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The Changing Face of Emergency General Surgery

A 20-year Analysis of Secular Trends in Demographics, Diagnoses, Operations, and Outcomes

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Objective: The aim of the study was to evaluate secular trends in the epidemiology of emergency general surgery (EGS), by analyzing changes in demographics, diagnoses, operations, and outcomes between 1997 and 2016.

Summary Background Data: The provision and delivery of EGS services is a globally and regionally important issue. The impact of changing demographics and surgical disease incidence on EGS services is not well understood.

Methods: Data from all EGS hospital episodes of adults (aged >15) in Scotland between 1997 and 2016 were prospectively collected, including ICD-10 diagnostic codes and OPCS-4 procedure codes. The number and age- and sex-standardized rates per 100,000 population, per year, of the most common diagnoses and operations were calculated. We analyzed demographic changes over time using linear regression, and changes in characteristics, diagnoses, operations, and outcomes using Poisson analysis.

Results: Data included 1,484,116 EGS hospital episodes. The number and age- and sex-standardized rate, per 100,000 population, of EGS admissions have increased over time, whereas that of EGS operations have decreased over time. Male admissions were unchanged, but with fewer operations over time, whereas female admissions increased significantly over time with no change in the operation rate. Poisson analysis demonstrated secular trends in demographics, admissions, operations, and outcomes in depth.

Conclusions: This 20-year epidemiological study of all EGS hospital episodes in Scotland has enhanced our understanding of secular trends of EGS, including demographics, diagnoses, operations, and outcomes. These data will help inform stakeholders in EGS service planning and delivery, as well as in surgical training, what has occurred in recent history.

Keywords: acute care surgery, admissions, diagnosis, emergency general surgery, epidemiology, operations, surgical outcomes, trauma

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The provision and delivery of emergency general surgery (EGS) services is an important issue. In the United Kingdom, the general surgical professional association, the Association of Surgeons of Great Britain and Ireland, and the two largest specialty associations—the Association of Coloproctology of Great Britain and Ireland and the Association of Upper GI Surgeons—have asserted that there is a need to adapt the provision of Emergency General Surgery to improve the efficiency and quality of care.[1] The Royal College of Surgeons of England has similarly raised concerns, and proposed far-reaching changes to the delivery of emergency care.[2–4] However, difficulties relating to the provision of emergency general surgical services are by no means confined to the United Kingdom. Emergency general surgery is a global issue, as the Lancet Commission on Global Surgery has emphasized.[5,6]

The calls for change are driven by changes in demographics, disease, and workforce. The latter are relatively well understood—increasing subspecialization has resulted in improved outcomes for patients requiring planned specialist intervention, but has also created difficulties in having an appropriately trained and available surgical workforce for the treatment and management of EGS patients. The impact of changing demographics and surgical disease incidence, in contrast, is not well understood. Although several studies have evaluated EGS in the United States,[7] England,[8,9] and Scotland.[10,11] none have investigated secular trends in EGS in relation to changing demographics. Scotland's demographics are changing. Between 2012 and 2035, the population aged over 65 will increase from 17% to 25%, and those aged over 75 from 8% to 13%.[12]

We have recently conducted a 1-year, population-based study of emergency general surgery admissions in Scotland, characterizing contemporary emergency surgical practice.[13] We demonstrated that many diagnoses increased with age (cholelithiasis, constipation, diverticulitis, small bowel obstruction, urinary tract infection, cholecystitis, gastrointestinal bleeds, and anorectal disease), a smaller percentage of elderly patients admitted to an EGS service are operated upon (14.5% of those aged >75 y have an operation, compared with 25% of all EGS admissions), all-cause mortality increases with age (20% aged >75 died during or after their admission), and median length of hospital stay increases with age. Clearly, Scotland's increasingly ageing population will have a significant impact on the cost of EGS care, as well as the type of services required, which may require a shift in EGS service planning and delivery of care.

Scotland has excellent health data, reaching back several decades, and therefore lends itself to the study of changes in practice over time. The aim of this present study was to evaluate secular trends in the epidemiology of emergency general surgery, by analyzing changes in demographics, admission diagnoses, and operations performed, between 1997 and 2016, to facilitate the future planning of emergency care delivery.

