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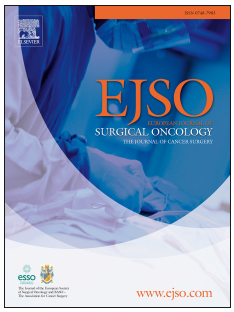

Changes in volume, clinical practice and outcome after reorganisation of oesophago-gastric cancer care in England: A longitudinal observational study

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Changes in volume, clinical practice and outcome after reorganisation of oesophago-gastric cancer care in England: A longitudinal observational study

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ABSTRACT

Aim: The centralisation of oesophago-gastric (O-G) cancer services in England was recommended in 2001, partly because of evidence for a volume-outcome effect for patients having surgery. This study investigated the changes in surgical services for O-G cancer and postoperative mortality since centralisation

Methods: Patients with O-G cancer who had an oesophageal or gastric resection between April 2003 and March 2014 were identified in the national Hospital Episodes Statistics database. We derived information on the number of NHS trusts performing surgery, their surgical volume, and the number of consultants operating. Postoperative mortality was measured at 30 days, 90 days and 1 year. Logistic regression was used to examine how surgical outcomes were related to patient characteristics and organisational variables.

Results: During this period, 29 205 patients underwent an oesophagectomy or gastrectomy. The number of NHS trusts performing surgery decreased from 113 in 2003-04 to 43 in 2013-14, and the median annual surgical volume in NHS trusts rose from 21 to 55 patients. The annual 30 day, 90 day and 1 year mortality decreased from 7.4%, 11.3% and 29.7% in 2003-04 to 2.5%, 4.6% and 19.8% in 2013-14, respectively. There was no evidence that high-risk patients were not undergoing surgery. Changes in NHS trust volume explained only a small proportion of the observed fall in mortality.

Conclusion: Centralisation of surgical services for O-G cancer in England has resulted in lower postoperative mortality. This cannot be explained by increased volume alone.

Key Words

Oesophageal, Gastric, Cancer, Centralisation, surgical outcomes

INTRODUCTION

In 2001, the UK Department of Health published guidance on the commissioning of health care for patients with oesophago-gastric (O-G) cancer [1]. It contained a number of recommendations that would require a major restructuring of NHS services. First, it recommended that cancer networks should be established, with specialist hospitals within each network responsible for performing curative surgery and specialist diagnostic tests (cancer centres). Other hospitals in the Network would continue to provide routine diagnostic investigations and palliative services (cancer units). Second, it recommended that clinicians from different specialties (eg, upper gastrointestinal surgeon, gastroenterologist, oncologist, radiologist, pathologist and clinical nurse specialist) should work together in multi-disciplinary teams, in order to improve the coordination of clinical management. The National Cancer Peer Review Programme was established in 2004 to monitor implementation of these organisation changes [2]. The National Oesophago-Gastric Cancer Audit has complemented this by assessing whether O-G cancer services meet the relevant standards of care as measured against various process and outcomes indicators [3].

One rationale for centralisation was the thought that expanding the volume and variety of cases treated in larger cancer centres would address apparent regional inequalities in life expectancy [1,4]. This was partly underpinned by an increasing number of international studies that showed a volume-outcome relationship in O-G cancer surgery [5-8]. Moreover, this relationship was observed across O-G cancer services in England between 2004 and 2008 by Coupland et al [9]. They reported that increasing hospital volume was strongly associated with lower postoperative mortality at 30 days.

This study was designed to investigate the changes in surgical activity and outcomes that have occurred over the eleven year period from April 2003 to March 2014. The reorganisation of O-G cancer services was still ongoing during 2004 and 2008 [10] and it is unclear how this might have influenced the results describing the period between 2003 and 2013. In addition, since 2001, there have also been many improvements in areas of diagnosis, pre-operative staging, peri-operative care, and the introduction of neoadjuvant and adjuvant oncology [11]. In this study, we examined trends in (i) the numbers of NHS trusts performing curative surgery, (ii) the median patient volume of these trusts, (iii) the number of consultants performing surgery, and how these might be associated with changes in postoperative mortality after surgical resection at 30 days, 90 days and 1 year.

METHODS

Data source

Data on the inpatient care received by patients with O-G cancer in English NHS trusts was obtained from Hospital Episodes Statistics (HES), a hospital administrative database that contains records on all same day and overnight admissions to English NHS acute trusts. Clinical information is captured using the International Classification of Disease (ICD-10) diagnostic codes and the Classification of Surgical Operations and Procedures (OPCS-4), but it lacks specific information about tumour characteristics (such as pathological stage) and cancer care (such as date of diagnosis). Records for the same individual are allocated the same anonymised identifier, which allows treatment pathways to be followed over time.

Patient cohort and characteristics

We identified all patients (aged 18 years and over) diagnosed with oesophageal or stomach cancer (ICD-10: C15 and C16) between 1 April 2003 and 31 March 2014, taking the first instance of these codes as the date of diagnosis. Variables were defined for patient age at diagnosis, sex, tumour type (oesophageal / stomach), and number of comorbidities. Comorbidities were identified using the RCS Charlson score [12], which covers 14 conditions known to be associated with the risk of postoperative mortality (the score includes categories for malignancy and metastatic tumours, and these were excluded when calculating the score in this study). Patients were labelled as having 0, 1, 2, and 3 or more comorbidities. A variable for socioeconomic deprivation was also defined using the 2004 Index of Multiple deprivation (IMD) [13]. We categorised the IMD score into ordered quintiles, with the first and fifth quintiles corresponding to the least and most deprived, respectively.

