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Nursing skill mix in European hospitals: cross-sectional study of the association with mortality, patient ratings, and quality of care

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► Additional material is published online only. To view please visit the journal online (<http://dx.doi.org/10.1136/bmjqs-2016-005567>).

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Received 7 April 2016

Revised 4 October 2016

Accepted 8 October 2016

ABSTRACT

Objectives To determine the association of hospital nursing skill mix with patient mortality, patient ratings of their care and indicators of quality of care.

Design Cross-sectional patient discharge data, hospital characteristics and nurse and patient survey data were merged and analysed using generalised estimating equations (GEE) and logistic regression models.

Setting Adult acute care hospitals in Belgium, England, Finland, Ireland, Spain and Switzerland.

Participants Survey data were collected from 13 077 nurses in 243 hospitals, and 18 828 patients in 182 of the same hospitals in the six countries. Discharge data were obtained for 275 519 surgical patients in 188 of these hospitals.

Main outcome measures Patient mortality, patient ratings of care, care quality, patient safety, adverse events and nurse burnout and job dissatisfaction.

Results Richer nurse skill mix (eg, every 10-point increase in the percentage of professional nurses among all nursing personnel) was associated with lower odds of mortality (OR=0.89), lower odds of low hospital ratings from patients (OR=0.90) and lower odds of reports of poor quality (OR=0.89), poor safety grades (OR=0.85) and other poor outcomes (0.80<OR<0.93), after adjusting for patient and hospital factors. Each 10 percentage point reduction in the proportion of professional nurses is associated with an 11% increase in the odds of death. In our hospital sample, there were an average of six caregivers for every 25 patients, four of whom were professional nurses. Substituting one nurse assistant for a professional nurse for every 25 patients is associated with a 21% increase in the odds of dying.

Conclusions A bedside care workforce with a greater proportion of professional nurses is associated with better outcomes for patients and nurses. Reducing nursing skill mix by adding nursing associates and other categories of assistive nursing personnel without professional nurse qualifications may contribute to preventable deaths, erode quality and safety of hospital care and contribute to hospital nurse shortages.

INTRODUCTION

Ensuring good patient outcomes in hospitals is increasingly challenging as national economic concerns, austerity spending and health system reforms converge to create hard choices in resource allocation.¹⁻³ At its core, hospital care is labour intensive. Health reforms have made it more so by reducing hospital length of stay and diverting discretionary admissions to outpatient settings, such that the remaining inpatients have more complex care needs. Medical advances and new technologies have been more likely to increase hospital nurse staffing requirements than to decrease them.⁴ The growing use of intensive care beds where professional nurse staffing is highest is but one example.

Yet the notion persists in policy and management discussions that hospitals should be able to transition to a lower complement of high skilled workers like professional nurses to reduce costs following examples in other sectors of the economy.^{5 6} The premise is that fewer highly skilled/higher cost professional nurses supported by lower skilled and

To cite: Aiken LH, Sloane D, Griffiths P, et al. *BMJ Qual Saf* Published Online First: [please include Day Month Year] doi:10.1136/bmjqs-2016-005567

lower wage assistants would result in lower costs of care without adversely affecting patient outcomes, although evidence to support such contentions is lacking. Political leaders in England have recently introduced a category of hospital caregiver called ‘nursing associate’, akin to the enrolled nurse position which was phased out in the 1990s.^{7 8} Notably, this proposal in England for a less educated caregiver (18 months of on-the-job training is proposed) has been made in the context of concern about poor quality of hospital care,^{9 10} and nursing skill mix in National Health Service (NHS) hospitals already being one of the lowest in Europe.¹¹

Policy debates in Europe about hospital skill mix are happening in a context where evidence is limited and there is substantial variation in skill mix between and within countries.^{3 12–15} Hospital nursing skill mix varies from a high of 82% professional nurses in Germany to a low of 57% professional nurses in England and 54% in Spain.¹⁶ Variation in hospital nurse skill mix within countries is great as illustrated in NHS hospitals in England where nursing skill mix varies from a high of 79% professional nurses in some hospitals to a low of 47% in others.¹⁷

