

# Nurse staffing and quality of care in UK general practice: cross-sectional study using routinely collected data

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## ABSTRACT

### Background

In many UK general practices, nurses have been used to deliver results against the indicators of the Quality and Outcomes Framework (QOF), a 'pay for performance' scheme.

### Aim

To determine the association between the level of nurse staffing in general practice and the quality of clinical care as measured by the QOF.

### Design of the study

Cross-sectional analysis of routine data.

### Setting

English general practice in 2005/2006.

### Method

QOF data from 7456 general practices were linked with a database of practice characteristics, nurse staffing data, and census-derived data on population characteristics and measures of population density. Multi-level modelling explored the relationship between QOF performance and the number of patients per full-time equivalent nurse. The outcome measures were achievement of quality of care for eight clinical domains as rated by the QOF, and reported achievement of 10 clinical outcome indicators derived from it.

### Results

A high level of nurse staffing (fewer patients per full-time equivalent practice-employed nurse) was significantly associated with better performance in 4/8 clinical domains of the QOF (chronic obstructive pulmonary disease, coronary heart disease, diabetes, and hypertension,  $P = 0.004$  to  $P < 0.001$ ) and in 4/10 clinical outcome indicators (diabetes: glycosylated haemoglobin [HbA<sub>1c</sub>]  $\leq 7.4\%$ , HbA<sub>1c</sub>  $\leq 10\%$  and total cholesterol  $\leq 193$  mg/dl; and stroke: total cholesterol  $\leq 5$  mmol/L,  $P = 0.0057$  to  $P < 0.001$ ).

### Conclusion

Practices that employ more nurses perform better in a number of clinical domains measured by the QOF. This improved performance includes better intermediate clinical outcomes, suggesting real patient benefit may be associated with using nurses to deliver care to meet QOF targets.

### Keywords

cross-sectional studies; family practice; health care; incentive; nursing staff; personnel staffing and scheduling; physician incentive plans; quality indicators; quality of health care; reimbursement.

## BACKGROUND

The Quality and Outcomes Framework (QOF) has been a major initiative in UK primary care. The framework is intended to incentivise and reward quality care for a number of significant patient groups with long-term conditions in addition to generic organisational factors.<sup>1</sup> It consists of a range of indicators of process, and intermediate clinical outcome and practices are rewarded for achievement against those indicators. Most English general practices participate in the scheme.

In many practices much of the work involved in delivering results against the QOF indicators has been delegated by GPs to nurses,<sup>2</sup> and over recent years there has been a steady increase in both the number of nurses employed in general practice and the proportion of consultations that are undertaken by them.<sup>3,4</sup> Some have argued that there is considerable scope to further increase the amount of primary care delivered by nurses,<sup>5,6</sup> but the potential extent and desirability of substitution is contested.<sup>7</sup> Evidence of the impact on the quality of care of this increased nursing contribution is scant and there is little if any data on which to plan an optimal skill mix between nurses and GPs in general practice.

In observational studies, quality of performance in general practice has been linked to a number of

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organisational factors including practice size, number of GPs, and list size per full-time equivalent (FTE) GP.<sup>8,9</sup> However, while the association between practice size and performance has been attributed to the ability of larger practices to better deliver multidisciplinary care,<sup>9</sup> few studies examining performance in general practice have directly considered nurse staffing. Furthermore, not all studies show the expected benefits of a larger team when considering the quality of clinical aspects of care,<sup>10,11</sup> and studies covering limited geographical areas have failed to find a link between nurse staffing and quality of clinical care.<sup>12,13</sup>

This study examines whether practices that employ more registered nurses (practice nurses/nurse practitioners) deliver better clinical care as measured by the clinical indicators of the QOF.

## METHOD

### Data sources

A number of data sources were used (Appendices 1 and 2). QOF data for 2005/2006 were obtained from the NHS Information Centre at Leeds and linked to practice and population data.<sup>9</sup> It was not possible to identify a source for the number of FTE practice-employed nurses in individual practices. The number of nurses employed by each practice (head count) for 2006 was obtained from the healthcare information specialist Binleys, and the number of FTE practice nurses employed within each primary care trust (PCT) (2005/2006) was obtained from the NHS Workforce Projects benchmarking database.<sup>14</sup> The number of FTE practice nurses for each practice was estimated by assuming that the ratio of FTEs to the headcount is constant across all practices within the same PCT.

To validate this estimate, a survey was conducted on a random sample of GP practices in early 2008 (stratified by 28 strategic health authorities) and practice sizes. One hundred and twenty-four of 167 practices (74%) responded. There was good concordance between the estimated FTE practice nurses for 2008 and actual FTE practice nurses based on the intraclass (measure of agreement) and Pearson correlations (both 0.68).<sup>15</sup> This indicates substantial levels of agreement. The mean difference between the survey and an estimate using the study model was 0.01 FTE nurses. Errors were not significantly related to practice characteristics except practice size, with errors of lower magnitude in smaller practices due to a floor effect.

In 2005/2006, the QOF consisted of four domains (clinical, organisational, patient experience, and additional services). Within the clinical domain there are 10 clinical areas each consisting of a number of

## How this fits in

Performance in general practice has been linked to a number of organisational factors including practice size, number of GPs, and list size per full-time equivalent GP. The association between larger practices and performance has been attributed to the ability of larger practices to better deliver multidisciplinary care, and many practices extensively use nurses to deliver performance on QOF targets, but few studies have directly considered nurse staffing, the single largest non-medical clinical profession working within general practice. Furthermore, extensive nurse for doctor substitution is often advocated based on evidence from trials whose results may not translate into routine practice. This study demonstrates that practices that employ more nurses perform better in a number of areas measured by the QOF and that patients of these practices have better intermediate clinical outcomes.

indicators: asthma (7), cancer (2), chronic obstructive pulmonary disease (COPD) (8), coronary heart disease (CHD) (15), diabetes (18), epilepsy (4), hypertension (5), hypothyroidism (2), severe long-term mental health (5), and stroke (10). Some indicators relate to all patients with a particular condition (for example, diabetes mellitus glycosylated haemoglobin [HbA<sub>1c</sub>] recorded), whereas others relate to a subset of patients (for example, diabetes mellitus HbA<sub>1c</sub> ≤10%, which relates only to those whose HbA<sub>1c</sub> is recorded). Associated with each indicator is a measure of reported achievement (number of patients who have achieved the indicator divided by the number of patients for whom the indicator was deemed appropriate), population achievement (same as for reported achievement except divided by the register size) and exception reporting (subtract number of patients for whom the indicator is deemed appropriate from the register size and divide by register size). Because there was a 6-week gap between the reporting of registers and the end of the QOF period, the register size was estimated. Either the reported register size or the largest indicator denominator was used, whichever was the larger.

