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**CENTRALISATION OF RADICAL CYSTECTOMIES FOR BLADDER CANCER IN ENGLAND, A DECADE ON FROM THE 'IMPROVING OUTCOMES GUIDANCE': THE CASE FOR SUPER CENTRALISATION**

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**Abstract:**

Objective: To analyse the impact of centralisation of radical cystectomy provision for bladder cancer in England, on post-operative mortality, length of stay, complications and re-intervention rate, from implementation of centralisation from 2002, until 2014.

In 2002, UK policymakers introduced the Improving Outcomes Guidance (IOG) for urological cancers after a global cancer surgery commission identified substantial shortcomings in provision of care of radical cystectomies. One key recommendation was centralisation of cystectomies to high output centres. No study has yet robustly analysed the changes since IOG, to assess a national healthcare system which has mature data on such institutional transformation.

Methods: Radical Cystectomies performed for bladder cancer in England between 2003/2004 and 2013/2014 were analysed from Hospital Episode Statistics (HES) data.

Outcomes including 30-day, 90-day, and one-year all-cause post-operative mortality, median length of stay, complications and re-interventions were calculated.

Multivariable statistical analysis was undertaken to describe the relationship between each surgeon and the providers' annual case volume and mortality.

Results: 15,292 cystectomies were identified. Percentage of cystectomies performed in discordance with IOG reduced from 65.0% to 12.4%, corresponding with improvement in 30-day mortality from 2.7% to 1.5% ( $p=0.0235$ ). Procedures adhering to IOG had

superior 30-day mortality (2.9% vs. 2.1%;  $p=0.0029$ ) to those which did not, and superior one-year mortality (25.6% vs. 21.5%;  $p<0.001$ ), length of stay (16 vs. 14days  $P<0.001$ ) and re- intervention rates (33.6% vs. 30.0%;  $p<0.001$ ). Each single extra surgery per centre reduced odds of death at 30 days by 1.5% (OR-0.985; 95%CI (0.977, 0.992) and 1% at one year (OR-0.990; 95%CI (0.988-0.993)), and significantly reduced rates of re-intervention.

Conclusion: Centralisation has been implemented across England since publication of the IOG in 2002. The improved outcomes shown, including that a single extra procedure per year per centre can significantly reduce mortality and re-intervention, may serve to offer healthcare planners an evidence base to propose new guidance for further optimisation of surgical provision, and hope for other healthcare systems that such widespread institutional change is achievable and positive.

## **INTRODUCTION**

In 2015, a global commission on cancer surgery identified substantial shortcomings in provision of care, and was able to provide several key areas for improvement (1). Amongst these was the importance of surgical volume, processes and outcomes for delivering safe and effective cancer surgery. Super-centralisation of surgical services was proposed as one possible solution.

There is an ongoing reconfiguration of cancer surgery services in the United Kingdom, in response to the NHS Cancer Plan and Improving Outcomes Guidance (IOG) released over a decade ago (2). One of the key recommendations of these guidelines was the centralisation of radical cystectomies (RCs) for bladder cancer to high-output centres. The IOG recommended that radical surgery for prostate and bladder cancer

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should be provided by teams serving populations of one million or more, and carrying out a cumulative total of at least 50 operations per annum. Surgeons carrying out small numbers of either operation (a total of five or fewer per annum) were advised to refer this work on to more specialised colleagues. The overall aim was to reduce 30-day mortality rate to 3.5% or less for all providers and surgeons performing RCs across the UK. Since these guidelines were published there has been a shift in the national distribution of RCs to high output centres (3).

The volume-outcome relationship for RCs has been previously described, indicating a consistent inverse association between increased surgical workload and outcomes including mortality and post-operative complications (4,5). The main body of evidence supports the centralisation process for RCs (6-11).

However, due to the complexity of this debate, doubts remain about a direct link between centralisation and improved outcomes. Furthermore, the methodological cogency of some of the published literature has also come under scrutiny (11-13).

