


Diagnosis and treatment for gastro-oesophageal cancer in England and Wales: analysis of the National Oesophago-Gastric Cancer Audit (NOGCA) database 2012–2020

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Abstract

Background: The National Oesophago-Gastric Cancer Audit (NOGCA) captures patient data from diagnosis to end of primary treatment for all patients with oesophagogastric (OG) cancer in England and Wales. This study assessed changes in patient characteristics, treatments received, and outcomes for OG cancer surgery for the period 2012–2020, and examined which factors may have led to changes in clinical outcomes over this time.

Methods: Patients diagnosed with OG cancer between April 2012 and March 2020 were included. Descriptive statistics were used to summarize patient demographics, disease site, type, and stage, patterns of care, and outcomes over time. The treatment variables of unit case volume, surgical approach, and neoadjuvant therapy were included. Regression models were used to examine associations between surgical outcomes (duration of stay and mortality), and patient and treatment variables.

Results: In total, 83 393 patients diagnosed with OG cancer during the study period were included. Patient demographics and cancer stage at diagnosis showed little change over time. Altogether, 17 650 patients underwent surgery as part of radical treatment. These patients had increasingly more advanced cancers, and a greater likelihood of pre-existing comorbidity in more recent years. Significant decreases in mortality rates and duration of stay were noted, along with improvements in oncological outcomes (nodal yields and margin positivity rates). Following adjustment for patient and treatment variables, increasing audit year and trust volume were associated, respectively, with improved postoperative outcomes: lower 30-day mortality (odds ratio (OR) 0.93 (95 per cent c.i. 0.88 to 0.98) and OR 0.99 (95 per cent c.i. 0.99–0.99)) and lower 90-day mortality (OR 0.94 (95 per cent c.i. 0.91 to 0.98) and OR 0.99 (95 per cent c.i. 0.99–0.99)), and a reduction in duration of postoperative stay (incidence rate ratio (IRR) 0.98 (95 per cent c.i. 0.97 to 0.98) and IRR 0.99 (95 per cent c.i. 0.99 to 0.99)).

Conclusion: Outcomes of OG cancer surgery have improved over time, despite little evidence of improvements in early diagnosis. The underlying drivers for improvements in outcome are multifactorial.

Introduction

As part of a continuing process to improve care and patient outcomes, multimodal treatment for oesophagogastric (OG) cancer has changed significantly over the past decade. Within surgery, there has been the increasing adoption of minimal-access or robotic approaches^{1,2}, while developments in oncological treatments have increased the efficacy of systemic and local tumour response^{3,4}. However, radical surgery for OG cancer continues to be associated with major morbidity, with

curative multimodal treatment resulting in relatively poor overall survival compared to other tumour types^{4–7}.

In England and Wales, the National Oesophago-Gastric Cancer Audit (NOGCA) was established in its current form in 2012 to evaluate the quality of care in National Health Service (NHS) services and promote improvement in outcomes for patients with oesophageal and gastric cancer in England and Wales⁸. NOGCA is commissioned by an independent national body, the UK Healthcare Quality Improvement Partnership, and delivered

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by a multiorganizational partnership, including national specialty societies representing surgeons, gastroenterologists, and radiologists. While data entry is not mandated, participation in NOGCA is recommended as a priority by NHS England in its Quality Accounts List; units' audit participation and case ascertainment are included as quality metrics in NOGCA reports. The audit covers the care pathway from diagnosis to the end of primary treatment, and includes therapies given with curative or palliative intent, covering surgery, antisytemic cancer therapies, and radiotherapy. Information about individual NHS trusts (and, in previous iterations, individual surgeons) is publicly available to view online, with the aim of increasing transparency and driving quality improvement (QI) by enabling NHS organizations to benchmark themselves on different aspects of patient management. The audit website (www.nogca.org.uk) also directs organizations to various QI tools.

National clinical audit programmes have highlighted their roles in successfully improving care for OG cancer in the Netherlands⁹, and for other cancer types in England⁹⁻¹². Past improvements in outcomes for patients undergoing OG cancer surgery in England have been linked to the centralization of services that took place during the 2000s¹³. However, more recent trends in OG cancer presentation, treatment, and outcomes, as well as the impact of more recent developments in OG cancer care have not been described.

This study aimed to investigate changes in characteristics of patients (demographics and tumour characteristics), treatments received, and clinical outcomes for OG cancer surgery (duration of postoperative stay, lymph node yield, and 30-day mortality) in England and Wales since 2012, and to examine which factors may have led to changes in clinical outcomes in this time.

Methods

All patients

The study used an extract of NOGCA data that included information about patients diagnosed with OG cancer between 1 April 2012 and 31 March 2020. Patients were eligible for inclusion if they were aged 18 years and older, and had a histological diagnosis of epithelial OG cancer; hospital staff complete a data set that covers the care pathway from diagnosis to the end of initial treatment. Patient records are then linked with information from other national healthcare data sets that cover hospital admissions, chemotherapy, and radiotherapy (see Park *et al.*⁸ for more details). Case ascertainment has progressively improved during the lifetime of NOGCA, from approximately 80 per cent to 90 per cent¹⁴. Survival data are obtained by linking to national mortality data (Office for National Statistics (ONS)). Data collection is permitted under section 251 of the NHS Act 2006, with study analysis permitted as this entailed analysis of pre-existing anonymized data.