This paper focuses on reporting results on overall population achievement for eight of the 10 clinical domains where at least one domain indicator applies to all patients on the domain register. Neither cancer nor epilepsy met this criterion, so it was not possible to calculate a composite population activity score for these two domains.

To determine if nurses had an impact on specific clinical outcomes as well as processes, a subset of clinical indicators, taken from the 10 clinical domains, was selected for modelling, in addition to the composite scores. These are referred to as clinical outcome indicators. These indicators were:

- CHD: blood pressure  $\leq 150/90$  mmHg, total cholesterol  $\leq 5$  mmol/l;
- diabetes mellitus: HbA<sub>1c</sub>  $\leq 7.4\%$ , HbA<sub>1c</sub>  $\leq 10\%$ , Blood pressure  $\leq 145/85$  mmHg, total cholesterol  $\leq 5$  mmol/l;
- hypertension: blood pressure  $\leq 150/90$  mmHg;
- stroke: blood pressure  $\leq 150/90$  mmHg, total cholesterol  $\leq 5$  mmol/l; and
- epilepsy: seizure free for 12 months.

### Sample

The QOF dataset for 2005/2006 holds data on a total of 8409 practices. The study excluded very small practices (<1000 patients), practices without condition-specific registers or with registers that had no patients, practices that included less than half of patients subsequently reported for individual indicators in their registers, and practices with missing data on practice nurse staffing at the PCT level. The number of practices remaining in the analysis ranged from 7431 to 7456, depending on the outcome variable being analysed, representing about 48 million patients registered in England. The unit of analysis was the practice.

### Model fitting

The methodology of Doran and colleagues was used to model variation across performance on these clinical domains and outcome indicators.<sup>8</sup>

A two-level multilevel model (practices nested within PCTs) was estimated using the multilevel modelling software MLwiN.

A weighted sum of indicator achievement and exception reporting was calculated for each clinical area, where each indicator was weighted by its maximum number of QOF points. Intercepts were allowed to vary across PCTs. All other variables were estimated as fixed effects. Normally distributed random effects were assumed in models of composite scores and percentage achievement. Collinearity among the unstandardised independent variables was explored before proceeding to fitting the model using the condition index, removing variables where collinearity was indicated, to keep the index below 30 as suggested by Belsey.<sup>16,17</sup> In subsequent modelling, standardised independent variables were used, except for single-handed practice (0 = two or more GPs; 1 = one GP) and the primary medical services contract (0 = general medical services; 1 = primary medical services) variables, to allow for ease of computation of the multilevel model,<sup>18</sup> and to assist in identifying those independent variables with the largest effects.

A variable that indicated whether an indicator was used to calculate the register was derived and included in the model for population activity, to

correct for any associated biases. Regression models of the subset of clinical outcome indicators included independent variables that measured exception reporting, that is, whether the indicator had been recorded (for example, diabetes mellitus blood pressure recorded) and if so whether the recorded measurement was actually reported (for example, diabetes mellitus blood pressure  $\leq 145/85$  mmHg).

The model included independent variables for geographic area (density, Index of Multiple Deprivation), characteristics of the patients (percentage of patients aged  $\geq 65$  years, percentage from a racial or ethnic minority), the practices (size, list size per FTE GP, single-handed practice, primary medical services contract), the GPs (percentage aged  $\geq 45$  years, percentage of females, percentage qualified in the UK), prevalence, and exception reporting. Three independent variables were excluded due to collinearity (percentage whose health was good, percentage of patients aged <15 years, and percentage of patients who were female).

A variable was added to these models representing practice nurse staffing. Variation associated with the nurse variable was tested globally and, in order to explore threshold effects, the practice nurse variable was grouped into quintiles ( $\leq 3038.01$  patients per FTE practice nurse, 3038.02–3901.48, 3901.49–4823.44, 4823.45–6210.68,  $\geq 6210.69$ ), and a sixth category added to identify those practices that did not have a practice nurse. 'No practice nurse' was used as the reference category that all other categories were compared against.

## RESULTS

Nurse staffing (list size per FTE practice-employed nurse) was significantly associated with a number of practice characteristics (Appendices 1 and 2). Practices without a practice nurse were more likely to be found in densely populated and deprived areas where there was a higher proportion of patients from racial and ethnic minorities. The GP profile of these practices was older and male, and over 50% were qualified outside the UK. They were often run by a single GP under a general medical services contract. After controlling for profile variables, higher levels of nurse staffing are associated with better performance on the QOF in a number of areas.

Better performance on the clinical domains of the QOF was significantly associated with higher nurse staffing for COPD, CHD, diabetes, and hypertension ( $P = 0.004$  to  $P < 0.001$ ) [Table 1]). The highest levels of nurse staffing (list size <3038.02 patients per FTE practice nurse) was significantly ( $P < 0.05$ ) associated

**Table 1. Variation in adjusted QOF Scores by levels of nurse staffing: clinical domains.**

Domain	List size per FTE practice nurse (quintiles) <sup>a</sup>					$\chi^2$ (P-value)
	$\leq 3038.01$ $\beta$ (95% CI)	3038.02– 3901.48 $\beta$ (95% CI)	3901.49–4823.44 $\beta$ (95% CI)	4823.45–6210.68 $\beta$ (95% CI)	$\geq 6210.69$ $\beta$ (95% CI)	
Asthma	0.40 (–1.66 to 2.47)	0.29 (–1.75 to 2.32)	–0.13 (–2.21 to 1.95)	0.49 (–1.56 to 2.55)	0.13 (–1.96 to 2.23)	3.94 (0.56)
COPD	2.03 (0.20 to 3.86) <sup>c</sup>	1.85 (–0.10 to 3.81)	1.27 (–0.67 to 3.21)	1.09 (–0.88 to 3.06)	0.65 (–1.34 to 2.64)	26.91 (<0.001)
CHD	0.90 (0.18 to 1.62) <sup>c</sup>	0.84 (0.11 to 1.58) <sup>c</sup>	0.70 (–0.06 to 1.46)	0.56 (–0.21 to 1.33)	0.52 (–0.22 to 1.25)	15.20 (0.01)
Diabetes	1.94 (0.75 to 3.12) <sup>c</sup>	1.78 (0.57 to 2.99) <sup>c</sup>	1.51 (0.27 to 2.74) <sup>c</sup>	1.43 (0.20 to 2.66) <sup>c</sup>	1.07 (–0.15 to 2.30)	27.45 (<0.001)
Hypertension	0.47 (–0.03 to 0.97)	0.42 (–0.09 to 0.92)	0.24 (–0.31 to 0.78)	0.11 (–0.44 to 0.65)	–0.06 (–0.62 to 0.50)	17.27 (0.004)
Hypothyroidism	0.77 (0.16 to 1.38) <sup>c</sup>	0.62 (–0.01 to 1.26)	0.49 (–0.24 to 1.23)	0.49 (–0.19 to 1.17)	0.36 (–0.33 to 1.05)	10.44 (0.06)
Mental health	–0.11 (–2.18 to 1.95)	1.25 (–0.78 to 3.27)	0.24 (–1.74 to 2.22)	0.89 (–1.1 to 2.96)	0.87 (–1.17 to 2.90)	8.65 (0.12)
Stroke	0.61 (–0.22 to 1.45)	0.57 (–0.28 to 1.43)	0.29 (–0.59 to 1.16)	0.11 (–0.77 to 0.99)	0.29 (–0.58 to 1.17)	8.12 (0.15)

