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Resource variation in colorectal surgery; a national centre-level analysis

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Keywords:

Colorectal cancer; resources; outcomes; staffing.

What does this study add:

This study finds that increased use of laparoscopy and presence of a dedicated colorectal ward are associated with reduced mortality and readmission rate in hospitals in England.

Abstract

Background

Delivery of quality colorectal surgery requires adequate resources. We set out to assess the relationship between resources and outcomes in English colorectal units.

Methods

Data was extracted from the ACPGBI resource questionnaire to profile resources. This was correlated with Hospital Episode Statistics (HES) outcome data including 90-day mortality and readmissions. Patient satisfaction measures were extracted from the Cancer Experience Patient Survey (CEPS) and compared at unit level. Centres were divided by workload into low, middle, and top tertile.

Results

Completed questionnaires were received from 75 centres in England. Service resources were similar between low and top tertiles in access to CEPOD theatre, level 2 or 3 beds per 250,000 population or likelihood of having a dedicated colorectal ward. There was no difference in staffing levels per 250,000 unit of population. Each 10% increase in the proportion of cases attempted laparoscopically,

was associated with reduced 90-day unplanned readmission (RR 0.94, 95% CI 0.91 to 0.97, $p<0.001$). The presence of a dedicated colorectal ward (RR 0.85, 95% CI 0.73 to 0.99, $p = 0.040$) was also associated with a significant reduction in unplanned readmissions. There was no association between staffing or service factors and patient satisfaction.

Discussion and conclusions

Resource levels do not vary based on unit of population. There is benefit associated with increased use of laparoscopy and a dedicated surgical ward. Alternative measures to assess the relationship between resources and outcome, such as failure to rescue, should be explored in UK practice.

Introduction

Delivery of surgical care is provided by multi-professional teams within a complex environment with many differing institutional structures and processes. Underpinning the safe delivery of surgical care is the adequate provision of targeted resources. In several non-surgical settings, the provision and availability of resources have been found to be significantly associated with patient outcomes- with greater resources a key factor in delivering improved patient care. In colorectal surgery, it is well recognised that there is variation in outcome between healthcare providers and priority is being given to reducing unacceptable variation across providers [1,2].

Contemporary studies shed very little light on the effects of resource provision in colorectal surgery, although the effects of resources on some areas of surgical care, such as emergency surgery [3,4] and aortic aneurysm surgery have been previously described[5]. Optimal colorectal surgical care also necessitates the availability of a wide variety of resources. Theseinclude acute inpatient and intensive care beds, and adequate staffingin the form of nurses, surgeons and oncologists. In the United Kingdom, the Association of Coloproctology of Great Britain and Ireland (ACPGBI) has published guidelines the resources required to deliver a colorectal service. [6].

The aim of this study was to assess the relationship between reported resource levels and outcomes in English hospitals.

Methods

Data was obtained from the ACPGBI resource survey. This was a survey developed and prospectively delivered by the professional association (ACPGBI) with the aim of understanding and helping to reduce resource variation in the UK. The survey assessed practice across several domains of care including inpatients, outpatients, endoscopy and nursing care. Questions on current practice were developed for each domain by a group of four or more expert clinicians, following review of relevant literature. These questions were combined into one single questionnaire and sent to all acute trusts across the country. Responses were sought for a period of four months between November 2014 and February 2015, with telephone and email prompting for initial non-responders. For the purpose of this analysis, only responses relevant to inpatient care were included. Resource variables were defined as per the resource document. Specifically 'colorectal' ward refers to a designated ward for colorectal patients, and population served was based on that reported by each hospital in the survey[6].

We used 90-day adjusted mortality as the primary outcome to measure safety, along with secondary outcome measures of colorectal surgical care, which included, 90-day readmission and 18-month adjusted stoma rate. Hospital Episode Statistics (HES) data were obtained to calculate 90 day readmission rates, 90 day adjusted mortality rates and the 18-month adjusted stoma rate. Patient satisfaction was used as a patient reported experience measure. Patient reported experience measures were taken from the 2014 Cancer Patient Experience Survey (CPES). Results of questions 45-54 were included for assessment and question 70 as a global measure of patient satisfaction (table 1). We only considered data for England, as both Welsh and Scottish data used different outcome measures.