The location and number of cystectomies performed in the NHS in England are all recorded in the Hospital Episode Statistics (HES) database, allowing the centralisation process to be tracked. HES also records patient demographics and other variables including post-operative complications. We reviewed the post-operative outcomes for RCs performed in England over the 11-year period following the introduction of IOG for urological cancers, to ascertain the nature and describe the impact of reconfiguration of RC provision.

## **MATERIALS AND METHODS**

### **Database inclusions and variable coding**

All adult patients aged 18 and over, resident in England undergoing a cystectomy with a diagnosis of bladder cancer with admission dates between 1st April 2003 and 31st March 2014 were included into the analysis. Cystectomies were identified using the Office of Population Censuses and Surveys Classification of Interventions and Procedures (OPCS-4) codes M34\*, and prostatectomies were ascertained using code M61\*. Bladder cancer was identified using the International Statistical Classification of Diseases and Related Health Problems tenth revision (ICD-10) code C67\*. We excluded all procedures where the total length of stay for the RC patient was two days or less and where there was no record of the patient dying in hospital.

The number of prostatectomies and cystectomies performed in each centre each year was also extracted. Procedures were identified as IOG guidance compliant if the centre where the surgery took place had conducted 50 or more prostatectomies and cystectomies; and if the operating surgeon had performed more than 5 of either type of surgery in that year.

### **Patient demographic variables**

Patient's age; gender; ethnicity; indices of multiple deprivation (IMD) 2007 score and Charlson co-morbidity score were extracted for each procedure. The Charlson score predicts one-year mortality for a patient who may have a range of co-morbidities, and is considered in three categories: 0, 1-4, and  $\geq 5$ . The IMD are an overall score of deprivation derived from seven domains; income, employment, health, education, training and skills, barriers to housing and services, crime and living environment. Scores were used in models as a continuous variable, but quintiles derived from these scores; classified from 1 (most deprived) to 5 (least deprived) were also used for categorical comparisons.

### **Outcome variables**

We ascertained 30-, 90-day, and one-year all-cause post-operative mortality. Deaths within 1 year are ascertained through linkage between HES records and the Office of National Statistics mortality data based on death certificates. Length of stay is the time (in days) spent in hospital during the primary admission for RC. Median length of stay (with interquartile range) is referred to in unadjusted analyses. Complications and re-interventions were calculated using the coding set out in Mayer et al (15).

### **Data exclusions**

Records in the HES database are for 'hospital episodes' which relate to a period of care for a patient under a single specialist. A stay in hospital can be made up of one or more episodes of care. For each RC, if no date of discharge was available on the episode, but was included in another episode within the same stay then that date of discharge was used. Records with no updateable discharge date were excluded, as it was not possible to calculate length of stay. If there was a date of death which occurred more than one day before the procedure, then the record was removed as it

is not possible to tell whether an error in data linkage has occurred. For those where the date of death occurred the day before the procedure and the HES record stated that the patient died during the stay then the length of time between operation and death was updated to zero days. Patients with no recorded age or sex were also removed from analyses as these two variables are always used in determining the patient ID along with NHS number. Patients whose region of residence was recorded as being outside of England, or where this information was not available were also removed from analysis as follow-up may have occurred elsewhere.

### **Univariable and multivariable analysis**

Categorical variables were tested for association with the 30-day and one-year outcome variables using the  $\chi^2$  test. Kaplan Meier survival curves were produced to examine survival over time. Multivariable mixed effects logistic regression was used to investigate 30-day death rates; complication rates; re-intervention rates and deaths within one year of the operation, adjusting for factors which may have an impact on outcome. To account for uncaptured differences at each hospital, a centre-level random effect was added when considering the effects of number of procedures per centre. Survival was modelled using Cox regression. For all regression models, continuous variables were fitted using suitable transformations, such as a log transformation of IMD and Charlson score, and a cubic spline for age. The multivariable models were first fitted with all variables; and then tested to see whether any variables could be excluded from the analyses.

Statistical analyses were carried out using R statistical package (version 3.0). A P-value of <0.05 was considered statistically significant in the analysis.

## RESULTS

### Centralisation

The study included 15,292 radical cystectomies; 11,793 (71.1%) in male patients, and 3,499 (22.9%) in females, with a median age of 69 years (IQR 62, 74). The majority of patients did not have a co-morbidity recorded (53.8%) and 16.0% came from the most deprived regions, according to IMD deprivation scores.