<sup>a</sup>Reference category 'no practice nurse'. <sup>b</sup>5 degrees of freedom. <sup>c</sup>Significant ( $P < 0.05$ ) relative to reference category. Full models can be found in Appendix 3. CHD = coronary heart disease. COPD = chronic obstructive pulmonary disease. FTE = full-time equivalent.

with better performance when compared with having no practice nurse for COPD, CHD, diabetes and hypothyroidism (although in the latter case the global test was not significant). The largest effects were for COPD ( $\beta = 2.03$ ) and diabetes ( $\beta = 1.94$ ). Better performance was significantly associated with all levels of staffing above the fifth quintile (list size <6210.69 patients per FTE nurse) for diabetes and above the third quintile for CHD (list size <3901.49 patients per FTE nurse). Although not reported here, the results for models using reported achievement for these clinical domains were broadly similar.

Better performance on four of the ten clinical outcome indicators was significantly associated with higher nurse staffing ( $P = 0.006$  to  $P < 0.001$ ) (Table 2). For diabetes HbA<sub>1c</sub>  $\leq 7.4\%$ , better performance was significantly associated with practice nurse staffing in the third quintile and above (list size <3901.49 per FTE nurse). For diabetes total cholesterol  $\leq 5$  mmol/l, benefits were apparent with all nurse staffing levels above the fifth quintile (list size <6210.69 per FTE nurse). A similar relationship existed for CHD total cholesterol  $\leq 5$  mmol/l, although the overall relationship was not significant ( $P = 0.06$ ). For

**Table 2. Variation in adjusted QOF scores by levels of nurse staffing: clinical outcome indicators.**

Indicator	List size per FTE practice nurse (quintiles) <sup>a</sup>					$\chi^2$ (P-value)
	$\leq 3038.01$ $\beta$ (95% CI)	3038.02– 3901.48 $\beta$ (95% CI)	3901.49–4823.44 $\beta$ (95% CI)	4823.45–6210.68 $\beta$ (95% CI)	$\geq 6210.69$ $\beta$ (95% CI)	
CHD blood pressure $\leq 150/90$ mmHg	0.62 (–0.31 to 1.54)	0.48 (–0.48 to 1.43)	0.64 (–0.29 to 1.56)	0.63 (–0.33 to 1.58)	0.48 (–0.51 to 1.46)	2.79 (0.73)
CHD total cholesterol $\leq 5$ mmol/l	1.70 (0.24 to 3.16) <sup>c</sup>	1.43 (0.03 to 2.82) <sup>c</sup>	1.76 (0.34 to 3.17) <sup>c</sup>	1.50 (0.06 to 2.93) <sup>c</sup>	1.25 (–0.15 to 2.66)	10.57 (0.06)
Diabetes HbA <sub>1c</sub> $\leq 7.4\%$	2.25 (0.85 to 3.65) <sup>c</sup>	2.05 (0.68 to 3.41) <sup>c</sup>	1.51 (0.10 to 2.91) <sup>c</sup>	1.19 (–0.23 to 2.62)	0.78 (–0.59 to 2.14)	35.78 (<0.001)
Diabetes HbA <sub>1c</sub> $\leq 10\%$	1.76 (0.88 to 2.64) <sup>c</sup>	1.64 (0.78 to 2.50) <sup>c</sup>	1.42 (0.56 to 2.28) <sup>c</sup>	1.50 (0.60 to 2.40) <sup>c</sup>	0.92 (0.08 to 1.75) <sup>c</sup>	56.82 (<0.001)
Diabetes blood pressure $\leq 145/85$ mmHg	0.68 (–0.72 to 2.08)	0.58 (–0.89 to 2.05)	0.36 (–1.11 to 1.83)	0.60 (–0.89 to 2.09)	–0.02 (–1.56 to 1.53)	6.11 (0.30)
Diabetes total cholesterol $\leq 5$ mmol/l	1.86 (0.62 to 3.10) <sup>c</sup>	1.54 (0.32 to 2.75) <sup>c</sup>	1.34 (0.05 to 2.62) <sup>c</sup>	1.75 (0.44 to 3.07) <sup>c</sup>	1.12 (–0.15 to 2.39)	19.33 (0.002)
Epilepsy convulsion free for 12 months (age >16 years)	–2.36 (–4.56 to –0.17) <sup>c</sup>	–1.61 (–3.67 to 0.46)	–2.31 (–4.34 to –0.28) <sup>c</sup>	–1.61 (–3.74 to 0.52)	–2.11 (–4.25 to 0.03)	8.04 (0.15)
Hypertension blood pressure $\leq 150/90$ mmHg	–0.55 (–1.60 to 0.50)	–0.46 (–1.52 to 0.60)	–0.30 (–1.33 to 0.72)	–0.44 (–1.53 to 0.65)	–0.49 (–1.59 to 0.61)	1.56 (0.91)
Stroke blood pressure $\leq 150/90$ mmHg	–0.74 (–1.94 to 0.45)	–0.76 (–1.95 to 0.43)	–0.66 (–1.79 to 0.47)	–0.65 (–1.81 to 0.52)	–0.55 (–1.73 to 0.64)	2.04 (0.84)
Stroke total cholesterol $\leq 5$ mmol/l	2.48 (0.58 to 4.38) <sup>c</sup>	2.05 (0.13 to 3.96) <sup>c</sup>	2.88 (0.92 to 4.85) <sup>c</sup>	2.05 (0.09 to 4.02) <sup>c</sup>	2.58 (0.65 to 4.51) <sup>c</sup>	16.44 (0.006)

<sup>a</sup>Reference category 'no practice nurse'. <sup>b</sup>5 degrees of freedom. <sup>c</sup>Significant ( $P < 0.05$ ) relative to reference category. Full models can be found in Appendix 3. CHD = coronary heart disease. FTE = full-time equivalent.

diabetes HbA<sub>1c</sub> ≤10% and stroke total cholesterol ≤5 mmol/l, better performance was associated with any level of nurse staffing. In all these cases except stroke total cholesterol ≤5 mmol/l, higher levels of nurse staffing were associated with greater improvements.

