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Extended Research Article

# Consequences, costs and cost-effectiveness of workforce configurations in English acute hospitals

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Published July 2025
DOI: 10.3310/ZBAR9152

## Scientific summary

### Consequences, costs and cost-effectiveness of workforce configurations in English acute hospitals

Health and Social Care Delivery Research 2025; Vol. 13: No. 25
DOI: 10.3310/ZBAR9152

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# Scientific summary

## Background

The consequences of staff shortages in the NHS are potentially serious. Several inquiries, NHS guidance and an extensive body of research indicate that lower registered nurse (RN) staffing levels are associated with adverse patient and staff outcomes. Patient outcomes associated with lower nurse staffing include increased risk of death, hospital-acquired infections, falls, poor patient experience and nursing care omissions. Adverse nurse outcomes include burnout, job dissatisfaction and intention to leave.

Maintaining adequate staffing for hospital wards is challenging. As of March 2022, approximately 10% of nursing posts in acute settings were vacant, totalling 38,972 vacancies. In the aftermath of the Francis inquiry and the publication of guidance for safe staffing in adult wards in acute hospitals by the National Institute for Health and Care Excellence in 2014, the number of RNs employed in acute hospitals increased. However, this followed a period where absolute numbers fell, and the increases have not matched activity growth. Although there appeared to be an immediate uplift in the number of applicants for nursing courses following the start of the COVID-19 pandemic in 2020, this has not been sustained. Steps taken to increase supply will not resolve shortages for some time, assuming they are successful. In the face of such scarcity and the need to manage expenditure on staff, care providers and policy-makers face difficult decisions as they plan how to provide adequate nurse staffing levels.

Despite extensive evidence demonstrating associations between low nurse staffing levels and adverse outcomes, important uncertainties remain. Most evidence is from cross-sectional studies which have not considered staffing by other staff groups. This means that estimates of nurse staffing effects could be biased, and the importance of the multidisciplinary team may not be recognised. Although there is a growing body of longitudinal studies which avoid many of the limitations of cross-sectional studies, these are still limited. Most economic studies rely on studies with a high risk of bias to estimate the effects of changes in staffing configurations.

## Aims and objectives

This study aims to provide evidence to inform cost-effective deployment of nursing and other care staff on hospital wards in England and policy decisions to address nursing workforce shortages. We address the question of which combinations of care staff employed by hospitals and deployed on hospital wards provide the most cost-effective care in terms of patient safety, experience and efficient use of resources by undertaking two studies. First, we explore hospital-level cross-sectional associations between staffing and outcomes and, second, we assess how outcomes and costs vary as patients and nurses are exposed to low staffing on hospital wards longitudinally.

## Methods

We undertook a national cross-sectional panel study using routine data from all English acute hospital Trusts and a patient-level longitudinal observational study in four Trusts. We used natural variation in workload (beds per staff member) and, for the longitudinal study, staffing shortfalls relative to the expected staffing for the ward to determine the association between staffing levels and outcomes and to estimate the effects of change. For nursing, we considered RNs (band 5+) and nursing assistant staff (bands 2–4), which would include nursing associates (although current numbers are small). In the longitudinal study, we also considered the composition of the nursing team in terms of the staff grade mix (proportion of band 4 assistant staff, proportion of band 6+ RNs) and the proportion of bank and agency staff. Across the two studies, we considered a range of outcomes including death, length of stay, re-admission, patient experience, staff experience and staff sickness. For the economic analysis, we considered costs, consequences and quality-adjusted life-years (QALYs), estimating incremental cost-effectiveness ratios (cost per life saved and cost per QALY gained) for eliminating low staffing. Our data were derived from publicly available records of hospital activity,

staffing and outcomes for the cross-sectional study and hospital administrative systems for the longitudinal study. We tested associations with multivariable mixed statistical models including random terms to account for the clustering of observations in Trust or ward, as appropriate. We used the national standardised hospital mortality indicator model to adjust for risk of death and for national patient and the staff experience models included the Trust's mortality rate to adjust for the acuity of the case mix.

## Results

### *Cross-sectional study*

We included 138 hospital Trusts. The number of beds per full-time equivalent (FTE) staff member varied considerably between Trusts. The largest variation was in allied healthcare professional (AHP) staff (mean 2.4 beds per FTE) and support to AHP staff (mean 11.1 beds per FTE), where the standard deviation was 38% and 44% of the mean, respectively. RN staffing levels were strongly correlated with staffing levels by doctors ($\rho > 0.71$). Although the number of beds per RN had the largest effect on mortality in models including single staff groups [rate ratio (RR) 1.33, 95% confidence interval (CI) 1.15 to 1.54], this was greatly reduced and no longer statistically significant when all staff groups were included in the model, although it remained the largest effect size (RR 1.07, 95% CI 0.88 to 1.31).