During the study period there was a clear trend toward centralisation of provision of RCs: the number of operations performed increased annually, and the number of urological surgeons and providers performing RCs reduced annually (**Figure 1**). The percentage of radical cystectomies performed by a provider in discordance with IOG guidelines reduced each year, from 52.7% in 2003 to 2.0% in 2013 (**Figure 2**). The percentage of radical cystectomies performed by a surgeon in discordance with IOG guidelines also reduced each year, from 29.9% in 2003 to 11.1% in 2013 (**Figure 2**). By 2013 the percentage of cystectomies being performed in discordance with IOG guidelines on provider or surgeon volume was 12.4%, a reduction from 60.7% in 2003 (**Figure 2**). Over the 11-year period there was a significant improvement in the overall 30-day crude mortality rate with a reduction from 2.7% to 1.5% ( $p=0.024$ ), and 90-day

crude mortality dropped from 7% to 4%. The number of providers performing at least fifty surgeries increased from 35(26.7%) in 2003 to 53(91.4%) in 2014.

During the study period, there were 4,547 cystectomies performed in discordance with the guidelines, compared to 10,745 in concordance (**Table 1**).

There were significant differences in characteristics between the two patient groups, with the compliant group having slightly older patients (compliant: median 69 years, IQR 62-74, non-compliant: median 68 years, IQR 61-74), and the proportion of patients over 70 years was 47.2%, compared with 43.4% in the non-compliant group ( $p<0.001$ ). The patients treated in the compliant group also had more co-morbidities (35.6% Charlson score 5+) compared to the non-compliant group (32.5% Charlson score 5+;  $p<0.001$ ). The outcomes for those cystectomies performed in concordance and discordance with IOG guidelines were directly compared (**Table 1, Figure 3**). The compliant group demonstrated significantly better 30-day mortality rates (2.1% vs. 2.9%;  $p=0.003$ ), 90-day mortality rates (5.2% vs. 7.2%;  $p<0.001$ ) one-year mortality rates (21.5% vs. 25.6%;  $p<0.001$ ), length of stay (14 vs. 16 days;  $P<0.001$ ) and re-intervention rates (30.0% vs. 33.6%;  $p<0.001$ ) compared to the non-compliant group (**Figure 3**).

After adjusting for age, co-morbidities, gender, deprivation, readmissions and re-interventions, people were more likely to die at 30-days (OR 1.41 (95% CI:1.13-1.76)), and at 1 year (OR 1.31 (95% CI (1.21, 1.43)) if they were in the non-compliant group compared to the compliant group. This pattern is continued if the IOG compliance variable was removed and just the adjusted number of procedures per centre is modelled, with each extra RC reducing the odds of death at 30-days by 1.5%(OR 0.985; 95% CI (0.977, 0.992) and 1% at one year (OR 0.990; 95% CI(0.988-0.993)).

After adjustment for confounders, there were no statistically significant differences in complication rates (OR 0.96, (95% CI 0.88, 1.04); but there was a difference in re-intervention rates, with the non-compliant group more likely to have a re-intervention (OR 1.20 (95% CI: 1.12-1.30)). Here, examining just the number of operations per centre, instead of looking at IOG compliance, showed that each additional procedure also had no significant effect on the complications rate, but significantly decreased the odds of re-intervention (OR 0.99, (95% CI 0.991 – 0.995)).

The compliant group also had an increased median survival time over the non-compliant group: 5.41 years (95% CI: 5.05-5.85) vs. 4.07 (95% CI: 3.69-4.50) (**Figure 3**). When censoring the data at 90 days, the non-compliant group have a median survival of 5.1 years, whereas those in the compliant survive 6.4 years (p<0.001).

