond the nursing
37 literature affirms this. Many reviews or policy documents appear to be confined to the
38 nursing or medical literature and yet a rich seam of enquiry appears outside of these
39 fields. What is striking is that there was very little overlap in areas of enquiry such as
40 safety critical operations research, demand modelling or knowledge based workforce
41 research and acute nurse staffing (Figure 2). Researchers should widen their
42 perspectives on methodologies and approaches to include other disciplines
43 particularly the approaches of safety critical industries. By doing so it is possible to
44 iterate an initial understanding of demand which can begin to integrate areas such as
45 workforce and safety- an interpretation is given in Figure 3.
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Conclusion

There is a wide variety of literature from different paradigms that support a complex interrelationship between different factors in acute nurse staffing. Despite a growing body of knowledge, there appears to be little reference to nursing as safety critical nor is the problem viewed through this lens.

Key Points for practice

- The issue of nurse staffing is a complex one and the relationships between factors such as nursing and patient outcomes is also complex. Despite this no papers examined nursing as a knowledge intensive operation or as a safety critical workforce.
- There is an increasing body of knowledge outside of nursing which has focussed on this topic but is rarely utilised.
- Although this is an emerging area, evidence repeatedly suggested a complex interdependent relationship between nurse staffing and various factors such as patient safety.
- Given the asserted complexity of work, time and motion or other simplistic activity analysis (measuring nursing in a linear or deterministic way) should be avoided.
- The importance of this emerging relationship should be considered when examining staffing.

Contributor Statement

AL contributed to design, analysis and writing. GP contributed to analysis and writing.

Competing interests

There are no competing interests.

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Data Sharing Statement

The data is in the public domain.

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12 **Figure Legends**

13
14 **Figure 1:** The hermeneutic review (Boell & Cecez-Kecmanovic, 2014).

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16 **Figure 2:** The areas of enquiry and potential overlap with other interdisciplinary
17 areas- the bordered area contains the literature reviewed.

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19 **Figure 3:** Contextualising the findings in terms of demand.
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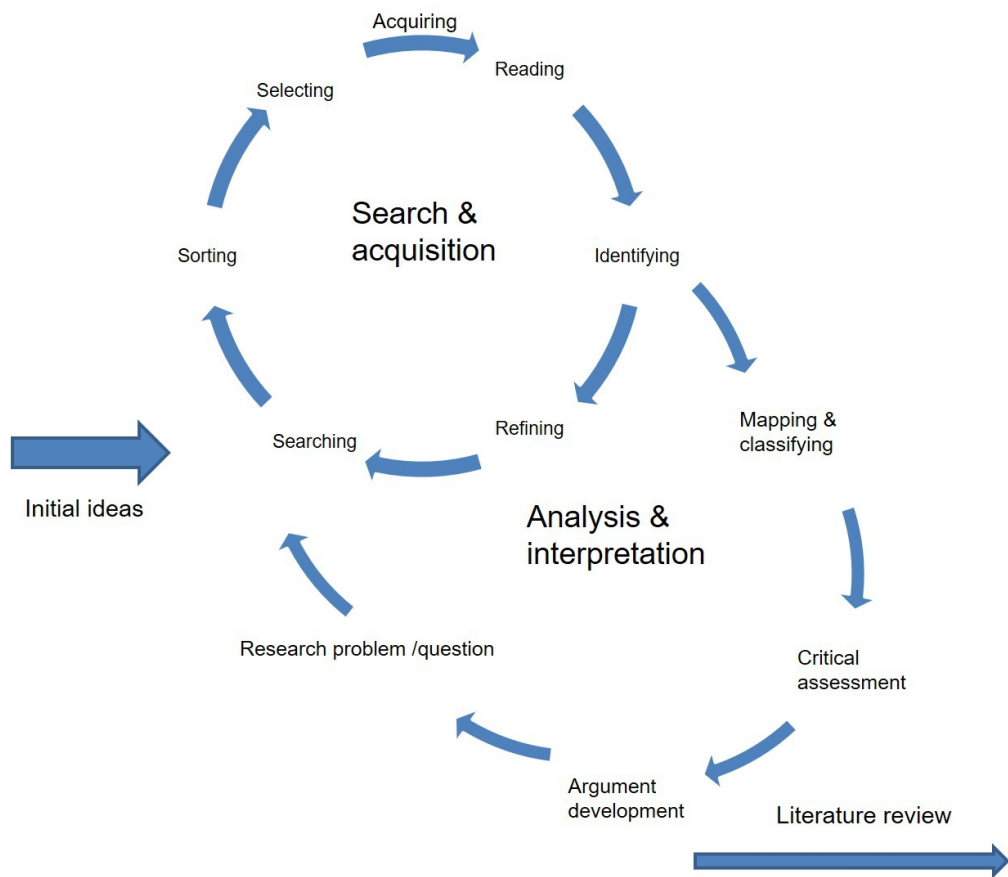


Figure 1

103x90mm (300 x 300 DPI)

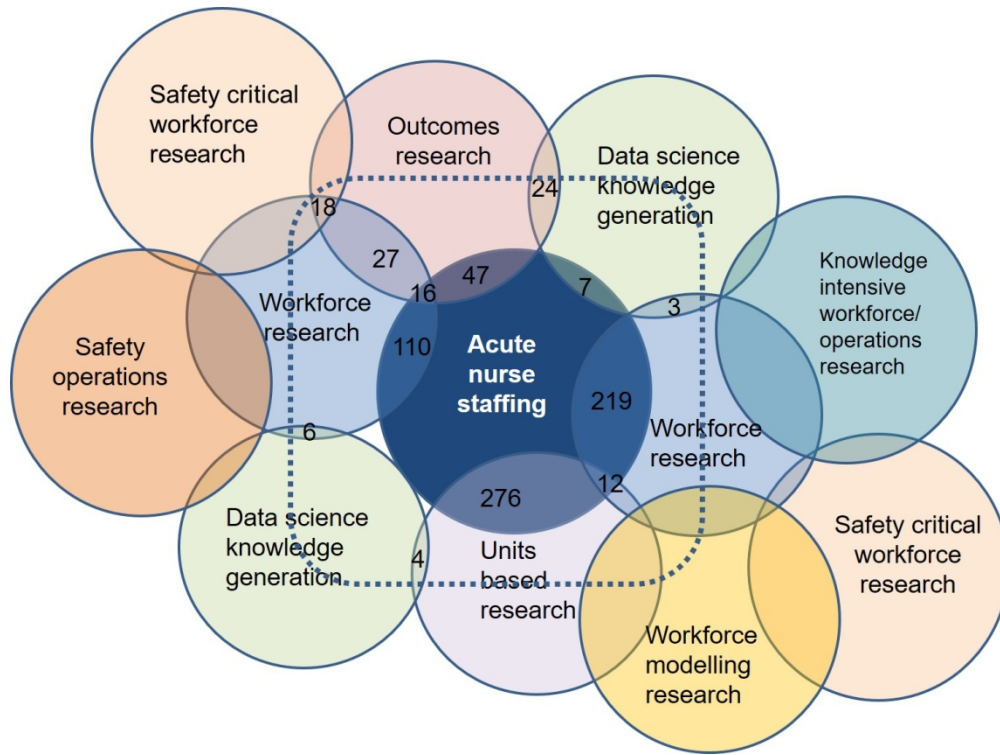


Figure 2

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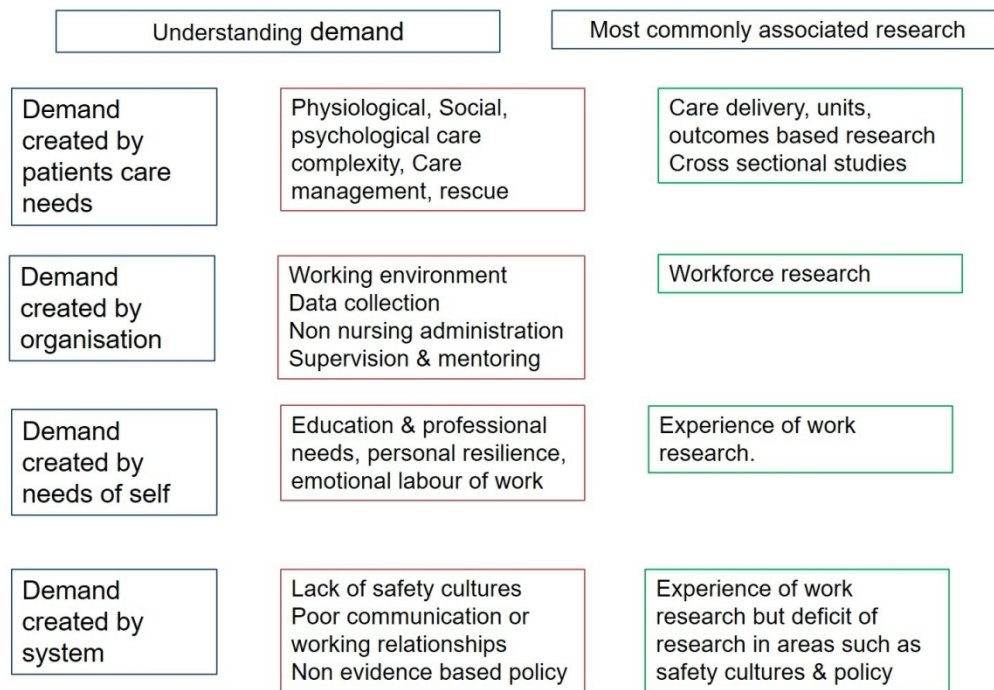


Figure 3

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Determining acute nurse staffing, a hermeneutic review of an evolving science.