Services and treatments at NHS hospitals

Patients were flagged as having curative surgery if they underwent either oesophagectomy or gastrectomy (OPCS codes: G01, G02, G03-oseophageal resections; G27, G28-gastric resections). We flagged an NHS trust as performing curative surgery if it had performed more than five procedures in a financial year (April-March). Individual consultants were identified using the anonymised consultant code, and were counted as part of the O-G surgical team within an NHS trust if they had performed at least one operation in a year. The consultant codes were available from the 2005-06 financial year. Surgical volume at NHS trust and consultant level was defined as the total number of procedures performed in the financial year.

Over the study period, there was an increase in the combination of neoadjuvant chemotherapy and radiotherapy with surgery. As inpatient HES records do not capture information about the provision of chemo/radiotherapy reliably, we used the time from diagnosis to surgery as a proxy marker for a patient having neoadjuvant therapy (Appendix, Figure A). If the time from diagnosis to surgery was greater than 100 days, a patient was flagged as having neoadjuvant therapy and surgery; otherwise, they were flagged as having surgery alone.

Outcome variables

The primary outcomes were postoperative mortality at 30 days, 90 days or 1 year and was calculated for each patient as the difference between the date of operation and date of death. The date of death was obtained from the Office for National Statistics Death Register, with patients identified using the same anonymised HESID used within the HES database. Dates of death were available until 16 October 2016, hence all patients had a minimum of 1 year follow up information . Length of postoperative hospital stay was defined as a secondary outcome and calculated as the difference between operation date and the discharge date.

Statistical analysis

For each financial year, we derived the number of NHS trusts undertaking curative surgery, the number of consultants per NHS trust performing surgery, the annual number of operations performed at a trust, and the number of patients having surgery. The financial years were labelled as the year in which they begin.

Patient characteristics were described using proportions, with continuous variables being categorised to show the skewness of the distributions. The analysis was undertaken using year of operation. We grouped the data into periods for presentation only. The association between year of operation and categorical variables were assessed using chi-squared tests, and the association between year of operation and continuous variables were assessed using linear regression where the year of operation was defined as a linear term.

Logistic regression models were used to examine the association between postoperative mortality (at 30 day, 90 day and 1 year), trust volume, and patient variables (age, sex, type of cancer, comorbidities, social deprivation, and whether or not a patient was flagged as having neoadjuvant therapy). Estimates were derived with robust standard errors to account for the clustering of patients within NHS trusts.

Adjusted mortality rates for each financial year were derived by dividing the observed deaths by the number expected multiplied by the mean rate over the study period. A predicted risk of death for each patient was derived from multivariable logistic regression models and summed up for each year to create the expected number [14]. All statistical tests were two-sided, with p-values of less than 0.05 indicating a significant result. The analyses were performed using STATA® version 14 (StataCorp, College Station, Texas, USA).

RESULTS

Changes in trust and consultant volumes

Between financial years 2003-04 and 2013-14, a total of 139 724 patients were diagnosed with O-G cancer in English NHS trusts. Of these, 29 205 patients (20.9%) had an oesophagectomy or gastrectomy. The number of operations per year typically fluctuated between 2500 and 2900, with no obvious change in overall annual surgical activity. However, there was a steady decline in the number of NHS trusts performing curative surgery and an increase in the median volume of patients having surgery at NHS trusts as the process of centralisation was rolled out (Figure 1). In 2003-04, there were 113 NHS trusts performing surgery, which had declined to 43 in 2013-14. There was a corresponding increase in median annual surgical volume at NHS trusts over this period (from 21 in 2003-04 to 55 in 2013-14), with the principal period of change occurring between financial years 2006-07 and 2010-11 (see Figure 1). The impact of these changes for patients is illustrated in Figure B (Appendix). In 2003-04, around 40% of patients had their procedure at a cancer centre with an annual activity at least 40 cases; in 20013-14, over 85% of patients had their procedure at a cancer centre with at least this volume, and 32% of patients had surgery at a centre with an annual volume above 80.

Although the cancer centres more than doubled their median numbers of operations over the 11 year period, there was less change in the annual case volumes among consultants. The median increased from 11 in 2005-06 to 14 in 2013-14, which reflected the increase in the number of consultant surgeons working within each NHS trust. In 2005-06, 44.1% centres (41/93) had teams of two surgeons, but by 2013-14, 88.4% centres trusts (38/43) had three or more surgeons (see Table 1 in Appendix for full details).

Outcomes in length of stay and postoperative mortality

The unadjusted rates of 30 day, 90 day, and 1 year postoperative mortality for operations performed each financial year are shown in Figure 2. Our results show that both 30 day and 90 day, mortality decreased significantly, from 7.4% and 11.3 % in 2003-04 to 2.5% and 4.6% in 2013-14, respectively. One year mortality decreased from 29.7% to 19.8%. A sensitivity analysis using segmented regression did not find statistical evidence for any changes in the speed of decline over the study period for the three mortality rates (results not shown).