Adjusting for age, co-morbidities, gender and deprivation, discordance with IOG increased the hazard of death (HR 1.17; 95% CI: 1.12- 1.23). Furthermore, the

incremental effect of increasing the number of procedures conducted by a provider by one significantly reduced the hazard of death (HR=0.993; 95% CI=0.992-0.995)

## **DISCUSSION**

To our knowledge, this is the largest UK study to date robustly assessing the process of centralisation of RC provision. A recent study by Hounsome et al has investigated outcomes after radical cystectomy since the introduction of IOG until 2010, but their analyses only provided circumstantial evidence as the comparison of outcomes between IOG compliant and non-compliant centres was not made (33). When analysing survival outcomes, they compare outcomes with nationally representative background rates making no comment on the impact on the effects of centralisation, and importantly, adjustment for important potential confounders, such as the changing age of the population during this time, amongst others, was not made. Our analyses are directly comparing the outcomes of patients undergoing operations from IOG compliant and non-compliant centres, with multivariable adjustment for several known confounders.

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Due to the complexity of IOG guidance, flexibility was originally given around implementation timescales, but it soon became apparent that local health economies had deferred action in favour of other priorities. This was addressed by employment of agreed milestones for health authorities after 2006, and our results demonstrate a clear and profound acceleration in centralisation of RCs provision after this date, which reaches a plateau after 2011 (Figure 2). This finding corroborates the Lancet Oncology Commission's suggestion of the importance of politics and policy in this area.

There has been a clear trend in centralisation since publication of IOG guidelines in 2002. The number of cystectomies has risen each year but number of providers and surgeons have dropped (Figure 1). In 2003/4 there were 290 surgeons and 135 providers, reducing to 199 surgeons and 60 providers by 2013-14 (Figure 1). Cystectomies in concordance with IOG since its publication have an improved 30-day and one-year mortality rate over those in discordance. Furthermore, median overall survival rates were significantly improved for guidance compliant procedures (5.41 years) over guidance non-compliant procedures (4.07 years).

The difference seen in survival outcomes in our study between compliant and non-compliant procedures is more marked than those described in previous studies in the UK (14-16). This disparity may well be as a result of the acceleration in centralisation noted after 2007. The last national study in England looking at outcomes of radical cystectomies with specific analysis of the impact of centralisation only analysed information up to 2007, just five years after IOG had been introduced, when 56.1% of cystectomies were still in discordance with IOG guidelines (Figure 2). By 2011-12, only 12.5% of cystectomies were in discordance with IOG guidance (Figure 2).

This study strengthens the link between high volume providers and improved outcomes, by including all surgeons and centres therefore analysing “real data”, but has not addressed how this is occurring. An exact cause-effect relationship is unlikely to be formulated, but the relationship is most probably multifactorial (17,18). There are numerous potential reasons for the superior outcomes seen. Firstly, high patient volumes have inherent benefits ranging from increased surgeon experience to improved numbers for audits, trials and research. A good example is robotic surgery which requires high numbers of patients per year to be cost-effective (19). High volume providers also often have additional services at their disposal which may improve perioperative selection of patients, allow for adoption of enhanced recovery pathways, provide additional treatments, improve treatment of post-operative complications and improve follow up and surveillance of patients (17). Furthermore, local access to specialist oncology and radiotherapy services at high volume centres may impact overall survival. Finally, having fewer hospitals performing a certain type of highly complicated intervention allows better regulation and provision of more uniform and consistent care.

There are an increasing number of radical cystectomies being performed each year even though the number of newly diagnosed bladder cancers is decreasing (20). As outcomes have improved more patients who are over 70 years or have serious co-morbidities are being considered suitable for surgery (21). The majority of this group of patients are being operated on at high volume providers by high volume surgeons (Table 1). Our finding that over the 11-year period crude 30- day

mortality has dropped from 2.7% to 1.5% is encouraging, but remains sub-optimal given previously described single-centre experiences of significantly better outcomes both in the UK and United States (22-24). However, a clear correlation between the process of centralisation in the last decade and improved survival post-cystectomy is shown in this paper. Indeed, when the adjusted number of procedures per centre was modelled, with each single extra surgery the odds of death significantly reduced at 30 days and at one year, as did re-intervention rates. This is a novel observation that has not yet been previously published.