In order to construct summary tables to compare resources, hospitals were classified as either low (fewer than 140 elective cancer resections per year), middle (140 to 162 elective cancer resections per year) or high volume centres (over 162 elective cancer resections per year). These boundaries were set at the values for the tertiles contained in the data respectively (i.e. the 33.3 and 66.6 percentile values). We divided the dataset into three parts as this permitted relatively robust analysis. Further division into quartiles or quintiles would have resulted in smaller groups for analysis and potentially decreased reliability of data. Differences in volume groups were described as simple percentages and number of centres (n). Summary statistical tests were performed using either the Chi-squared test (for categorical variables) or Kruskall-Wallace (for continuous variables). Univariate quasi-poisson modelling was used to estimate the relationships between patient outcomes and resources. Resource variables were classified into two groups, service (variables which described the facilities for colorectal surgery) and staffing factors (variables which described the quantity of staff available for patient care). Laparoscopy was modelled as per 10 percent increase in laparoscopy rate. Effect sizes for each factor are presented as risk ratios, alongside their corresponding 95% confidence interval. All analyses were undertaken in R v3.2.2 (R-Foundation for Statistical Computing, Vienna, AUT). Statistical significance was set at the level of $p<0.05$ *a-priori*.

Results

Questionnaire responses were received from 75/145 English colorectal units (response rate 51.7%). Eleven centres did not report their annual caseload. Data from the ACPGBI surgeon and unit level outcomes publication were retrieved for these centres and all 11 centres allocated to a volume group [7].For the final analysis there were 28 low volume, 22 middle volume and 25 high volume centres.

High volume centres served a mean population of 491,667 with a mean of 222 cases per year. Middle volume centres had similar catchment populations with an average of 440,000 but had lower elective volumes with a mean average of 148 cases per year. Low volume centres had a smaller average catchment population of 308,200 and a low elective volume, with 102 cases per year on average (table 2).

Summary of service factors

Table 2 summarises differences in service factors across hospital volume. There was 24-hour access to CEPOD theatre for 76.0% of high volume centres vs 64.3% of low volume centres (p=0.634), although there was no difference in reported numbers of admissions via emergency take (9.3 vs 10.7, p=0.323). High volume centres were more likely than low volume centres to have dedicated colorectal wards (56.0% vs 28.6%, p=0.268). There was no difference in the number of level two (3.5 vs 4.1, p=0.809) or level three critical care beds (5.4 vs 6.0, p=0.669) per 250,000 of population served.

Summary of staffing factors

There was no statistically significant difference between high and low volume centres in terms of number of surgeons per 250,000 (3.2 vs 3.9, p=0.424), number of stoma nurses per 250,000 (1.3 vs 1.9, p=0.09) or number of oncologists per 250,000 (1.4 vs 1.6, p= 0.62), suggesting per unit population centres have a similar number of staff (table 3).

Univariate modelling of resources and 90-day mortality.

Only the use of laparoscopy was associated with significantly reduced 90-day mortality – RR per 10% increase in case attempted laparoscopically 0.89 (95% CI 0.83 to 0.94, p<0.001, figure 1). Presence of a dedicated colorectal surgery ward, 24-hour CEPOD theatre, increased numbers of day time and night time nursing staff and availability of level two and three beds showed non-significant associations with reduced 90-day mortality. For staffing factors, a higher number of full-time equivalent (FTE) surgeons per 250,000 had a weak association with increased 90-day mortality (RR 1.07, 95% CI 0.98 to1.16, p=0.09, figure 1).

Univariate modelling of resources and 90-day unplanned readmission

For every 10 percent increase in the proportion of cases attempted laparoscopically, there was a statistically significant association with reduced 90-day unplanned readmission (RR 0.94, 95% CI 0.91 to 0.97)). The presence of a dedicated colorectal ward (RR 0.85, 95% CI 0.73 to 0.99, p =0.04) was also associated with a statistically significant reduction in unplanned readmission rates (figure 2).

Neither staffing factors, nor availability of other service factors such as level two or level three beds showed a significant association with readmission rates.

Univariate modelling of resources and 18-month HES adjusted stoma rate

Increased use of laparoscopy was significantly associated with a slightly lower stoma rate at 18 months (figure 3). There were otherwise no associations between resources and 18-month stoma rates.

Univariate modelling of resources and patient satisfaction

Neither service factors, including 24 hour CEPOD theatre, increased number of level two or three beds, presence of a dedicated colorectal ward or increased use of laparoscopy were associated with improved global satisfaction scores (figure 4). The same was true for staffing factors.