Study variables

The following patient and tumour variables from the NOGCA data set were included: age at diagnosis (in years); date of diagnosis; sex; quintile of socio-economic deprivation (based on the Index of Multiple Deprivation ranking for small geographical areas in England and Wales^{15,16}, derived from the patient's postcode of residence and assigned to national quintiles); number of documented comorbidities (from list: ischaemic heart disease, chronic obstructive pulmonary disease/asthma, chronic renal

impairment, liver failure/cirrhosis, diabetes, peripheral vascular disease, cerebrovascular disease, mental illness, or other significant condition); disease site and histology (categorized as oesophageal squamous cell carcinoma, upper or mid-oesophageal adenocarcinoma, lower oesophageal adenocarcinoma, stomach); clinical tumour (T) stage and clinical node (N) stage; performance status; and intended treatment. For those patients who had curative surgery, the following surgical variables were included: receipt of neoadjuvant therapy (yes/no); main procedure; and surgical approach (minimally invasive or open).

The NOGCA data set was linked to ONS death registration data for information on mortality outcomes.

Outcomes after surgery included duration of postoperative stay in days (defined as from operation date to discharge date), 30- and 90-day postoperative mortality, the proportion of specimens with 15 or more lymph nodes examined, and the proportion of specimens with positive margins (longitudinal resection margins for oesophagectomy and gastrectomy; circumferential margins for oesophagectomy).

Surgical case volumes were calculated for each individual NHS organization (trusts in England and local health boards in Wales) where curative surgery was undertaken, and reported as the number of surgical resection procedures performed with curative intent per organization per year.

Analysis

Descriptive statistics were used to summarize patient characteristics, patterns of care, and outcomes over time (analysed as individual audit years, from 1 April to 31 March, but grouped into 2-year periods for presentation), and by tumour site (oesophagus or stomach), using χ^2 tests to evaluate associations between audit year and categorical variables. Linear regression analysis was used to assess the associations between audit year and continuous variables.

Multivariable logistic regression models were used to examine the associations between 30- and 90-day postoperative mortality and audit year (odds ratio (OR) for annual change in mortality, relative to 2012-13). An initial model adjusted for patient variables (age at diagnosis, sex, deprivation quintile, number of comorbidities, tumour group, clinical T stage, clinical N stage, and performance status). In a second stage, the model was additionally adjusted for variables related to the patterns of care (neoadjuvant therapy, surgical procedure, and NHS trust volume). Robust standard errors were used to account for clustering within NHS trusts.

Poisson regression models (with robust standard errors) were used to assess the associations between duration of postoperative stay and audit year. As above, two models were used with adjustment in two stages to examine the degree to which the changes in duration of stay over time were associated with practice variables. Outcomes were expressed as incidence rate ratios (IRRs), indicating the relative risk of incurring an additional day in hospital.

Missing values for patient characteristics were imputed with multiple imputation using chained equations creating 10 data sets with the assumption that missing values were only related to the observed data (that is missing at random). The imputation model included all of the variables in the analysis models. Rubin's rules were used to pool the estimated regression model coefficients and intercept. All statistical tests were two sided and the threshold of statistical significance was defined as a P value of 0.05. Statistical analysis was performed using STATA version 17 (StataCorp, College Station, Texas, USA).

Ethics approval

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research. Patient consent for publication was not required. The study was exempt from UK National Research Ethics Committee approval as it involved secondary analysis of an existing data set of anonymized data. The National Oesophago-Gastric (OG) Cancer Audit has approval for processing healthcare information under Section 251 (reference number: ECC 1-06 (c)/2011) for all NHS patients diagnosed with OG cancer in England and Wales. Data for this study were based on patient-level information collected by the NHS, as part of the care and support of patients with cancer.

Results

NOGCA records were available for a total of 83 393 patients diagnosed during the study period. The characteristics of this cohort are summarized in [Table 1](#).

Over the 8-year study period, there was little change in the distribution of patient demographics (age, sex, or socio-economic deprivation index). The pattern of clinical stage was also stable, with approximately one-third of patients presenting with metastatic disease at diagnosis. In more recent audit years, a greater proportion of patients had one or more documented comorbidities (55.6 per cent in 2018–2020 versus 37.6 per cent in 2012–2014; $P < 0.001$), but a greater proportion also had a WHO performance status of 0 (38.1 per cent versus 29.5 per cent; $P < 0.001$).

Patients undergoing radical surgery

Of all patients diagnosed with OG cancer between 2012 and 2020, 17 650 underwent radical surgery as part of treatment with curative intent; the percentage of all diagnosed patients who had a record of radical surgical resection decreased from 23.2 per cent to 18.0 per cent ($P < 0.001$) between 2012 and 2020 ([Table 2](#)).