Several papers have been critical of using the HES database due in part to coding errors (25). Potential sampling bias exists and there is the possibility that a very small number of patients with RCs were not captured. Furthermore, there will undeniably be an impact on our findings from hospital mergers and closures, although these would account for a very small proportion of our dataset. Nevertheless, a core limitation of this study is that it is a secondary analysis of administrative data, therefore misclassification bias may exist due to coding errors. We were not able to fully capture the outcomes of outpatient visits and records of potentially minor events. Our minor complication rates were therefore lower than that reported by single-institution series (26,27). Detailed oncological information, such as chemotherapy, stage and grade of MIBC was also not fully captured in this review.. England, unlike North America or other European countries is geographically very tight within a single health care service (NHSe). We recognise this as an assumption and therefore a potential limitation to the study.(28) However, the Cancer registry (ONS) suggests that region wide stage-specific variations

are uniform across England. Hence, we can presume that the disease characteristics between IOG compliant and non-compliant centres are also uniform.

Moreover, the retrospective nature of this analysis means that potential unmeasured confounders that can account for differences in outcomes such as smoking status (28), albumin levels (29,30), and outpatient management strategies will not be captured. Surgeon skill and experience is another potential uncaptured confounder, as the British Association of Urological Surgeons (BAUS) annual workforce reports at the beginning and end of the study period show the composition of the surgical workforce changed greatly.

In our methodology we have taken steps to minimise the impact of potential coding errors, and although coding errors are likely to have a bearing on our results we feel this will be negligible. The key search criteria of bladder cancer and cystectomy along with outcomes such as mortality and length of stay leave little space for interpretation. Furthermore, it is noteworthy that our analysis is of a population-based dataset and no statistical assumptions or weighting was necessary to achieve patient numbers, unlike some previous studies (31). Given the association between centralisation and improved outcomes in RCs over the last decade described in this paper, it would be logical to consider that continuation of the centralisation process could further enhance outcomes. This raises the question of the optimum number of centres and surgeons needed to achieve the most favourable outcomes and, whether a decade on from IOG, new guidance needs to be provided to optimise service reconfiguration.

Since the first volume-outcome relationships in medical care were reported by Luft et al in 1979 (32), there has been a persistent and sometimes emotional debate about whether certain sorts of complex, elective care should be restricted to high-volume medical centres. A decade ago IOG guidance set out to centralise surgical care for cancer as one method for improving cancer outcomes in the UK, yet a robust and up to date review of this process is lacking in the literature. Our group's analysis of cystectomies provides this information for just one cancer type, but goes some way to showing the impact of centralisation. We have demonstrated that the variance in outcomes between high and low volume surgeons and providers is more profound than that shown by any previous UK studies. We have also demonstrated a sudden and steep acceleration of the process of centralisation after 2007, indicative of the NHS Cancer Reform Strategy which sought to push for concordance with IOG; no studies have extensively analysed outcomes after this date. The effects of caseload levels for surgeons and providers proposed in this paper, including the fact that a single extra procedure per year per centre can significantly reduce mortality and re- intervention, may serve to offer healthcare planners an evidence base to propose new guidance for further optimisation of RC provision.

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**Table 1:** Comparison of characteristics between cystectomies which are compliant and those which are non-compliant with IOG guidance (all years: 2003/04 - 2013/14).