METHODS

Design and Setting

This was a population-based, epidemiological cohort study set in Scotland, one of the home nations of the United Kingdom. Scotland has a population of 5.2 million, and an EGS service delivery framework which is typical of the United Kingdom. The majority of general surgeons declare a subspecialty interest, but provide emergency services on an intermittent basis.

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Data Sources

The Information Services Division (ISD) of NHS Scotland has been collecting hospital episode data, from all Scottish Hospitals, since the 1960s.[14] Admission diagnoses have been coded using ICD-10 (International Statistical Classification of Diseases and Related Health Problems 10th Revision) codes since 1996.[15] Operations are coded using OPCS-4 (OPCS Classification of Interventions and Procedures version 4) codes.[16] Patients have a unique identifier, allowing repeated admissions, even to different hospitals, to be identified. Anonymized data were transferred to the Data Safehaven (DaSH) of the University of Aberdeen for analysis. Population data were acquired from National Records of Scotland.[17]

Case Definition

An emergency general surgical patient was defined as a patient aged 16 years or older, admitted to a Scottish hospital, under the care of a consultant general surgeon, as an emergency, between the January 1, 1997 and the December 31, 2016. Based on our previous study, we identified the most common diagnoses and operations, for further analyses.

Analysis

Data were analyzed descriptively, in terms of (1) demographics, and age- and sex-adjusted rates per 100,000 population, and numbers of (2) diagnoses, (3) operations/procedures, and (4) outcomes. Unless stated otherwise, the analyses refer to the number of admissions, rather than the number of patients. Directly standardized age- and sex-standardized rates were calculated based on the formula by Schoenbach.[18] Data were managed in Microsoft Excel v 16.0 (Microsoft, Redmond, WA) and then transferred into SPSS v 24.0 (IBM, New York, NY). Statistical analysis of changes over time in demographics was performed using linear regression, reporting slope, *P* values, and 95% confidence intervals of the slope. Statistical analysis of changes over time of baseline characteristics, diagnoses, operations, and outcomes was performed using Poisson distribution, reporting exp(b) (which equals the incidence rate ratio), *P* values, and 95% confidence intervals of exp(b).

Poisson regression is used to model count variables—specifically, to predict a dependent variable that comprises ‘‘count data’’ given one or more independent variables.[19] Poisson analysis assumes that the dependent variable represents count data; that the independent variables are continuous, ordinal or nominal data; that observations are independent of one another; that the distribution of counts follows a Poisson distribution; and that the mean and variance of the model are identical.[19] In this study, the Poisson modeled the dependent variable—the number of occurrences (counts) of baseline characteristics, diagnoses, operations, and outcomes—and for each Poisson, included two categorical independent variables (age group and sex), a continuous variable (y), and was offset by the natural logarithm of the population.

Graphs were created using DataGraph v 4.3 (Visual Data Tools Inc., Chapel Hill, NC), and tables using Microsoft Word for Mac v 15.38 (Microsoft, Redmond, WA). The results are presented as histograms of the number of admissions and number of operations per year; and graphs of the age- and sex-adjusted rate of admissions per 100,000 population, per year; and the age- and sex-adjusted rate of operations per 100,000 population, per year. Tables display results from linear regression and Poisson distribution.

Permissions

This project was approved by the Public Benefit and Privacy panel (PBPP) of NHS Scotland (Ref 1617-0207) and was registered by the research governance department of NHS Grampian and the University of Aberdeen.

RESULTS

There were 1,484,116 emergency admissions, of 905,129 patients (1.6 admissions per patient), to general surgical wards in Scotland over the 20-year period of this study. The number of admissions per year increased from 65,033 in 1997 to 81,617 in 2016. The age- and sex-standardized admission rate per 100,000 population, per year, also increased from 1662 to 1818 ($P < 0.001$) (Figure 1). In contrast, there has been a decrease in the number of operations performed per year from 19,073 in 1997 to 17,688 in 2016, although the number was highest in 2008 (Figure 1). The age- and sex-standardized operation rate, per 100,000 population, per year, decreased from 487 to 394 from 1997 to 2016 ($P = 0.001$) (Figure 1).