List size per FTE GP was negatively associated with QOF scores (that is, the more patients each GP looked after the lower the score) for the asthma clinical area ( $\beta = -0.17$ , 95% confidence interval (CI)  $-0.32$  to  $-0.02$ ,  $P = 0.035$ ) and the total cholesterol clinical outcome indicators for CHD ( $\beta = -0.12$ , 95% CI  $-0.20$  to  $-0.04$ ,  $P = 0.004$ ) and stroke ( $\beta = -0.12$ , 95% CI  $-0.21$  to  $-0.03$ ,  $P = 0.011$ ). However, practices with larger list size per GP had better QOF scores for mental health ( $\beta = 0.25$ , 95% CI  $0.11$  to  $0.39$ ,  $P = 0.001$ ) and diabetes HbA<sub>1c</sub> ≤7.4% ( $\beta = 0.15$ , 95% CI  $0.05$  to  $0.25$ ,  $P = 0.007$ ).

Single-handed practices performed worse for the HbA<sub>1c</sub> ≤10% clinical outcome indicator ( $\beta = -0.54$ , 95% CI  $-1.04$  to  $-0.05$ ,  $P = 0.038$ ) but better for epilepsy convulsion free for 12 months ( $\beta = 1.60$ , 95% CI  $0.20$  to  $3.00$ ,  $P = 0.032$ ), hypertension blood pressure ≤150/90 mm/Hg ( $\beta = 0.99$ , 95% CI  $0.31$  to  $1.66$ ,  $P = 0.006$ ), and stroke blood pressure ≤150/90 mmHg ( $\beta = 0.83$ , 95% CI  $0.17$  to  $1.49$ ,  $P = 0.019$ ).

## DISCUSSION

### Summary of main findings

This study has found evidence of an association between nurse staffing and the quality of clinical care as measured by the QOF in English general practice. Those practices that had more nurses performed better in a number of clinical domains. The analysis of clinical outcome indicators suggests that this improved performance on the QOF may be linked to real improvements in patient condition, not simply improved compliance with processes. The link between QOF performance and GP staffing was less clear. The study found both positive and negative associations with QOF scores for list size per GP and single-handed practices.

### Strengths and limitations of the study

This study includes data covering the vast majority of patients in English general practice. Although some practices were excluded, the study has examined evidence from English general practices providing care to 48 million patients. It controlled for potential confounding variables, but observational studies such as this cannot account for unmeasured factors. It may be that higher nurse staffing is associated with other unmeasured attributes of quality within the practice, and if this is the case increasing nurse staffing will not bring benefits unless these factors

are attended to. The QOF is a self-reported measure and practices can selectively choose not to include some patients in it. Population achievement was used for the primary analysis, and exception reporting was considered in the analysis of clinical outcome indicators as an attempt to control for this, but the success of bias correction using this approach is uncertain.

Because there is likely to be dependency of varying magnitude between quality scores across the different areas of care, it would not be possible to arrive at a correct adjustment factor for  $P$ -values to accurately determine statistical significance in the light of multiple tests. However, all but one of the statistically significant global tests of a relationship with nurse staffing showed a  $P$ -value of  $<0.01$ , and so type one error is unlikely to completely explain the study findings.

The QOF only measures some aspects of care and it is not possible to be sure that the quality of care in other areas and conditions has not declined as the QOF performance is prioritised. Practice nurses among others have suggested that delivery of QOF targets has been to the detriment of patient care.<sup>19</sup> Although the study conclusion, that improved outcomes are associated with higher nurses staffing, is supported by the analysis of objective clinical outcome indicators, these are intermediate outcomes. Finally, although the study estimates of nurse staffing were reliable, they did contain error. It may well be that if actual practice staffing data were available, the magnitude of the relationship could change.

### Comparison with existing literature

There is evidence from controlled trials that nurse-for-doctor substitution can be effective and deliver care that is essentially equivalent,<sup>20</sup> but evidence from such experimental implementations does not necessarily translate into routine care. Recently it has been suggested that the vast majority of 'routine' care in general practice could be delivered by nurses.<sup>5</sup> Previous research on quality in general practice has not found a clear association between nurse staffing and outcomes,<sup>12,13</sup> but these studies were considerably smaller than the present one. While this study cannot directly address a wholesale shift in care, it did not identify a threshold of nurse staffing above which the association between nurse staffing and quality disappears.

Although the greatest increases in performance were associated with having any practice nurses, no clear evidence was seen of a plateau or ceiling effect. In most cases where there was a significant relationship there was a clear trend for increasing performance with increasing nurse staffing. In some

cases, differences in performance relative to practices with no nurses were only significant when compared to those with the highest staffing levels.

It may be that additional nurses simply add to the number of clinical staff available and thus lead to larger and more diverse teams, as has been suggested by some.<sup>13</sup> However, this study did not show any consistent relationship between performance and list size per GP or single-handed practices. The magnitude of the relationship observed is relatively small, but the relationships identified between performance and nurse staffing are among the stronger relationships identified in the models used.

### Implications for clinical practice and future research

A higher level of nurse staffing is associated with higher-quality care and better clinical outcomes in some areas measured by the QOF criteria. These findings lend some support to the call for an increased nursing contribution in primary care and suggest that there may be scope for more growth in the number of nurses being employed in UK general practice. While this observational evidence supports the findings of controlled trials of nurse-for-doctor substitution, it is unclear if the benefits observed are due to effective substitution, an overall increase in capacity, or a combination of both. Further research is required to determine if the relationship is causal. The variations in results across clinical domains may relate to variations in activity or effectiveness of nurses in those areas, and future research needs to investigate the configuration of services and deployment of nurses more specifically. Further evidence is required to determine if the clinical benefits suggested by intermediate outcomes are translated into substantial benefits to patients, ideally using data external to the QOF.