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3 **Title: Determining acute nurse staffing, a hermeneutic review of an evolving**
4 **science.**
5

6 ***Corresponding Author***
7

8 ***Leary, Alison***
9

10 Prof Alison Leary PhD RN
11

12 London South Bank University
13

14 School of Health & Social Care
15

16 103 Borough Rd London SE1 0AA
17

18 alisonleary@yahoo.com
19
20
21
22

23
24 ***Punshon, Geoffrey***
25

26 Dr Geoffrey Punshon PhD
27

28 London South Bank University
29

30 School of Health & Social Care
31

32 103 Borough Rd London SE1 0AA
33

34 punshongeoff@yahoo.co.uk
35
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39 **Competing interests**
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41 **There are no competing interests. This review is unfunded.**
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44

45 **Key words**
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47 **Staffing, Safety, Nursing, Skillmix, education, modelling, hermeneutics**
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51 **Word count 4252**
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Abstract

Background

Calculating nurse staffing in the acute hospital has become a key issue but solutions appear distant. Community, mental health and areas such as learning disability nursing have attracted less attention and remain intractable. This review aims to examine current approaches to the issue across many disciplines.

Design

The approach taken is iterative and in the form of a hermeneutic review. 769 pieces of evidence were reviewed from across disciplines such as nursing, medicine, engineering, statistics, population science, computer science and mathematics where hospital nurse staffing was the subject of the study.

Results

A number of themes emerged. The first iteration showed the predominance of unit base approaches (e.g. nurse numbers, ratios, activity and workload) the second was the development of methodologies. Subsequent iterations examined issues such as demand, safety, nurse education, turnover, patient outcomes, patient or staff satisfaction, workload and activity. The majority of studies examined (n=767) demonstrated some association between staffing (units or type/skill) and various factors such as staff or patient satisfaction, working conditions, safety parameters, outcomes complexity of work achieved, work left undone or other factors. Many potential areas such as operational safety research were not utilised.

Conclusion

Although the relationship between staffing in acute care and factors such as units, safety or workload is complex, the evidence suggests an interdependent relationship which should only be dismissed with caution. The nature of these relationships should be further examined in order to determine nurse staffing. The body of knowledge appears substantial and complex yet appears to have little impact on policy.

Strengths and limitations of this study

This is a review of the existing literature across many fields and focuses on cross disciplinary approaches.

By encompassing many fields breadth rather than depth limits the analysis.

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3 This study suggests looking at the issue of safe staffing from a wider operational
4 safety perspective could uncover additional insight and solutions.
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8 9 **Funding Statement**

10 This research received no specific grant from any funding agency in the public,
11 commercial or not-for-profit sectors.
12
13

14 **Competing interests**

15 There are no competing interests.
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18 **Data sharing agreement**

19 All of the papers reviewed are in the public domain.
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23 **Introduction**

24
25 The question of registered nurses staffing hospitals to a level that is safe, high
26 quality and cost effective has become a key issue worldwide. In terms of research it
27 has also become something of a Gordian knot-one that attracts many attempts to
28 solve but few solutions. Extending this question to community nursing and areas
29 such as mental health or learning disability nursing demonstrate the complexity of
30 the problem. Fundamental questions such as “How many nurses are needed?”
31 “What kind of skill mix?” “Are staffing ratios the solution?” remain largely
32 unanswered.
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36 These issues present interesting theoretical problems but they have a very real world
37 application as they underpin the safety of patients both in hospital and community. It
38 could be argued that nursing is only visible by its absence such as those reported by
39 Francis in the enquiry into the deaths at Mid Staffordshire NHS Foundation trust¹.
40 Nursing is the largest part of the healthcare workforce² and attempts to curtail costs
41 have seen radical workforce changes including reducing the number of registered
42 nurses or replacing them with assistive personnel (Needleman 2016). It is of interest
43 that there have been a number of coroners commenting on staffing levels under
44 section 28 of the Coroners & Justice Act 2009³. This allows a Coroner in England to
45 report circumstances where it may prevent further deaths. There are several
46 examples of this for both the acute and care home sectors in recent years⁴.
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51 Issues of staffing are further complicated by a lack of consensus within the
52 profession around the levels of care that should be provided or calculated. Is there a
53 difference between safe care and good care? Should all care be given by a
54 registered nurse (RN)? Certainly, policy decisions in England are promoting the
55 transfer of care to assistive personnel such as Nursing Associates⁵ for a variety of
56 reasons such as shortage of RNs and increasing costs. Financial burden is a primary
57 driver of workforce determinants. Investing in one aspect of staffing often means
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3 scaling back elsewhere, resulting in “trade-offs” for example using less educated
4 staff or changing nurse patient ratios⁶.
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6 Different countries within the UK are taking different policy positions on staffing
7 which varies from guidance in England to legislation in Scotland and Wales⁷.
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10 In order to make sense of the variation in published work a hermeneutic approach is
11 taken. Such an approach is to question and to remain open to what might be
12 revealed⁸. Different researchers have used different approaches to understand
13 various aspects of this problem and the aim of this work to reveal a deeper
14 understanding and understand more about the interrelational nature of the problem.
15 This paper reviews the approaches that have been used to investigate the idea of
16 safe staffing, the knowledge elicited and explores direction this area of research
17 might take in the future.
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23 **Method**

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25 Hermeneutic reviews⁹ utilise a process of searching and interpretation as
26 interrelational activity (Figure 1). This is because the focus is on the understanding
27 and interpretation of the materials. In a subject with a high volume of literature, this
28 approach allows the integration of interpretation and analysis of the literature and the
29 development of searching as part of the review. A hermeneutic framework describes
30 the literature review process as fundamentally a process of developing
31 understanding that is iterative in nature⁹. This has allowed a much wider perspective
32 incorporating a wider search and analysis than for example a systematic review
33 utilising methods such as PRISMA¹⁰. This body of evidence uses an extremely
34 diverse set of methodologies ranging from inductive studies reliant on qualitative
35 data to areas of computational mathematics. This would make approaches such as
36 meta-analysis almost impossible.
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42 Initial reading indicated that the work on this topic was not limited to the nursing
43 literature and so the first iteration was to expand the search to areas such as
44 computer science, maths and engineering. A search of the common databases was
45 undertaken including those in informatics and computational mathematics (PubMed,
46 CINAHL, arXiv, CiteSeerX, IEEEXplore) using search terms “nursing” (for computer
47 science, maths and engineering only as this is a minority term) “nurse staffing”
48 “nurse workload” “hospital staffing” “nursing ratios” “safe staffing” “staffing” AND
49 “patient safety” in the past 15 years (2003-2018). All terms were in English. A
50 successive fractions approach was used to refine this search⁹. Systematic reviews
51 were included where primary research is available. Initial reading also revealed a
52 paucity of work in area such as mental health, community care and learning disability
53 and so the focus remained on acute hospital staffing.
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3 This generated 7323 items. A significant proportion of work in the area of nurse
4 staffing has taken the form of editorials and various types of commentary or opinion
5 pieces rather than empirical studies. After elimination of opinion pieces and
6 professional non peer reviewed literature there remained in excess of 700 papers
7 (n=769) across the different disciplines. These were reviewed and have broadly
8 been themed to gain insight into the different approaches and relational research
9 used to examine the issue of staffing within a wider context of safety. A
10 supplementary file contains more detail on how these studies were selected.
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14 **Patient and public involvement**

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16 This is a review of the existing literature and so there was no patient involvement at
17 this stage. Subsequent iterations would have patients/public co-researchers to co-
18 create questions and design subsequent studies.
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21 **Results**

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23 In terms of analysis specific themes started to emerge which were anchored around
24 methodology and the different lenses through which the issue of nurse staffing is
25 seen. Approaches to the question framed as “how many do we need?” are
26 commonly approached as units, for example, numbers of workforce, ratios (nurse to
27 patient or nurse to furniture) unit/ward levels of activity, job (different types of nursing
28 such as paediatric, theatres or intensive care) or contextually/situationally. It is
29 interesting to note that some situational perspectives originated from systems
30 engineering approaches such as Caryaon & Gurses¹¹ systems engineering approach
31 in intensive care units.
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36 After examining the literature iteratively, a number of themes emerge. Any of these
37 themes would merit study in their own right, but a broad overview of the different
38 approaches and their application is given here. What is striking is the range of
39 approaches used. These range from descriptive studies to the development of
40 operational mathematical models.
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44 **Nursing as units, workload or activity.**

45
46 The literature on the development of a ratio or the effect of nurse to patient ratios is a
47 common theme in the nursing literature. A meta-analysis by Driscoll¹² draws on 35
48 studies which show an association between nurse staffing ratios and patient
49 outcomes. These studies use large administrative data sets and found that higher
50 staffing levels were associated with reduced mortality, reduced medication errors,
51 reduction in incidence of pressure ulcers, reduced use of restraint, reduction in
52 infections, such as hospital acquired pneumonia, higher aspirin use and a greater
53 number of patients receiving treatment. It is interesting to note that all of these
54 studies are either cross sectional or point prevalence studies. When examining this
55 section of the literature, cross sectional studies dominate.
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3 Shindul-Rothschild et al¹³ notes how workload impacts on efficiency in emergency
4 departments. Using regression in trauma centres, the time to a diagnostic evaluation
5 significantly increased when nurses cared for a higher number of patients. Aikens
6 work on RN 4Cast¹⁴ shows that an increase in a nurses' workload by one patient
7 increased the likelihood of an inpatient dying within 30 days of admission by 7%.
8 They also found that every 10% increase in bachelor's degree nurses was
9 associated with a decrease in this likelihood by 7%. These associations imply that
10 patients in hospitals in which 60% of nurses had bachelor's degrees and nurses
11 cared for an average of six patients would have almost 30% lower mortality than
12 patients in hospitals in which only 30% of nurses had bachelor's degrees and nurses
13 cared for an average of eight patients. Skillmix is also a feature of this body of work.
14 Graduate RNs are associated with better outcomes while higher registered nurse to
15 patient ratios or support worker to registered nurse ratios are associated with poorer
16 outcomes¹⁵. Diane Boyle's study¹⁶ found that higher Registered Nurse Hours Per
17 Patient Day (RNHPPD) was associated with improvements in total fall rates over
18 time. This finding was not unique with various studies exposing the same association
19 for example Staggs and Dunton¹⁷ found that skillmix of a higher rate of assistive
20 personnel was associated with an increase in falls but there was variation. On acute
21 medical units there was a weak association between decrease in falls and increase
22 in RN staffing, but in step down and medical units the authors concluded that
23 increasing non RN staffing was ineffective for decreasing falls. Increasing RN
24 staffing did have a positive impact but this varied by unit type. White et al¹⁸ in
25 another cross-sectional study (N=353,333) examined a historical dataset using
26 thirty-day mortality and failure to rescue as endpoints and found that each 10%
27 increase in the proportion of graduate nurses was associated with 4% lower odds of
28 death in the older population 10% lower odds of death for those with dementia. This
29 was associated with better odds of rescue where graduate nurses are deployed.