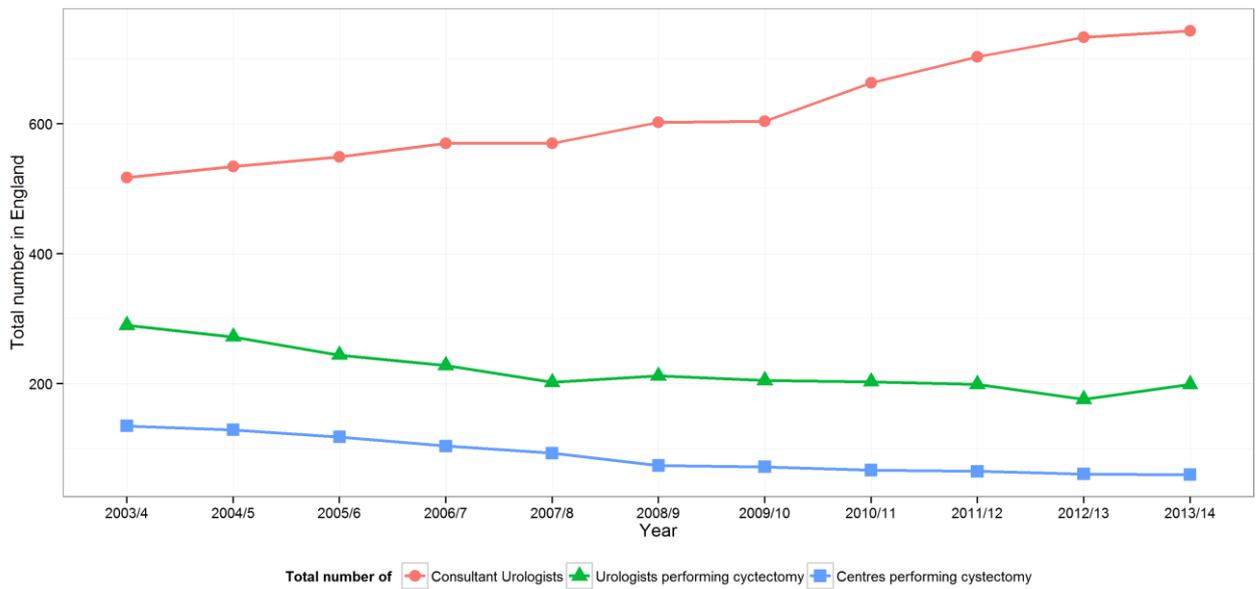
Characteristic		Not complying	Complying	Significance
Total number of cystectomies		4547	10745	-
Patient age (median, IQR)		68 (61 - 74)	69 (62 - 74)	P<0.001
Patient age >70 (n, %)		1,972 (43.4%)	5,075 (47.2%)	P<0.001
Patient gender: Male (n, %)		3,433 (75.5%)	8,360 (77.8%)	p = 0.002
Patient IMD quintile (n, %)	1 (most deprived)	796 (17.5%)	1,649 (15.3%)	P<0.001
	2	910 (20.0%)	1,928 (17.9%)	
	3	984 (19.7%)	2,353 (21.9%)	
	4	967 (21.3%)	2,398 (22.3%)	
	5 (least deprived)	796 (17.5%)	1,649 (15.3%)	
Patient Charlson co-morbidity score	0	2,626 (57.8%)	5,603 (52.1%)	P<0.001
	1-4	441 (9.7%)	1,319 (12.3%)	
	5+	1,480 (32.5%)	3,823 (35.6%)	
30 day mortality (n, %)		133 (2.9%)	227 (2.1%)	0.003
90 day mortality (n,%)		329 (7.2%)	564 (5.2%)	P<0.001
1 year mortality (n, %)		1,165 (25.6%)	2,306 (21.5%)	P<0.001
Length of stay (median, IQR)		16 (13, 23)	14 (11, 19)	P<0.001
Re-intervention required		1,526 (33.6%)	3,222 (30.0%)	P<0.001