Discussion

This paper describes resources available to colorectal surgeons in England, and shows that whilst high and low volume centres have different population sizes and levels of activity, underlying resources are not significantly different per unit population. Centre level analysis suggests that increased use of laparoscopy is associated with reduced 90-day mortality. Increased use of laparoscopy and the presence of a dedicated colorectal surgery ward significantly reduced rates of unplanned readmissions.

A key finding of this study is that units performing colorectal surgery across the nation have similar numbers of staff and resources per unit population. This suggests that that a natural minimum level of resource required for functioning may have already been achieved in most centres in the country.. There is variation in use of laparoscopic surgery and dedicated colorectal wards across the dataset, allowing associations with outcomes to be detected. Nevertheless, there is a possibility that the factors measured are unrelated to outcomes of colorectal surgery. For example, a colorectal surgical unit without nurses or support staff could not support good outcomes for patients.

A better way of measuring of outcomes and resources utilisation may be by using the concept of 'failure to rescue'. First proposed in 1992, this is defined as the number of patients who die following a major complication of surgery divided by the number of patients who develop a major complication following surgery [1,10]. Surgeons in North America have undertaken assessments of this concept in colorectal cancer, and found that whilst complication rates were not significantly different between high and low mortality units, rates of death following complications were significantly different [11]. The ability to 'rescue' from complications requires a combination of processes including recognising the complication and allocating appropriate resources to support this. This has been previously recommended as a quality marker for colorectal surgery, although it is not routinely measured in the UK [12,1,13].

The analysis performed in this study was limited to data collected as part of the ACPGBI resource survey. This survey is designed by an expert group and focuses on factors previously defined as important, as well as those of interest to policy-makers, regardless of clinical significance. With the current design, data on access to imaging was not collected. Access to scanning has been shown to be associated with survival in emergency surgery in the UK[3]. There is also no objective assessment of how well an MDT functions. Preoperative[14] and perioperative[15] interventions have been shown to be key differences between high and low mortality centres in non-colorectal and colorectal cancers cancers, but this was not measured as part of this assessment. Caution should be exercised when comparing this study to findings from the US. Previous studies split centres into high and low mortality to undertake analysis. Our a priori strategy was to assess the relationship of resources to outcome based on operative volume. This was borne out as an appropriate strategy by the close measures of mortality across all hospitals. This different approach to data may account for variation in results between countries. Differences may also arise due to greater volume and increased availability of patient level data in US studies.

There are further limitations which must be considered. Firstly, some of the results of this study are based on a self-reported survey. Limitations in the accuracy of reported centre-level local data may have introduced bias. Still, this is an unlikely limitation for the reported outcome measures, as they were obtained through national HES data for outcomes chosen to be least subject to coding inaccuracies, a widely acknowledged limitation of administrative data [16]. Furthermore, this data was only available at the hospital level, not at the patient level. Patient level data would have permitted greater statistical power to detect subtle temporal differences in resource availability. The presence of a resource is only one aspect of how the given resource is effectively used, not necessarily the utility of the resource. Thirdly, the response rate to the survey of English centres was 51.7% meaning not all centres in England being captured. Nevertheless, the outcome measures were adjusted for confounders at the centre level and this study did capture a wide range of different hospitals, from large teaching hospitals to small district general hospitals. Finally, although the outcomes were adjusted for confounding variables at the patient level, there may be other unobserved institutional or process factors that are not accounted for. An example of this may be for our findings for use of laparoscopic surgery and colorectal wards. The presence of a colorectal ward and increasing use of laparoscopy may be surrogate markers for improved hospital infrastructure or patient case mix. Therefore, the possibility this may be a chance finding cannot be excluded. Despite this caveat, there appears to be a dose response relationship with use of laparoscopy (i.e. a higher utilisation of laparoscopy associated with better outcomes), which lends support to the beneficial effects of laparoscopy. This finding was also noted in a large Dutch cohort study [17].

The processes governing the efficient utilisation of resource are likely to have greatest impact in improving outcomes. For example, there may be the presence of laparoscopic surgery facilities, but without efficient use by a laparoscopically trained surgeon, the presence of the resource will have limited effects on patient outcomes. These processes are more difficult to assess as there is no standard measure and therefore no routine data collection. Furthermore, use of mortality may reduce the power of this analysis to detect significant differences between resource levels due to the relative infrequency of mortality as a post-operative outcome. Variation between centres may be measured to a greater degree of power by using outcomes which are more prevalent, such as wound infection, anastomotic leak or quality of life, or as in this study; adjusted stoma rate and readmission [1].