30 Relationships between staffing factors and outcomes are complex^{19,20,21} and the
31 causal relationship is not fully understood. However we know from other studies that
32 there is a deficit in care if staffing is not adequate. For example, in a study by Ball et
33 al²² nurses (86%) reported that one or more care activity had been left undone due
34 to lack of time on their last shift. Most care frequently left undone were: comforting or
35 talking with patients (66%), educating patients (52%) and developing/updating
36 nursing care plans (47%). The odds of care being left undone halved when nurses
37 had six or less patients to care for. The work left undone has become a more specific
38 area of enquiry with more authors coming to essentially the same conclusions²³.
39 Missed care appears to be common and perhaps even predictable. The work of
40 Bragadottir et al²⁴ examined the correlates and predictors of missed nursing care in
41 hospitals using regression. Such approaches may contribute to future demand based
42 models.

43 A substantial body of evidence has been built which uses the approach of nurses,
44 nursing care or patients as units of work activity.
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3 Many factors contribute to workload and the relationship with safety is frequently
4 investigated. Adequate staffing and resources, administrative support, and
5 collaborative workplace relationships have been shown to improve patient safety,
6 and factors such as low job satisfaction, staff turnover, and high workload increase
7 risk to patient safety^{25,26}.
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10 Nursing workload is subjected to “measurement” using a plethora of measurement
11 tools which numerate tasks. Most of these tools tend to view nursing workload as
12 countable tasks, which is likely to be an oversimplification of complex work. Such
13 tools do not recognise the ‘other’ work which nurses do related to workplace culture
14 and climate²⁷. Fasoli & Haddock²⁸ after an extensive review of nurse workload
15 classification systems, reported there was no gold standard system for doing this
16 and current measures were not sensitive enough. This is reflected in findings that the
17 data collected routinely by nurses is not of sufficient quality to perform such complex
18 modelling^{17,29,30}.
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23 There has been a preoccupation with “time and motion” studies but these are of
24 limited use in complex work^{31,32} as a result this method cannot handle relational
25 work³³ and is therefore likely to underestimate nursing workload.
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28 There are measures which consider the complexity of the work³⁴ and workload
29 emerged as a theme including systematic reviews of the effect of workload on
30 patient safety^{35,11}. Several inductive subgroups emerged including the role of
31 workload and subsequent delegation of tasks which leads to delegation of safety
32 critical activity such as vital signs monitoring for example how local modifications to
33 track and trigger systems can reduce accuracy the of predictive algorithms³⁶ or the
34 workplace environment as a factor of workload³⁷.
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38 There has been some examination of redistribution of workload³⁸ in which there has
39 been some measurable increase in clinical time by workload redistribution. Although
40 this review does not consider the costs of staffing there are some interesting papers
41 on this. Perhaps one of the most interesting is Newbold’s 2008 model³⁹ which used
42 Aiken’s 2003⁴⁰ study, looked at nurse levels of education and patient mortality in
43 terms of a trade-off: what would a cost/mortality look like. Other researchers have
44 also utilised the cross sectional work to iterate mathematical models with some
45 success.
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51 **Workforce**

52 Levels of workforce skill and education also feature in the literature. Much of the
53 work linking staffing (units or education) to outcomes looks at specific aspects of
54 care or harm. Boyle et al¹⁶ found an association between speciality nursing
55 education (post registration certification) and improvement in the rates of falls using
56 a longitudinal model (903 hospitals over 6 years) which echoed the findings of
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3 Kendall-Gallagher & Blegen⁴¹, Lange et al⁴² and Boltz et al⁴³. For example, the Lang
4 paper found that units staffed with two or more geriatric-certified nurses had
5 significantly lower fall rates than units with one or no geriatric-certified nurses⁴².
6 There appears to be a body of evidence supporting a higher skilled educated
7 workforce as associated with less harm although it is interesting to note that Magnet
8 hospitals were associated with higher rates of falls⁴⁴. There are numerous papers
9 linking RN staffing with patient outcomes/harm but fewer on education. One
10 interesting single centre study looked at the consequences of outlying patients to
11 non-specialist wards which was associated with an increase in mortality⁴⁵.
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16 In a recent systematic review⁴⁶ eighteen studies were examined which gave
17 subjective reports of missed care. 75% or more nurses reported omitting some care.
18 Fourteen of these studies found low nurse staffing levels were significantly
19 associated with higher reports of missed care. There was little evidence that adding
20 support workers to the team reduced this. The authors noted that the extent to which
21 the relationships observed link to outcomes has yet to be investigated.
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25 Other work suggests that adding assistive nursing personnel without professional
26 nurse qualifications may contribute to preventable deaths, erode quality and safety of
27 hospital care¹⁴. Where studies have explored the impact of second level nurses,
28 similar to enrolled nurse qualification, the evidence is not supportive of the role⁴⁷.
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31 Satisfaction with work and other factors such as environmental, workload, working
32 hours and effect of skill mix. In some cases there is evidence of an association
33 between shift length, staff satisfaction and patient outcomes⁴⁸ which associated
34 longer shifts with more care left undone. These studies usually take the form of cross
35 sectional surveys as there appears to be no routine data collection of these data.
36 Unlike the concepts of staffing, there is much more consistency in the reporting of
37 issues related to workload such as moral distress, burn out and compromise of both
38 personal and professional values including the erosion of identity⁴⁹. The corollary of
39 this also occurs in that papers describing moral distress also cite inadequate staffing
40 as a causative attribute⁵⁰.
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45 Staffing and turnover is also occasionally reported in terms of outcomes for example
46 turnover and patient outcomes. In 2014 Park et al⁵¹ examined episodic unit-level
47 data from 2008 to 2010. This study examined 10,935 unit-quarter observations
48 (2,294 units, 465 hospitals) using multilevel regression. They found that the effect of
49 RN turnover on unit-acquired pressure ulcers was significant and “lagged” in terms of
50 time. For every 10 percentage-point increase in RN turnover in a quarter, the odds of
51 a patient having a pressure ulcer increased by 4 percent in the next quarter. Higher
52 RN turnover in a quarter was associated with lower RN staffing in the current and
53 subsequent quarters. Higher RN staffing was associated with lower pressure ulcer
54 rates, but it did not mediate the relationship between turnover and pressure ulcers.
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3 There appears to be a growing body of literature which examines resilience. The
4 emotional labour of nursing involves managing the emotional demands of nursing
5 work. An integrative review by Delgado et al²⁶ identified the difficult nature of not only
6 the work but the opportunities, or lack of, to build personal resilience.
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10 Alves et al⁵² found that RNs nurses with greater autonomy, good working
11 relationships and control over their work environment had lower levels of emotional
12 exhaustion, higher job satisfaction, less intention of leaving. Although they did not
13 associate findings with patient outcomes these and other authors have found
14 positive associations with autonomy and rescue rates and mortality-and they are
15 more likely to experience this in small and non-teaching hospitals⁵³. This a consistent
16 theme in the literature reflected in a scoping review of twelve studies⁵⁴ which
17 concludes that structural empowerment effects the quality of care and patient safety
18 in hospital. This is also reflected in perceptions of safety culture and outcomes.
19 When adequate resource is allocated in terms of staffing the perception of safety and
20 patient satisfaction improves⁵⁵.
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27 **Understanding the complex relationship**

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29 There were a number of studies that used various aspects of data science. These
30 ranged from Baysian approaches⁵⁶, to systems thinking, modelling, computational
31 mathematics and approaches such as machine learning. Many of these papers
32 appeared outside of the nursing literature and were located via databases that serve
33 the physical sciences, engineering and mathematics.
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37 This includes work such as Aickelin et al⁵⁷, who developed a memetic evolutionary
38 algorithm to achieve explicit learning in rule-based nurse rostering, which involves
39 applying a set of heuristic rules for each nurse's assignment. This uses a set of
40 building blocks in terms of data and rules to build an Estimation of Distribution
41 Algorithm (EDA). As the authors point out, although this performs well in some "real
42 world" situations it is limited by its ability to learn-one of the solutions is to add more
43 nurses to the model without understanding that this might be a constraint.
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47 Pitkaaho et al⁵⁸ used Finnish data from over 35,000 episodes of care to determine
48 relationships between nurse staffing and patients' length of stay in acute care units
49 and to determine whether non-linear relationships exist between variables using a
50 Bayesian approach. They found that acuity was the overriding factor that connected
51 all eleven variables in the dependency network of nurse staffing and short length of
52 stay. Non-linear associations were found between short length of stay and the
53 proportion of RNs. Skill mix consisting of an average proportion of Registered
54 Nurses (65–80%) was conducive to a short length of stay and predicted a 66%
55 likelihood of short length of stay. Lower percentages of RN predicted lower likelihood
56 of short length of stay.
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3 An overriding theme in these approaches are challenges in the real world. Well-
4 constructed approaches to calculating staffing needing more work than authors
5 anticipated when tested in reality. This is not unusual-these approaches tend to be
6 iterative, however it is interesting to note that a number of these approaches
7 concluded that previous staffing models had underestimated ratios and staffing
8 requirements in areas examined such as recovery⁵⁹.
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12 Other authors such as Park⁶⁰ are now building more optimized models based on
13 operational mathematical approaches and are likely to yield a more comprehensive
14 approach to the problem of computing staffing and outcomes as they accommodate
15 complexity.
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18 Data science approaches were the only ones to consider knowledge stock or
19 knowledge flow in the early part of the 21st century but little consideration was given
20 to this after this time⁶¹.
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23 The advent of data science offers many opportunities however nursing may not be
24 placed to capitalise on them⁶². Lack of high quality data is a recurring issue in terms
25 of both unit based approaches and approaches using data science to examine
26 complexity. Nursing data is generally episodic and lacks sensitivity to the activity that
27 nurses perform. In the studies, most informatics systems use taxonomies or lists of
28 tasks which are limited and show no apparent relationship with time taken. Another
29 issue is the dominance of supply side (nurse units of time for example) and not the
30 demand from patients which is rarely looked at.
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33 34 **Refining and leaving the hermeneutic circle**