(n, %)			
Median survival (years)	4.1	5.4	P<0.001

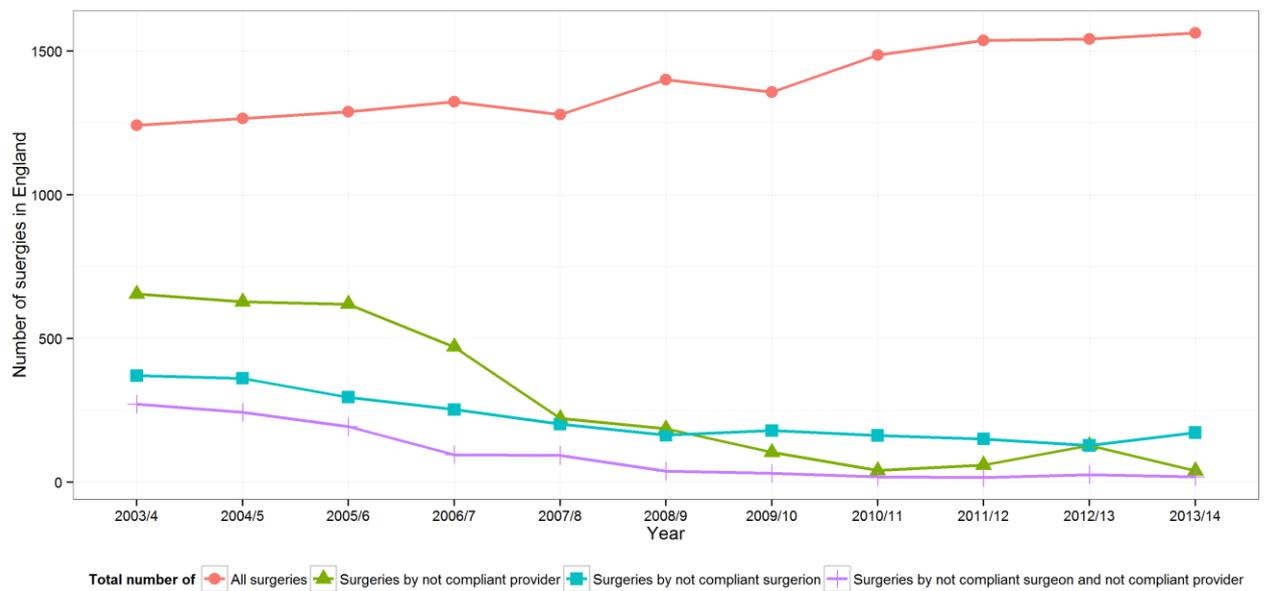
**Table 2** Results of multivariable mixed effects logistic regression.

	Mortality 30 days		Mortality 90 days		Mortality 1 year		Complications		Re-intervention	
	OR(95% CI)	P-Value								
Male (reference Group)	1		1		1		1		1	
Female	1.02 (0.79, 1.32)	0.8679	1.21 (1.03, 1.42)	0.0201	1.40 (1.28, 1.53)	<0.0001	0.98 (0.89, 1.06)	0.5679	1.05 (0.97, 1.14)	0.2210
log (IMD Score +1)	1.18 (1.01, 1.37)	0.0321	1.20 (1.09, 1.33)	0.0002	1.12 (1.06, 1.18)	<0.0001	1.07 (1.02, 1.12)	0.0111	1.00 (0.95, 1.05)	0.9340
log(Charlson + 2)	1.50 (1.34, 1.69)	<0.0001	1.48 (1.37, 1.59)	<0.0001	1.38 (1.32, 1.44)	<0.0001	1.42 (1.37, 1.48)	<0.0001	1.30 (1.25, 1.35)	<0.0001
Non-Compliant	1.41 (1.13, 1.76)	0.0022	1.46 (1.26, 1.69)	<0.0001	1.31 (1.21, 1.43)	<0.0001	1.00 (0.92, 1.08)	0.9946	1.20 (1.12, 1.30)	<0.0001
Readmitted	0.17 (0.10, 0.29)	<0.0001	1.59 (1.35, 1.86)	<0.0001	1.31 (1.19, 1.45)	<0.0001				
Reintervened	2.67 (2.15, 3.30)	<0.0001	2.29 (2.00, 2.63)	<0.0001	1.42 (1.31, 1.54)	<0.0001				

**Figure 1:** Number of providers, urologists and urologists performing cystectomies in England from 2003 until 2014. Clearly the crude number of urologists increases over time, whereas the number of those urologists performing cystectomies reduces, as do the number of centres performing cystectomies.



**Figure 2:** A comparison of the numbers of cystectomies performed in discordance with IOG guidelines in England from 2003 until 2014, and the number of cystectomies overall during this time. A clear trend can be seen for reducing number of discordant surgeons and centres, yet increasing numbers of cystectomies overall.



**Figure 3:** Kaplan Meier Survival graphs, comparing overall survival between IOG compliant and non-compliant centres. There is a better overall survival seen with patients treated at IOG compliant centres, as the Kaplan Meier curves separate early and stay separated.