Outcomes with direct relevance to colorectal surgery would be useful for both clinicians and policymakers. At present, mortality and readmission, although useful metrics, do not provide adequate power to detect outliers or describe morbidity in a manner which is informative for patients. The patient reported measures in this study are taken from a generic cancer survey which describes experiences rather than outcomes. The components selected for analysis are common to all branches of practice including surgery. It would be helpful to have disease or organ-specific patient reported measures available as part of the dataset. This is of particular relevance to colorectal surgery, where surgery can have a life changing effect on bowel function, sexual function and cosmetic appearance. Although the patient experience measures do collect data on patient centred outcomes, more comprehensive assessments focussed on these domains would be preferred.

There are several strengths to this this study. WE used a wide selection of clinical and patient centred outcomes. The importance of using multiple outcome measures to assess quality has previously been described [18]. We used 90-day post-operative outcomes for mortality and readmission to both increase the power and sensitivity of our analysis and detect differences in care attributable to late complications or other factors influencing quality of care [19,20]. Furthermore, the large sample of this study in the setting of the English NHS increases the generalisability of this study to similar health systems across the world. Finally, we used patient reported experience measures to assess the effects of resource on perceived care. Patient satisfaction is a multi-factorial measure, which may relate to processes and interactions, as shown by previous assessments of satisfaction in surgical settings [21,22].

Future research with regards to resources for surgery should focus on translating interventions demonstrated to be effective in the research setting into routine clinical care, and measuring processes related to resource utilisation. An example of this may be laparoscopic surgery, which as this study suggestsmay deliver improvements in patient care. I. Policy makers should formulate an evidence-based minimum resource requirement for units performing colorectal surgery in order to provide cost-effective care, with a clear audit standard. We would encourage policy makers to take into account the findings of this study and use the average level of resource per unit population as a guide to informing future resource guidelines. Further cost-effectiveness modelling should be performed, particularly with regards to staffing levels.

The annual National Bowel Cancer Audit findings in 2015 demonstrated that almost half of patients underwent laparoscopic surgery for bowel cancer, improving post-operative mortality rates and shortening lengths of stay. Considerable regional variation in 2-year survival rates was observed by the national audit. Our study should be utilised by policymakers and departments across the UK to compare their resource levels to and identify whether this may be a factor in this observed variation.

Conclusion

In a centre level analysis, there is benefit associated with increased use of laparoscopy and a dedicated colorectal surgery ward, however, these findings should be treated with caution. Processes and efficient utilisation of resources are likely to have an equal effect on patient outcomes and should be studied in detail in future research.

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Table 1: CEPS questions

Question	
45	While you were in hospital did you ever think that the doctors or nurses were deliberately not telling you certain things that you wanted to know?
46	While you were in hospital, did it ever happen that one doctor or nurse said one thing about your condition or treatment, and another said something different?
47	While you were in hospital did the doctors and nurses ask you what name you prefer to be called by?
48	Were you given enough privacy when discussing your condition or treatment?
49	Were you given enough privacy when being examined or treated?
50	Were you able to discuss any worries or fears with staff during your hospital visit?
51	Do you think the hospital staff did everything they could to help control your pain?
52	Were you treated with respect and dignity by the doctors and nurses and other hospital staff?
53	Were you given clear written information about what you should or should not do after

	leaving hospital?
54	Did hospital staff tell you who to contact if you were worried about your condition or treatment after you left hospital?
70	Overall, how would you rate your care?

Cancer Patient Experience Survey, extracted from http://www.ncpes.co.uk/index.php/reports/guidance/2486-2015-national-cancer-patient-experience-survey-questionnaire/file