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36 A key facet of Gadamer's⁸ approach is not to leave the hermeneutic circle due to its
37 inescapability and as such the review has focussed on the search. However the
38 author is from a positivist paradigm and so has broken the circle at this juncture. This
39 method is an inductive one and as such recognises that the iterations of searching
40 and analysis could be infinite. The themes that emerge here across the literature are
41 not exhaustive but provide a break in the cycle of searching and analysis. The
42 exploration of these themes can be further built up. The papers reviewed offered
43 many directions in which to expand this area of enquiry and these are shown in
44 Figure 2.
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49 **Discussion**

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51 Although the evidence in the nursing literature appears to offer no firm guidance on
52 staffing models or absolute solutions, this could be seen as reassurance because it
53 also demonstrates the complexity of the problem. The literature describes different
54 associations between various factors such as outcomes and staffing numbers/skill
55 mix. Each piece of work gives a slightly different perspective but an overarching
56 emerging theme is that a relationship does exist between different factors even if
57 these relationships are not fully understood, there is an apparent effect.
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3 The conceptual difficulty safety presented in the context of staffing was an emerging
4 theme. How is safe differentiated from unsafe, what is optimal staffing and where
5 should trade off occur. These studies help with clarification of the problem but there
6 is little consistency in this body of work in terms of a solution.
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11 One of the themes herein was the repeated association with not only numbers of
12 RNs but the educational level in the workplace. This appeared to show an overall
13 benefit in employing RNs and also RNs with a degree level qualification. Some
14 authors note this in the employment marketplace-that employers are acting on these
15 findings and recording a downward trend in using assistive roles in the USA⁶³.
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19 It is interesting that only one paper mentioned knowledge stock and knowledge flow.
20 None of the papers reviewed examined nurse staffing in terms of being a knowledge
21 intense occupation which is a factor in modelling workforces in other safety critical
22 industries or in other fields where operations are highly reliant on professional
23 knowledge such information technology⁶⁴. This might be because the approach to
24 workforce modelling in nursing is focussed on linear, deterministic approaches such
25 as time and motion or time filled with tasks. This is more akin to workforce modelling
26 in the service industries⁶⁵.
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31 There is narrative which focusses on a fixed ratio as staffing model in nursing. Ratios
32 are common in other safety critical industries or area such as mass gatherings
33 however it is often used as a failsafe rather than a staffing model⁶⁶ which might be a
34 more practical option for nursing.
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37 The literature is supportive of a relationship between staffing, skillmix and education
38 and this has been reviewed before⁶⁷ however circling out beyond the nursing
39 literature affirms this. Many reviews or policy documents appear to be confined to the
40 nursing or medical literature and yet a rich seam of enquiry appears outside of these
41 fields. What is striking is that there was very little overlap in areas of enquiry such as
42 safety critical operations research, demand modelling or knowledge based workforce
43 research and acute nurse staffing (Figure 2). Researchers should widen their
44 perspectives on methodologies and approaches to include other disciplines
45 particularly the approaches of safety critical industries. By doing so it is possible to
46 iterate an initial understanding of demand which can begin to integrate areas such as
47 workforce and safety-an interpretation is given in Figure 3.
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51 **Strengths and limitations of this study**

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53 This is a review of the existing literature across many fields and focuses on cross
54 disciplinary approaches. By encompassing many fields, breadth rather than depth
55 limits the analysis but does take the literature in context to form an overall view.
56 There is a risk of over simplifying the literature and the knowledge at this scale.
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Conclusion

There is a wide variety of literature from different paradigms that support a complex interrelationship between different factors in acute nurse staffing. Despite a growing body of knowledge, there appears to be little reference to nursing as safety critical nor is the problem viewed through this lens. It is suggested that looking outside the discipline of nursing might add valuable insight to this problem.

The issue of nurse staffing is a complex one and the relationships between factors such as nursing and patient outcomes is also complex. Despite this no papers examined nursing as a knowledge intensive operation or as a safety critical workforce. There is an increasing body of knowledge outside of nursing which has focussed on this topic but is rarely utilised.

Although this is an emerging area, evidence repeatedly suggested a complex interdependent relationship between nurse staffing and various factors such as patient safety. Hermeneutic approaches can offer new insight by focussing in interpretation and has been used to generate knowledge⁶⁸.

Given the asserted complexity of work, time and motion or other simplistic activity analysis (measuring nursing in a linear or deterministic way) should be avoided. The importance of this emerging relationship should be considered when examining staffing. This study suggests looking at the issue of safe staffing from a wider operational safety perspective could uncover additional insight and solutions.

Ethical Permissions

This is a review of the literature. Ethical permission was not sought.

Author's contribution

AL design, analysis, writing, GP analysis and writing.

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Figure Legends

Figure 1 The hermeneutic circle as a framework for literature reviews

Figure 2 The areas of enquiry and potential overlap with other interdisciplinary areas- the bordered area contains the literature reviewed

Figure 3 Contextualising the findings in terms of demand

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For peer review only

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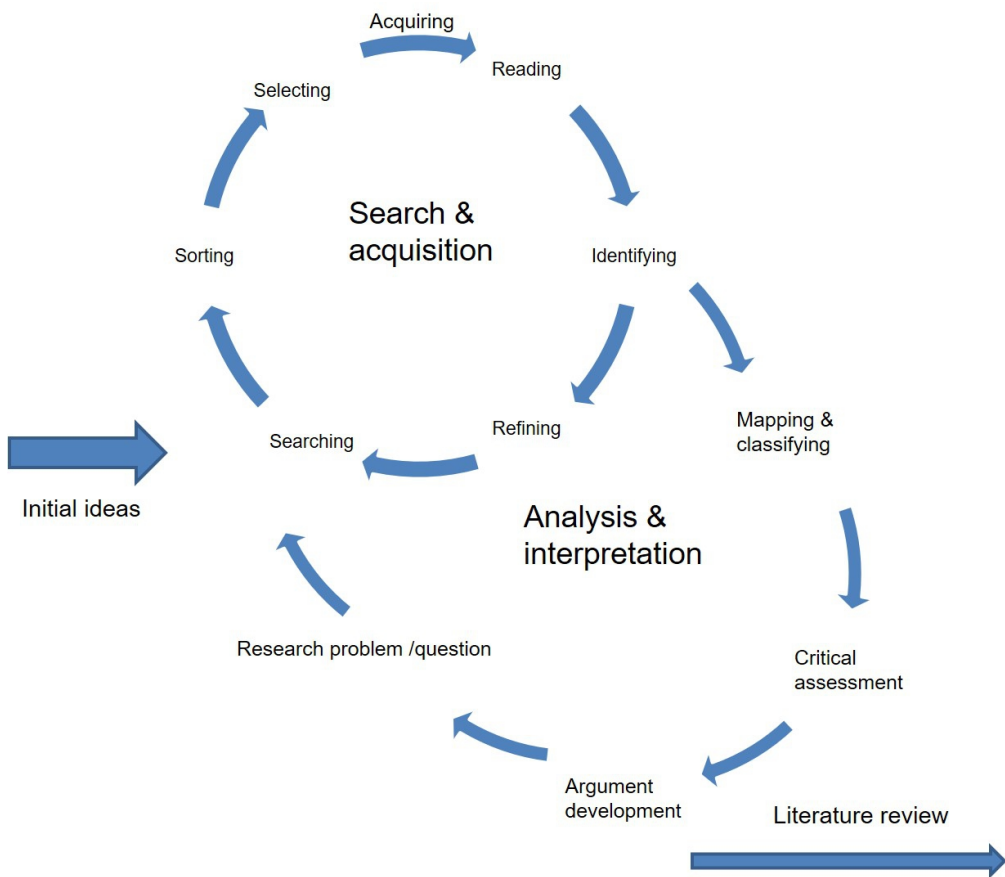


Figure 1

103x90mm (300 x 300 DPI)

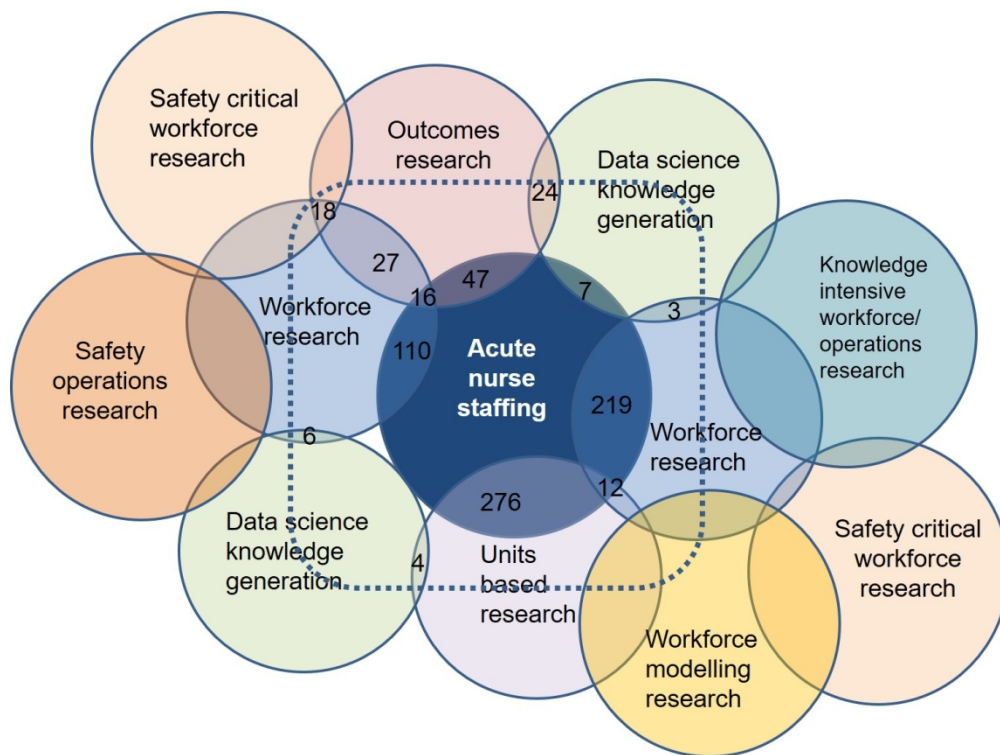


Figure 2

128x95mm (300 x 300 DPI)