Over the same time period, there was also a small reduction in the average postoperative length of stay, with the mean (SD) falling from 16.9 (12.3) days in 2003-04 to 14.8 (12.2) days in 2013-14 (p-value <0.001).

Profile of patient characteristics

Table 1 shows the characteristics of patients who had curative surgery over the study period.

For both oesophageal and gastric cancer patients, patients undergoing surgery as a proportion of all patients diagnosed decreased with increasing age and was lower among women compared to men (Table 1). Although the quality of coding of co-morbidities has improved with time, there is no evidence to suggest that patients with more co-morbidities were less likely to have surgery.

The change in the organisation of surgery did not appear to have resulted in large changes in the characteristics of patients being selected for surgery (Table 1). Over time, the proportions of patients having surgery remained stable across the age categories, by gender, and for increasing numbers of comorbidities. The distribution of surgical patients with oesophageal tumours across the deprivation quintiles was also little changed.

Relationship between outcomes and other factors

Table 2 shows the odds ratios for the annual change in mortality, relative to the baseline of 2003/04 for 30 day, 90 day and 1 year mortality. The table describes the effect of, first, adjusting for patient characteristics (partial model) and, second, adjusting for patient characteristics, trust volume and time to surgery (complete model). In the models for all three

outcomes, higher mortality was associated with increasing age, oesophageal tumours (compared to stomach), and increasing number of comorbidities. In the complete model, an increase in 5 cases was associated with lower 30 and 90 day mortality (adjusted OR = 0.97 and 0.98, respectively) but not with 1-year mortality (adjusted OR = 1.0). The adjustment for these factors, however, did not explain much of the downward trend in mortality. Year on year, there was still an 11% reduction in 30 day mortality, 10% reduction in 90 day mortality and 6% reduction in 1 year mortality. This can be seen in Figure 3, which shows the adjusted 90 day mortality rate (patient characteristics only-partially adjusted model) alongside the 90 day mortality rate adjusted for patient characteristics, time to surgery and NHS trust volume (fully adjusted model) . A similar pattern was seen with adjusted graphs of 30 day and 1 year mortality.

DISCUSSION

This study investigated the changes in NHS trust volume, consultant numbers, and clinical practice since the policy of centralisation was introduced in England, and how these might be related to patterns of postoperative mortality after curative O-G cancer surgery over this period. The number of NHS trusts performing surgical resections has reduced by more than half. There has been a corresponding increase in surgical volume within NHS trusts, and this has led to a large increase in the proportion of patients having their surgery in large-volume centres. This greater volume has been achieved by a rise in the number of consultants working within NHS trusts. Additional surgeons were employed by the cancer centres to share in the specialist upper GI rota needed to provide 24 hours a day care, 365 days of the year for these patients. A consequence of this was that there was only a small rise in the number of procedures performed by consultants each year. The observed data on consultant volume suggests that only half of the current surgeons meet the minimum volumes (15-20) as recommended by the Association of Upper Gastrointestinal Surgeons of Great Britain and Ireland (AUGIS) [15].

Our results show that postoperative mortality has improved markedly since centralisation began. The annual 30 day, 90 day and 1 year mortality decreased from 7.4%, 11.3% and 29.7% in 2003-04 to 2.5%, 4.6% and 19.8 % in 2013-14, respectively. The improvements were seen in both oesophageal cancer and gastric cancer when analysed separately (results not shown.) This improvement did not appear to be linked to the selection of healthier cases, as

the age profile of patients did not change noticeably from 2003-04 to 2013-14 and there was no evidence that patients who underwent surgery had less comorbid disease. The statistical analysis found a weak association between the change in short-term postoperative mortality and NHS trust volume. However, this was unable to explain all of the observed improvements in outcome.

Previous work and what our study adds

Our results show that the period of centralisation of O-G cancer surgery has achieved the desired outcome of higher surgical volumes in NHS trusts, and that the NHS is now delivering better patient outcomes. Studies done at the local level in the UK support these high level findings but, like this study, they have been unable to disentangle the complex relationships between changes in hospital and surgeon volume, improvements in medical care (oncological treatments, staging and advances in intensive care) and patient outcomes. In relation to the process of care, the surgical centralisation of O-G cancer services in South East Wales was reported to result in a manageable workload that offered a substantial increase in cancer-related operative training opportunities [16]. Another study from Wales showed that oesophageal cancer patients treated by multi-disciplinary teams experienced a lower post-operative mortality than control patients, and were more likely to survive 5 years ($p<0.001$) [17]. An organisational survey on the progress due to centralisation has shown that targets of minimum staffing levels have been achieved and the use of formal assessment of nutritional needs has improved [18]. In relation to the outcomes of surgery, a study examining the effect centralisation on O-G cancer services in Gloucester reported improvement in the median survival time and substantial reductions in 30 day post-operative mortality from 10.3% pre-centralisation to 3.6% post-centralisation ($p = 0.006$) [19]. Experiences from abroad have been similar. Work conducted in the Netherlands demonstrate comparable improvements to those observed in our study [20].

