



Research Paper

The association between physician staff numbers and mortality in English hospitals

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ABSTRACT

Background: Physician medical specialties place specific demands on medical staff. Often patients have multiple co-morbidities, frailty is common, and mortality rates are higher than other specialties such as surgery. The key intervention for patients admitted under physician subspecialties is the care provided on the ward. The current evidence base to inform staffing in physician medical specialty wards is limited. The aim of this analysis is to investigate the association between medical staffing levels within physician medical specialties and mortality.

Methods: This study is a cross-sectional analysis of national data, which is aggregated at provider level. Medical beds per senior, middle grade and junior physicians employed in physician medical specialties were calculated from national employment records for acute hospitals in England, in 2017. Outcome measures included unadjusted mortality rate and Summary Hospital-level Mortality Indicator (SHMI) in physician medical specialties. Both Raw mortality and SHMI include deaths during admission or within 30 days following discharge. Linear regression models were constructed for each medical staffing grade for unadjusted mortality, SHMI and SHMI adjusted for local provider factors.

Findings: The mean number of medical beds per senior, middle grade and junior physicians were 7.3(SD 2.5), 19.7(11.5), 10.1(3.1) respectively. Lower bed numbers per medical staff grade were associated with lower than expected mortality by SHMI; senior(Coefficient 0.012(95%CI:0.005–0.018), $p = 0.001$), middle grade (0.002(0.0002–0.005), $p = 0.032$) and junior(0.008(0.002–0.015), $p = 0.014$). Hospital providers were more likely to achieve a better than expected mortality (SHMI<1) if beds per physician were lower than; 5.3, 14.6 and 9.0 for senior, middle grade and junior doctors respectively.

Interpretation: Acute hospital providers with fewer beds per medical staff of all grades are associated with lower than expected mortality.

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1. Introduction

Increasing hospital admissions have led to increasing workloads for all grades of medical staff internationally [1]. In the UK 43% of medical consultant posts advertised were not appointed to in 2018 reflecting supply deficiencies [2] and recent surveys of the UK middle grade doctor workforce suggest that their workload has become unsustainable at current staffing levels [3]. The quality of hospital care is influenced by the number of medical staff such as consultants in the UK and residents in the USA (4–6). Hospital doctors as a group influence mortality [7], however, data on the differential impact of

junior, middle grade and senior doctor staffing are lacking. Significant variation in care quality has also been attributed to the number of community and hospital doctors employed per head of population [8].

Physician medical specialties, such as Care of the elderly or Respiratory medicine, place specific demands on the doctors working in such subspecialties. The key intervention for patients admitted under physician specialties is usually the care provided on the hospital ward rather than a specific intervention such as an operation [9]. A previous systematic review suggested a key aspect of hospital staffing is “service design and skill mix” [10], highlighting the importance of adequate numbers of senior and junior medical staff. It is therefore important to examine the impact of variation in the number of different grades of medical staff within physician medical specialties to optimise patient outcomes.

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Research in Context

Evidence before this study

Previous analyses have demonstrated that care across all specialties was enhanced with improved hospital staffing and more primary care doctors per head of population, but there is little evidence on staffing levels specific to Physician specialties. The Royal College of Physicians has published guidance based on tiers of medical staff members, but raised concerns that there was little published research to guide their recommendations.

Added value of this study

For the first time, this study examines the effect on standardised mortality in physician specialties of staffing levels for different tiers of seniority of medical staff (i.e. junior, middle grade and senior doctors). The analysis demonstrated that increasing numbers of doctors in all tiers of medical staff have significant associations with improved standardised mortality.

Implications of all the available evidence

There is developing evidence that increasing numbers of staff per patient (in both primary and secondary care) improves outcomes. Hospital providers seeking to reduce mortality rates within physician specialties should consider improving the ratios of beds per medical staff member. This should include not only senior doctors, but also middle grade and junior members of medical staff.

general internal medicine, care of the elderly, infectious disease, renal medicine, respiratory medicine and rheumatology were considered to be medical staff providing inpatient care. Consultants in the above specialties with the exception of rheumatology were considered to provide inpatient care and therefore likely to affect outcomes of inpatients. All Core medical trainees were included. Foundation trainees were included as 0.33 of whole time equivalents due to proportion of their time spent within physician medical specialties and other hospital specialties.