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### Ethic approval

The study was judged by the authors to be service evaluation

### Competing interests

The authors have stated that there are none.

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**Appendix 1. Data sources.**

Characteristic	Source
<b>Geographic area</b>	
Density, people per hectare 2001	Office for National Statistics
Index of Multiple Deprivation	Office for National Statistics
Good self-rated health, %	Office for National Statistics
<b>Patients</b>	
≤15 years of age, %	National Primary Care R&D Centre, University of Manchester
≥65 years of age, %	National Primary Care R&D Centre, University of Manchester
Female, %	National Primary Care R&D Centre, University of Manchester
Member of racial or ethnic minority, %	National Primary Care R&D Centre, University of Manchester
<b>Disease prevalence</b>	
Unadjusted prevalence	NHS Information Centre
<b>Practice</b>	
Size of practice population	National Primary Care R&D Centre, University of Manchester
List size per FTE GP	National Primary Care R&D Centre, University of Manchester
Single-handed practice	National Primary Care R&D Centre, University of Manchester
Primary medical services contract	National Primary Care R&D Centre, University of Manchester
<b>Family practitioners</b>	
≥45 years of age, %	National Primary Care R&D Centre, University of Manchester
Female GPs, %	National Primary Care R&D Centre, University of Manchester
GPs qualified in UK, %	National Primary Care R&D Centre, University of Manchester
<b>Practice nurses</b>	
List size per FTE practice nurse (quintiles)	Binleys and NHS Healthcare Workforce

**Appendix 2. Practice characteristics by nurse staffing.**

Characteristic	Patients per nurse (FTE)					No practice nurse	All
	≤3038.01	3038.02–3901.48	3901.49–4823.44	4823.45–6210.68	≥6210.69		
Density (number of people per hectare), mean (SD)	44 (40)	42 (35)	41 (33)	44 (36)	47 (39)	68 (50)	45 (38)
Index of Multiple Deprivation score, mean (SD)	28 (17)	26 (17)	24 (16)	25 (17)	25 (17)	31 (17)	26 (17)
% Patients aged >65 years, mean (SD)	15 (6)	16 (5)	15 (5)	15 (5)	15 (5)	13 (6)	15 (5)
% Member of racial/ethnic minority, mean (SD)	13 (20)	12 (18)	11 (17)	11 (17)	12 (17)	26 (26)	12 (19)
Practice list size, mean (SD)	4224 (2712)	5930 (3518)	7079 (3974)	7724 (4082)	8075 (3735)	3007 (1737)	6438 (3896)
List size per FTE GP, mean (SD)	2108 (766)	2135 (770)	2178 (1379)	2206 (741)	2278 (845)	2235 (804)	2183 (928)
% GPs aged ≥45 years, mean (SD)	74 (33)	66 (32)	64 (30)	63 (30)	61 (29)	88 (27)	67 (31)
% Female GPs, mean (SD)	30 (33)	32 (29)	33 (26)	33 (25)	34 (24)	26 (37)	32 (28)
% GPs qualified in UK, mean (SD)	62 (44)	71 (39)	74 (37)	75 (36)	76 (34)	44 (48)	70 (39)
Single-handed practice, %	42	25	18	14	8	69	24
Primary medical services contract, %	42	35	32	32	32	26	34