The quality of evidence about the outcomes of nursing skill mix in Europe is very limited as noted in a Cochrane Collaboration systematic review.^{4 18} Jarman *et al*¹⁹ research of English hospitals 15 years ago, remaining one of the few multihospital studies of the outcomes of nursing skill mix in Europe, found that higher proportions of auxiliary nurses (nurse assistants with limited training) were associated with higher hospital mortality. Similarly, a more recent study of NHS hospitals confirmed that more healthcare support workers (ie, nurse assistants) were associated with higher mortality.²⁰ Most research on nursing skill mix has been of the US hospitals, where applicability to the European context is unknown.^{21–24} The US studies have generally concluded that a hospital skill mix with proportionately more professional nurses yields greater value because higher wages of professional nurses are offset by reductions in length of stay, lower use of intensive care, fewer costly adverse events such as hospital-acquired infections and lower readmission rates.^{25–29} Needleman *et al* estimated that holding constant the total number of hours of nursing care provided, replacing lower qualified licensed practical nurses with fewer years of education with professional nurses would result in lower hospital mortality, shorter length of stay, fewer complications and net savings.³⁰

The aim of this paper is to inform managerial and policy decision-making about hospital nursing skill mix in Europe through an analysis of the association between nursing skill mix and patient mortality, patient ratings of their care and quality of care indicators in hospitals in six European countries: Belgium, England, Finland, Ireland, Spain and Switzerland. We also consider the association between nursing skill

mix and factors associated with professional nurse retention in hospital bedside care, important in view of evidence of present and future hospital nurse shortages in Europe.³¹ Our study adds substantially to the empirical evidence by its multicountry focus and the use of analytic strategies to disentangle nursing skill mix from total staffing—a limitation of previous research. Moreover, for the first time, we evaluate nursing skill mix while taking account of the educational qualifications of professional nurses, and in the context of the quality of hospital work environments that potentially enhance or undermine nurse productivity.³²

DATA AND METHODS

Data include patient discharge data by hospital, hospital administrative information and nurse and patient surveys from the six countries in the RN4CAST study that had data from all four sources—Belgium, England, Finland, Ireland, Spain and Switzerland. This is the largest data-based study of its kind. For analyses of nurse-reported outcomes, data were from 13 077 nurses in a representative sample of 243 hospitals across the six countries. For analyses of patient mortality, data were from a subset of 188 of the 243 hospitals (77%) for which detailed individual-level patient outcomes were available and included 275 519 surgical patients. The analysis of patient ratings of care included a subset of 182 of the 243 hospitals (75%) in which 18 828 patients were surveyed.

Detailed accounts of the design of the 12-country RN4CAST study, the sampling of hospitals, the surveys of patients and nurses and the assembly of the surgical patient discharge records have been provided in prior reports.^{11 33 34} The most salient features of the design and methods as they pertain to the six countries included in the present analysis are repeated here.

Hospital, nurse and patient samples

Representative samples of at least 30 general acute care hospitals with at least 100 beds in each country were selected for the nurse surveys, which were conducted in 2009–2010. The number of hospitals ranged from all 30 hospitals in Ireland to 67 in Belgium. Medical and surgical wards were randomly sampled in each hospital and all professional nurses providing direct patient care in these wards were surveyed. In Belgium, Finland and Switzerland, patients in the same hospitals and on the same wards as the nurses were also surveyed, and in Ireland and Spain patients were surveyed from subsets of the hospitals in which nurses were surveyed. In England, all adult patients discharged from study hospitals between June and August 2010 were surveyed. In five of the six countries—all except England—the patient survey instrument used was the US Agency for Healthcare Research and Quality (AHRQ) Hospital Consumer

Assessment of Healthcare Providers and Systems (HCAHPS) survey.³⁵ Patient surveys were undertaken between 2009 and 2010, and involved a 1-day census of patients on study units in each hospital that were able to participate and who understood one of the eight questionnaire languages available. In England, we analysed data from study hospitals using the 2010 NHS Adult Inpatient Survey.³⁶ Nurse response rates in the six European countries averaged 58%, and the response rates for patients averaged 51%.