Staff were allocated into tiers based on seniority, adapted from the guidance on safe medical staffing report [15]; Junior doctors, Middle Grade Doctors and Senior Doctors. Junior doctors included Foundation trainees and Core medical trainee grade doctors, who are generally between 0 and 4 years following graduation. These doctors undertake routine ward work, for example; interpreting results, ward based practical procedures and initial review of unwell patients under supervision. Middle grade doctors included higher specialist trainees, representing advanced specialty trainees. These doctors would be expected to be able to manage a ward or acute admissions unit including the supervision of a team of Junior doctors without on-site support. Senior doctors were Consultants, equivalent to the American Attending Grade. These highly experienced doctors take ultimate responsibility for the care of patients provided by their team.

2.3. Hospital provider characteristics

Hospital providers in the UK vary by patient volume and the services provided. Providers' association to a university and the total number of inpatient attendances (quintiles) are presented to attempt to correct for local factors. These data are publically available from the NHS England statistical work areas and NHS Digital [17, 18].

2.4. Hospital provider medical bed data

The number of physician medical specialty beds open between October and December 2017 was provided by NHS England [19]. This period is the midpoint of the year for which mortality data is available for each hospital (see below). The ratio of beds per staff member was calculated by dividing the number of beds at a hospital provider by each tier of clinicians.

Hospital providers were excluded if they were delivering only specialist services (e.g. orthopaedics) or were community and mental health trusts. Hospital providers were also excluded if less than 1 Middle grade doctor was employed per 60 beds or less than 1.5 Junior doctors per 30 beds, as this was considered unlikely to be accurate in the context of an acute provider.

2.5. Summary hospital-level mortality indicator

The Summary Hospital-level Mortality Indicator (SHMI) is the ratio of actual to expected deaths while an inpatient or within 30 days of discharge [20, 21]. Expected deaths are calculated based upon national data in England, adjusted for case mix including diagnoses, co-morbidity, demographic details, admission month and admission method of patients presenting to the hospital provider. The original data source is Hospital Episode Statistics (HES), a national administrative database which includes diagnostic (International classification of diseases ICD10) and procedural (OPCS4) codes to give primary diagnoses (primary position in HES) and co-morbidities (using secondary diagnosis HES codes). HES has been used extensively for research including studies that suggest it has a high degree of accuracy [22].

SHMI was used at hospital provider level, including only patients likely to be cared for by Physician medical teams, covering the period July 2017 to June 2018 [18]. SHMI is publically available on a yearly

Lower levels of nursing staff are recognised to be associated with increased inpatient mortality (11-13). In the UK this has led to specific guidance produced by the National Institute for Health and Clinical Excellence regarding nursing staff numbers [14]. No equivalent guidance is available for medical staffing, therefore the Royal College of Physicians published guidance on safe medical staffing in July 2018 [15]. It was noted that there was little published data upon which to base the numbers of staff recommended in the guidance [15].

The aim of this study was to examine the influence of physician medical specialties doctors' staffing, in terms of numbers of beds per physician on hospital providers', on standardised mortality in hospital and 30 days following discharge.

2. Methods

2.1. Study design

This cross-sectional analysis combines national data describing hospital providers' physician medical specialties staffing with hospital provider level descriptive data and mortality data (inpatient and within 30 days of admission).

2.2. Medical staff numbers

Data regarding medical staff numbers were provided by Health Education England from the UK national health service electronic staff record in 2017 [16]. Staff numbers were established per provider as whole time equivalents, including locum staff. Specialties were included if they make a significant contribution to inpatient care. Higher specialist trainees within rehabilitation medicine, palliative care medicine, neurology, haematology, cardiology, acute internal medicine, clinical pharmacology, endocrinology, gastroenterology,

basis for both providers as a whole. This period was selected to overlap with the other data used in this analysis. SHMI is available for specific diagnosis groups, allowing providers to identify any area in which they may have higher than expected mortality. A Specific SHMI was therefore constructed for use in this analysis. Patients with conditions likely to be cared for by other specialties, or in who it was unclear which specialty would look after them, were not included in the SHMI value used in this analysis. Included patient diagnosis groups can be found in Appendix 1. All references to SHMI in this manuscript relate to the Specific SHMI variant described here.