Strengths and Limitations

The main strength of the study comes from its comprehensive coverage of all English NHS acute trusts. Its principal limitations arise from the use of routine administrative hospital data. First, HES lacked cancer-related clinical information such as the date of cancer diagnosis. We used the admission date of the first O-G cancer related admission as a proxy for the date of diagnosis. This will introduce some error in the time from diagnosis to surgery but it is

regarded as a robust method of approximation. Second, the estimates of surgical volume rely on the accurate coding of oesophageal and gastric resections. However, work comparing records of O-G cancer patients in HES and the National O-G cancer audit found excellent levels of agreement in use of the appropriate OPCS procedure codes for O-G surgical resection [21]. As a result, we expect the overall effect of coding errors to be small.

Third, the HES database does not contain data on patient characteristics that could influence their postoperative outcome such as histology, stage of disease, and frailty [22]. The omission of these factors from the risk adjustment model could have reduced its explanatory power, but there is no evidence for these characteristics having changed greatly over study period. Consequently, it seems this is unlikely to account for the observed changes in postoperative mortality over time.

Finally, HES does not capture many of the changes in the organisation of services that could have had an impact on outcomes such as the involvement of multi-disciplinary team (MDT) meetings. Care under professionals with specialised knowledge and surgical expertise could have led to better tailored treatments. Furthermore, dedicated perioperative support, specialist support nurses and palliative care services might have led to better outcomes for patients [23].

Conclusion

The results of this study reveal the large change in the delivery of curative surgery to patients with O-G cancer between April 2003 and March 2014. The large decrease in the number of NHS trusts performing surgical resections that resulted from the centralisation process shows that its aim of increasing the median NHS trust volumes was achieved. The study also shows that a substantial reduction in postoperative mortality was also achieved over this time.

From the steady decrease in mortality over the study period, we might expect improvements in patient survival to have continued since March 2014. There is some evidence that this has occurred, with the National O-G Cancer Audit reporting that the postoperative mortality rate at 90 days for patients diagnosed between April 2014 and March 2016 was 3.3% and 3.1% for oesophagectomy and gastrectomy, respectively [24]. The precise reasons for these historical trends are unclear, however. The process of centralisation has continued in some regions of England since 2014 (notably, the London and Manchester areas), but at a national level, the amount of organisational change has slowed. It is important to identify the reasons for these historical changes in outcome so that services can use them as building blocks for further improvements.

Conflict of interest:

The authors declare that they have no competing interests.

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REFERENCES

1. Department of Health. Guidance on Commissioning Cancer Services: Improving Outcomes in Upper Gastro-Intestinal Cancers: The Manual. London: Her Majesty's Stationary Office, 2001.

2. Department of Health. The National Cancer Manual: Upper GI specific measures. London: Her Majesty's Stationary Office, 2004

3. National Oesophago-Gastric Cancer Audit. http://www.digital.nhs.uk/og (accessed October 2017)

4. Department of Health. Cancer Reform Strategy. Her Majesty's Stationary Office. London. 2007.

5. Begg CB, Cramer LD, Hoskins WJ, Brennan MF. Impact of hospital volume on operative mortality for major cancer surgery. JAMA. 1998; 280(20): 1747-51.

6. Finlayson EV, Goodney PP, Birkmeyer JD. Hospital volume and operative mortality in cancer surgery: a national study. Arch Surg. 2003; 138(7): 721-5; discussion 6.

7. Rouvelas I, Jia C, Viklund P, Lindblad M, Lagergren J.Surgeon volume and postoperative mortality after oesophagectomy for cancer. Eur J Surg Oncol. 2007; 33(2): 162-8.

8. Gruen RL, Pitt V, Green S, Parkhill A, Campbell D, Jolley D. The effect of provider case volume on cancer mortality: systematic review and meta-analysis. CA Cancer J Clin. 2009; 59(3): 192-211.

9. Coupland VH, Lagergren J, Lüchtenborg M, et al . Hospital volume, proportion resected and mortality from oesophageal and gastric cancer: a population-based study in England, 2004-2008. GUT 2013; 62(7): 961-6.

10. Palser TR, Cromwell DA, Hardwick RH,et al . Re-organisation of oesophago-gastric cancer care in England: progress and remaining challenges. BMC Health Serv Res. 2009; 9: 204.

11. Allum WH, Blazeby JM, Griffin SM, et al . Guidelines for the management of oesophageal and gastric cancer. GUT 2011; 60(11): 1449-72.

12. Armitage JN, van der Meulen JH. Identifying co-morbidity in surgical patients using administrative data with the Royal College of Surgeons Charlson Score. Br J Surg. 2010; 97(5): 772-81.