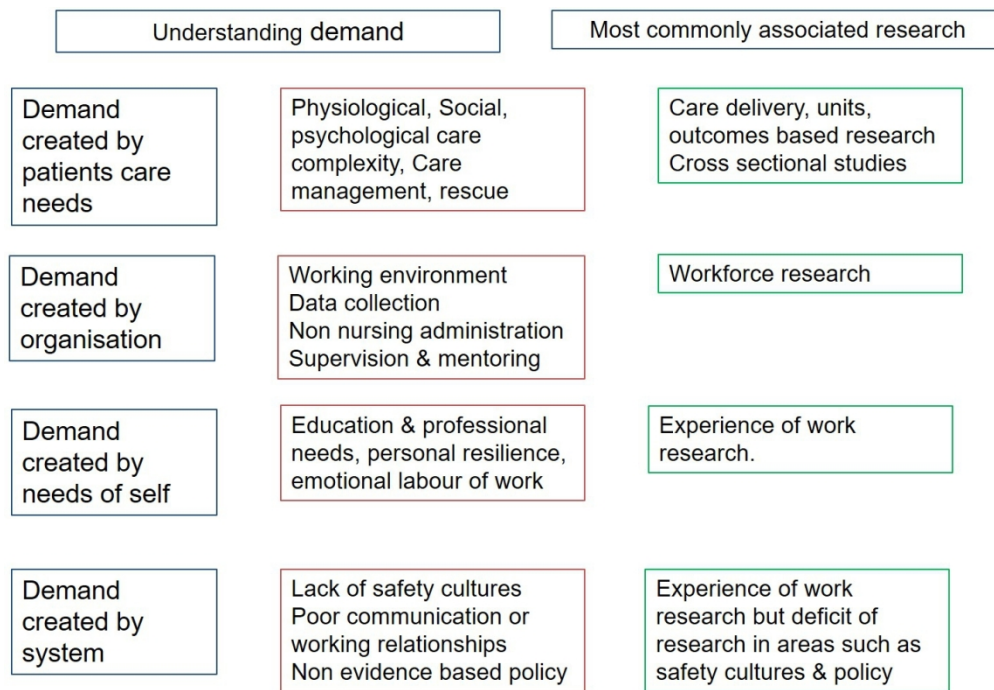


Figure 3

121x84mm (300 x 300 DPI)

Supplementary file

Search Strategy

Database selection

PubMed, CINAHL, arXiv, CiteSeerX, IEEEExplore

Key words/terms (Boolean)

“nursing” arXiv, CiteSeerX, IEEEExplore (as this is a minority term) “nurse staffing” “nurse workload” “hospital staffing” “nursing ratios” “safe staffing” “staffing” AND “patient safety” in PubMed and CINAHL

Criteria for inclusion

Primary research, secondary analysis or reviews on any relationship between acute hospital nurse staffing (registered, licenced and unregistered) and an specified outcome.

First iteration

7323 items

Exclude opinion pieces, editorials, commentaries and proceedings, professional opinion, consensus pieces (5281)

Exclude papers with no English translation (47)

Include systematic reviews (24)

Include primary research (2034)

2054 Items

Exclude other non-peer reviewed work such as reports (23)

Exclude papers which did not meet criteria on reading abstract/full text (1262)

Papers reviewed 769

Mapping and classification by discipline/area of research, major concepts, lens and unit of analysis

Critical assessment of the work was for rigour/associations and primarily “gap spotting” To visualise the relationships within discipline areas a Venn diagram was constructed (Figure 2). With the further application for example of Łoś's Theorem, and ultra product could eventually be defined.

Second iteration

Search to same criteria adding Nursing AND knowledge intense occupations, safety critical workforce revealed opinion pieces which referenced the terms to describe the labour market but no additional papers reviewed as they did not meet the criteria.

BMJ Open

Determining acute nurse staffing, a hermeneutic review of an evolving science.

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2018-025654.R2
Article Type:	Research
Date Submitted by the Author:	28-Feb-2019
Complete List of Authors:	Leary, Alison; London South Bank University Punshon, Geoffrey; London South Bank University,
Primary Subject Heading:	Health services research
Secondary Subject Heading:	Nursing
Keywords:	Nursing, Staffing, Skillmix, Education, Safety, Modelling

SCHOLARONE™
Manuscripts

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3 **Title: Determining acute nurse staffing, a hermeneutic review of an evolving**
4 **science.**
5

6 **Correspondence to**

7
8 **Prof Alison Leary PhD RN**

9
10 **London South Bank University**

11
12 **School of Health & Social Care**

13
14 **103 Borough Rd London SE1 0AA**

15
16 **alisonleary@yahoo.com**
17
18
19

20
21 **Dr Geoffrey Punshon**

22
23 **London South Bank University**

24
25 **School of Health & Social Care**

26
27 **103 Borough Rd London SE1 0AA**

28
29 **punshongeoff@yahoo.co.uk**
30
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33
34 **Competing interests**

35
36 **There are no competing interests. This review is unfunded.**
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40
41 **Key words**

42
43 **Staffing, Safety, Nursing, Skillmix, education, modelling, hermeneutics**
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47 **Word count 4252**
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Abstract

Background

Calculating nurse staffing in the acute hospital has become a key issue but solutions appear distant. Community, mental health and areas such as learning disability nursing have attracted less attention and remain intractable. This review aims to examine current approaches to the issue across many disciplines.

Design

The approach taken is iterative and in the form of a hermeneutic review. 769 pieces of evidence were reviewed from across disciplines such as nursing, medicine, engineering, statistics, population science, computer science and mathematics where hospital nurse staffing was the subject of the study.

Results

A number of themes emerged. The first iteration showed the predominance of unit base approaches (e.g. nurse numbers, ratios, activity and workload) the second was the development of methodologies. Subsequent iterations examined issues such as demand, safety, nurse education, turnover, patient outcomes, patient or staff satisfaction, workload and activity. The majority of studies examined (n=767) demonstrated some association between staffing (units or type/skill) and various factors such as staff or patient satisfaction, working conditions, safety parameters, outcomes complexity of work achieved, work left undone or other factors. Many potential areas such as operational safety research were not utilised.

Conclusion

Although the relationship between staffing in acute care and factors such as units, safety or workload is complex, the evidence suggests an interdependent relationship which should only be dismissed with caution. The nature of these relationships should be further examined in order to determine nurse staffing. The body of knowledge appears substantial and complex yet appears to have little impact on policy.

Strengths and limitations of this study

This is a review of the existing literature across many fields and focuses on cross disciplinary approaches.

By encompassing many fields breadth rather than depth limits the analysis.

This study suggests looking at the issue of safe staffing from a wider operational safety perspective could uncover additional insight and solutions.

Funding Statement

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests

There are no competing interests.

Data sharing agreement

All of the papers reviewed are in the public domain.

Introduction

The question of registered nurses staffing hospitals to a level that is safe, high quality and cost effective has become a key issue worldwide. In terms of research it has also become something of a Gordian knot-one that attracts many attempts to solve but few solutions. Extending this question to community nursing and areas such as mental health or learning disability nursing demonstrate the complexity of the problem. Fundamental questions such as “How many nurses are needed?” “What kind of skill mix?” “Are staffing ratios the solution?” remain largely unanswered.

These issues present interesting theoretical problems but they have a very real world application as they underpin the safety of patients both in hospital and community. It could be argued that nursing is only visible by its absence such as those reported by Francis in the enquiry into the deaths at Mid Staffordshire NHS Foundation trust¹. Nursing is the largest part of the healthcare workforce² and attempts to curtail costs have seen radical workforce changes including reducing the number of registered nurses or replacing them with assistive personnel (Needleman 2016). It is of interest that there have been a number of coroners commenting on staffing levels under section 28 of the Coroners & Justice Act 2009³. This allows a Coroner in England to report circumstances where it may prevent further deaths. There are several examples of this for both the acute and care home sectors in recent years⁴.

Issues of staffing are further complicated by a lack of consensus within the profession around the levels of care that should be provided or calculated. Is there a difference between safe care and good care? Should all care be given by a registered nurse (RN)? Certainly, policy decisions in England are promoting the transfer of care to assistive personnel such as Nursing Associates⁵ for a variety of reasons such as shortage of RNs and increasing costs. Financial burden is a primary driver of workforce determinants. Investing in one aspect of staffing often means scaling back elsewhere, resulting in “trade-offs” for example using less educated staff or changing nurse patient ratios⁶.