2.6. Statistical analysis

Data sources were matched using the unique organisation ID. Descriptive statistics are provided for included hospital providers by medical bed number, raw physician staffing level and mean medical staffing tier to bed ratios. Linear regression models, including provider episodes by quintile and university status, were used to assess the correlation between the bed ratio for each medical staffing tier (Senior doctors, Middle grade doctors, Junior doctors) to SHMI. Linear regression model assumptions were checked using a residual plot.

A secondary analysis was performed using a linear regression model of bed ratio quintiles for each medical staffing tier to SHMI. The use of quintiles treats the relationship as non-linear, therefore demonstrating the impact from different medical staff ratios on SHMI.

All statistical analyses were performed in Stata version 15 [23]. A p -value < 0.05 was considered statistically significant.

3. Results

3.1. Medical staffing and provider characteristics

Following the exclusion of specialist, community and non-current NHS providers, data were available for 131 acute hospital providers in England. Based upon the exclusions described in the methods section 0, 9 and 2 providers were excluded from the Senior doctors, Middle grade doctors and Junior doctors analyses respectively. Full study variables describing providers and staffing are shown in Table 1.

3.2. Unadjusted mortality

The mean raw mortality during or within 30 days of admission was 3.5% (SD 0.8%). Univariate linear regression analysis demonstrated statistically significant associations between raw mortality and beds per Senior doctor (coefficient 0.130 (95%CI 0.081–0.180), $p < 0.001$), beds per Middle grade doctor (0.033 (0.021–0.045), $p < 0.001$) and beds per Junior doctor (0.095 (0.050–0.140), $p < 0.001$). The full results are presented in Table 2.

3.3. Summary hospital level mortality indicator

The mean SHMI was 1.003 (SD 0.097). Multivariate linear regression analysis, including provider admission volume and university status, demonstrated associations between SHMI and beds per Senior doctor (Coefficient 0.012 (95%CI 0.005–0.018), $p = 0.001$), beds per Middle grade doctor (0.002 (0.0002–0.005), $p = 0.032$), and beds per Junior doctor (0.008 (0.002–0.015), $p = 0.014$). The full results are presented in Table 2. Full details of the adjusted model can be found in Appendix 2.

A secondary analysis of SHMI data and beds per tier of physicians by quintile, including provider admission volume and university status, also demonstrated that increasing the ratio of numbers of beds per medical staff tier was associated with significantly higher (worse) SHMI in Senior doctors [Table 3]. Increasing the number of beds per Senior doctor from < 5.3 to 5.3–6.3 was associated with 7.4% more

Table 1
Study variables.

Variable	
Included hospital providers*	131
Hospital providers with university status*	33 (25.2%)
Annual inpatient episodes^	68,948 (35,050)
Medical beds+	398 (277–496)
Senior doctors per provider +	54 (38–87)
Middle grade doctors per provider+	23 (14–42)
Junior doctors per provider+	38 (28–60)
Beds per Senior doctor^	7.3 (2.5)
Beds per Middle grade doctor^	19.7 (11.5)
Beds per Junior doctor^	10.1 (3.1)
Percentage unadjusted 30 day mortality^	3.5 (0.8)
Summary Hospital-level Mortality Indicator^	1.003 (0.097)

Reported units: *number (%), ^Mean (standard deviation), +medial (interquartile range).

observed deaths compared to those expected in this model. In Junior doctors, above a threshold of 9.04 beds per Junior doctors, SHMI increased (worsened). A similar pattern was observed in Middle grade doctors.

Better than expected mortality (lower SHMI) in physician medical specialties was associated with fewer than; 5.3 beds per Senior doctor, 14.6 beds per Middle grade doctor, and 9.0 beds per Junior doctor [Table 3]. Full details of the adjusted model can be found in Appendix 3.

4. Discussion

In this analysis of medical staffing data and mortality, acute hospital providers are associated with lower than average mortality (SHMI less than 1) in physician medical specialties if there are fewer than 5.3 beds per Senior doctor, 14.6 beds per Middle grade doctor and 9.0 beds per Junior doctor. However, it is important to consider these estimates in the context of the methodological challenges described below.