13. The English Indices of Deprivation 2004. https://www.gov.uk/government/collections/english-indices-of-deprivation .(accessed November 2015)

14. Spiegelhalter DJ. Funnel plots for comparing institutional performance. Stat Med 2005; 24(8): 1185-202.

15. Association of Upper Gastrointestinal Surgeons of Great Britain and Ireland (AUGIS) (2010). Guidance on minimum surgeon volumes. http://wwwaugisorg/wp-Content/uploads/2014/05/AUGIS_recommendations_on_Minimum_Volumespdf. (accessed November 2015)

16. Morgan MA, Goodson M, Escofet X, Clark GW, Lewis WG. Workload and resource implications of upper gastrointestinal cancer surgical centralisation in South East Wales. Annals of the Royal College of Surgeons of England. 2008;90(6):467-71. Epub 2008/09/04.(accessed 16 October 2015)

17. Stephens MR, Lewis WG, Brewster AE, et al. Multidisciplinary team management is associated with improved outcomes after surgery for esophageal cancer. Diseases of the esophagus : official journal of the International Society for Diseases of the Esophagus / ISDE. 2006;19(3):164-71. Epub 2006/05/26.(accessed 16 October 2015)

18. Groene O, Chadwick G, Riley S, et al. Re-organisation of oesophago-gastric cancer services in England and Wales: a follow-up assessment of progress and remaining challenges. BMC research notes. 2014;7:24. Epub 2014/01/11.(accessed 16 October 2015)

19. Boddy AP, Williamson JM, Vipond MN. The effect of centralisation on the outcomes of oesophagogastric surgery--a fifteen year audit. Int J Surg. 2012;10(7):360-3. Epub 2012/06/05.(accessed 5 September 2015)

20. Wouters MW, Karim-Kos HE, le Cessie S, et al. Centralization of esophageal cancer surgery: does it improve clinical outcome? Annals of surgical oncology. 2009;16(7):1789-98. Epub 2009/04/17.(accessed 5 September 2015)

21. National Oesophago- Gastric Cancer Audit. Annual Report 2010. http:// https://digital.nhs.uk/catalogue/PUB02758 (accessed November 2017)

22. Fischer C, Lingsma H, Hardwick R, Cromwell DA, Steyerberg E, Groene O. Risk adjustment models for short-term outcomes after surgical resection for oesophagogastric cancer. Br J Surg. 2016 Jan;103(1):105-16

23. Woo YL, Kyrgiou M, Bryant A, Everett T, Dickinson HQ. Centralisation of services for gynaecological cancer. The Cochrane database of systematic reviews. 2012;3:CD007945. Epub 2012/03/16.(accessed 8 October)

24. National Oesophago- Gastric Cancer Audit. Annual Report 2017. (In press)

FIGURE LEGENDS

Figure 1: Annual numbers of trusts performing surgery and corresponding median volume of patients in the trusts at the national level between 2003 and 2014. Procedures are grouped by financial year (2003 = April 2003 – March 2004).

Figure 2: Unadjusted rates of 30 day, 90 day and 1 year postoperative mortality between April 2003 and March 2014. Procedures are grouped by financial year (April – March) and are shown with 95% confidence intervals

Figure 3: Partially and fully adjusted annual postoperative 90-day mortality for patients with oesophago-gastric cancer having curative surgery between April 2003 and March 2014. Procedures are grouped by financial year (April – March)

Table 1: Characteristics of patients having surgery, as proportion of all patients diagnosed, by time period

	Apr2003-Mar 2005		Apr2005-Mar 2008		Apr2008-Mar 2011		Apr 2011-Mar 2014	
Oesophaeal tumours (C15)								
No of patients	3316	20.6%	4944	19.6%	5103	19.97%	5136	19.8%
Age group								
Under 60	1007	32.5%	1470	31.1%	1449	31.25%	1274	29.5%
60 to 69	1189	30.3%	1915	29.3%	2006	30.18%	2034	28.3%
70 to 79	1007	19.6%	1395	17.9%	1471	19.03%	1609	21.1%
80 and over	112	2.9%	163	2.6%	173	2.71%	209	3.2%
missing	1	4.5%	1	4.0%	4	2.60%	10	4.9%
Gender N(%), male	2534	23.6%	3766	22.2%	3975	22.55%	4026	22.3%
Female	782	14.6%	1178	14.2%	1127	14.20%	1110	15.8%
Missing	0	0.0%	0	0.0%	1	9.09%	0	0.0%
Deprivation N(%)								
1 (Least)	646	22.4%	977	21.3%	1005	21.95%	1097	22.0%
2	690	21.6%	1115	22.0%	1153	21.67%	1153	21.8%
3	689	20.5%	1028	19.6%	1100	20.88%	1049	19.6%
4	610	19.1%	950	18.9%	957	19.06%	951	18.8%
5 (Most)	618	19.4%	775	15.9%	849	17.50%	833	18.0%
missing	63	21.6%	99	20.2%	39	7.65%	53	8.4%
Co-morbidities N (%)								
0	2402	18.9%	3321	17.4%	2996	16.90%	2745	16.8%
1	752	29.1%	1246	26.9%	1590	28.61%	1725	26.5%
2	142	22.3%	290	25.0%	406	24.68%	514	23.3%
3 or more	20	10.9%	87	21.6%	111	17.99%	152	16.9%
Stomach tumours (C16)								
No of patients	2329	25.1%	3065	22.5%	2810	22.2%	2502	22.2%
Age group								
Under 60	361	29.5%	544	28.5%	550	29.7%	453	27.2%
60 to 69	613	32.4%	751	28.7%	673	29.6%	609	29.7%
70 to 79	960	29.4%	1289	26.7%	1129	26.0%	1045	27.8%
80 and over	393	13.7%	479	11.3%	454	11.0%	394	10.4%
missing	2	15.4%	2	9.1%	4	11.1%	1	4.0%
Gender N(%), male	1473	26.3%	1952	23.3%	1793	23.3%	1600	23.0%
Female	856	23.3%	1113	21.3%	1017	20.6%	902	20.8%
missing	0		0	0.0%	0	0.0%	0	0.0%
Deprivation N(%)								
1 (Least)	293	22.4%	453	22.6%	474	23.8%	457	25.2%
2	414	25.6%	561	22.9%	506	21.6%	478	22.5%
3	455	24.8%	603	22.6%	579	23.0%	494	22.8%
4	514	25.6%	652	22.2%	578	22.4%	487	20.9%
5 (Most)	632	26.7%	762	23.0%	651	21.8%	564	22.0%
missing	21	16.7%	34	13.3%	22	10.3%	22	7.6%
Co-morbidities N (%)								
0	1595	23.5%	1936	20.4%	1580	20.2%	1247	19.6%
1	544	29.9%	817	27.3%	866	26.4%	815	26.2%
2	148	30.6%	233	27.3%	268	24.8%	316	25.9%
3 or more	42	23.0%	79	27.3%	96	20.6%	124	20.7%