## Appendix 3. Full regression models for performance on QOF clinical areas (population achievement).

Clinical area	Asthma (n = 7438)		COPD (n = 7446)		CHD (n = 7452)		Diabetes (n = 7441)		Hypertension (n = 7440)		Hypothyroid (n = 7445)		Mental health (n = 7452)		Stroke (n = 7451)	
	$\beta$	SE( $\beta$ )	$\beta$	SE( $\beta$ )	$\beta$	SE( $\beta$ )	$\beta$	SE( $\beta$ )	$\beta$	SE( $\beta$ )	$\beta$	SE( $\beta$ )	$\beta$	SE( $\beta$ )	$\beta$	SE( $\beta$ )
Intercept	73.687	1.023	81.814	0.954	82.795	0.382	85.136	0.619	92.568	0.269	94.576	0.339	82.807	0.992	76.531	0.43
Bias adjustment	4.930 <sup>c</sup>	0.376	2.484 <sup>c</sup>	0.259	1.275 <sup>c</sup>	0.111	1.421 <sup>c</sup>	0.142	0.439 <sup>c</sup>	0.098	0.906 <sup>c</sup>	0.104	10.513 <sup>c</sup>	0.550	1.971 <sup>c</sup>	0.178
Denominator used	-0.214	0.167	-0.433 <sup>b</sup>	0.156	-0.156 <sup>b</sup>	0.066	-0.135	0.115	-0.176 <sup>a</sup>	0.075	-0.200 <sup>b</sup>	0.070	-0.034	0.241	-0.150	0.122
Area	-1.089 <sup>c</sup>	0.169	-0.767 <sup>c</sup>	0.184	-0.123	0.105	-0.246	0.131	0.053	0.075	0.092	0.065	-0.884 <sup>c</sup>	0.226	-0.348 <sup>b</sup>	0.107
Density (people per hectare 2001)	-0.542 <sup>b</sup>	0.168	-0.148	0.161	0.452 <sup>a</sup>	0.201	0.256	0.196	0.132	0.322	-0.099	0.209	-0.850 <sup>b</sup>	0.264	-0.174	0.174
Index of Multiple Deprivation	-0.058	0.225	-0.393 <sup>a</sup>	0.195	-0.131	0.102	-0.075	0.222	-0.194 <sup>a</sup>	0.084	-0.142	0.087	0.364	0.229	-0.361 <sup>a</sup>	0.160
Patients																
≥65 years of age																
% Member of racial or ethnic minority																
Disease prevalence																
Unadjusted prevalence	0.171	0.256	-0.564 <sup>b</sup>	0.201	-0.758 <sup>b</sup>	0.290	-0.406	0.404	-0.288	0.461	0.275	0.393	0.912 <sup>b</sup>	0.311	0.570 <sup>b</sup>	0.212
Practice																
Size of practice population	-0.844 <sup>c</sup>	0.146	-0.071	0.135	-0.148 <sup>b</sup>	0.050	-0.052	0.078	-0.213 <sup>c</sup>	0.057	-0.087	0.054	-0.417 <sup>a</sup>	0.203	-0.181 <sup>a</sup>	0.082
List size per FTE GP	-0.172 <sup>a</sup>	0.078	-0.041	0.069	-0.024	0.036	-0.120	0.072	-0.014	0.052	0.019	0.022	0.249 <sup>c</sup>	0.072	0.007	0.057
Single-handed practice	0.610	0.471	-0.662	0.491	-0.110	0.212	-0.681	0.353	-0.431	0.233	-0.326	0.259	-1.156	0.668	-0.239	0.288
Primary medical services contract	-0.331	0.289	0.178	0.240	-0.125	0.111	0.202	0.175	-0.116	0.114	0.072	0.118	-0.816 <sup>a</sup>	0.392	-0.122	0.164
GPs																
≥45 years of age	-0.167	0.155	-0.199	0.129	-0.179 <sup>c</sup>	0.052	-0.095	0.092	-0.107	0.056	-0.092	0.050	0.236	0.245	-0.101	0.087
% Female GPs	0.140	0.155	0.426 <sup>b</sup>	0.142	0.136 <sup>a</sup>	0.059	0.394 <sup>c</sup>	0.112	0.220 <sup>b</sup>	0.071	0.328 <sup>c</sup>	0.064	0.529 <sup>a</sup>	0.209	0.278 <sup>b</sup>	0.094
% GPs qualified in UK	0.151	0.209	1.040 <sup>c</sup>	0.172	0.385 <sup>c</sup>	0.064	0.613 <sup>c</sup>	0.130	0.378 <sup>c</sup>	0.069	0.367 <sup>c</sup>	0.083	0.048	0.245	0.864 <sup>c</sup>	0.122
Practice nurses																
List size per FTE practice nurse (Quintiles)																
1st ≤3038.01	0.402	1.054	2.032 <sup>a</sup>	0.933	0.902 <sup>a</sup>	0.368	1.935 <sup>b</sup>	0.604	0.469	0.257	0.773 <sup>a</sup>	0.311	-0.113	1.055	0.614	0.425
2nd 3038.02-3901.48	0.285	1.037	1.854	0.999	0.844 <sup>a</sup>	0.376	1.777 <sup>a</sup>	0.618	0.416	0.257	0.624	0.324	1.246	1.033	0.574	0.438
3rd 3901.49-4823.44	-0.132	1.060	1.270	0.988	0.702	0.387	1.505 <sup>a</sup>	0.630	0.237	0.278	0.494	0.373	0.238	1.009	0.285	0.448
4th 4823.45-6210.68	0.493	1.049	1.091	1.004	0.562	0.393	1.430 <sup>a</sup>	0.627	0.108	0.278	0.489	0.348	0.888	1.057	0.110	0.448
5th ≥6210.69	0.134	1.067	0.652	1.014	0.516	0.377	1.073	0.626	-0.059	0.286	0.360	0.350	0.865	1.039	0.293	0.447
No practice nurse	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Glocal test for effect if nurse staffing -2 log likelihood (IGLS)																
Model without practice nurse variable	56674.875		54382.727		41977.87		48650.395		42035.926		42503.215		62172.301		48558.688	
Model with practice nurse variable	56670.934		54355.82		41962.691		48622.941		42018.652		42492.777		62163.653		48550.57	
Difference in log likelihood (5df)	3.941		26.907		15.196		27.454		17.274		10.438		8.648		8.188	
Variance	P = 0.56		P < 0.0001		P = 0.0096		P < 0.0001		P = 0.0040		P = 0.064		P = 0.12		P = 0.15	
PCT level	3.689	0.627	4.373	0.530	1.536	0.177	7.693	1.353	0.713	0.106	0.584	0.123	8.115	1.345	1.952	0.270
Practice level	92.117	3.165	59.199	2.771	11.888	1.124	30.856	1.953	12.773	1.588	12.642	2.113	165.301	6.176	27.091	1.551

df = degrees of freedom. CHD = coronary heart disease. COPD = chronic obstructive pulmonary disease. FTE = full-time equivalent. SE = standard error. \*P<0.05; <sup>b</sup>P<0.01; <sup>c</sup>P<0.001.

continued ...

**Appendix 3 continued. Full regression models for performance on QOF clinical outcome indicators (reported achievement): CHD.**

Clinical indicator	Blood pressure ≤150/90 mmHg (n = 7452)		Total Cholesterol ≤5mmol/l (n = 7452)	
	β	SE(β)	β	SE(β)
<b>Characteristic</b>				
Intercept	86.604	0.474	76.798	0.719
<b>Area</b>				
Density (people per hectare 2001)	-0.175	0.104	-0.345 <sup>a</sup>	0.139 <sup>a</sup>
Index of Multiple Deprivation	-0.163	0.087	-0.270	0.138
<b>Patients</b>				
≥65 years of age	0.105	0.140	0.397	0.213
% Member of racial or ethnic minority	-0.322 <sup>b</sup>	0.111	0.054	0.719
<b>Disease prevalence</b>				
Unadjusted prevalence	-0.480 <sup>c</sup>	0.142	-0.623 <sup>b</sup>	0.192
<b>Practice</b>				
Size of practice population	-0.272 <sup>b</sup>	0.086	0.032	0.110
List size per FTE GP	-0.097	0.073	-0.119 <sup>b</sup>	0.039
Single-handed practice	0.239	0.273	-0.522	0.331
Primary medical services contract	-0.122	0.156	0.021	0.218
<b>GPs</b>				
≥45 years of age	-0.061	0.082	-0.584 <sup>c</sup>	0.113
% Female GPs	0.139	0.086	0.518 <sup>c</sup>	0.112
% GPs qualified in UK	0.202	0.105	1.444 <sup>c</sup>	0.140
<b>Exception reporting</b>				
CHD blood pressure recorded	-0.041	0.105		
CHD blood pressure ≤150/90 mmHg	0.717 <sup>c</sup>	0.097		
CHD total cholesterol recorded			-0.529 <sup>c</sup>	0.123
CHD total cholesterol ≤ 5mmol/l			4.073 <sup>c</sup>	0.128
<b>Practice nurses</b>				
List size per FTE practice nurse (quintiles)				
1st ≤3038.01	0.616	0.470	1.697 <sup>a</sup>	0.744
2nd 3038.02–3901.48	0.477	0.486	1.425 <sup>a</sup>	0.711
3rd 3901.49–4823.44	0.636	0.473	1.756 <sup>a</sup>	0.720
4th 4823.45–6210.68	0.627	0.488	1.498 <sup>a</sup>	0.732
5th ≥6210.69	0.475	0.501	1.253	0.718
No practice nurse	0.000		0.000	
<b>Global test for effect of nurse staffing –2 log likelihood (IGLS)</b>				
Model without practice nurse variable	48060.285		52306.914	
Model with practice nurse variable	48057.492		52296.348	
Difference in log likelihood (5df)	2.793		10.566	
P-value	0.730		0.061	
<b>Variance</b>				
PCT level	1.481	0.203	7.106	0.824
Practice level	27.432	0.752	47.209	1.459

df = degrees of freedom. CHD = coronary heart disease. FTE = full-time equivalent. SE = standard error. <sup>a</sup>P<0.05; <sup>b</sup>P<0.01; <sup>c</sup>P<0.001.

continued ...