Table 1 Characteristics of patients diagnosed with oesophagogastric cancer by time period

	2012–2014 (n = 21 004)	2014–2016 (n = 21 356)	2016–2018 (n = 20 714)	2018–2020 (n = 20 319)
Age group (years)				
<60	3362 (16.0)	3456 (16.2)	3322 (16.0)	3245 (16.0)
60–69	5362 (25.5)	5380 (25.2)	5155 (24.9)	4878 (24.0)
70–79	6624 (31.5)	6921 (32.4)	6904 (33.3)	6974 (34.3)
≥80	5656 (26.9)	5599 (26.2)	5333 (25.8)	5222 (25.7)
Male sex	14 273 (68.1)	14 577 (68.4)	14 395 (69.6)	14 256 (70.3)
Missing	49	31	37	40
Deprivation quintiles				
1 (least deprived)	3692 (17.7)	3685 (17.3)	3750 (18.2)	3730 (18.5)
2	4129 (19.8)	4310 (20.3)	4170 (20.2)	4086 (20.2)
3	4262 (20.4)	4391 (20.7)	4325 (21.0)	4241 (21.0)
4	4330 (20.7)	4393 (20.7)	4119 (20.0)	4082 (20.2)
5 (most deprived)	4487 (21.5)	4476 (21.1)	4259 (20.6)	4075 (20.2)
Missing	104	101	91	105
Comorbidities				
None	13 106 (62.4)	12 749 (59.7)	10 368 (50.1)	9031 (44.4)
1	4454 (21.2)	4978 (23.3)	6161 (29.7)	7371 (36.3)
2	2328 (11.1)	2492 (11.7)	2900 (14.0)	2939 (14.5)
3 or more	1116 (5.3)	1137 (5.3)	1285 (6.2)	978 (4.8)
Tumour group				
Oesophageal SCC	3844 (18.3)	3810 (17.8)	3857 (18.6)	3878 (19.1)
Oesophageal ACA upper/mid	1415 (6.7)	1611 (7.5)	1487 (7.2)	1599 (7.9)
Oesophageal ACA lower (including SI–SII)	8742 (41.6)	9248 (43.3)	9195 (44.4)	9231 (45.4)
Stomach (including SIII)	7003 (33.3)	6687 (31.3)	6175 (29.8)	5611 (27.6)
Clinical T category				
0/1	1049 (5.4)	1099 (5.6)	995 (5.3)	1008 (5.5)
2	2525 (13.0)	2557 (12.9)	2323 (12.3)	2352 (12.8)
3	9612 (49.6)	10 001 (50.6)	9486 (50.4)	9087 (49.3)
4	3618 (18.7)	3855 (19.5)	3907 (20.7)	3828 (20.8)
X	2579 (13.3)	2259 (11.4)	2118 (11.2)	2140 (11.6)
Missing	1621	1585	1885	1904
Clinical N category				
0	5500 (28.4)	5502 (27.8)	5529 (29.4)	5540 (30.1)
1	6920 (35.7)	7104 (35.9)	6210 (33.0)	6033 (32.8)
2	3551 (18.3)	3883 (19.6)	3887 (20.6)	3736 (20.3)
3	1572 (8.1)	1747 (8.8)	1813 (9.6)	1622 (8.8)
X	1840 (9.5)	1535 (7.8)	1390 (7.4)	1484 (8.0)
Missing	1621	1585	1885	1904
Clinical M category				
0	12 857 (67.2)	13 015 (66.7)	12 436 (66.6)	12 604 (69.0)
1	6268 (32.8)	6506 (33.3)	6226 (33.4)	5660 (31.0)
Missing	1879	1835	2052	2049
Performance status				
0	6196 (29.5)	7117 (33.3)	7031 (33.9)	7749 (38.1)
1	7197 (34.3)	7112 (33.3)	6981 (33.7)	6738 (33.2)
≥2	7611 (36.2)	7127 (33.4)	6702 (32.4)	5832 (28.7)

Values are n (%) unless otherwise stated. SCC, squamous cell carcinoma; ACA, adenocarcinoma; SI–SIII, Siewert type I–III.

Table 2 Characteristics of patients having curative surgery for oesophago-gastric cancer by time period