Demographics

The mean admission age was 52.6 years (range 16–104), and the median was 52 years (interquartile range 37.5–69.5). 709,153 (47.8%) of the admissions involved male patients, 774,950 (52.2%) females. The median age of female admissions was 53.0 in 1997 (IQR 34–72), and 51.0 in 2016 (IQR 33–69) ($P = 0.976$); however, the median age of male admissions increased from 50.0 in 1997 (IQR 33–68) to 56.0 in 2016 (IQR 39–70) ($P < 0.001$).

Figure 2A and B show the number of male and female EGS admissions, broken down by age group, and the male and female admission rates, per 100,000 population. The number of male admissions increased by 11%; however, the number of admissions of young patients (aged 16–30 and 31–45) decreased, whereas admissions of older patients remained unchanged (aged 46–60), or increased (aged 61–75 and >75) (Table 1). The rate of male EGS admissions per 1000 population has not changed overall, though the

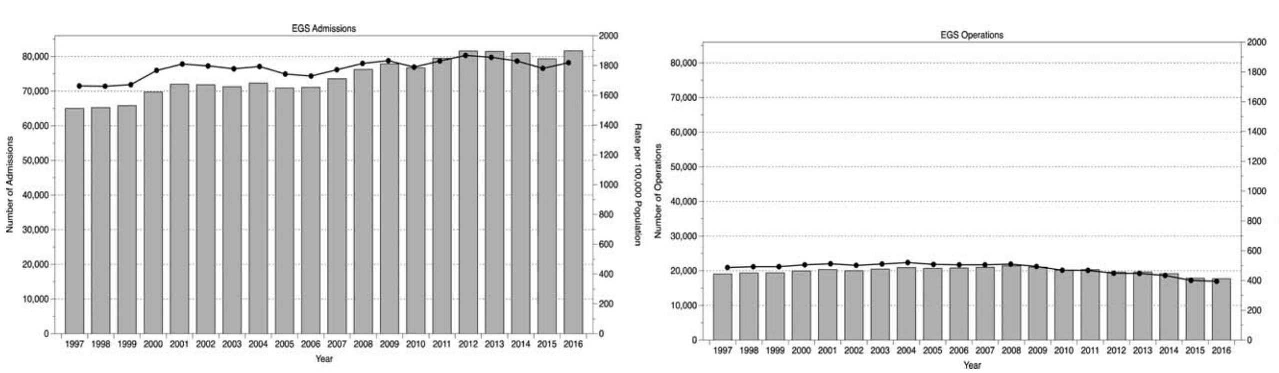

FIGURE 1. Overall trends: numbers (bars) and age- and sex-standardized rates (lines), per 100,000 population.