Table 2: Adjusted odds ratios for annual changes in the postoperative outcomes between April 2003 and March 2014, after accounting for patient characteristics and changes in the organisation of services.

Surgical outcome	**Unadjusted OR (95% CI) for average annual changes**	**OR (95% CI) after adjusting for patient characteristics**	**OR (95% CI) after adjusting for patient characteristics, trust volume and time to surgery**
30 day mortality	0.89 (0.87,0.91)[a]	0.87 (0.85,0.89)[a]	0.89 (0.87,0.91)[a]
90 day mortality	0.90 (0.89,0.92)[a]	0.89 (0.87,0.90)[a]	0.90 (0.89,0.92)[a]
1 year mortality	0.94 (0.93,0.95)[a]	0.93 (0.92,0.94)[a]	0.94 (0.92,0.95)[a]

[a] $p<0.001$

Figure 1: Annual numbers of English NHS trusts performing surgery and the median volume of patients per trust between 1 April 2003 and 31 March 2014. Procedures are grouped by financial year (2003 = April 2003 – March 2004).

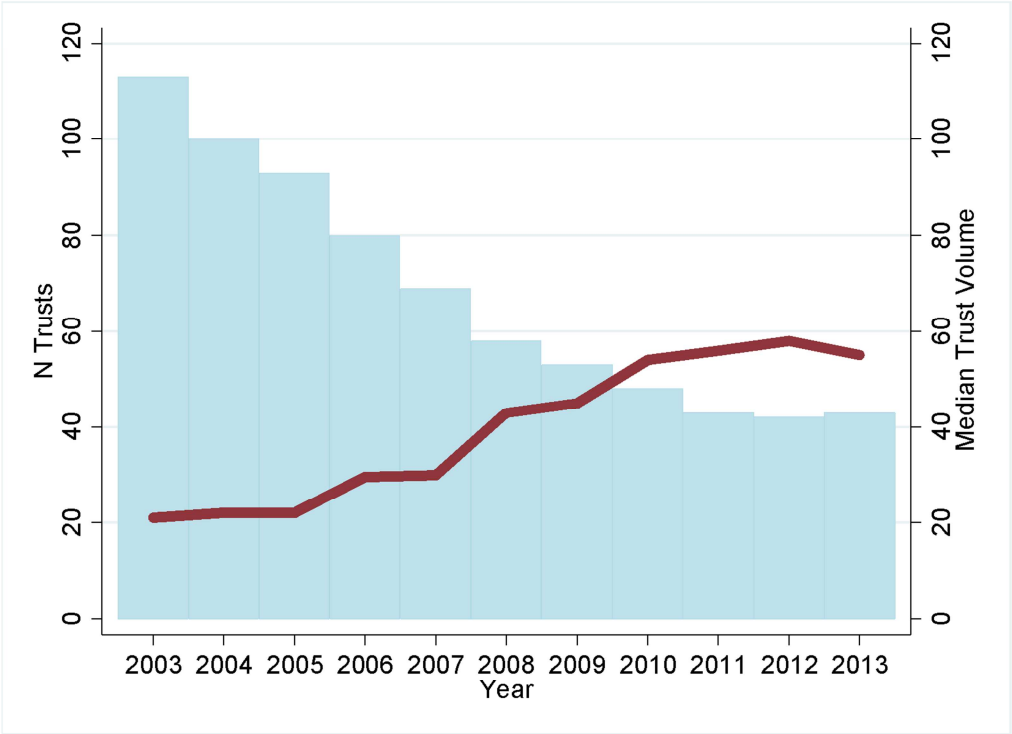


Figure 2: Unadjusted rates of 30 day, 90 day and 1 year postoperative mortality between April 2003 and March 2014. Procedures are grouped by financial year (April – March) and are shown with 95% confidence intervals.