The RCP guidance for safe medical staffing used expert consensus to estimate the number of staff based on the time required to complete the tasks associated with a 30 bed, physician medical specialty, hospital ward [15]. This analysis is done at provider level and therefore the findings are applicable to employed staff across physician medical specialties, rather than at ward level. The present study uses

Table 2
Univariate linear regression analysis of the association between unadjusted mortality and the number of beds per medical staff by tier.

	Staff tier	Co-efficient	95% CI	p value
Unadjusted Mortality	Beds per SED	0.130	0.081 – 0.180	<0.001
	Beds per MGD	0.033	0.021 – 0.045	<0.001
	Beds per JD	0.095	0.050 – 0.140	<0.001
Summary Hospital-level Mortality Indicator	Beds per SED	0.014	0.008 – 0.020	<0.001
	Beds per MGD	0.002	0.001 – 0.004	0.005
	Beds per JD	0.010	0.004 – 0.016	0.001
Summary Hospital-level Mortality Indicator adjusted for local factors*	Beds per SED	0.012	0.005 – 0.018	0.001
	Beds per MGD	0.002	0.0002 – 0.005	0.032
	Beds per JD	0.008	0.002 – 0.015	0.014

*Adjusted linear regression models including university status and quintile of annual hospital provider inpatient episodes (appendix 2).

SED – senior doctor.

MGD – Middle grade doctor.

JD – junior doctor.

Table 3

Univariate linear regression analysis of the association between adjusted mortality and the number of beds per medical staff by tier.

	Staff tier	Beds per staff	Co-efficient	95% CI	p value
Summary Hospital-level Mortality Indicator adjusted for local factors*	SED	<5.30	(Reference category)		
		5.30–6.29	0.074	0.024 – 0.124	0.004
		6.30–7.49	0.047	–0.003 – 0.099	0.067
		7.50–9.10	0.095	0.041 – 0.148	0.001
		>9.10	0.099	0.045 – 0.152	<0.001
	MGD	<11.10	(Reference category)		
		11.10–14.59	0.015	–0.057 – 0.087	0.681
		14.60–19.29	0.080	0.012 – 0.147	0.022
		19.30–30.00	0.065	–0.006 – 0.136	0.072
		>30.00	0.080	0.001 – 0.159	0.049
	JD	<7.40	(Reference category)		
		7.40–9.03	0.035	–0.023 – 0.093	0.232
		9.04–10.29	0.098	0.039 – 0.158	0.001
10.30–12.40		0.075	0.014 – 0.133	0.017	
		>12.40	0.070	0.008 – 0.132	0.028

*Adjusted linear regression models including university status and quintile of annual hospital provider inpatient episode number (appendix 3).

SED – senior doctor.

MGD – Middle grade doctor.

JD – junior doctor.

mortality as the outcome measure and therefore it does not necessarily reflect all aspects of high quality care; however reducing unexpected mortality is an important aspect of safe care. Furthermore, mortality is a robust outcome measure, which is clearly important to patients and their families and recorded to a high degree of accuracy, as deaths must be registered by law. Therefore, the numbers of beds per employed doctor described in the present study provide important supporting evidence to inform future medical staffing plans.

The 2018 RCP guidance explicitly recognised that supporting evidence to inform medical staffing plans was limited [15]. There is little recent data specific to physician specialties for comparison, likely due to the challenges of performing such research. The English National Health Service is an ideal environment in which to perform this research, as nationwide staffing and mortality data can be collated. An important strength of this manuscript is the use of national data. Only by including a large number of providers can medical staffing levels be examined. This is the first study to combine national staff employment records data provided by Health Education England, and robust outcome data from NHS digital. This data supports previous findings from similar data sources [7,8].

Many Senior doctors will have varied job plans that include time looking after inpatients, but also other roles e.g. outpatient care. Therefore the total number of Senior doctors is not the number looking after inpatients at any given time. Despite this, a relationship was observed between fewer beds per Senior doctors and lower mortality. This is likely to be because anecdotally hospitals that have more Senior doctors per bed are able to ensure that the number of patients cared for by a Senior doctor at any one time is more manageable and safer and that there are periods of time performing roles that are not inpatient facing. Time not directly managing inpatients potentially helps those Senior doctors to avoid burnout and exhaustion and maintain higher standards of care.