Patients having curative surgery	2012–2014 (n = 4806; 22.9%)	2014–2016 (n = 4684; 21.9%)	2016–2018 (n = 4246; 20.5%)	2018–2020 (n = 3914; 19.3%)
Age group (years)				
<60	1136 (23.6)	1137 (24.3)	1000 (23.6)	971 (24.8)
60–69	1690 (35.2)	1590 (33.9)	1433 (33.7)	1277 (32.6)
70–79	1636 (34.0)	1571 (33.5)	1501 (35.4)	1385 (35.4)
≥80	344 (7.2)	386 (8.2)	312 (7.3)	281 (7.2)
Male sex				
Missing	3569 (74.4)	3505 (74.9)	3177 (75.1)	3001 (76.8)
	11	6	17	7
Deprivation quintiles				
1 (least deprived)	936 (19.6)	890 (19.1)	892 (21.1)	800 (20.5)
2	1003 (21.0)	1039 (22.3)	869 (20.6)	833 (21.4)
3	969 (20.3)	964 (20.7)	881 (20.9)	805 (20.7)
4	928 (19.5)	930 (20.0)	818 (19.4)	782 (20.1)
5 (most deprived)	931 (19.5)	830 (17.8)	758 (18.0)	677 (17.4)
Missing	39	31	28	17
Comorbidities				
None	2510 (52.2)	2524 (53.9)	2069 (48.7)	1861 (47.5)
1	1262 (26.3)	1158 (24.7)	1280 (30.1)	1312 (33.5)
2	691 (14.4)	678 (14.5)	610 (14.4)	574 (14.7)
3 or more	343 (7.1)	324 (6.9)	287 (6.8)	167 (4.3)
Tumour group				
Oesophageal SCC	414 (8.6)	418 (8.9)	359 (8.5)	314 (8.0)
Oesophageal ACA upper/mid	211 (4.4)	239 (5.1)	198 (4.7)	198 (5.1)
Oesophageal ACA lower (w SI, SII)	2456 (51.1)	2448 (52.3)	2229 (52.5)	2131 (54.4)
Stomach (w SIII)	1725 (35.9)	1579 (33.7)	1460 (34.4)	1271 (32.5)
Clinical T category				
0/1	433 (9.4)	469 (10.4)	349 (8.6)	293 (7.6)
2	981 (21.3)	931 (20.6)	861 (21.2)	779 (20.3)
3	2561 (55.7)	2519 (55.6)	2256 (55.6)	2134 (55.6)
4	361 (7.9)	400 (8.8)	371 (9.1)	406 (10.6)
X	259 (5.6)	209 (4.6)	223 (5.5)	223 (5.8)
Missing	211	156	186	79
Clinical N category				
0	1967 (42.8)	1953 (43.1)	1864 (45.9)	1727 (45.0)
1	1770 (38.5)	1733 (38.3)	1412 (34.8)	1365 (35.6)
2	608 (13.2)	605 (13.4)	614 (15.1)	571 (14.9)
3	140 (3.0)	148 (3.3)	110 (2.7)	100 (2.6)
X	110 (2.4)	89 (2.0)	60 (1.5)	72 (1.9)
Missing	211	156	186	79
Performance status				
0	2532 (52.7)	2678 (57.2)	2479 (58.4)	2509 (64.1)
1	1748 (36.4)	1677 (35.8)	1466 (34.5)	1230 (31.4)
≥2	526 (10.9)	329 (7.0)	301 (7.1)	175 (4.5)

Values are n (%) unless otherwise stated. SCC, squamous cell carcinoma; ACA, adenocarcinoma; w SI–III, with Siewert type I–III.

Among patients undergoing curative surgery for OG cancer, patient age, sex, and socio-economic deprivation did not change over the study period. The percentage of patients with any comorbidities recorded increased from 48.5 per cent among those diagnosed in 2012–13 to 51.9 per cent diagnosed in 2019–20 ($P < 0.001$). There was a statistically insignificant increase in the proportion of lower oesophageal and Siewert I–II adenocarcinomas (from 50.4 per cent to 55.5 per cent), and a decline in Siewert III/stomach cancers (from 37.0 per cent to 32.4 per cent; $P = 0.055$). The percentage of patients with more locally advanced cancers increased; for instance, the percentage of patients with cT4 disease increased from 7.2 per cent to 10.5 per cent ($P < 0.001$). Patients undergoing surgery in more recent years had a better performance status than those in the earlier period, with the percentage with performance status 0 (fully active) increasing from 53.3 per cent to 65.2 per cent ($P < 0.001$).

Multimodal treatment and surgical practice

The use of neoadjuvant treatment increased over the study period in patients undergoing oesophagectomy (from 70.0 per cent to

74.8 per cent; $P < 0.001$) and gastrectomy (from 6.4 per cent to 56.3 per cent; $P < 0.001$) (Table 3).

Among patients undergoing oesophagectomy, use of the two-phase (Ivor Lewis) procedure increased from 80.3 per cent to 86.8 per cent, while the use of thoracoabdominal (from 11.5 per cent to 7.0 per cent) and transhiatal (from 3.1 per cent to 1.7 per cent) procedures decreased ($P < 0.001$). For both oesophagectomy and gastrectomy, the use of minimally invasive approaches increased over the study period. Open approaches accounted for 57.3 per cent of oesophagectomies in 2012–14 versus 47.1 per cent in 2018–20 ($P < 0.001$), and 84.7 per cent of gastrectomies in 2012–14 versus 80.3 per cent in 2018–20. Few procedures involved robotic surgery during the study period. There was substantial hospital-level variation in the use of minimally invasive approaches (including hybrid and converted procedures) over the study period, for both oesophagectomy (interquartile range (i.q.r.) 12.5 per cent to 81.0 per cent) and gastrectomy (i.q.r. 0.5 per cent to 41.1 per cent).