Mortality data are for postoperative patients discharged from study hospitals in the year most proximate to the nurse survey, which ranged across countries from 2007 to 2009.³³ We included all patients discharged from the study hospitals 50 years of age and older who stayed in the hospital for at least 2 days and underwent common general, orthopaedic or vascular surgery, and for whom complete data were available on comorbidities present on admission, surgery type, discharge status and other variables used for risk adjustment. Common surgeries and comorbidities were defined following procedures published previously.^{22 37 38} Data were coded in all countries following a standard protocol using variants of the 9th or 10th version of the International Classification of Diseases.³⁹

Patient involvement

Patients were not participants in the initial design of the overall study but were active participants in the development of measures of patients' experiences with care used in the study. In developing the HCAHPS survey, AHRQ conducted patient interviews, patient focus groups, patient testing of items and numerous small-scale field tests.⁴⁰ Further, Centers for Medicare and Medicaid Services⁴¹ offered three opportunities for public comment on HCAHPS and responded to over 1000 comments before finalising the instrument used in 5 of 6 countries in this study. The Picker Institute, developers of the NHS Adult Inpatient Survey used by this study in England, employed patient focus groups and cognitive interviews with patients during pilot testing. Patients were offered one page to describe what they thought of the inpatient questionnaire and which aspects of patient care were most important to them. The qualitative research did not identify major questions missing from the survey but it did lead to minor modifications that were incorporated.⁴²

We further engaged patients in Europe to ensure that the HCAHPS survey was understandable by patients in their native languages and included aspects of patient care that were most important to them. Each country team recruited 7–12 patients who had experienced a hospital admission within the year to rate the HCAHPS questions; a total of 68 patients participated in the review process. Patients gave the

HCAHPS high ratings on understandability and relevance.⁴³

Patients in our study are anonymous. We have a detailed plan to disseminate the study results through print, broadcast and social media in every participating country. We gratefully acknowledged the contributions of participating patients in the acknowledgement section.

Primary measures

Hospital nurse characteristics

We used four different measures of the nurse characteristics of study hospitals, each of which were derived by aggregating nurse responses to survey questions to the hospital level. Staffing measures were calculated for day shift only because of substantial variation in night staffing. *Nursing skill mix* was calculated for each hospital by dividing the number of professional nurses by the number of direct care nursing personnel of all qualifications that each nurse reported were present on their unit on their last shift, and averaging those ratios across all nurse respondents in each hospital. Higher ratios indicate a richer skill mix. Professional nurses in Europe meet minimum standards published by the European Commission including at least 10 years of general education at the secondary level plus 3 years of nursing education that can be in a vocational setting or university. The primary differentiation of professional nurses in Europe is whether they have bachelor's qualifications or not. Training requirements and regulations governing nurse assistants vary widely across hospitals in Europe and our measure does not differentiate nurse assistants by the specifics of their qualifications.^{44–45}

Total staffing was calculated by dividing the total number of nursing personnel (including professional nurses and others) by the number of patients that each nurse reported were present on their unit on their last shift, and averaging those ratios across all nurse respondents in each hospital. These averages were then multiplied by 25, the average number of patients per unit, so the resulting numbers indicate how many staff were present for every 25 patients across each hospital. Higher ratios indicate more favourable staffing. *Nurse education* was the percentage of all professional nurses in each hospital reporting they had a bachelor's degree. The *nurse work environment* in each hospital was measured using the Practice Environment Scale of the Nursing Work Index (PES-NWI), an internationally validated measure.^{46 47}

The PES-NWI measures modifiable organisational behaviours that comprise five subscales indicating: (1) managerial support for nursing, (2) nurse participation in hospital affairs, (3) doctor-nurse relations, (4) promotion of care quality and (5) staffing and resource adequacy. We measure the hospital work environment by averaging across all nurses in each hospital their responses (scored from 1 to 4) to the

items comprising the first four subscales. The staffing and resource adequacy subscale was dropped because of its high correlation with the direct measures of nurse staffing included in the analytic models as in previous studies.³²

Our estimates of nursing skill mix and total staffing in the different hospitals involve estimates from nurses working different shifts on different units on different days. Thus, it is not possible with our data to determine the consistency between nurses on the same shift on the same unit in the same hospital on the same day. But with reasonably large numbers and in many cases very large numbers of nurses in all of our study hospitals, we are confident that when we will aggregate these numbers across nurses to the hospital level we will get reasonable estimates of skill mix and total staffing.

Other hospital characteristics

In analyses of both patient outcomes and nurse-reported outcomes we controlled for hospital size, technology and teaching status. Hospital size was the number of beds. Teaching status distinguished hospitals that were non-teaching (no medical residents or fellows) and teaching hospitals (which had residents or fellows). High technology hospitals had facilities for open-heart surgery, major organ transplants or both. Dummy variables account for unmeasured differences across countries.