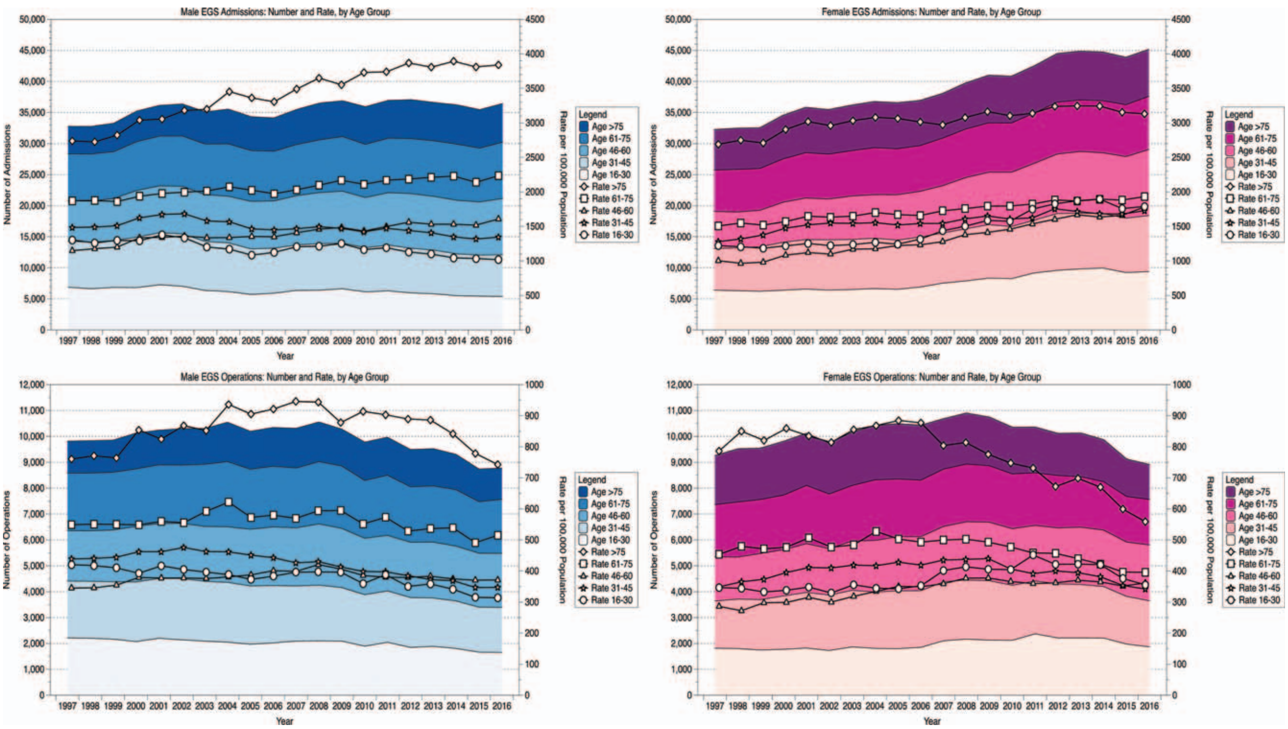

FIGURE 2. Demographics: number (area) and rate (lines) of admissions and operations, by sex and age group, per 100,000 population.

TABLE 1. Logistic Regression Results of Secular Trends in Demographics: Non-standardized Number (% Change) and Standardized Rates of EGS Admissions and Operations, per 100,000 Population, by Age Group and Sex

Group	EGS Admissions		EGS Operations	
	Number % Change	Slope (95% CI)	Number % Change	Slope (95% CI)
All adults	+25%	11.0 (7.60 to 14.4)***	−7%	−3.75 (−5.72 to −1.79)**
16–30	+11%	7.77 (3.37–12.2)**	−13%	−1.88 (−3.61 to −0.149)*
31–45	+12%	14.0 (10.6–17.5)***	−12%	−0.259 (−1.59 to 1.07)
46–60	+58%	16.3 (13.0–19.5)***	−16%	−1.59 (−3.01 to −0.174)*
61–75	+24%	−2.93 (−7.78–1.93)	−9%	−10.0 (−13.3 to −6.77)***
>75	+26%	−5.83 (−15.6 to 3.97)	−19%	−20.7 (−26.2 to −15.1)***
All male adults	+11%	−4.00 (−8.55 to 0.540)	−11%	−5.84 (−7.69 to −3.99)***
16–30	−22%	−21.1 (−27.3 to −15.0)***	−25%	−6.88 (−8.54 to −5.21)***
31–45	−9%	−2.21 (−6.43 to 2.01)	−21%	−2.94 (−3.98 to −1.89)***
46–60	+40%	4.13 (0.091–8.16)*	+8%	−3.70 (−5.10 to −2.29)***
61–75	+20%	−15.7 (−21.6 to −9.78)***	−6%	−12.3 (−15.7 to −8.95)***
>75	+40%	−25.9 (−39.2 to −12.7)**	−2%	−23.5 (−30.1 to −16.9)***
All female adults	+40%	24.7 (21.6–27.7)***	−4%	−1.89 (−4.02 to 0.236)
16–30	+46%	36.6 (31.0–42.2)***	+3%	3.06 (0.944–5.18)**
31–45	+35%	29.5 (26.2–32.9)***	−2%	2.29 (0.516–4.05)*
46–60	+78%	28.0 (24.4–31.6)***	+26%	0.450 (−1.11–2.01)
61–75	+28%	6.62 (2.60–10.6)**	−13%	−8.45 (−11.7 to−5.16)***
>75	+16%	−0.282 (−8.72 to 8.15)	−29%	−20.5 (−25.7 to−15.3)***