The number of NHS organizations performing curative surgery was relatively stable over the study period, ranging from 45 to

Table 3 Patterns of care for patients having curative surgery for oesophagogastric cancer by time period and tumour site

	2012–2014	2014–2016	2016–2018	2018–2020
Oesophagectomy, n	3071	3078	2765	2557
Neoadjuvant therapy, n (%)	2151 (70.0)	2090 (67.9)	1904 (68.9)	1878 (73.5)
Main procedure				
Thoracoabdominal	309 (10.1)	283 (9.2)	181 (6.6)	161 (6.3)
Two-phase	2517 (82.0)	2473 (80.3)	2369 (85.7)	2221 (86.9)
Three-phase	144 (4.7)	197 (6.4)	153 (5.5)	136 (5.3)
Transhiatal	101 (3.3)	125 (4.1)	62 (2.2)	39 (2.5)
Surgical access				
Open	1675 (58.5)	1639 (57.7)	1367 (51.7)	1150 (47.0)
Hybrid	771 (26.9)	867 (30.5)	789 (29.9)	745 (30.4)
Laparoscopic completed	290 (10.1)	256 (9.0)	412 (15.6)	450 (18.4)
Laparoscopic converted	129 (4.5)	81 (2.9)	75 (2.8)	65 (2.7)
Robotic	0	0	<5	37 (1.6)
Missing	206	235	120*	110
Gastrectomy	1735	1606	1481	1357
Neoadjuvant therapy	801 (46.2)	673 (41.9)	618 (41.7)	695 (51.2)
Main procedure				
Total gastrectomy	794 (45.8)	673 (41.9)	700 (42.3)	640 (47.2)
Extended gastrectomy	122 (7.0)	143 (8.9)	127 (8.6)	125 (9.2)
Proximal	28 (1.6)	37 (2.3)	24 (1.6)	16 (1.2)
Distal gastrectomy	733 (42.3)	714 (44.5)	587 (39.6)	556 (41.0)
Other	58 (3.4)	39 (2.5)	43 (2.9)	20 (1.5)
Surgical access				
Open	1481 (85.4)	1346 (83.8)	1213 (82.0)	1079 (80.1)
Laparoscopic completed	207 (11.9)	219 (13.6)	237 (16.0)	248 (18.4)
Laparoscopic converted	47 (2.7)	41 (2.6)	29 (2.0)	20 (1.5)
Robotic	0	0	0	<5
Missing	0	0	2	10*
Surgical volumes				
NHS organizations performing surgery	56	66	51	57
Median number of patients per organization over 2 years (i.q.r.)	84.5 (28–129.5)	72 (1–113)	87 (36–127)	64 (2–105)

Values are n (%) unless otherwise stated. Data suppression applied to small numbers (<5) and percentages calculated treating suppressed values as 0. *Rounded to the nearest 5. NHS, National Health Service; i.q.r., interquartile range.

59 per audit year. Surgical volumes were also largely consistent, with median annual volumes ranging from 38 to 49 per organization.

Outcomes after radical surgery

Thirty- and 90-day postoperative mortality rates decreased over the study period. The overall 30-day mortality rate was 2.6 per cent in 2012–13 versus 1.3 per cent in 2019–20 ($P=0.062$), while 90-day mortality decreased from 4.7 per cent to 2.7 per cent ($P=0.005$). After adjusting for patient factors, audit year was associated with both 30-day mortality (adjusted OR 0.93, 95 per cent c.i. 0.89 to 0.98) and 90-day mortality (adjusted OR 0.95, 95 per cent c.i. 0.91 to 0.98). Further adjustment for treatment factors had little impact on the observed associations, and audit year remained significantly associated with 30-day (OR 0.93, 95 per cent c.i. 0.88 to 0.98) and 90-day mortality (OR 0.94, 95 per cent c.i. 0.91 to 0.98) (Table 4).

Median duration of postoperative stay declined from 12 days (i.q.r. 9 to 18) in 2012–13 to 10 days (i.q.r. 8 to 15) in 2019–20 ($P<0.001$, from non-parametric equality of medians test). This reduction remained statistically significant after adjustment for patient characteristics (IRR 0.98, 95 per cent c.i. 0.97 to 0.98). Additional adjustment for practice variables produced similar results (IRR 0.98, 95 per cent c.i. 0.97 to 0.98). Table 4 describes the models in detail.

Increasing age, comorbidity, worse performance status, not receiving neoadjuvant therapy, and lower annual hospital case volume were associated with an increased risk of mortality and longer duration of stay (Table 4). Increased deprivation was

associated with a longer length of stay (IRR for patients in the most deprived versus those in the least deprived quintile 1.09, 95 per cent c.i. 1.05 to 1.13) but not mortality.

Other outcomes

The median number of lymph nodes examined after surgery increased from 23 (i.q.r. 16 to 32) in 2012–13 to 28 (i.q.r. 20 to 37) in 2019–20. The percentage of procedures in which 15 or more lymph nodes were examined increased from 82.0 per cent to 89.1 per cent ($P<0.001$; Fig. 1).

Positive circumferential margin rates for oesophagectomy decreased from 27.8 per cent in 2012–13 to 19.2 per cent in 2019–20 ($P<0.001$). Rates of positive longitudinal margins (oesophagectomy and gastrectomy combined) did not change over the study period ($P=0.370$; Fig. 2).