Patient mortality

Patient discharge records allow us to determine whether patients died in the hospital within 30 days of admission. In our analyses of the associations between hospital nursing characteristics and the likelihood of dying, we risk adjust those likelihoods by controlling for patient age, sex, admission type (emergency/elective), 43 dummy variables indicating surgery type and 17 dummy variables indicating comorbidities present on admission, which are included in the Charlson Comorbidity Index.^{33 48}

Patient ratings

In every country except England, patients were asked to rate their hospitals on a scale from 0 (worst possible) to 10 (best possible). In England, patients were asked whether they would rate the care they received in their hospital as excellent, very good, good, fair or poor. We classified patients as giving low ratings to their hospital if, in England, they described their care as anything less than excellent, or if, in the other countries, they scored their hospital as 8 or less. This corresponds to the manner in which patient ratings are 'top-coded' in the HCAHPS survey.³⁵

Nurse-reported outcomes

Nine nurse-reported outcomes were measured by creating simple dichotomous variables. Low or poor *quality of patient care* was assessed as the proportion of nurses who reported, on a single survey item, that

the quality of care on their units was fair or poor. Nurse-assessed quality of care has been shown to be highly related to independent measures of patient outcomes such as mortality.⁴⁹ Quality of care was also indirectly assessed as the proportion of nurses who would recommend their hospital to friends and family. Low or poor *patient safety grade* was assessed as the proportion of nurses who gave their ward a poor or fair safety grade. *Patient safety culture* was assessed using responses to seven items which, like patient safety grade, was derived from the Agency for Healthcare Research and Quality Hospital Survey on Patient Safety Culture, and which asked nurses whether they felt their mistakes were held against them, whether important patient information is lost during shift changes and whether the actions of hospital management show that patient safety is a top priority, among others.⁵⁰ Poor *patient safety culture* was assessed as the proportion of nurses whose responses to three or more of the seven items indicated unsafe conditions. We assessed nurse-reported adverse events by calculating the proportions of nurses who reported that (1) pressure ulcers, (2) falls with injuries and (3) urinary tract infections occurred occasionally or frequently (combining 'a few times a month', 'once a week', 'a few times a week' and 'every day') rather than rarely or never (combining categories 'never', 'a few times a year or less' and 'once a month or less'). *Nurse job dissatisfaction* was assessed using a single item which asked nurses how satisfied they were with their current job. *Nurse burnout* was measured with the emotional exhaustion subscale of the Maslach Burnout Inventory,⁵¹ an instrument with established reliability and validity in international research.⁵² We assessed these factors as the proportion of dissatisfied nurses, and the proportion of nurses with high burnout (scores above 27 on the emotional exhaustion subscale).

Analytic methods

Descriptive information on the variables of interest is provided, and shows how skill mix, total bedside caregiver staffing, nurse practice environments and nurse education vary across different hospitals. The association of nursing skill mix is then estimated for patient mortality, patient ratings of their hospitals and nurse reports of quality of care, patient safety, adverse events and nurse burnout and dissatisfaction, before and after controlling for other hospital characteristics, patient characteristics (in the mortality analyses) and nurse characteristics (in the analyses of nurse-reported outcomes). Other hospital characteristics controlled included total nursing personnel staffing, nurse education and the nurse practice environment, as well as size, teaching status and technology. Patient characteristics included age, sex, admission type, surgery type and comorbidities present on admission. Nurse characteristics included age, sex, full-time employment

status and unit specialty. Dummy variables representing the different countries were also included in the models with controls to allow for unmeasured differences across countries. Generalised estimating equations (GEE) were used in analysing mortality and logistic regression models were used in analysing patient ratings and nurse-reported outcomes. In both approaches, we took account of patients being nested within hospitals. We tested for interactions but found none. We also dropped from the models the association of the nurse practice environment with mortality, since it was insignificant, and the association of nurse education with patient ratings and nurse-reported outcomes, for the same reason. In online supplementary tables in the appendix, we show the correlations between nursing characteristics and other hospital characteristics, and the relationships of the full set of nursing and hospital characteristics with the different outcomes.