Table 2: Summary of centres and services

		Low (n=28)	Middle (n=22)	High (n=25)	p-value
Catchment population	Mean (SD)	308200 (106545)	440000 (160822)	491666 (134226)	<0.001
Approximate number of elective procedures per year	Mean (SD)	102 (28.7)	147.8 (7.2)	222.1 (63.7)	<0.001
Number of FTE Surgeons per 250,000 population	Mean (SD)	3.9 (1.9)	3.4 (1.4)	3.2 (0.8)	0.424
Number of HDU beds per 250,000 population	Mean (SD)	4.1 (4.3)	3.7 (4.6)	3.5 (4)	0.809
Number of ITU beds per 250,000 population	Mean (SD)	6 (4.5)	5.2 (4.6)	5.4 (5.1)	0.669
Number of patients admitted on emergency take	Mean (SD)	10.7 (3.6)	8.9 (2.8)	9.3 (4)	0.323
FTE nurse practitioners per 250,000 population	Mean (SD)	1.7 (1.5)	0.7 (0.9)	1.3 (1)	0.018
FTE stoma nurses per 250,000 population	Mean (SD)	1.9 (1.3)	1 (0.9)	1.3 (1)	0.099
How many patients per ward?	Mean	28.1 (8)	29.8 (13.7)	28.8 (11.2)	0.525

	(SD)				
Is the CEPOD theatre available 24 hours per day	No	7 (25.0)	2 (9.1)	4 (16.0)	0.634
	Yes	18 (64.3)	17 (77.3)	19 (76.0)	0.634
	Missing	3 (10.7)	3 (13.6)	2 (8.0)	0.634
When on-call, are surgeons free of elective commitments	No	0 (0.0)	1 (4.5)	1 (4.0)	0.802
	Yes	25 (89.3)	18 (81.8)	22 (88.0)	0.802
	Missing	3 (10.7)	3 (13.6)	2 (8.0)	0.802
Is there a dedicated colorectal ward	No	17 (60.7)	8 (36.4)	9 (36.0)	0.268
	Yes	8 (28.6)	11 (50.0)	14 (56.0)	0.268
	Missing	3 (10.7)	3 (13.6)	2 (8.0)	0.268

*FTE- Full time equivalent. Tests are Kruskal-Wallace, except where indicated by * for chi squared test. Data are n (%) for categorical variables.*

Table 3: Staffing by centre volume

		Low (n=28)	Middle (n=22)	High (n=25)	p-value
Number of FTE Surgeons per 250,000 population	Mean (SD)	3.9 (1.9)	3.4 (1.4)	3.2 (0.8)	0.424
Number of FTE stoma nurses per 250,000 population	Mean (SD)	1.9 (1.3)	1 (0.9)	1.3 (1)	0.099
Number of FTE nurse practitioners per 250,000 population	Mean (SD)	1.7 (1.5)	0.7 (0.9)	1.3 (1)	0.018
Number of FTE consultant oncologists that specialise in colorectal cancer per 250,000 population	Mean (SD)	1.6 (0.7)	1.4 (0.8)	1.4 (0.6)	0.629

FTE- Full time equivalent. All values are mean (standard deviation). Statistical tests are Kruskall-Wallis.

Table 4: Outcomes by centre volume

		Low (n=28)	Middle (n=22)	High (n=25)	p-value
HES adjusted 90 day mortality	Mean (SD)	5.2 (2.5)	5.8 (5.6)	5.2 (3.7)	0.644
Unplanned readmission within 90 days	Mean (SD)	20.1 (5)	21.4 (7.7)	21.2 (9.8)	0.848
Adjusted 18-month stoma rate using HES	Mean (SD)	49.4 (14)	50.8 (11.4)	49.3 (12.9)	0.734
Overall patient satisfaction	Mean (SD)	87.7 (5)	89.6 (3.5)	88 (4.1)	0.277

HES- Hospital Episode Statistics. Tests are Kruskal-Wallace. Data are %.

Figure 1- Factors associated with 90-day mortality rates

CEPOD- Confidential Enquiry into Patient Outcome and Death, FTE- Full time equivalent.

Factor		Risk ratio (95% CI)	P-value
Dedicated colorectal ward	No	1.00 (Reference)	-
	Yes	0.94 (0.71 to 1.26)	0.694
24 hours CEPOD theatre	No	1.00 (Reference)	-
	Yes	0.99 (0.70 to 1.45)	0.965
Laparoscopic surgery rate		0.89 (0.83 to 0.94)	<0.001
Number of patients in emergency take	(per 10% increase)	1.01 (0.98 to 1.03)	0.696
Daytime nursing staff		0.91 (0.77 to 1.06)	0.236
Night-time nursing staff		0.92 (0.76 to 1.09)	0.361
FTE surgeons per 250,000 population		1.07 (0.98 to 1.16)	0.099
Level 2 beds per 250,000 population		1.00 (0.97 to 1.04)	0.859
Level 3 beds per 250,000 population		1.01 (0.98 to 1.04)	0.444

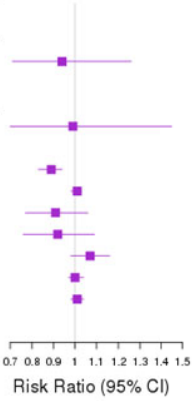

Figure 2- Factors associated with 90-day unplanned readmission

CEPOD- Confidential Enquiry into Patient Outcome and Death, FTE- Full time equivalent.