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3 Different countries within the UK are taking different policy positions on staffing
4 which varies from guidance in England to legislation in Scotland and Wales⁷.
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7 In order to make sense of the variation in published work a hermeneutic approach is
8 taken. Such an approach is to question and to remain open to what might be
9 revealed⁸. Different researchers have used different approaches to understand
10 various aspects of this problem and the aim of this work to reveal a deeper
11 understanding and understand more about the interrelational nature of the problem.
12 This paper reviews the approaches that have been used to investigate the idea of
13 safe staffing, the knowledge elicited and explores direction this area of research
14 might take in the future.
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18 19 20 **Method**

21
22 Hermeneutic reviews⁹ utilise a process of searching and interpretation as
23 interrelational activity (Figure 1). This is because the focus is on the understanding
24 and interpretation of the materials. In a subject with a high volume of literature, this
25 approach allows the integration of interpretation and analysis of the literature and the
26 development of searching as part of the review. A hermeneutic framework describes
27 the literature review process as fundamentally a process of developing
28 understanding that is iterative in nature⁹. This has allowed a much wider perspective
29 incorporating a wider search and analysis than for example a systematic review
30 utilising methods such as PRISMA¹⁰. This body of evidence uses an extremely
31 diverse set of methodologies ranging from inductive studies reliant on qualitative
32 data to areas of computational mathematics. This would make approaches such as
33 meta-analysis almost impossible.
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39 Initial reading indicated that the work on this topic was not limited to the nursing
40 literature and so the first iteration was to expand the search to areas such as
41 computer science, maths and engineering. A search of the common databases was
42 undertaken including those in informatics and computational mathematics (PubMed,
43 CINAHL, arXiv, CiteSeerX, IEEEXplore) using search terms “nursing” (for computer
44 science, maths and engineering only as this is a minority term) “nurse staffing”
45 “nurse workload” “hospital staffing” “nursing ratios” “safe staffing” “staffing” AND
46 “patient safety” in the past 15 years (2003-2018). All terms were in English. A
47 successive fractions approach was used to refine this search⁹. Systematic reviews
48 were included where primary research is available. Initial reading also revealed a
49 paucity of work in area such as mental health, community care and learning disability
50 and so the focus remained on acute hospital staffing.
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55 This generated 7323 items. A significant proportion of work in the area of nurse
56 staffing has taken the form of editorials and various types of commentary or opinion
57 pieces rather than empirical studies. After elimination of opinion pieces and
58 professional non peer reviewed literature there remained in excess of 700 papers
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3 (n=769) across the different disciplines. These were reviewed and have broadly
4 been themed to gain insight into the different approaches and relational research
5 used to examine the issue of staffing within a wider context of safety. A
6 supplementary file contains more detail on how these studies were selected.
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9 **Patient and public involvement**

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11 This is a review of the existing literature and so there was no patient involvement at
12 this stage. Subsequent iterations would have patients/public co-researchers to co-
13 create questions and design subsequent studies.
14
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16 **Results**

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18 In terms of analysis specific themes started to emerge which were anchored around
19 methodology and the different lenses through which the issue of nurse staffing is
20 seen. Approaches to the question framed as “how many do we need?” are
21 commonly approached as units, for example, numbers of workforce, ratios (nurse to
22 patient or nurse to furniture) unit/ward levels of activity, job (different types of nursing
23 such as paediatric, theatres or intensive care) or contextually/situationally. It is
24 interesting to note that some situational perspectives originated from systems
25 engineering approaches such as Caryaon & Gurses¹¹ systems engineering approach
26 in intensive care units.
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31 After examining the literature iteratively, a number of themes emerge. Any of these
32 themes would merit study in their own right, but a broad overview of the different
33 approaches and their application is given here. What is striking is the range of
34 approaches used. These range from descriptive studies to the development of
35 operational mathematical models.
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39 **Nursing as units, workload or activity.**

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41 The literature on the development of a ratio or the effect of nurse to patient ratios is a
42 common theme in the nursing literature. A meta-analysis by Driscoll¹² draws on 35
43 studies which show an association between nurse staffing ratios and patient
44 outcomes. These studies use large administrative data sets and found that higher
45 staffing levels were associated with reduced mortality, reduced medication errors,
46 reduction in incidence of pressure ulcers, reduced use of restraint, reduction in
47 infections, such as hospital acquired pneumonia, higher aspirin use and a greater
48 number of patients receiving treatment. It is interesting to note that all of these
49 studies are either cross sectional or point prevalence studies. When examining this
50 section of the literature, cross sectional studies dominate.
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55 Shindul-Rothschild et al¹³ notes how workload impacts on efficiency in emergency
56 departments. Using regression in trauma centres, the time to a diagnostic evaluation
57 significantly increased when nurses cared for a higher number of patients. Aikens
58 work on RN 4Cast¹⁴ shows that an increase in a nurses' workload by one patient
59 increased the likelihood of an inpatient dying within 30 days of admission by 7%.
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3 They also found that every 10% increase in bachelor's degree nurses was
4 associated with a decrease in this likelihood by 7%. These associations imply that
5 patients in hospitals in which 60% of nurses had bachelor's degrees and nurses
6 cared for an average of six patients would have almost 30% lower mortality than
7 patients in hospitals in which only 30% of nurses had bachelor's degrees and nurses
8 cared for an average of eight patients. Skillmix is also a feature of this body of work.
9 Graduate RNs are associated with better outcomes while higher registered nurse to
10 patient ratios or support worker to registered nurse ratios are associated with poorer
11 outcomes¹⁵. Diane Boyle's study¹⁶ found that higher Registered Nurse Hours Per
12 Patient Day (RNHPPD) was associated with improvements in total fall rates over
13 time. This finding was not unique with various studies exposing the same association
14 for example Staggs and Dunton¹⁷ found that skillmix of a higher rate of assistive
15 personnel was associated with an increase in falls but there was variation. On acute
16 medical units there was a weak association between decrease in falls and increase
17 in RN staffing, but in step down and medical units the authors concluded that
18 increasing non RN staffing was ineffective for decreasing falls. Increasing RN
19 staffing did have a positive impact but this varied by unit type. White et al¹⁸ in
20 another cross-sectional study (N=353,333) examined a historical dataset using
21 thirty-day mortality and failure to rescue as endpoints and found that each 10%
22 increase in the proportion of graduate nurses was associated with 4% lower odds of
23 death in the older population 10% lower odds of death for those with dementia. This
24 was associated with better odds of rescue where graduate nurses are deployed.
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33 Relationships between staffing factors and outcomes are complex^{19,20,21} and the
34 causal relationship is not fully understood. However we know from other studies that
35 there is a deficit in care if staffing is not adequate. For example, in a study by Ball et
36 al²² nurses (86%) reported that one or more care activity had been left undone due
37 to lack of time on their last shift. Most care frequently left undone were: comforting or
38 talking with patients (66%), educating patients (52%) and developing/updating
39 nursing care plans (47%). The odds of care being left undone halved when nurses
40 had six or less patients to care for. The work left undone has become a more specific
41 area of enquiry with more authors coming to essentially the same conclusions²³.
42 Missed care appears to be common and perhaps even predictable. The work of
43 Bragadottir et al²⁴ examined the correlates and predictors of missed nursing care in
44 hospitals using regression. Such approaches may contribute to future demand based
45 models.
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51 A substantial body of evidence has been built which uses the approach of nurses,
52 nursing care or patients as units of work activity.
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54 Many factors contribute to workload and the relationship with safety is frequently
55 investigated. Adequate staffing and resources, administrative support, and
56 collaborative workplace relationships have been shown to improve patient safety,
57 and factors such as low job satisfaction, staff turnover, and high workload increase
58 risk to patient safety^{25,26}.
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3 Nursing workload is subjected to “measurement” using a plethora of measurement
4 tools which numerate tasks. Most of these tools tend to view nursing workload as
5 countable tasks, which is likely to be an oversimplification of complex work. Such
6 tools do not recognise the ‘other’ work which nurses do related to workplace culture
7 and climate²⁷. Fasoli & Haddock²⁸ after an extensive review of nurse workload
8 classification systems, reported there was no gold standard system for doing this
9 and current measures were not sensitive enough. This is reflected in findings that the
10 data collected routinely by nurses is not of sufficient quality to perform such complex
11 modelling^{17,29,30}.

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16 There has been a preoccupation with “time and motion” studies but these are of
17 limited use in complex work^{31,32} as a result this method cannot handle relational
18 work³³ and is therefore likely to underestimate nursing workload.

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21 There are measures which consider the complexity of the work³⁴ and workload
22 emerged as a theme including systematic reviews of the effect of workload on
23 patient safety^{35,11}. Several inductive subgroups emerged including the role of
24 workload and subsequent delegation of tasks which leads to delegation of safety
25 critical activity such as vital signs monitoring for example how local modifications to
26 track and trigger systems can reduce accuracy the of predictive algorithms³⁶ or the
27 workplace environment as a factor of workload³⁷.

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31 There has been some examination of redistribution of workload³⁸ in which there has
32 been some measurable increase in clinical time by workload redistribution. Although
33 this review does not consider the costs of staffing there are some interesting papers
34 on this. Perhaps one of the most interesting is Newbold’s 2008 model³⁹ which used
35 Aiken’s 2003⁴⁰ study, looked at nurse levels of education and patient mortality in
36 terms of a trade-off: what would a cost/mortality look like. Other researchers have
37 also utilised the cross sectional work to iterate mathematical models with some
38 success.
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45 **Workforce**