## Appendix 3 continued. Full regression models for performance on QOF clinical outcome indicators (reported achievement): Diabetes.

Clinical indicator	HbA <sub>1c</sub> ≤7.4% (n = 7456)		HbA <sub>1c</sub> ≤10% (n = 7456)		Blood pressure ≤145/85 mmHg (n = 7456)		Total cholesterol ≤5 mmol/l (n = 7456)	
	β	SE(β)	β	SE(β)	β	SE(β)	β	SE(β)
Characteristic								
Intercept	60.076	0.737	90.006	0.443	74.720	0.758	77.294	0.631
Area								
Density (people per hectare 2001)	-0.035	0.160	-0.275 <sup>c</sup>	0.076	0.007	0.166	-0.091	0.123
Index of Multiple Deprivation	-0.460 <sup>b</sup>	0.155	-0.517 <sup>c</sup>	0.069	-0.001	0.144	-0.140	0.126
Patients								
≥65 years of age	1.599 <sup>a</sup>	0.172	0.884 <sup>a</sup>	0.081	-0.552 <sup>a</sup>	0.166	0.377 <sup>a</sup>	0.158
% Member of racial or ethnic minority	-1.529 <sup>c</sup>	0.187	-0.586 <sup>c</sup>	0.090	-0.427 <sup>a</sup>	0.198	-0.508 <sup>b</sup>	0.158
Disease prevalence								
Unadjusted prevalence	0.689 <sup>b</sup>	0.245	-0.070	0.101	-0.031	0.169	0.158	0.150
Practice								
Size of practice population	-0.066	0.108	0.115 <sup>a</sup>	0.051	-0.282 <sup>a</sup>	0.122	0.000	0.093
List size per FTE GP	0.148 <sup>b</sup>	0.052	-0.002	0.048	-0.039	0.082	-0.041	0.047
Single-handed practice	-0.047	0.394	-0.544 <sup>a</sup>	0.251	0.205	0.416	-0.007	0.313
Primary medical services contract	0.282	0.214	0.108	0.111	-0.183	0.239	0.101	0.193
GPs								
≥45 years of age	-0.523 <sup>c</sup>	0.116	-0.250 <sup>c</sup>	0.056	-0.079	0.125	-0.315 <sup>b</sup>	0.113
% Female GPs	0.851 <sup>c</sup>	0.114	0.537 <sup>c</sup>	0.063	0.205	0.138	0.546 <sup>c</sup>	0.111
% GPs qualified in UK	0.615 <sup>c</sup>	0.159	0.703 <sup>c</sup>	0.095	0.667 <sup>c</sup>	0.157	0.939 <sup>c</sup>	0.130
Exception reporting								
HbA <sub>1c</sub> recorded	-0.128	0.132	0.093	0.067				
HbA <sub>1c</sub> ≤7.4%	4.060 <sup>c</sup>	0.132						
HbA <sub>1c</sub> ≤10%			2.051 <sup>c</sup>	0.074				
Blood pressure recorded					0.668 <sup>c</sup>	0.160		
Blood pressure ≤145/85 mmHg					-0.197	0.157		
Total cholesterol							-0.474 <sup>c</sup>	0.121
Total cholesterol ≤5 mmol/l							3.669 <sup>c</sup>	0.116
Practice nurses								
List size per FTE practice nurse (quintiles)								
1st ≤3038.01	2.249 <sup>b</sup>	0.713	1.763 <sup>b</sup>	0.449	0.679	0.715	1.862 <sup>b</sup>	0.632
2nd 3038.02–3901.48	2.046 <sup>b</sup>	0.695	1.639 <sup>b</sup>	0.440	0.578	0.751	1.537 <sup>a</sup>	0.619
3rd 3901.49–4823.44	1.505 <sup>a</sup>	0.718	1.420 <sup>b</sup>	0.438	0.362	0.751	1.335 <sup>a</sup>	0.655
4th 4823.45–6210.68	1.193	0.726	1.499 <sup>b</sup>	0.460	0.598	0.759	1.754 <sup>b</sup>	0.670
5th ≥6210.69	0.776	0.695	0.915 <sup>a</sup>	0.425	-0.015	0.786	1.122	0.648
No practice nurse	0.000		0.000		0.000		0.000	
Global test for effect of nurse staffing -2 log likelihood (IGLS)								
Model without practice nurse variable	52990.910		43200.699		54991.270		51088.563	
Model with practice nurse variable	52955.133		43143.883		54985.156		51069.234	
Difference in log likelihood (5df)	35.777		56.816		6.114		19.329	
P-value	<0.001		<0.001		0.30		0.0017	
Variance								
PCT level	23.490	2.382	2.022	0.274	4.006	0.609	8.426	0.862
Practice level	52.617	1.271	14.768	0.751	74.060	1.641	42.346	1.073

df = degrees of freedom. FTE = full-time equivalent. SE = standard error. <sup>a</sup>P<0.05; <sup>b</sup>P<0.01; <sup>c</sup>P<0.001.

continued ...