Discussion

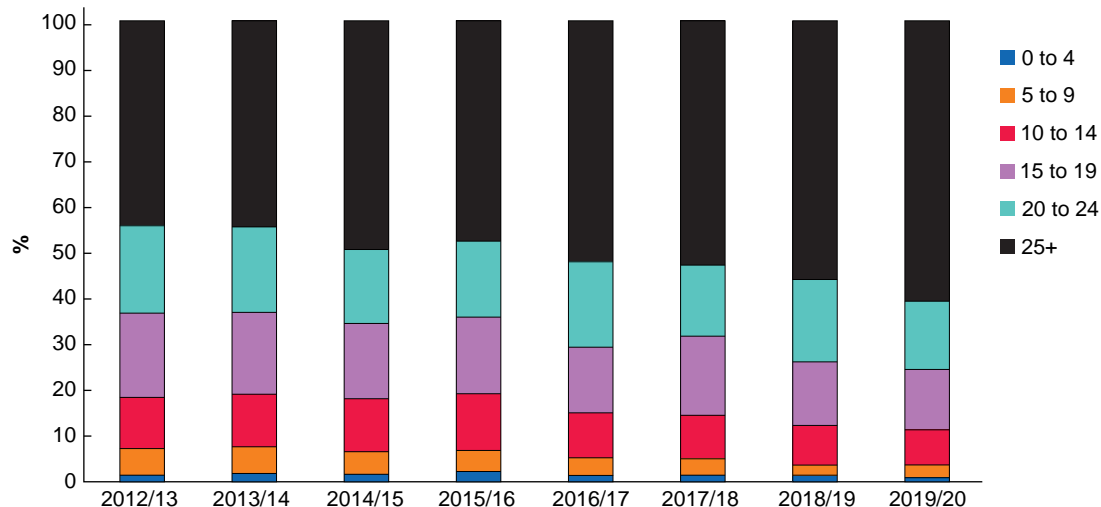
This study describes the changes in patient characteristics, management, and outcomes of radical surgery for OG cancer in England and Wales over an 8-year period since the national audit of OG cancer care began. Over the course of the 8 years, there have been significant reductions in postoperative mortality rates and durations of stay, even after adjusting for patient and treatment factors, as well as improvement in histological outcome metrics, with reduced positive margin rates and improved nodal yields.

The publication of hospital- and surgeon-specific audit figures by NOGCA has, in the past, resulted in fears that this might result in

Table 4 Multivariable logistic regression models for 30- and 90-day postoperative mortality and Poisson regression model for duration of postoperative stay in patients diagnosed from 2012 to 2020 who had curative surgery for oesophagogastric cancer

	30-day mortality		90-day mortality		Duration of stay	
	aOR (95% c.i.) (n = 17 650)	P value	aOR (95% c.i.) (n = 17 650)	P value	aIRR (95% c.i.) (n = 16 392)	P value
Audit year	0.93 (0.88–0.98)	0.004	0.94 (0.91–0.98)	0.003	0.98 (0.97–0.98)	<0.001
Age (years)	1.04 (1.02–1.05)	<0.001	1.03 (1.02–1.04)	<0.001	1.00 (1.00–1.01)	<0.001
Male sex	1.15 (0.87–1.53)	0.318	1.15 (0.94–1.42)	0.184	0.98 (0.95–1.00)	0.103
Deprivation quintiles						
1 (least deprived)	1	0.662	1	0.300	1	<0.001
2	1.09 (0.76–1.55)		1.24 (0.95–1.61)		1.02 (0.98–1.06)	
3	1.10 (0.77–1.58)		1.25 (0.96–1.64)		1.03 (0.99–1.07)	
4	1.29 (0.91–1.83)		1.30 (0.99–1.70)		1.02 (0.98–1.06)	
5 (most deprived)	1.22 (0.84–1.76)		1.31 (0.99–1.73)		1.09 (1.05–1.13)	
Comorbidities						
None	1	<0.001	1	<0.001	1	0.001
1	1.80 (1.37–2.37)		1.56 (1.28–1.92)		1.04 (1.01–1.07)	
2	2.09 (1.51–2.88)		1.84 (1.45–2.33)		1.05 (1.01–1.09)	
3 or more	2.78 (1.89–4.08)		2.58 (1.94–3.42)		1.10 (1.04–1.16)	
Tumour group						
Oesophageal SCC	1	0.146	1	0.195	1	0.007
Oes ACA upper/mid	1.02 (0.58–1.82)		1.06 (0.69–1.64)		0.93 (0.87–0.99)	
Oes ACA lower (SI, SII)	0.84 (0.56–1.27)		0.84 (0.62–1.15)		0.90 (0.86–0.94)	
Stomach (w SIII)	0.52 (0.28–0.96)		0.64 (0.40–1.04)		0.85 (0.79–0.90)	
Clinical T category						
0/1	1	0.350	1	0.152	1	0.008
2	0.68 (0.43–1.06)		1.07 (0.74–1.54)		1.03 (0.98–1.08)	
3	0.90 (0.59–1.37)		1.37 (0.96–1.94)		1.00 (0.95–1.05)	
4	0.81 (0.44–1.47)		1.19 (0.76–1.89)		1.07 (1.00–1.14)	
X	0.99 (0.53–1.87)		1.44 (0.89–2.31)		0.95 (0.89–1.02)	
Clinical N category						
0	1	0.517	1	0.162	1	0.124
1	1.22 (0.92–1.62)		1.27 (1.04–1.56)		1.00 (0.97–1.03)	
2	1.18 (0.80–1.74)		1.28 (0.97–1.69)		1.02 (0.98–1.07)	
3	0.87 (0.37–2.05)		0.97 (0.55–1.73)		1.07 (0.99–1.15)	
X	1.59 (0.72–3.50)		1.32 (0.72–2.42)		1.09 (0.99–1.19)	
Performance status						
0	1	0.041	1	<0.001	1	<0.001
1	1.05 (0.82–1.35)		1.05 (0.88–1.26)		1.06 (1.03–1.09)	
≥2	1.57 (1.09–2.25)		1.74 (1.33–2.26)		1.16 (1.11–1.22)	
Neoadjuvant therapy	0.78 (0.60–1.02)	0.068	0.73 (0.60–0.89)	0.002	0.96 (0.93–0.99)	0.008
Main procedure						
Oesophagectomy	1	0.790	1	0.425	1	<0.001
Gastrectomy	0.94 (0.57–1.53)		0.85 (0.58–1.26)		0.78 (0.74–0.82)	
Trust volume	0.99 (0.99–0.99)	<0.001	0.99 (0.99–0.99)	<0.001	0.99 (0.99–0.99)	<0.001