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47 Levels of workforce skill and education also feature in the literature. Much of the
48 work linking staffing (units or education) to outcomes looks at specific aspects of
49 care or harm. Boyle et al¹⁶ found an association between speciality nursing
50 education (post registration certification) and improvement in the rates of falls using
51 a longitudinal model (903 hospitals over 6 years) which echoed the findings of
52 Kendall-Gallagher & Blegen⁴¹, Lange et al⁴² and Boltz et al⁴³. For example, the Lang
53 paper found that units staffed with two or more geriatric-certified nurses had
54 significantly lower fall rates than units with one or no geriatric-certified nurses⁴².
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56 There appears to be a body of evidence supporting a higher skilled educated
57 workforce as associated with less harm although it is interesting to note that Magnet
58 hospitals were associated with higher rates of falls⁴⁴. There are numerous papers
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3 linking RN staffing with patient outcomes/harm but fewer on education. One
4 interesting single centre study looked at the consequences of outlying patients to
5 non-specialist wards which was associated with an increase in mortality⁴⁵.
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8 In a recent systematic review⁴⁶ eighteen studies were examined which gave
9 subjective reports of missed care. 75% or more nurses reported omitting some care.
10 Fourteen of these studies found low nurse staffing levels were significantly
11 associated with higher reports of missed care. There was little evidence that adding
12 support workers to the team reduced this. The authors noted that the extent to which
13 the relationships observed link to outcomes has yet to be investigated.
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16 Other work suggests that adding assistive nursing personnel without professional
17 nurse qualifications may contribute to preventable deaths, erode quality and safety of
18 hospital care¹⁴. Where studies have explored the impact of second level nurses,
19 similar to enrolled nurse qualification, the evidence is not supportive of the role⁴⁷.
20
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22 Satisfaction with work and other factors such as environmental, workload, working
23 hours and effect of skill mix is also reported as a factor. In some cases there is
24 evidence of an association between shift length, staff satisfaction and patient
25 outcomes⁴⁸ which associated longer shifts with more care left undone. These studies
26 usually take the form of cross sectional surveys as there appears to be no routine
27 data collection of these data. Unlike the concepts of staffing, there is much more
28 consistency in the reporting of issues related to workload such as moral distress,
29 burn out and compromise of both personal and professional values including the
30 erosion of identity⁴⁹. The corollary of this also occurs in that papers describing moral
31 distress also cite inadequate staffing as a causative attribute⁵⁰.
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36 Staffing and turnover is also occasionally reported in terms of outcomes for example
37 turnover and patient outcomes. In 2014 Park et al⁵¹ examined episodic unit-level
38 data from 2008 to 2010. This study examined 10,935 unit-quarter observations
39 (2,294 units, 465 hospitals) using multilevel regression. They found that the effect of
40 RN turnover on unit-acquired pressure ulcers was significant and “lagged” in terms of
41 time. For every 10 percentage-point increase in RN turnover in a quarter, the odds of
42 a patient having a pressure ulcer increased by 4 percent in the next quarter. Higher
43 RN turnover in a quarter was associated with lower RN staffing in the current and
44 subsequent quarters. Higher RN staffing was associated with lower pressure ulcer
45 rates, but it did not mediate the relationship between turnover and pressure ulcers.
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50 There appears to be a growing body of literature which examines resilience. The
51 emotional labour of nursing involves managing the emotional demands of nursing
52 work. An integrative review by Delgado et al²⁶ identified the difficult nature of not only
53 the work but the opportunities, or lack of, to build personal resilience.
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57 Alves et al⁵² found that RNs nurses with greater autonomy, good working
58 relationships and control over their work environment had lower levels of emotional
59 exhaustion, higher job satisfaction, less intention of leaving. Although they did not
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3 associate findings with patient outcomes these and other authors have found
4 positive associations with autonomy and rescue rates and mortality-and they are
5 more likely to experience this in small and non-teaching hospitals⁵³. This a consistent
6 theme in the literature reflected in a scoping review of twelve studies⁵⁴ which
7 concludes that structural empowerment effects the quality of care and patient safety
8 in hospital. This is also reflected in perceptions of safety culture and outcomes.
9 When adequate resource is allocated in terms of staffing the perception of safety and
10 patient satisfaction improves⁵⁵.
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17 **Understanding the complex relationship**

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19 There were a number of studies that used various aspects of data science. These
20 ranged from Bayesian approaches⁵⁶, to systems thinking, modelling, computational
21 mathematics and approaches such as machine learning. Many of these papers
22 appeared outside of the nursing literature and were located via databases that serve
23 the physical sciences, engineering and mathematics.
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25

26 This includes work such as Aickelin et al⁵⁷, who developed a memetic evolutionary
27 algorithm to achieve explicit learning in rule-based nurse rostering, which involves
28 applying a set of heuristic rules for each nurse's assignment. This uses a set of
29 building blocks in terms of data and rules to build an Estimation of Distribution
30 Algorithm (EDA). As the authors point out, although this performs well in some "real
31 world" situations it is limited by its ability to learn-one of the solutions is to add more
32 nurses to the model without understanding that this might be a constraint.
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36 Pitkaaho et al⁵⁸ used Finnish data from over 35,000 episodes of care to determine
37 relationships between nurse staffing and patients' length of stay in acute care units
38 and to determine whether non-linear relationships exist between variables using a
39 Bayesian approach. They found that acuity was the overriding factor that connected
40 all eleven variables in the dependency network of nurse staffing and short length of
41 stay. Non-linear associations were found between short length of stay and the
42 proportion of RNs. Skill mix consisting of an average proportion of Registered
43 Nurses (65–80%) was conducive to a short length of stay and predicted a 66%
44 likelihood of short length of stay. Lower percentages of RN predicted lower likelihood
45 of short length of stay.
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50 An overriding theme in these approaches are challenges in the real world. Well-
51 constructed approaches to calculating staffing needing more work than authors
52 anticipated when tested in reality. This is not unusual-these approaches tend to be
53 iterative, however it is interesting to note that a number of these approaches
54 concluded that previous staffing models had underestimated ratios and staffing
55 requirements in areas examined such as recovery⁵⁹.
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3 Other authors such as Park⁶⁰ are now building more optimized models based on
4 operational mathematical approaches and are likely to yield a more comprehensive
5 approach to the problem of computing staffing and outcomes as they accommodate
6 complexity.
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9 Data science approaches were the only ones to consider knowledge stock or
10 knowledge flow in the early part of the 21st century but little consideration was given
11 to this after this time⁶¹.
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14 The advent of data science offers many opportunities however nursing may not be
15 placed to capitalise on them⁶². Lack of high quality data is a recurring issue in terms
16 of both unit based approaches and approaches using data science to examine
17 complexity. Nursing data is generally episodic and lacks sensitivity to the activity that
18 nurses perform. In the studies, most informatics systems use taxonomies or lists of
19 tasks which are limited and show no apparent relationship with time taken. Another
20 issue is the dominance of supply side (nurse units of time for example) and not the
21 demand from patients which is rarely looked at.
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25 **Refining and leaving the hermeneutic circle**

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27 A key facet of Gadamer's⁸ approach is not to leave the hermeneutic circle due to its
28 inescapability and as such the review has focussed on the search. However the
29 authors are from a positivist paradigm and so has broken the circle at this juncture.
30 This method is an inductive one and as such recognises that the iterations of
31 searching and analysis could be infinite. The themes that emerge here across the
32 literature are not exhaustive but provide a break in the cycle of searching and
33 analysis. The exploration of these themes can be further built up. The papers
34 reviewed offered many directions in which to expand this area of enquiry and these
35 are shown in Figure 2, a Venn diagram of the areas explored, the numbers of papers
36 reviewed and potential for intersection with areas of knowledge not reviewed herein.
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42 **Discussion**

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44 Although the evidence in the nursing literature appears to offer no firm guidance on
45 staffing models or absolute solutions, this could be seen as reassurance because it
46 also demonstrates the complexity of the problem. The literature describes different
47 associations between various factors such as outcomes and staffing numbers/skill
48 mix. Each piece of work gives a slightly different perspective but an overarching
49 emerging theme is that a relationship does exist between different factors even if
50 these relationships are not fully understood, there is an apparent effect.
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54 The conceptual difficulty safety presented in the context of staffing was an emerging
55 theme. How is safe differentiated from unsafe, what is optimal staffing and where
56 should trade off occur. These studies help with clarification of the problem but there
57 is little consistency in this body of work in terms of a solution.
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3 One of the themes herein was the repeated association with not only numbers of
4 RNs but the educational level in the workplace. This appeared to show an overall
5 benefit in employing RNs and also RNs with a degree level qualification. Some
6 authors note this in the employment marketplace-that employers are acting on these
7 findings and recording a downward trend in using assistive roles in the USA⁶³.
8
9

10 It is interesting that only one paper mentioned knowledge stock and knowledge flow.
11 None of the papers reviewed examined nurse staffing in terms of being a knowledge
12 intense occupation which is a factor in modelling workforces in other safety critical
13 industries or in other fields where operations are highly reliant on professional
14 knowledge such information technology⁶⁴. This might be because the approach to
15 workforce modelling in nursing is focussed on linear, deterministic approaches such
16 as time and motion or time filled with tasks. This is more akin to workforce modelling
17 in the service industries⁶⁵.
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22 There is narrative which focusses on a fixed ratio as staffing model in nursing. Ratios
23 are common in other safety critical industries or area such as mass gatherings
24 however it is often used as a failsafe rather than a staffing model⁶⁶ which might be a
25 more practical option for nursing.
26
27

28 The literature is supportive of a relationship between staffing, skillmix and education
29 and this has been reviewed before⁶⁷ however circling out beyond the nursing
30 literature affirms this. Many reviews or policy documents appear to be confined to the
31 nursing or medical literature and yet a rich seam of enquiry appears outside of these
32 fields. What is striking is that there was very little overlap in areas of enquiry such as
33 safety critical operations research, demand modelling or knowledge based workforce
34 research and acute nurse staffing (Figure 2). These areas show in the Venn diagram
35 (Figure 2) as a representation of the sets of knowledge reviewed and those not
36 reviewed specifically but where these different fields appear to intersect.
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40 Researchers should widen their perspectives on methodologies and approaches to
41 include other disciplines particularly the approaches of safety critical industries. By
42 doing so it is possible to iterate an initial understanding of demand which can begin
43 to integrate areas such as workforce and safety-an interpretation is given in Figure 3.
44
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46 **Strengths and limitations of this study**

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48 This is a review of the existing literature across many fields and focuses on cross
49 disciplinary approaches. By encompassing many fields, breadth rather than depth
50 limits the analysis but does take the literature in context to form an overall view.
51 There is a risk of over simplifying the literature and the knowledge at this scale.
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56 **Conclusion**

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58 There is a wide variety of literature from different paradigms that support a complex
59 interrelationship between different factors in acute nurse staffing. Despite a growing
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3 body of knowledge, there appears to be little reference to nursing as safety critical
4 nor is the problem viewed through this lens. It is suggested that looking outside the
5 discipline of nursing might add valuable insight to this problem.
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8 The issue of nurse staffing is a complex one and the relationships between factors
9 such as nursing and patient outcomes is also complex. Despite this no papers
10 examined nursing as a knowledge intensive operation or as a safety critical
11 workforce. There is an increasing body of knowledge outside of nursing which has
12 focussed on this topic but is rarely utilised.
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15 Although this is an emerging area, evidence repeatedly suggested a complex
16 interdependent relationship between nurse staffing and various factors such as
17 patient safety. Hermeneutic approaches can offer new insight by focussing in
18 interpretation and has been used to generate knowledge⁶⁸.
19
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21 Given the asserted complexity of work, time and motion or other simplistic activity
22 analysis (measuring nursing in a linear or deterministic way) should be avoided. The
23 importance of this emerging relationship should be considered when examining
24 staffing. This study suggests looking at the issue of safe staffing from a wider
25 operational safety perspective could uncover additional insight and solutions.
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31 **Ethical Permissions**