In multiprofessional models, more occupied beds per AHP (RR 1.04, 95% CI 1.02 to 1.06) and per medical doctor (RR 1.04, 95% CI 1.02 to 1.06) were associated with increased risk of death. More beds per nurse support (RR 0.85, 95% CI 0.79 to 0.91) and AHP support (1.00, 95% CI 0.99 to 1.00) were associated with lower death rates. In multiprofessional models, having more beds per RN was associated with lower scores for patient experience, staff health and well-being, and staff reports of quality of care. More beds per nurse support were associated with lower morale scores but more beds per surgical doctor were associated with higher morale scores. Using ward-level reports of nurse staffing we found that wards with more RN hours per patient day reported fewer harms on the national 'safety thermometer' but calculating a staffing shortfall, relative to the Trusts' reported staffing plans, did not strengthen the observed relationship and, for nursing assistant staff, shortfalls were associated with reduced harms.

### *Longitudinal study*

We linked staffing data for 626,313 adult admissions and 57,375 paediatric admissions with overnight stays from four hospital Trusts. We used the ward mean to define the expected staffing level, with staffing below this classified as low. During the first 5 days of hospital stay for adult patients low staffing (relative to the ward mean) occurred on 45% of days, with a mean exposure of 3.32 days. On days when RN staffing was low, the mean shortfall was 0.87 RN hours relative to average staffing of 5.3 hours per patient day. For nursing assistants, the mean shortfall on days of low staffing was 0.49 hours relative to average staffing of 2.9 hours per patient day.

For adult inpatients, exposure to days with lower-than-expected RNs or nursing assistant staff was associated with increased hazard of death [adjusted hazard ratio (aHR) 1.08/1.07, 95% CI 1.07 to 1.09/1.06 to 1.08] and longer hospital stays. Low RN staffing was also associated with increased hazard of re-admission (aHR 1.01, 95% CI 1.01 to 1.02). Results for paediatric admissions were similar, although low nursing assistant staffing was also significantly associated with increased risk of re-admission. Effect sizes were larger, but CIs were much wider. The risk of death was very low (0.25%) and associations with deaths were not statistically significant. Exposure to days of low RN staffing increased the odds of sickness absence for both RNs and assistants (adjusted odds ratio 1.02/1.03, 95% CI 1.00 to 1.03/1.01 to 1.04 for each 10% of the past 7 days worked that were understaffed).

Our primary analyses included staffing in the first 5 days of the hospital stay but results were not sensitive to the exposure window used. We had no measure of the availability of AHPs, doctors or other staff groups, but we tested models that included weekend and seasonal effects, both factors that may cause short staffing from other groups to correlate with low nurse staffing. Addition of these factors did not alter the estimated effect of low staffing. We modelled effects for various subgroups. The effects of low staffing on general wards and for less acute patients [National Early Warning Score (NEWS) < 5] only were similar to the original results. Effects in highly acute patients (NEWS 5+) and older peoples' wards were smaller. For highly acute patients, there was evidence of an adverse effect from nursing assistant staffing, as low staffing was associated with significant decreases in the hazard of death (aHR

0.98, 95% CI 0.96 to 1.00) and increased risk of re-admission (aHR 0.97, 95% CI 0.95 to 0.99). Nursing assistant low staffing was also associated with a lower hazard of re-admission for people over 75. There was no statistically significant association between low staffing and mortality in intensive care or for people over 75, but hospital stays were longer.

We found that days of low staffing were also associated with increased risk of the potentially nurse-sensitive adverse events of deep vein thrombosis (DVT), pneumonia and pressure ulcers in surgical admissions. Low RN staffing had a larger effect than low assistant staffing. For example, a patient who experienced low RN staffing on all the first 5 days of their stay had a 59% increased risk of DVT. For low assistant staffing, the risk was increased by 33%. Analysis of data from incident reporting systems gave counterintuitive associations consistent with ascertainment and reporting bias.

We used the ward mean as a threshold to define low staffing. Although our previous research has shown that mean staffing correlates strongly with planned staffing on a ward, it is an arbitrary threshold and may not reflect a desirable staffing level or any tolerance to lower than planned staffing. Estimated effects of low staffing were largely unchanged if the threshold to define low staffing was set at lower levels. For assistant staffing, this is also the case for higher thresholds, above the mean. However, for RN staffing the effects of days of low staffing increase when a higher threshold is used. For example, if low staffing were defined as when staffing falls below 110% of the mean, the HR associated with a day of low staffing is 1.12. We also explored continuous (net hours) effects, nonlinear and interaction effects. There was some evidence of nonlinearity and interaction, but the effects were mostly subtle, although there was some indication that the effect of additional days of low RN staffing was greater as the cumulative number of days exposure increased and that the marginal effect of change in net hours was slightly greater at very high as well as very low staffing levels.

We considered the mix of staff in terms of grades of RN and assistant staff and proportions of bank and agency staff. A higher proportion of band 6+ RNs and band 4 nursing assistants were associated with reduced hazard of death (aHR 0.98), although the result was not statistically significant for nursing assistants nor when all staff mix variables were considered simultaneously. Higher proportions of bank and agency staff (both RNs and nursing assistants) were associated with increased hazard of death, with the strongest adverse effect associated with agency assistant staff.