aOR, adjusted odds ratio; aIRR, adjusted incidence rate ratio; SCC, squamous cell carcinoma; Oes ACA, oesophageal adenocarcinoma; w SI–III, with Siewert type I–III. Bold values indicate statistically significant at $p < 0.05$.

**Fig. 1** Number of lymph nodes examined, by audit year

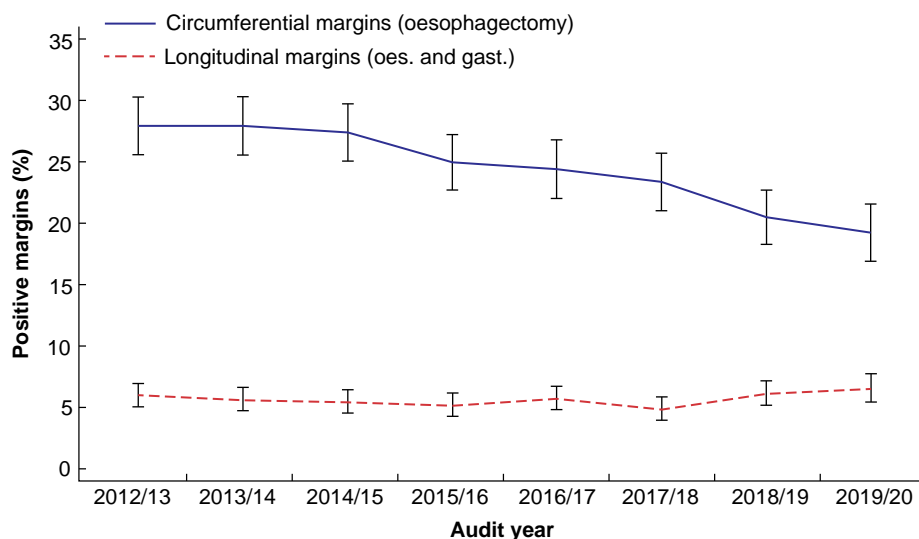


Fig. 2 Unadjusted rates of positive margins for oesophagectomy (oes.) and gastrectomy (gast.), 2012–2020

selection bias against more comorbid patients, to improve published outcomes. This study suggests that improvements in outcomes have occurred despite a shift in patient and disease demographics, with more comorbid patients and patients presenting with more advanced disease being treated with radical surgery, suggesting that these fears are unfounded. However, there has also been an overall decline in the proportion of patients being offered radical multimodal therapy, with those undergoing surgery having a better performance status. Further research into how changing presentations of disease, patient comorbidity, and oncological treatment options may affect patient selection and treatment recommendations is warranted. The use of neoadjuvant therapy has increased over the audit's lifetime, and the increasing efficacy of neoadjuvant chemotherapy and chemoradiation regimens may have contributed to the increasing proportion of patients with late-stage disease progressing to surgery. Ongoing trials of new chemotherapeutic agents, and of existing agents in expanded contexts, including oligometastatic disease, may, in future, broaden the scope of patients considered for surgery even further^{17,18}.

The centralization of major OG cancer services, since the last major reorganization of UK cancer services in the 1990s, has resulted in a stable number of centres and centre volumes. However, some centres still report low case volumes. Annual centre volume was the only organizational factor considered and, in adjusted analysis, demonstrated a statistically significant association with surgical outcomes; the well-established relationship between higher surgical volume and improved outcomes across various surgical disciplines suggests that low-volume centres may be at greater risk of fluctuations in care quality¹⁹.

NOGCA data suggest that minimally invasive approaches continue to be adopted, with steady increases in laparoscopy and thoracoscopy, in keeping with current evidence^{1,2}. Robotically assisted procedures, for which the evidence remains less clear, has remained novel in the UK, although they have been adopted at pace by a number of centres in the time since the period of audit covered in this study (Personal communication, Intuitive Surgical (Sunnyvale, CA, USA)). An increased standardization of surgical approach means that increasingly fewer thoracoabdominal or transhiatal oesophagectomies are

being performed, while proximal gastrectomies are almost completely absent in UK practice.