Factor		Risk ratio (95% CI)	P-value
Dedicated colorectal ward	No	1.00 (Reference)	-
	Yes	0.85 (0.73 to 0.99)	0.044
24 hours CEPOD theatre	No	1.00 (Reference)	-
	Yes	1.08 (0.87 to 1.35)	0.492
Laparoscopic surgery rate		0.94 (0.91 to 0.97)	<0.001
Number of patients in emergency take	(per 10% increase)	1.00 (0.98 to 1.01)	0.708
Daytime nursing staff		1.06 (0.96 to 1.16)	0.280
Night-time nursing staff		1.04 (0.93 to 1.16)	0.462
FTE surgeons per 250,000 population		0.99 (0.93 to 1.05)	0.752
Level 2 beds per 250,000 population		1.01 (0.99 to 1.03)	0.199
Level 3 beds per 250,000 population		1.01 (1.00 to 1.03)	0.153

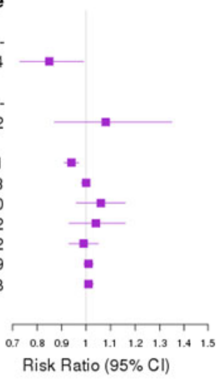

Figure 3- Factors associated with HES adjusted 18-month stoma rate

CEPOD- Confidential Enquiry into Patient Outcome and Death, FTE- Full time equivalent.

Factor		Risk ratio (95% CI)	P-value
Dedicated colorectal ward	No	1.00 (Reference)	-
	Yes	0.96 (0.85 to 1.10)	0.581
24 hours CEPOD theatre	No	1.00 (Reference)	-
	Yes	0.93 (0.79 to 1.10)	0.393
Laparoscopic surgery rate		0.97 (0.94 to 0.99)	0.016
Number of patients in emergency take	(per 10% increase)	1.00 (0.99 to 1.02)	0.444
Daytime nursing staff		1.03 (0.98 to 1.08)	0.245
Night-time nursing staff		1.02 (0.97 to 1.08)	0.468
FTE surgeons per 250,000 population		1.04 (1.00 to 1.08)	0.078
Level 2 beds per 250,000 population		1.01 (0.99 to 1.02)	0.396
Level 3 beds per 250,000 population		1.00 (0.99 to 1.01)	0.850

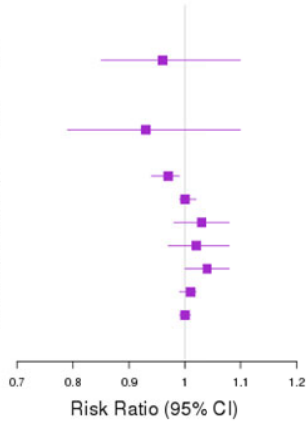

Figure 4- Factors associated with patient satisfaction

CEPOD- Confidential Enquiry into Patient Outcome and Death, FTE- Full time equivalent.

Factor		Risk ratio (95% CI)	P-value
Dedicated colorectal ward	No	1.00 (Reference)	-
	Yes	1.00 (0.98 to 1.03)	0.713
24 hours CEPOD theatre	No	1.00 (Reference)	-
	Yes	0.97 (0.94 to 1.00)	0.098
Laparoscopic surgery rate		1.00 (0.99 to 1.00)	0.184
Number of patients in emergency take	(per 10% increase)	1.00 (1.00 to 1.00)	0.222
Daytime nursing staff		0.99 (0.98 to 1.01)	0.343
Night-time nursing staff		0.99 (0.98 to 1.01)	0.391
FTE surgeons per 250,000 population		1.00 (1.00 to 1.01)	0.267
Level 2 beds per 250,000 population		1.00 (1.00 to 1.01)	0.118
Level 3 beds per 250,000 population		1.00 (1.00 to 1.00)	0.245