### *Economic analysis*

The estimated cost of providing care for our analysis cohort of adult inpatients was £4173 per admission. The mean cost of avoiding low staffing was £197 per admission. The mean discounted QALY lost among patients who died was estimated to be 6.82 and we used this as our base-case assumption for the QALY gained when modelling the effects of reducing understaffing. Eliminating low staffing cost £2778 per QALY gained. Savings from avoided sickness absence and re-admissions made cost-effectiveness estimates more favourable but did not have a major impact. If costs of avoided hospital stays are included, avoiding low staffing generates a net cost saving under all scenarios modelled except reducing understaffing by nursing assistants for highly acute patients, which led to a net cost increase and worse outcomes.

Avoidance of RN rather than assistant understaffing for highly acute patients gave more benefits and was more cost-effective. Avoiding low staffing using temporary agency staff reduced mortality but was less cost-effective than using substantive staff because benefits were reduced, and costs increased. Assuming agency staff cost 50% more than the cost of substantive staff, reducing low staffing with agency staff cost £10,980 per QALY. If agency staff were assumed to cost the same as substantive staff, this was still less cost-effective (£7320 per QALY) because the benefit of reduced mortality was weakened by the adverse effect from a higher proportion of temporary staff.

## Conclusions

The NHS faces multiple competing demands for scarce resources. The evidence presented here suggests that investment in nurse staffing in acute hospitals could be cost-effective, on a par with many public health interventions. If the benefits of reduced length of stay are considered and realised, for example through freeing capacity to improve flow through emergency departments or for elective surgery, then there could be net gains. The relative increase in costs is modest, although the supply of staff to meet demand remains challenging. It is important that this scarcity does

not obscure the need and demonstrated value for money. While decision-makers may, of necessity, need to experiment with novel approaches to addressing staffing shortages, this needs to be done in the context of a full understanding of what is already known. The safety and cost-effectiveness of alternatives should not be assumed.

Several priorities for future research emerge from this work.

- More research is needed into methods to determine nurse staffing requirements in hospital wards, for planning, real-time monitoring and for use in research. The requirements of service should inform decisions about the required timeliness of data, acceptable data gathering load and the necessary precision.
- Our findings, combined with the results of previous research, leave uncertainty about the trade-offs between staff shortages and temporary staffing levels, including the relative (adverse) effects of temporary staff at different levels and from different sources. Both qualitative and quantitative research would be of value.
- There remains uncertainty about the interaction between RN and assistant staffing levels which should be addressed through both qualitative and quantitative research.
- Research is required to better understand whether the observed variation in AHP staffing is based on variation in service and patient need. The observed association with mortality rates in this study suggests it may not be, and if that is the case, evidence-based methods for determining appropriate staffing need to be developed.

Our results not only show the adverse effects of low nurse staffing but also show that medical and AHP staffing are important considerations for patient safety. Eliminating low RN staffing gives more benefits than eliminating assistant staffing but both interventions are cost-effective in terms of QALYs gained relative to many public health interventions. Using agency staff to reduce staffing shortages is also less cost-effective than using substantive staff, because of higher costs but also reduced benefits. However, these findings suggest that while relatively less cost-effective, the use of agency staff to avoid staff shortages is still cost-effective relative to many public health interventions. These findings lend support to policy initiatives aimed at increasing the supply of RNs.

## Study registration

This study is registered as Current Controlled Trials ClinicalTrials.gov NCT04374812.

## Funding

This award was funded by the National Institute for Health and Care Research (NIHR) Health and Social Care Delivery Research programme (NIHR award ref: NIHR128056) and is published in full in *Health and Social Care Delivery Research*; Vol. 13, No. 25. See the NIHR Funding and Awards website for further award information.

# Health and Social Care Delivery Research

ISSN 2755-0079 (Online)

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This journal is a member of and subscribes to the principles of the Committee on Publication Ethics (COPE) (www.publicationethics.org/).

Editorial contact: journals.library@nihr.ac.uk

This journal was previously published as *Health Services and Delivery Research* (Volumes 1–9); ISSN 2050-4349 (print), ISSN 2050-4357 (online)

The full HSDR archive is freely available to view online at www.journalslibrary.nihr.ac.uk/hsdr.

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### This article

The research reported in this issue of the journal was funded by the HSDR programme or one of its preceding programmes as award number NIHR128056. The contractual start date was in March 2020. The draft manuscript began editorial review in December 2024 and was accepted for publication in January 2025. The authors have been wholly responsible for all data collection, analysis and interpretation, and for writing up their work. The HSDR editors and production house have tried to ensure the accuracy of the authors' manuscript and would like to thank the reviewers for their constructive comments on the draft document. However, they do not accept liability for damages or losses arising from material published in this article.



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