RESULTS

As noted in [table 1](#), there were 275 519 surgical discharges from the 188 study hospitals for which patient data were available, an average of 1466 discharges per hospital. There were 3569 surgical patient deaths—an average of 19 deaths per hospital during the study period—yielding an average hospital mortality rate of 12.8 per 1000 discharges. The middle panel of [table 1](#) shows that 18 828 patients were surveyed in 182 hospitals, for an average of just over 100 patient respondents per hospital. In the average hospital, 54% of the patients surveyed gave their hospitals low ratings. The bottom panel shows that 13 077 professional nurses were surveyed in the 243 study hospitals. The average

hospital had 54 nurse respondents. On average, slightly more than one in five nurses rated the quality of care on their hospital unit as poor or fair, and while only an average of 7% of the nurses across hospitals gave their hospital a poor or failing safety grade, one-third indicated that their hospital exhibited a poor safety culture. Nearly one in five nurses would not recommend their hospital to friend or family, and on average 9% of the nurses reported that pressure ulcers occurred in their hospitals occasionally or frequently, and 12% and 23% said the same about falls with injury and urinary tract infections, respectively. In the average hospital, almost 30% of nurses scored high on the burnout scale, and a similar per cent expressed dissatisfaction with their job.

[Table 2](#) shows that overall the skill mix, or the percentage of professional nurses among the total nursing personnel in this sample of hospitals, was roughly 66%, and ranged across hospitals from 41% to 87%. Total nursing personnel staffing overall was roughly 6.1 nursing personnel (all qualifications) for every 25 patients, and ranged from 2.7 per 25 patients in the poorest staffed hospital to 13.8 per 25 patients in the best. Practice environment scores averaged roughly 2.7 across the 188 hospitals—slightly above the middle of the 4-point scale—and ranged from 2.1 in the hospital with the worst environment to 3.4 in the hospital with the best. Nurse education, or the percentage of bachelor's prepared nurses among all professional nurses, averaged 47% overall, and ranged widely from 0% in some hospitals to 100% in others.

[Table 3](#) shows the associations of skill mix with inpatient mortality, patient ratings of their hospitals

Table 1 Patients discharged, patients surveyed and nurses surveyed in the study hospitals in six European countries, and descriptive information on outcomes derived from them (RN4CAST data)

	Total	Hospital mean	SD	25th percentile	75th percentile
Patient discharges	275 519	1466	1093	713	1947
Patient deaths	3569	19.0	19.8	6.5	25.0
Patient mortality rate (deaths per 1000 discharges)		12.8	9.1	8.0	16.2
Patient survey respondents	18 828	103	139	29	77
Percent giving hospital low ratings		54%	15%	39%	60%
Nurse survey respondents	13 077	54	27	37	65
Percent of nurses reporting					
Poor/fair unit quality		22%	14%	11%	32%
Poor/failing safety grade		7%	6%	2%	9%
Poor safety culture		34%	16%	24%	45%
Would not recommend hospital to friends or family		18%	12%	8%	24%
Pressure ulcers		9%	8%	3%	14%
Falls with injury		12%	9%	5%	15%
Urinary tract infections		23%	12%	15%	29%
High burnout		30%	17%	15%	42%
Job dissatisfaction		31%	16%	17%	42%

Patient discharge data (used for the mortality analyses) were available for 188 (77%) of the 243 hospitals in which nurses were surveyed. Patient survey data (used for the analyses of patient satisfaction) were available for 182 (75%) of the 243 hospitals.

Table 2 Nursing characteristics in the study hospitals in six European countries

Nursing characteristics	Mean	SD	25th percentile	75th percentile
Skill mix (% professional nurses)	65.6%	9.8%	56.4%	74.1%
Total staffing	6.09	1.61	5.01	7.10
Practice environment	2.67	0.24	2.51	2.82
Nurse education (% bachelors)	46.8%	26.3%	26.9%	68.0%

Skill mix is the percentage of professional nurses among all nursing personnel in the hospital. Total staffing is the total number of all nursing personnel (at all qualification levels) for every 25 patients they cared for. The practice environment measure is the average score for each hospital across four subscales indicating (1) managerial support for nursing, (2) nurse participation in hospital affairs, (3) doctor-nurse relations and (4) promotion of care quality (where a score of 1 would indicate extremely poor on all subscales, and a score of 4 would indicate excellent on all subscales). Nurse education is the percentage of all professional nurses in each hospital with bachelor's degrees.