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33 This is a review of the literature. Ethical permission was not sought.
34

35 **Author's contribution**

36
37 AL design, analysis, writing, GP analysis and writing.
38
39

40 **Acknowledgements**

41
42 The authors would like to acknowledge Dr M Alexander for help in identifying cases
43 from the coroner. Dr Elaine Maxwell for help in formulating the area of enquiry.
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46 **Figure Legends**

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48 Figure 1 The hermeneutic circle as a framework for literature reviews

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50 Figure 2 A Venn diagram of areas of enquiry and potential overlap with other
51 interdisciplinary areas-the bordered area contains the literature reviewed
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54 Figure 3 Contextualising the findings in terms of demand
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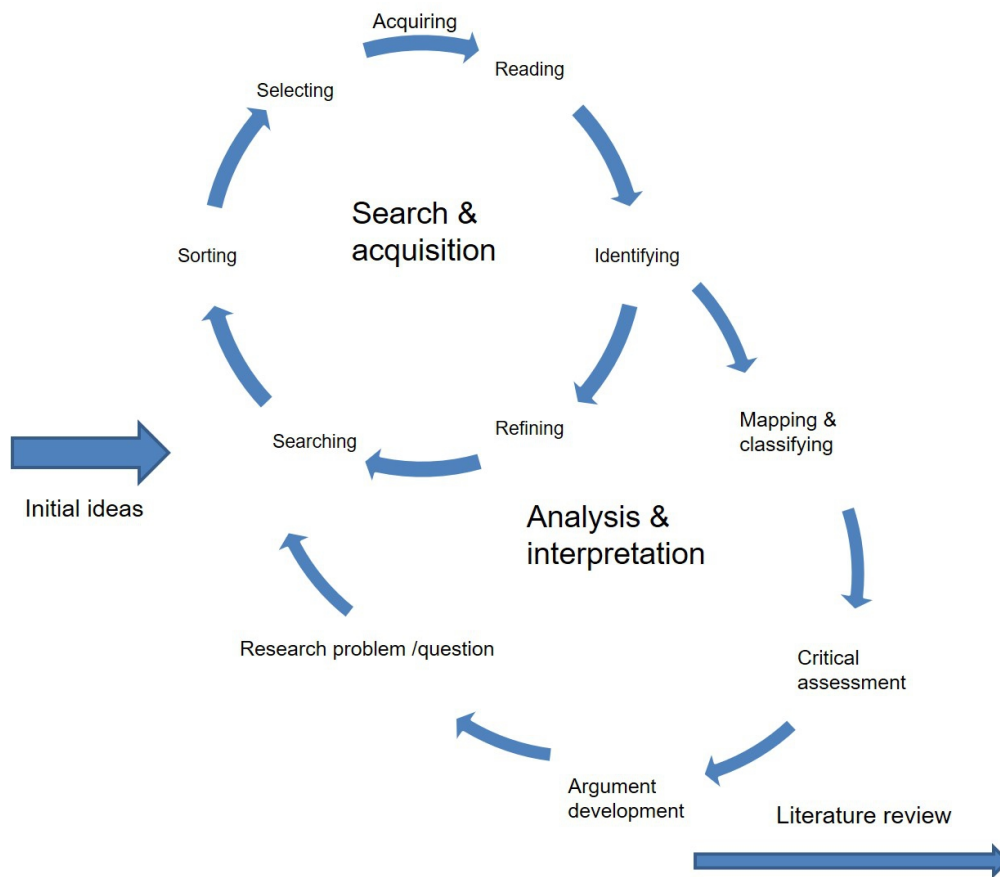


Figure 1

103x90mm (300 x 300 DPI)

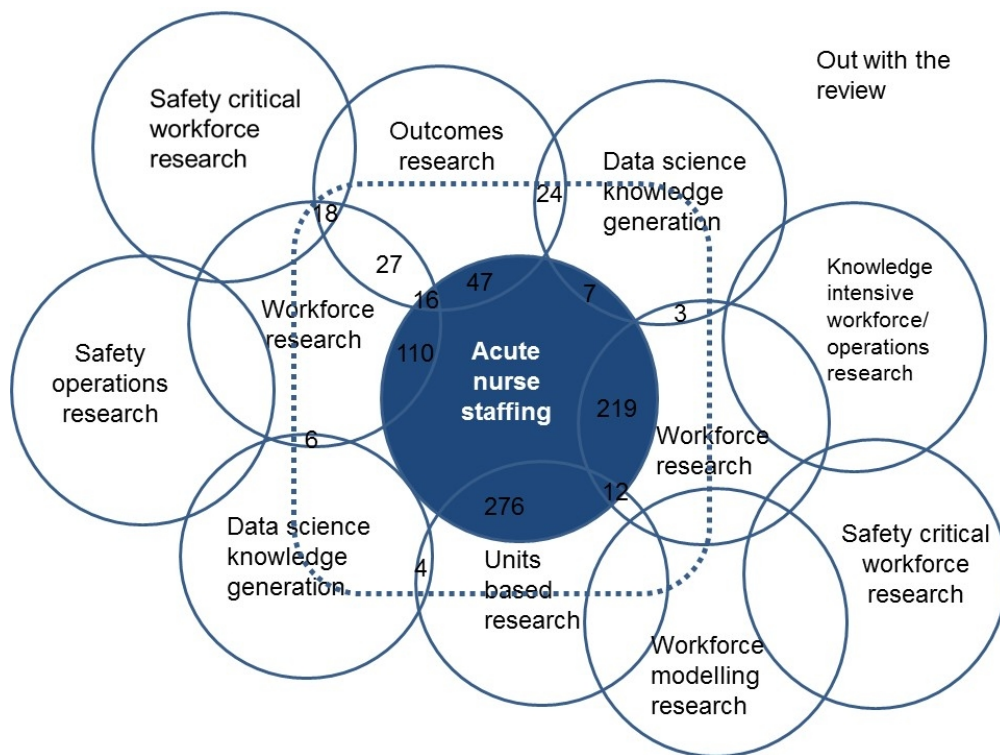


Figure 2 A Venn diagram of areas of enquiry and potential overlap with other interdisciplinary areas-the bordered area contains the literature reviewed herein.

254x190mm (96 x 96 DPI)

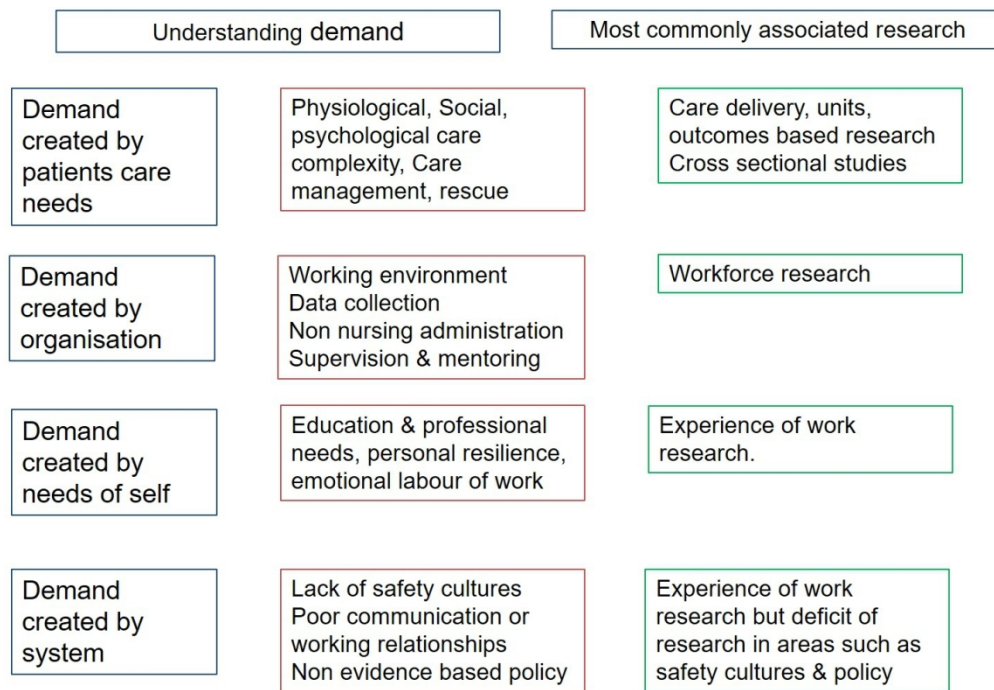


Figure 3

121x84mm (300 x 300 DPI)

Supplementary file

Determining acute nurse staffing, a hermeneutic review of an evolving science.

Search Strategy

Database selection

PubMed, CINAHL, arXiv, CiteSeerX, IEEEXplore

Key words/terms (Boolean)

“nursing” arXiv, CiteSeerX, IEEEXplore (as this is a minority term) “nurse staffing” “nurse workload” “hospital staffing” “nursing ratios” “safe staffing” “staffing” AND “patient safety” in PubMed and CINAHL

Years searched 2003-2018

Criteria for inclusion

Primary research, secondary analysis or reviews on any relationship between acute hospital nurse staffing (registered, licenced and unregistered) and an specified outcome.

First iteration used key terms as above.

This yielded 7323 items.

From this 5265 were excluded as these were opinion pieces, editorials, commentaries, proceedings, consensus pieces and papers with no English translation.

2058 Items were initially reviewed

Include systematic reviews (24)

Include primary research (2034)

Exclude other non-peer reviewed work such as reports (23)

Exclude papers which did not meet criteria on reading abstract/full text (1262)

Exclude other material (peer reviewed opinion pieces) (4)

Papers reviewed 769

Mapping and classification by discipline/area of research, major concepts, lens and unit of analysis. The result of this is shown in the main paper.

Critical assessment of the work was for rigour/associations and primarily “gap spotting” To visualise the relationships within discipline areas a Venn diagram was constructed (Figure 2). With the further application for example of Łoś's Theorem, and ultra product could eventually be defined.

Second iteration (as described in methods section)

Search to same criteria adding Nursing AND knowledge intense occupations, safety critical workforce revealed opinion pieces which referenced the terms to describe the labour market but no additional papers reviewed as they did not meet the criteria.