*$P < 0.05$.
**$P < 0.01$.
***$P < 0.001$.

admission rates of younger men (aged 16–30) and older men (aged 61–75 and >75) decreased. The admission rates of middle-aged men have either not changed (aged 31–45) or increased (aged 46–60) (Table 1). The number of female admissions increased by 40% between 1997 and 2016, and each age group increased, more pronounced in young and middle-aged women. The rate of female admissions is increasing overall, caused by an increase in the rate of admissions of all age groups except the most elderly (aged >75), which has remained unchanged (Table 1).

The number of male EGS operations has decreased by 11% (from 9813 to 8775) between 1997 and 2016. The number of operations on males decreased in each age group except those aged 46 to 60 (Table 1). The operation rate in males has decreased overall, and in every age group. The number of EGS operations performed on female patients decreased by 4% overall (from 9260 to 8913) between 1997 and 2016. Young (aged 16–30) and middle-aged (aged 46–60) women had more operations performed over this time period, whereas other age groups had less operations, especially the elderly. The operating rate in females has not changed overall, nor in the young and middle-aged (aged 16–30, 31–45, and 46–60), but have decreased in the elderly (aged 61–75 and >75) (Table 1).

Admissions and Diagnoses

Figure 3 demonstrates changes over time in number of admissions and age- and sex-standardized rates of the most common primary admission diagnoses. These were analyzed for significance using Poisson distribution (Table 2). Diagnosis incidence rate ratios (IRR) of non-specific abdominal pain (NSAP), biliary pathology, appendicitis, pancreatitis, constipation, diverticulitis, obstruction, and abscess all increased significantly over time, whereas head injury and anorectal diagnosis rates decreased. The IRR of female admissions was higher than males for the diagnoses of NSAP, biliary pathology, constipation, and diverticulitis, but lower than males for head injury, anorectal pathology, appendicitis, pancreatitis, and bowel obstruction.

Operations and Procedures

There has been an overall decrease in the number and standardized rate of EGS operations performed over time (Figure 1); however, Figure 4 demonstrates specific operations performed over the study period, including the number and age- and sex-standardized rates per 100,000 admissions of appendicectomy, cholecystectomy, adhesiolysis, diagnostic laparoscopy, small bowel resection, inguinal hernia repair, Hartmann's procedure, laparotomy, and right hemicolectomy. Poisson distribution (Table 2) was used to determine significance. Only cholecystectomy and umbilical hernia repair rates per 100,000 population increased significantly over the 20-year study period (Figure 4). The IRR of adhesiolysis, small bowel resection, inguinal hernia repair, Hartmann's procedure, laparotomy, and right hemicolectomy decreased over time, whereas appendicectomy and diagnostic laparoscopy did not change (Table 2). Superficial operations such as skin drainage, perianal abscess, pilonidal pathology, and examination under general anesthetic operations all have increasing IRR, whereas wound explorations are decreasing (Table 2). Regarding procedures, the IRR of endoscopic retrograde cholangiopancreatography has increased, whereas that of oesophago-gastro-duodenoscopy and flexible sigmoidoscopy have decreased over time.

Outcomes

There has been a decrease in the number of inpatient deaths over time, as well as age- and sex-standardized mortality rates per 100,000 population (Figure 5). There has also been a decrease in admissions of patients with a 10-year lookback Charlson Comorbidity score of ≥ 2 (Figure 5). The mean length of hospital stay is decreasing over time; however, more patients are being discharged to destinations that are not the patient's home (Figure 5). The median length of stay decreased from 3 days (IQR 1–6 d) in 1997 to 1 day (IQR 0–3 d) in 2016 ($P < 0.001$). Poisson analysis confirms that inpatient mortality, mean length of hospital stay, and level of comorbidities are decreasing over time (Table 2). There has been an increase in patients not being discharged directly home.