This analysis uses aggregated provider level data for mortality permitting comparison between providers. It is important to consider the potential for aggregation bias, i.e. that variation between providers will also be influenced by other provider specific factors. By adjustment for provider factors, such as university status and case mix adjustment for mortality, this can be minimized, albeit not entirely resolved.

SHMI, from which our outcome measure is a subgroup, is the national benchmark statistic for hospital mortality in England and is standardised for population demographics and patient comorbidities. However, several important factors can have a significant impact on SHMI that are not related to provider mortality. If

admission occurs in patients reaching the expected end of life, for example those receiving palliative care, this will increase the observed mortality. However, better than expected admission avoidance in such patients, e.g. from an effective local hospice or palliative care facility, may lead to reduced observed mortality and SHMI. This is because the patient will not be admitted to the hospital, but a separate palliative care provider, therefore the death of the patient will not be attributed to the hospital in SHMI. SHMI also does not include deprivation. However, because other demographic factors and co-morbidities are included in SHMI, deprivation does not add any additional discrimination between providers [20]. SHMI is also depth of coding dependent and hospital providers that have a poor depth of coding, that under-represents the co-morbidities of their case mix, may therefore have higher observed mortality than predicted by the SHMI statistical model. Despite these potential limitations SHMI is used as the national measure in England to benchmark hospital mortality and identify outliers for mortality. Ascertainment bias is an important consideration for analyses such as the present study. The study includes all non-specialist acute hospital providers in England, with relatively few exclusions due to data quality. This provides reassurance that the results presented are accurate and generalisable. We were not able to include data on non-training grade, non-consultant doctors and physician associates, all of whom may have an influence on hospital outcomes. In England, non-training grade, non-consultant doctors in physician medical specialties are much less numerous than those in training grades and physician associates remain uncommon.

A further limitation is that the distribution of Junior doctors is controlled nationally in England by Health Education England. In some instances Junior doctors may be removed from a department, but this is a rare occurrence. Common reasons for this can include poor training, bullying or workload. This may distort the relationship observed between Junior doctors and SHMI, however due to it being a rare occurrence the potential impact on our study findings will be small [24].

Measuring the complete impact of local factors on SHMI represents a significant challenge. University hospital status, which potentially attracts larger numbers of medical staff and due to research activity, may have higher coding depth leading to lower SHMI, has been corrected for. The number of inpatient episodes has also been corrected for as a measure of the total number of patients admitted by a provider. However, there may be residual local provider factors, such as the number of provider sites and local service configuration that we have not been able to account for in our analysis.

Unfortunately, the number of nurses employed in hospital providers within physician medical specialties could not be included in the analysis due to the ESR records utilised lacking sufficient clarity on which specialty the nurses worked in within providers. Nurse staffing is recognised to influence mortality (11-14), therefore hospitals in England were set clear standards for minimum levels of nurse staffing in 2014. Compliance with these standards is monitored by the Care Quality Commission following the Francis enquiry [25, 26]. Furthermore previous analyses, including a broader group of hospital patients and possible variables, have demonstrated that medical staffing levels are associated with mortality, even when corrected for nurse to bed and nurse to doctor ratios [8]. The same study demonstrates an association between general practitioners per head of population and SHMI. Unfortunately this data was not available for the current analysis.

The present study demonstrates an association within physician medical specialties between fewer beds per employed physician and lower than expected mortality. Despite the limitations discussed above, this study provides valuable supporting evidence to assist acute hospital providers in delivering appropriate staffing levels in physician medical specialties.

Author contributions

PH and NT conceived of the analysis. PH performed the initial data analysis. PH and NT further refined the analysis, and drafted the manuscript.

Ethics statement

Ethical approval was not required for this analysis.

Role of Funding

There was no external funding for this study.

Funding

No external funding was associated with this analysis

Data Sharing

Hospitals would be identifiable via freely available linked data as described above. Therefore the analysed dataset is not made available alongside this manuscript. Data that is anonymous can be made available following request.

Declaration of Competing Interests

None

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:[10.1016/j.eclinm.2020.100709](https://doi.org/10.1016/j.eclinm.2020.100709).

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