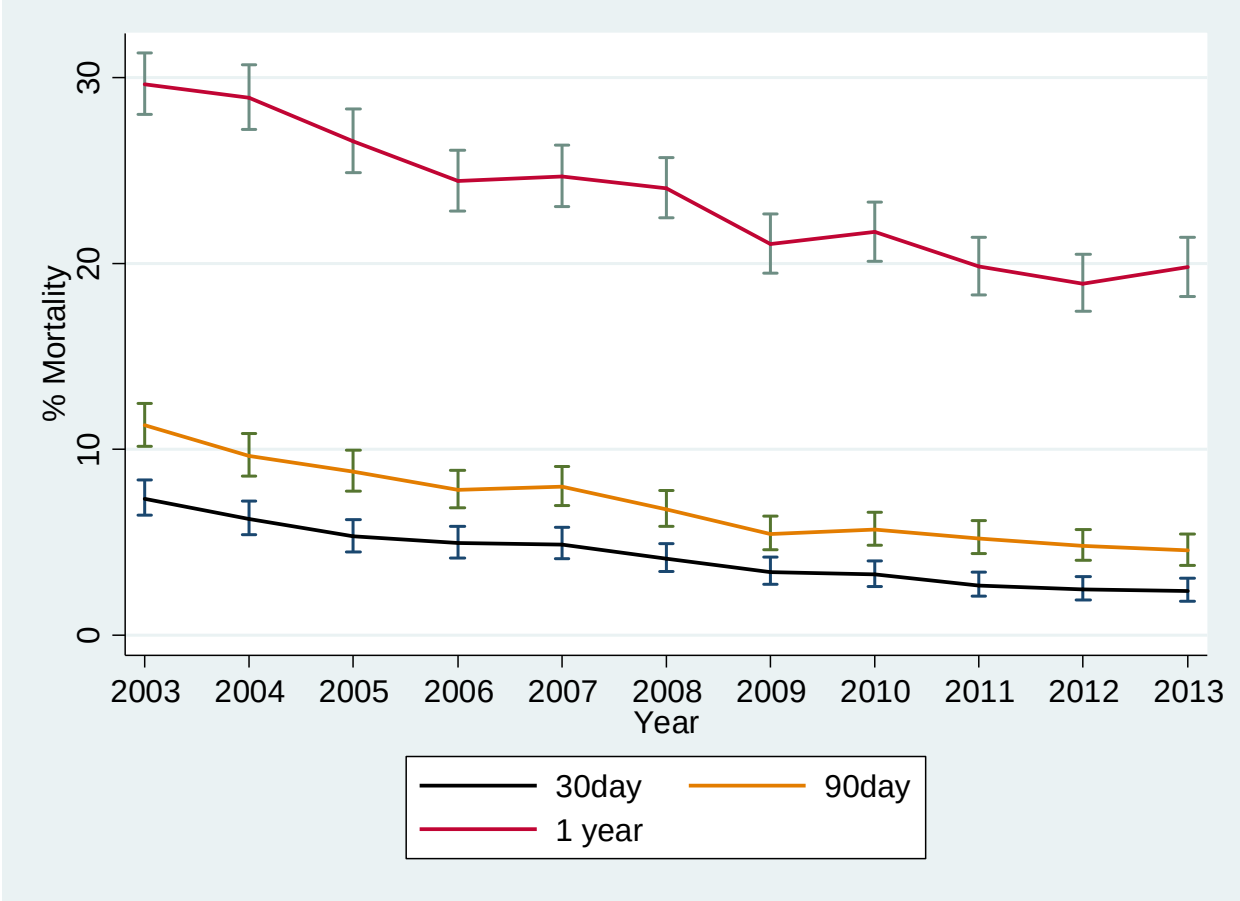
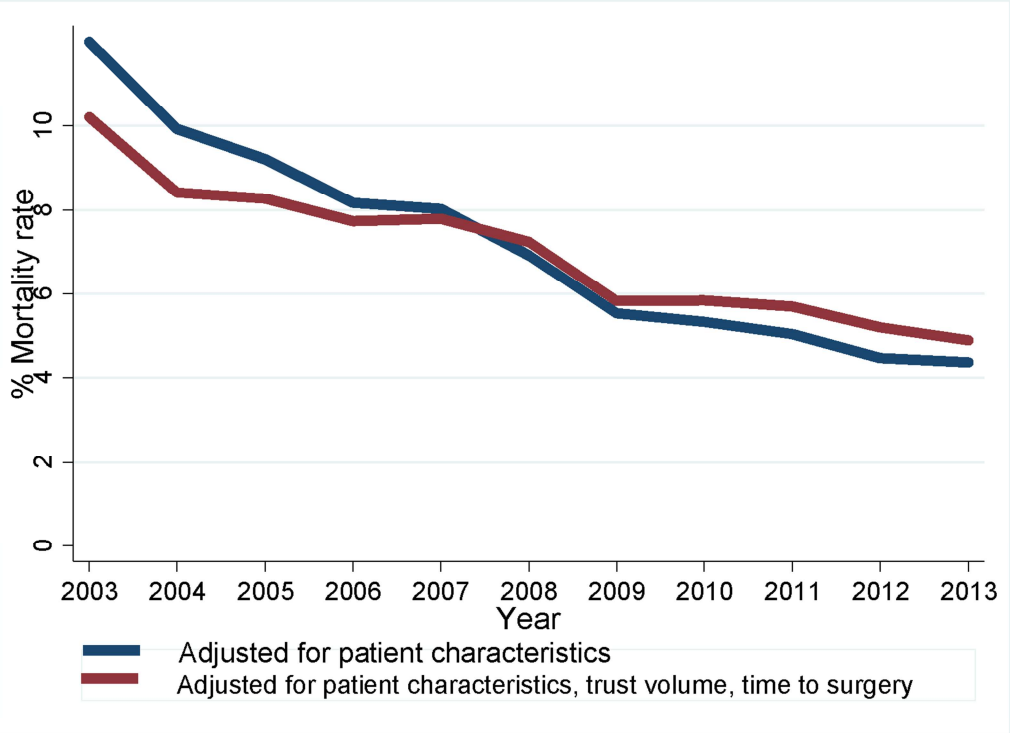