The data described herein also raise important broader issues to be considered at policy and organizational levels. Despite efforts to increase the awareness and earlier diagnosis of oesophageal cancer such as straight-to-test referrals to endoscopy from primary care and statutory 2-week targets from primary care referral to initial diagnostic test (that is endoscopy)^{20,21}, data presented in this study demonstrate there has been effectively no change in disease stage at presentation over the past decade. Concerns remain that the diagnostic delays induced by the COVID-19 pandemic may yet further exacerbate the problem of late diagnosis of cancers in the near future. In the absence of screening endoscopy programmes in Western countries, less invasive screening tests such as swallowable cell collection devices (Cytosponge)²² or breath testing for cancer-associated volatile organic compounds²³ have not yet been broadly adopted, but may help increase rates of early diagnosis in future. Variations in care and outcomes across socio-economic deprivation levels have been well described in many other developed health systems, and are partially reflected here with increased durations of stay for more deprived patients^{24,25}.

The use of outcome metrics and how to adjust for case mix continues to be debated. The use of oncological outcomes such as nodal count and positive resection margin (R1) rates are subject to significant variations in histopathological practice^{26,27}. Duration of stay, as demonstrated here, is subject to multiple factors including socio-economic and social care considerations, which will vary by geographical area. With short-term postoperative mortality an increasingly rare occurrence, other outcomes such as longer-term mortality may provide more information about quality of care. A multifactorial composite metric that considers all areas of the patient pathway at a unit level is mostly likely to best represent hospital care quality, and is currently being introduced by NOGCA⁸.

We contrast our findings to those from other recently published national data sets. A recently published analysis of the Dutch Upper Gastrointestinal Cancer Audit (DUCA) most closely approximates the timespan (2011–2018) of the data reported in this study⁹. DUCA is a mandatory national audit with data completeness

reported at >99 per cent; data from DUCA show similar trends in the characteristics of patients undergoing surgery for OG cancer as in England and Wales, with parallels in changes in histological subtype, more advanced stage at presentation, and increased comorbidity. Dutch centres were much more likely to employ hybrid or fully minimally invasive techniques (90 per cent hybrid/minimally invasive oesophagectomy rate in 2017–2018 versus 53 per cent in England and Wales in 2018–2020) but reported slightly higher 30-day mortality rates (as high as 4.4 per cent in 2013–2014 versus 2.5 per cent in UK). The publication of surgeon-level data by NOGCA versus hospital-level data only in DUCA does not appear to have impacted on these positive outcome trends. A particular strength of this publication and of NOGCA data is the inclusion of information about all patients diagnosed with histologically confirmed OG cancer, as opposed to DUCA, which captures surgical patient data only and therefore lacks a population denominator of patients not suitable for surgical treatment. Analyses of the Swedish (2007–2016) and Danish (2004–2013) national OG cancer registries found comparable improvements in clinical and histological outcomes; the Swedish registry also reported roughly similar rates of case ascertainment (89.2 per cent)^{28,29}.

The limitations of this data must be considered. Outcomes for non-surgically based treatment with curative intent, such as definitive chemoradiation or endoscopic therapy, have been historically less well captured by NOGCA, but consist of < 5 per cent of the total patient cohort and are thought to have a minimal impact on the overall results presented here. Surgical case ascertainment in NOGCA has been shown to be very high, but incomplete, when compared to national hospital data sets (Hospital Episode Statistics, HES) at over 90 per cent. No conclusions can be drawn over any potential bias incurred by these missing patients; efforts to further improve data capture in other areas are ongoing³⁰.

The results of this analysis of population-level audit data demonstrate both a failure to improve early diagnostic rates, as well as successful improvements in OG cancer care over time. The underlying drivers for improvements in outcome are multifactorial and cannot be easily isolated. However, audit and public accountability for outcomes are undoubtedly a critical factor to measure and improve any process, and, as such, national registries such as NOGCA remain vital to monitoring and improving OG cancer care.

Author contributions

Philip Pucher (Conceptualization, Formal analysis, Methodology, Project administration, Visualization, Writing—original draft, Writing—review & editing), Min Hae Park (Conceptualization, Data curation, Formal analysis, Methodology, Writing—original draft, Writing—review & editing), David Cromwell (Conceptualization, Data curation, Formal analysis, Resources, Supervision, Writing—original draft, Writing—review & editing), Tom Crosby (Conceptualization, Methodology, Writing—review & editing), Betsan Thomas (Data curation, Writing—review & editing), Nigel Trudgill (Conceptualization, Data curation, Methodology, Writing—review & editing), Muhammad Wahedally (Data curation, Formal analysis, Resources, Software, Supervision, Validation), Nick Maynard (Conceptualization, Data curation, Methodology, Supervision, Writing—review & editing), and James Gossage (Conceptualization, Data curation, Investigation, Methodology, Project administration, Supervision, Writing—review & editing).

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Disclosure

The authors declare no conflict of interest.

Data availability

Researchers may apply to the Healthcare Quality Improvement Partnership to access National Oesophago-Gastric Cancer Audit data for a research study. The approvals process for such requests is outlined here: <https://www.hqip.org.uk/national-programmes/accessing-ncapop-data/>

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