DISCUSSION

We have demonstrated significant changes in secular trends of demographics, diagnoses, operations, and outcomes in Scottish EGS admissions between 1997 and 2016.

Demographics

Our key finding is that despite an overall increase in the number and rate of admissions, there has been a decrease in overall number and rate of operations. However, this has not been uniform in all sexes and age groups. The number of both male and female admissions has increased over time, but this has been much more

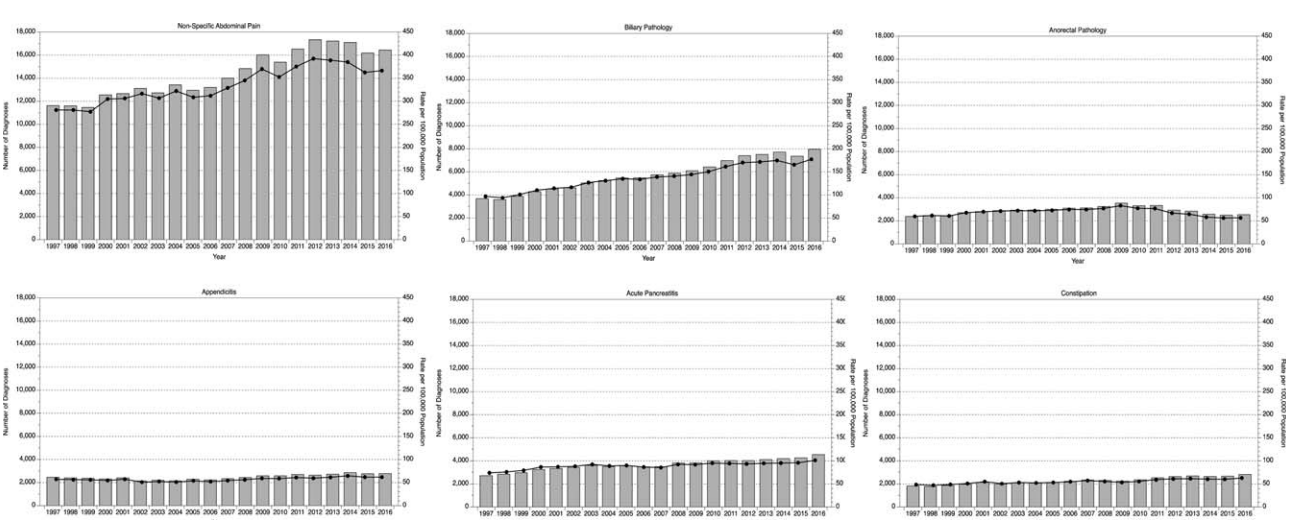

FIGURE 3. Diagnoses: numbers (bars) and age- and sex-standardized rates (lines), per 100,000 population.

TABLE 2. Poisson Distribution of Baseline Characteristics, Diagnoses, Operations, Procedures and Outcomes