Table 3 ORs indicating the association of nursing skill mix with inpatient mortality, patient ratings of their hospitals, nurse-reported quality of care and nurse outcomes in hospitals in six European countries

Outcome	ORs reflecting the associations of skill mix with the different outcomes			
	Without controls		With controls	
	OR 95% CI	p Value	OR 95% CI	p Value
30-day inpatient mortality	0.90 (0.81 to 1.00)	0.058	0.89 (0.80 to 0.98)	0.018
Low hospital rating by patients	0.81 (0.74 to 0.88)	<0.001	0.90 (0.81 to 0.99)	0.026
Poor/fair unit quality	0.90 (0.81 to 1.00)	0.053	0.89 (0.80 to 0.98)	0.016
Poor/failing safety grade	1.05 (0.93 to 1.17)	0.457	0.85 (0.73 to 0.99)	0.040
Poor safety culture	1.09 (1.01 to 1.15)	0.022	0.93 (0.87 to 0.99)	0.027
Nurse would not recommend hospital	0.97 (0.87 to 1.08)	0.616	0.82 (0.72 to 0.93)	0.001
Pressure ulcers	0.82 (0.74 to 0.91)	0.001	0.85 (0.73 to 0.98)	0.027
Falls with injury	0.89 (0.79 to 1.00)	0.058	0.80 (0.71 to 0.91)	0.001
Urinary tract infections	0.89 (0.83 to 0.96)	0.002	0.88 (0.78 to 1.00)	0.049
High nurse burnout	0.93 (0.85 to 1.01)	0.102	0.89 (0.80 to 1.00)	0.043
Nurse job dissatisfaction	0.87 (0.79 to 0.95)	0.003	0.91 (0.83 to 0.99)	0.025

Inpatient mortality was measured using patient discharge data, hospital rating by patients was measured using patient survey data and the remainder were measured using nurse survey data. Huber-White Cluster corrections were used to estimate SEs associated with the skill mix coefficients. Skill mix was measured in units of 10 percentage points. Controls in the mortality models include hospital characteristics (total bedside care staffing, nurse education, teaching status, high technology and bed size), patient characteristics (age, sex, admission type, 43 dummy variables indicating surgery type and 17 dummy variables indicating comorbidities present on admission) and country. Controls in the models estimating patient ratings included the same hospital characteristics and country. Controls in the models estimating nurse-reported outcomes included hospital characteristics (total nursing personnel staffing, nurse practice environment, teaching status, high technology and bed size) nurse characteristics (age, sex, full-time employment status and unit specialty) and country.

and the nine different nurse-reported outcomes before and after adjusting for differences across hospitals in patient and nurse characteristics and for other hospital characteristics of importance (total staffing, nurse education, the nurse work environment, size, teaching status and technology) and unmeasured differences across countries. Before adjustment (or without controls), hospitals with richer skill mixes appear to have higher odds on a couple of these 11 outcomes (involving poor safety grades and safety cultures) but lower odds on the others, and for 6 of the 11 outcomes the ORs are insignificant ($p > 0.05$). While controlling for the various potentially confounding characteristics affects the skill mix association with these 11 outcomes differently—some increase, others decrease, and some hardly change at all—after adjustment hospitals with richer nursing skill mixes have lower odds on all 11 of the

unfavourable outcomes and the differences are significant in every case. Every 10-point increase in the percentage of professional nurses among all nursing personnel diminishes the odds on patients dying by a factor of 0.89 and diminishes the odds on patients giving their hospitals low ratings by a factor of 0.90. And nursing skill mix is similarly related to all nine of the different nurse-reported outcomes. Net of the other nursing characteristics, and after taking account of unmeasured differences between countries and measured differences in nurse characteristics and other hospital characteristics that might affect nurse reports, nurses in hospitals with richer skill mixes have lower odds on reporting poorer quality care, lower patient safety, high burnout and job dissatisfaction. They also are more likely to recommend their hospital, less likely to report inadequate safety culture in their hospital and less likely to report occasional or

frequent pressure ulcers, falls with injuries and urinary infections involving their patients. The ORs associated with the effect of nursing skill mix on these different outcomes, which range from 0.80 for reporting falls with injury to 0.93 for reporting that their hospital has a poor safety culture, imply that such reports differ by somewhere between 7% and 20% in hospitals that differ by 10% in the proportion of professional nurses among all nursing personnel in the hospital.