**Appendix 3 continued. Full regression models for performance on QOF clinical outcome indicators (reported achievement): Epilepsy.**

Clinical indicator	Convulsion free for 12 months (age ≥16 years) (n = 7447)	
	β	SE(β)
Characteristic		
Intercept	73.551	1.051
Area		
Density (people per hectare 2001)	-0.265	0.230
Index of Multiple Deprivation	-3.643 <sup>c</sup>	0.255
Patients		
≥65 years of age	2.140 <sup>c</sup>	0.254
% Member of racial or ethnic minority	-1.055 <sup>c</sup>	0.308
Disease prevalence		
Unadjusted prevalence	-1.570 <sup>c</sup>	0.273
Practice		
Size of practice population	-0.160	0.192
List size per FTE GP	0.032	0.091
Single-handed practice	1.600 <sup>a</sup>	0.714
Primary medical services contract	-0.690	0.367
GPs		
≥45 years of age	-0.264	0.202
% Female GPs	0.649 <sup>c</sup>	0.190
% GPs qualified in UK	0.888 <sup>a</sup>	0.287
Exception reporting		
Convulsion free for 12 months	6.040 <sup>c</sup>	0.252
Practice nurses		
List size per FTE practice nurse (quintiles)		
1st ≤3038.01	-2.364 <sup>a</sup>	1.120
2nd 3038.02–3901.48	-1.609	1.054
3rd 3901.49–4823.44	-2.312 <sup>a</sup>	1.036
4th 4823.45–6210.68	-1.609	1.088
5th ≥6210.69	-2.107 <sup>a</sup>	1.092
No practice nurse	0.000	
Global test for effect of nurse staffing -2 log likelihood (IGLS)		
Model without practice nurse variable		60878.023
Model with practice nurse variable		60869.984
Difference in log likelihood (5df)		8.039
P-value		0.15
Variance		
PCT level	7.614	1.221
Practice level	150.811	4.599

df = degrees of freedom. FTE = full-time equivalent. SE = standard error. <sup>a</sup>P<0.05; <sup>b</sup>P<0.01; <sup>c</sup>P<0.001.

continued ...

**Appendix 3 continued. Full regression models for performance on QOF clinical outcome indicators (reported achievement): Hypertension.**

Clinical indicator	Blood pressure $\leq 150/90$ mmHg ( $n = 7456$ )	
	$\beta$	SE( $\beta$ )
Characteristic		
Intercept	76.197	0.508
Area		
Density (people per hectare 2001)	-0.155	0.130
Index of Multiple Deprivation	-0.312 <sup>b</sup>	0.112
Patients		
$\geq 65$ years of age	-0.455 <sup>b</sup>	0.158
% Member of racial or ethnic minority	-0.275	0.151
Disease prevalence		
Unadjusted prevalence	0.376 <sup>b</sup>	0.140
Practice		
Size of practice population	-0.411 <sup>c</sup>	0.097
List size per FTE GP	-0.132	0.105
Single-handed practice	0.986 <sup>b</sup>	0.343
Primary medical services contract	-0.449 <sup>a</sup>	0.184
GPs		
$\geq 45$ years of age	0.036	0.104
% Female GPs	0.005	0.098
% GPs qualified in UK	0.167	0.131
Exception reporting		
Hypertension blood pressure recorded	0.401 <sup>c</sup>	0.102
Hypertension blood pressure $\leq 150/90$ mmHg	0.981 <sup>c</sup>	0.140
Practice nurses		
List size per FTE practice nurse (quintiles)		
1st $\leq 3038.01$	-0.548	0.535
2nd 3038.02–3901.48	-0.459	0.542
3rd 3901.49–4823.44	-0.303	0.523
4th 4823.45–6210.68	-0.440	0.555
5th $\geq 6210.69$	-0.490	0.559
No practice nurse	0.000	
Global test for effect of nurse staffing -2 log likelihood (IGLS)		
Model without practice nurse variable	51490.410	
Model with practice nurse variable	51488.852	
Difference in log likelihood (5df)	1.558	
P-value	0.91	
Variance		
PCT level	3.436	0.451
Practice level	44.371	1.038

df = degrees of freedom. FTE = full-time equivalent. SE = standard error. <sup>a</sup> $P < 0.05$ ; <sup>b</sup> $P < 0.01$ ; <sup>c</sup> $P < 0.001$ .

continued ...

**Appendix 3 continued. Full regression models for performance on QOF clinical outcome indicators (reported achievement): Stroke.**

Clinical indicator	Blood pressure $\leq 150/90$ mmHg (n = 7450)		Total cholesterol $\leq 5$ mmol/l (n = 7449)	
	$\beta$	SE( $\beta$ )	$\beta$	SE( $\beta$ )
Characteristic				
Intercept	85.554	0.560	69.507	0.979
Area				
Density (people per hectare 2001)	-0.153	0.123	-0.193	0.203
Index of Multiple Deprivation	-0.439 <sup>c</sup>	0.102	-0.148	0.177
Patients				
$\geq 65$ years of age	-0.328 <sup>a</sup>	0.144	-0.781 <sup>b</sup>	0.249
% Member of racial or ethnic minority	-0.184	0.153	0.295	0.253
Disease prevalence				
Unadjusted prevalence	0.235	0.140	0.868 <sup>c</sup>	0.220
Practice				
Size of practice population	-0.331 <sup>c</sup>	0.095	-0.287 <sup>a</sup>	0.134
List size per FTE GP	-0.036	0.077	-0.124 <sup>b</sup>	0.046
Single-handed practice	0.830 <sup>a</sup>	0.335	0.416	0.472
Primary medical services contract	-0.285	0.180	-0.103	0.297
GPs				
$\geq 45$ years of age	-0.245 <sup>a</sup>	0.110	-0.399 <sup>c</sup>	0.153
% Female GPs	0.099	0.107	0.542 <sup>c</sup>	0.150
% GPs qualified in UK	0.137	0.130	1.176 <sup>c</sup>	0.214
Exception reporting				
Blood pressure recorded	0.423 <sup>c</sup>	0.111		
Blood pressure $\leq 150/90$ mmHg	1.213 <sup>c</sup>	0.160		
Total cholesterol recorded			-0.105	0.154
Total cholesterol $\leq 5$ mmol/l			5.488 <sup>c</sup>	0.182
Practice nurses				
List size per FTE practice nurse (quintiles)				
1st $\leq 3038.01$	-0.744	0.611	2.478 <sup>b</sup>	0.969
2nd 3038.02–3901.48	-0.761	0.606	2.045 <sup>a</sup>	0.979
3rd 3901.49–4823.44	-0.659	0.576	2.882 <sup>b</sup>	1.003
4th 4823.45–6210.68	-0.646	0.595	2.053 <sup>a</sup>	1.003
5th $\geq 6210.69$	-0.547	0.605	2.580 <sup>b</sup>	0.986
No practice nurse	0.000		0.000	
Global test for effect of nurse staffing –2 log likelihood (IGLS)				
Model without practice nurse variable		51373.121		56880.242
Model with practice nurse variable		51371.082		56863.805
Difference in log likelihood (5df)		2.039		16.437
P-value		0.84		0.0057
Variance				
PCT level	2.251	0.283	10.125	1.207
Practice level	39.551	0.963	81.485	2.339

df = degrees of freedom. FTE = full-time equivalent. SE = standard error. <sup>a</sup>P<0.05; <sup>b</sup>P<0.01; <sup>c</sup>P<0.001.