	Age Group (>75 is Reference)				Sex (Male is Reference)	
	16–30	31–45	46–60	61–75	Female	Year
Baseline characteristics						
Admissions	0.378 (0.376–0.380)***	0.383 (0.381–0.385)***	0.410 (0.408–0.412)***	0.580 (0.577–0.583)***	0.947 (0.944–0.950)***	1.005 (1.004–1.005)***
Operations	0.417 (0.413–0.421)***	0.397 (0.393–0.401)***	0.421 (0.417–0.426)***	0.616 (0.610–0.623)***	0.879 (0.873–0.884)***	0.990 (0.990–0.991)***
Diagnoses						
NSAP	1.264 (1.247–1.282)***	1.030 (1.015–1.045)***	0.858 (0.845–0.871)***	0.829 (0.816–0.842)***	1.720 (1.707–1.734)***	1.018 (1.017–1.019)***
Biliary	0.210 (0.205–0.214)***	0.352 (0.345–0.359)***	0.473 (0.464–0.481)***	0.701 (0.689–0.714)***	1.748 (1.726–1.769)***	1.034 (1.033–1.035)***
Head injury	0.499 (0.488–0.510)***	0.379 (0.371–0.388)***	0.344 (0.336–0.352)***	0.399 (0.390–0.409)***	0.349 (0.344–0.355)***	0.958 (0.957–0.959)***
Anorectal	0.294 (0.286–0.303)***	0.452 (0.441–0.464)***	0.404 (0.393–0.414)***	0.468 (0.455–0.481)***	0.674 (0.663–0.685)***	0.998 (0.997–1.000)**
Appendicitis	6.425 (6.062–6.811)***	3.364 (3.170–3.569)***	2.241 (2.109–2.381)***	1.519 (1.424–1.620)***	0.750 (0.737–0.763)***	1.008 (1.006–1.009)***
Pancreatitis	0.069 (0.067–0.071)***	0.173 (0.170–0.177)***	0.188 (0.185–0.192)***	0.167 (0.164–0.171)***	0.470 (0.463–0.477)***	1.012 (1.011–1.013)***
Constipation	0.170 (0.164–0.175)***	0.197 (0.192–0.203)***	0.231 (0.225–0.238)***	0.401 (0.391–0.412)***	1.323 (1.298–1.349)***	1.015 (1.013–1.016)***
Diverticulitis	0.008 (0.007–0.009)***	0.095 (0.092–0.099)***	0.289 (0.282–0.297)***	0.542 (0.529–0.555)***	1.335 (1.308–1.362)***	1.011 (1.009–1.013)***
Obstruction	0.046 (0.044–0.049)***	0.097 (0.093–0.101)***	0.201 (0.195–0.207)***	0.440 (0.428–0.452)***	0.881 (0.862–0.900)***	1.005 (1.003–1.007)***
Abscess	2.758 (2.595–2.932)***	3.432 (3.231–3.645)***	2.003 (1.882–2.132)***	1.253 (1.171–1.340)***	0.993 (0.971–1.014)	1.017 (1.015–1.019)***
Operations						
Appendicectomy	9.817 (9.166–10.514)***	4.829 (4.504–5.177)***	2.914 (2.714–3.129)***	1.797 (1.666–1.938)***	0.820 (0.806–0.835)***	0.999 (0.997–1.000)
Cholecystectomy	0.671 (0.638–0.706)***	1.048 (1.000–1.098)*	1.230 (1.175–1.288)***	1.364 (1.302–1.430)***	2.359 (2.298–2.421)***	1.040 (1.038–1.042)***
Adhesiolysis	0.099 (0.087–0.112)***	0.178 (0.161–0.195)***	0.294 (0.270–0.319)***	0.627 (0.581–0.676)***	1.150 (1.085–1.219)***	0.978 (0.973–0.983)***
Diagnostic laparoscopy	4.635 (4.100–5.239)***	1.930 (1.698–2.194)***	0.916 (0.796–1.053)	1.159 (1.006–1.335)*	3.386 (3.190–3.595)***	0.999 (0.995–1.003)
SB resection	0.088 (0.078–0.099)***	0.141 (0.128–0.155)***	0.281 (0.259–0.305)***	0.594 (0.552–0.639)***	0.966 (0.914–1.022)	0.992 (0.987–0.997)**
Inguinal hernia repair	0.055 (0.050–0.060)***	0.063 (0.058–0.069)***	0.117 (0.109–0.125)***	0.333 (0.314–0.352)***	0.101 (0.094–0.109)***	0.979 (0.975–0.983)***
Umbilical hernia repair	0.135 (0.114–0.160)***	0.584 (0.521–0.655)***	0.862 (0.774–0.960)**	0.894 (0.799–1.001)	0.765 (0.717–0.817)***	1.030 (1.024–1.036)***