DISCUSSION

In a context in Europe in which hospital nurse staffing is a frequent target for budget reductions, and policy makers are suggesting the introduction of lower skilled and less educated nurse substitutes like 'nursing associates', our results suggest caution is warranted. We find a nursing skill mix in hospitals with a higher proportion of professional nurses is associated with significantly lower mortality, higher patient ratings of their care and fewer adverse care outcomes. Specifically, each 10% increase in the proportion of nursing personnel who are professional nurses is associated with an 11% decrease in the odds of patient deaths after general surgery. Or from the perspective of reducing skill mix, which is more in vogue among policy makers, each 10% reduction in the proportion of professional nurses is associated with a 12% increase in the odds of patient deaths. We note that the proportion of professional nurses can be altered by either reducing the number of professional nurses or adding less skilled workers, both of which have the same effect on reducing skill mix and risking poor patient outcomes. Additional research is needed to establish that an increase in the proportion of professional nurses will have the aforementioned effect, since these estimates are inferred from cross-sectional data which make causal inferences less certain.

Our research suggests that substituting lower qualified personnel for professional nurses may result in an increase in preventable deaths and other adverse outcomes for patients. In our representative sample of European hospitals, there was an average of six nursing personnel for every 25 patients, four of whom were professional nurses. The effect of substituting one nurse assistant for one professional nurse to care for every 25 patients—thus reducing the skill mix from 66.7% to 50%, or by 16.7%—would be to increase the odds on mortality by 21% (or, mathematically, by a factor of $(1/0.89)^{1.667}=1.21$). Alternatively, the effect of substituting one professional nurse for one nurse assistant to care for every 25 patients—thus increasing the skill mix from 66.7% to 83.3%, or by the same 16.7%—would be to decrease the odds on mortality by 18% (or by a factor of $0.89^{1.667}=0.82$). Other adverse outcomes would be similarly affected. For example, every 10% increase in the percentage of professional nurses among all bedside caregivers was

associated with a 10% reduction in the odds of patients giving their hospital poor ratings. Total staffing, or the total number of nursing personnel per patient, was not a significant predictor of how patients rated their hospitals, only the proportion of professional nurses.

Our results also showed that nurses in hospitals with a greater proportion of professional nurses (higher skill mix) were less likely to rate the quality of care in their hospital as fair or poor, were less likely to report poor patient safety culture and less likely to have misgivings about recommending the hospital to family members and friends. Additionally nurses in hospitals with a rich nursing skill mix were less likely to report common adverse patient events such as falls with injuries, pressure ulcers and urinary tract infections. Previous research has established that nurse reports of quality are significantly associated with actual patient outcomes.⁴⁹

Paradoxically, despite policy and managerial interest in professional nurse substitutes driven by budget constraints, there are also concerns about existing and future shortages of professional nurses in Europe.⁵³ Our results suggest that in hospitals with richer skill mix, professional nurses are less likely to experience high job-related burnout—a patient safety hazard and nurse retention problem—or to be dissatisfied with their jobs potentially contributing to expensive and disruptive turnover and nurse shortage at the hospital bedside.

While this study is the largest and most comprehensive study of the outcomes of hospital nurse skill mix in Europe to date, some limitations should be noted. Given our study design, we are able to link nurses and patients to the same hospitals, but we cannot link specific nurses and patients, so results must be interpreted with some caution. The study is cross-sectional offering a snapshot of associations between hospital staffing and patient outcomes at a single point in time. Thus, and as noted above, we cannot be sure of causal links between skill mix and outcomes. We did, however, test and eliminate a number of alternative explanations for the relationships found between nursing skill mix and outcomes including variation in the quality of the work environment, hospital size and technology availability. A repeat study of the same hospitals over time, following the same research protocol, could provide greater certainty that improved skill mix would result in improved patient outcomes. A common research protocol and survey instruments were used across countries except in the measurement of patient ratings of their hospitals where data from a national survey in England was used instead of the primary patient survey instrument used in other countries. To reduce the effects of the methods resulting from the different instruments, we used a comparable measure of global patient ratings of hospital care in both surveys. We could not study

hospital physician staffing because uniform data across hospitals in different countries do not exist. However, in other research physician factors have been associated with patient outcomes independently of nurse staffing, and thus would not likely explain the relationships between nursing skill mix and patient outcomes.^{20 38} The absence of standardised qualifications for nurse assistants in Europe did not allow us to take into account the effects of differences in nurse assistants between countries, although we take account of unmeasured country differences through the use of ‘country’ dummy variables in our predictive models. Data availability in Europe did not permit a study of the comparative costs of nurse staff composition. The better patient outcomes associated in this study with richer skill mix suggest that, as in the USA where detailed cost information is available, fewer expensive complications like infection, shorter length of stay and fewer intensive care unit days among patients in hospitals with better professional nurse staffing would likely offset higher labour costs associated with richer skill mix and return good value to health systems.²⁶