Figure 3: Partially and fully adjusted annual postoperative 90-day mortality for patients with oesophago-gastric cancer having curative e surgery between April 2003 and March 2014. Procedures are grouped by financial year (April – March)



Appendix :

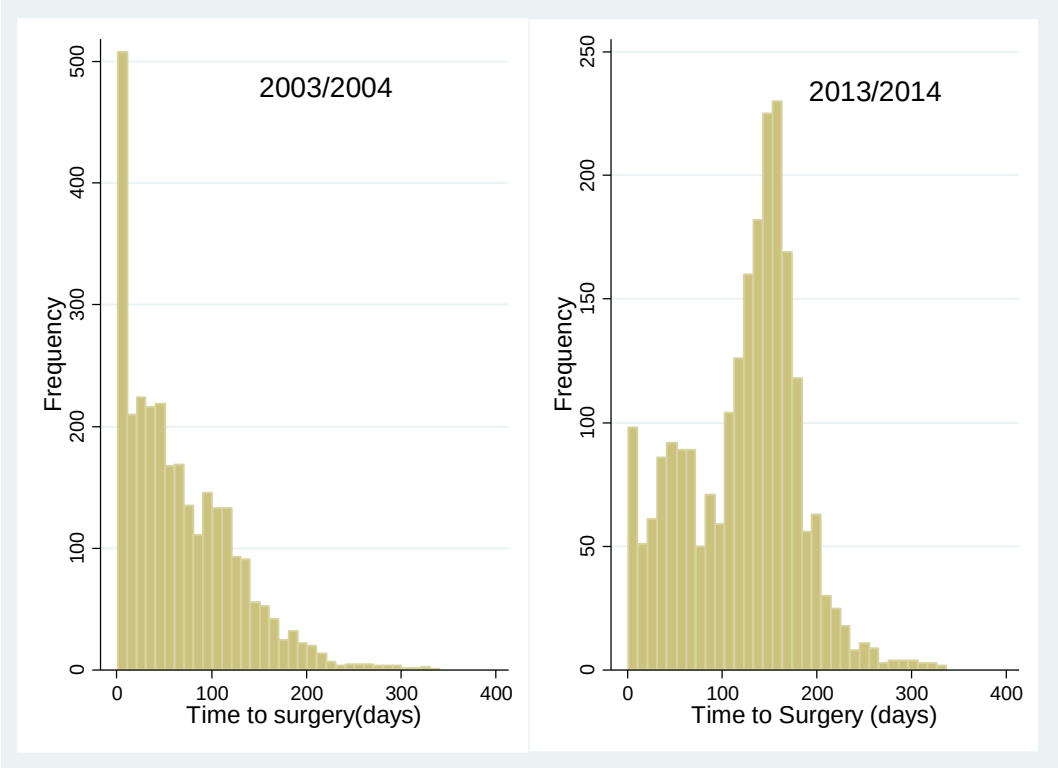
Table 1 Patients diagnosed and undergoing O-G cancer surgery and changes in NHS trust and consultant volume between 2003 and 2014

Year		**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
No. patients undergoing O-G resection per year		2974	2671	2634	2744	2631	2731	2542	2640	2565	2614	2459
Median annual volume of patients / NHS trust		21	22	22	29.5	30	43	45	54	56	58	55
Median annual volume of patients / consultant[a]		NA[b]	NA[b]	11	13	12	15	15	14	14	15	14
Number of consultants per NHS trust[a]	1 or 2	NA[b]	NA[b]	62	48	34	28	17	11	5	5	7
	3	NA[b]	NA[b]	21	21	20	14	16	18	19	16	17
	4 +	NA[b]	NA[b]	10	11	15	14	17	19	19	21	21

[a]Median consultant volume and median patient per consultant were calculated after excluding those consultants who had 1 patient in a year

[b]Details of anonymised consultant data became available on HES in financial year 2005-06

Figure A Histograms of time to surgery in 2003/4 and 2013/14



Caption Figure B: The distribution of time to surgery at the patient level shows that the majority of patients were operated on before 100 days in 2003 whereas in 2013 bimodal distribution is seen, with one group of patients operated on before 100 days and another group after 100 days The change in the distribution is consistent with the introduction of neoadjuvant chemotherapy in the treatment of O-G cancer patients during the time period of the analysis. The bimodal distribution suggests that the first group of patients goes straight to surgery after diagnosis, while the second group undergoes chemotherapy before proceeding to surgery.

Figure B Number of procedures per year in NHS trusts categories by the annual volume. Procedures are grouped by financial year (April – March).