Our results of one of the first comprehensive studies of nursing skill mix in Europe are similar to results obtained in studies of nursing skill mix in the USA. Our four state study in the USA showed 30-day general surgery mortality rates of 1.2%³² compared with European in-hospital mortality rates shown here of 1.28%; the US patients studied included all adult patients aged 20–85 years while the European patients were aged 50 years and older. The US hospitals have a higher nursing skill mix than Europe averaging 75% professional nurses, with hospitals ranging from a low of 68% to a high of 83% professional nurses. Hospital nursing skill mix in the European countries studied here averaged 66% professional nurses, varying from 41% to 87%. Nevertheless, studies in the USA have reached similar conclusions to what we found in Europe, that the higher the proportion of professional nurses the better the outcomes for patients.

CONCLUSIONS

Findings from this large and unique study of nursing skill mix in European hospitals suggests that caution should be taken in implementing policies to reduce hospital nursing skill mix because the consequences can be life threatening for patients. Beyond risking preventable death among hospitalised patients, the erosion of nursing skill mix could negatively impact overall quality and safety of care as well as patients’ perceptions of the adequacy of their hospitals at a time when there are growing concerns about eroding hospital care quality.^{9 10} Indeed, in this study we found that half of the almost 19 000 patients surveyed failed to rate their hospitals as excellent. For hospital managers and policymakers looking for evidence of how to get the most value for investments in hospital labour, our findings suggest the merits of increasing

the proportion of professional nurses as well as reducing disparities in nursing skill mix between hospitals within countries. Our study adds new and important evidence that diluting hospital nurse skill mix by adding lower skilled nurse assistants and/or reducing professional nurses is not in the public interest.

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Acknowledgements We thank Tim Cheney for analytic assistance, the patients and nurses who participated in our study, and the RN4CAST research teams in the participating countries.

Contributors All of the named authors participated in data collection, the writing of the manuscript and revisions.

Funding European Union’s Seventh Framework Program (223468), National Institute of Nursing Research, National Institutes of Health (NR014855), Spanish Ministry of Science and Technology.

Competing interests None declared.

Ethics approval The study was approved by the University of Pennsylvania human subjects committee.

Provenance and peer review Not commissioned; externally peer reviewed.

RN4CAST consortium Walter Sermeus (Director), Koen Van den Heede, Luk Bruyneel, Emmanuel Lesaffre, Luwis Diya (Belgium, Catholic University Leuven); Linda Aiken (Codirector), Herbert Smith, Douglas Sloane (USA, University of Pennsylvania); Anne Marie Rafferty, Jane Ball, Simon Jones (UK, King’s College London); Peter Griffiths (UK, University of Southampton); Juha Kinnunen, Anneli Ensio, Virpi Jylhä (Finland, University of Eastern Finland); Reinhard Busse, Britta Zander, Miriam Blümel (Germany, Berlin University of Technology); John Mantas, Dimitrios Zikos, Marianna Diomidous (Greece, University of Athens); Anne Scott, Anne Matthews, Anthony Staines (Ireland, Dublin City University); Ingeborg Strømseng Sjetne (Norwegian Knowledge Centre for the Health Services) Inger Margrethe Holter (Norwegian Nurses Organization); Tomasz Brzostek, Maria Kózka, Piotr Bryzski (Poland, Jagiellonian University Collegium Medicum); Teresa Moreno-Casbas, Carmen Fuentelsaz-Gallego, Esther Gonzalez-María, Teresa Gomez-Garcia (Spain, Institute of Health Carlos III); Carol Tishelman, Rikard Lindqvist, Lisa Smeds (Sweden, Karolinska Institute); Sabina De Geest, Maria Schubert, René Schwendimann (Switzerland, Basel University); Maud Heinen, Lisette Schoonhoven, Theo van Achterberg (Netherlands, Radboud University Nijmegen Medical Centre).

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