Hartmann's procedure	0.015 (0.012–0.019)***	0.073 (0.066–0.081)***	0.247 (0.230–0.266)***	0.650 (0.611–0.691)***	1.002 (0.953–1.055)	0.968 (0.964–0.973)***
Laparotomy	0.238 (0.216–0.263)***	0.241 (0.219–0.265)***	0.334 (0.306–0.365)***	0.610 (0.561–0.663)***	0.819 (0.773–0.867)***	0.964 (0.959–0.969)***
Right hemicolectomy	0.078 (0.071–0.087)***	0.102 (0.093–0.111)***	0.216 (0.200–0.232)***	0.524 (0.492–0.558)***	0.950 (0.903–0.999)*	0.983 (0.978–0.987)***
Superficial operations						
Drainage skin	1.841 (1.743–1.944)***	2.335 (2.214–2.463)***	1.641 (1.553–1.734)***	1.199 (1.130–1.272)***	0.963 (0.943–0.985)**	1.005 (1.003–1.007)***
Perianal abscess	3.627 (3.300–3.986)***	5.263 (4.795–5.776)***	3.821 (3.478–4.199)***	2.077 (1.880–2.294)***	0.450 (0.437–0.462)***	1.005 (1.002–1.007)***
Pilonidal	142.921 (96.527–211.613)***	39.422 (26.597–58.430)***	10.033 (6.738–14.941)***	3.166 (2.083–4.813)***	0.630 (0.610–0.651)***	1.006 (1.004–1.009)***
EUA	0.360 (0.326–0.397)***	0.417 (0.380–0.458)***	0.381 (0.346–0.420)***	0.432 (0.390–0.478)***	0.832 (0.783–0.883)***	1.021 (1.016–1.026)***
Wound exploration	0.618 (0.551–0.693)***	0.601 (0.537–0.674)***	0.686 (0.613–0.768)***	0.807 (0.719–0.906)***	0.620 (0.582–0.660)***	0.983 (0.977–0.988)***
Procedures						
ERCP	0.047 (0.044–0.051)***	0.097 (0.093–0.102)***	0.189 (0.182–0.197)***	0.462 (0.447–0.478)***	1.122 (1.090–1.154)***	1.005 (1.002–1.007)***
Upper GI endoscopy	0.150 (0.145–0.155)***	0.244 (0.237–0.250)***	0.331 (0.323–0.339)***	0.565 (0.552–0.579)***	0.849 (0.835–0.863)***	0.973 (0.971–0.974)***
Sigmoidoscopy	0.091 (0.087–0.095)***	0.136 (0.131–0.141)***	0.203 (0.196–0.210)***	0.422 (0.410–0.435)***	0.996 (0.973–1.019)	0.950 (0.948–0.952)***
Outcomes						
Mortality	0.002 (0.002–0.003)***	0.009 (0.008–0.010)***	0.049 (0.047–0.052)***	0.244 (0.237–0.251)***	0.803 (0.784–0.824)***	0.943 (0.941–0.946)***
LOS	0.106 (0.083–0.137)***	0.125 (0.100–0.157)***	0.189 (0.154–0.232)***	0.371 (0.308–0.446)***	0.915 (0.794–1.054)	0.957 (0.946–0.969)***
Not DC home	0.109 (0.108–0.111)***	0.133 (0.131–0.134)***	0.192 (0.191–0.194)***	0.400 (0.397–0.404)***	0.833 (0.827–0.839)***	1.022 (1.022–1.023)***
DC home	0.549 (0.545–0.552)***	0.541 (0.538–0.545)***	0.549 (0.545–0.552)***	0.693 (0.689–0.698)***	0.981 (0.977–0.984)***	1.000 (1.000–1.000)
Comorbidities	0.017 (0.017–0.018)***	0.070 (0.069–0.071)***	0.220 (0.218–0.223)***	0.586 (0.580–0.592)***	0.752 (0.746–0.758)***	0.993 (0.992–0.994)***

$^{*}P < 0.05$.
$^{**}P < 0.01$.
$^{***}P < 0.001$.
Presented as incidence rate ratios (95% CIs).
The model included 2 categorical variables (age group and sex), a continuous variable (y), and was offset by the natural logarithm of the population. All goodness-of-fit tests (Pearson χ^2/df) were >0.1, and all Omnibus tests were significant with $P < 0.001$.
DC, discharge; ERCP, endoscopic retrograde cholangiopancreatography; EUA, endoscopic under anesthesia; LOS, length of hospital stay; NSAP, nonspecific abdominal pain; SB, small bowel.

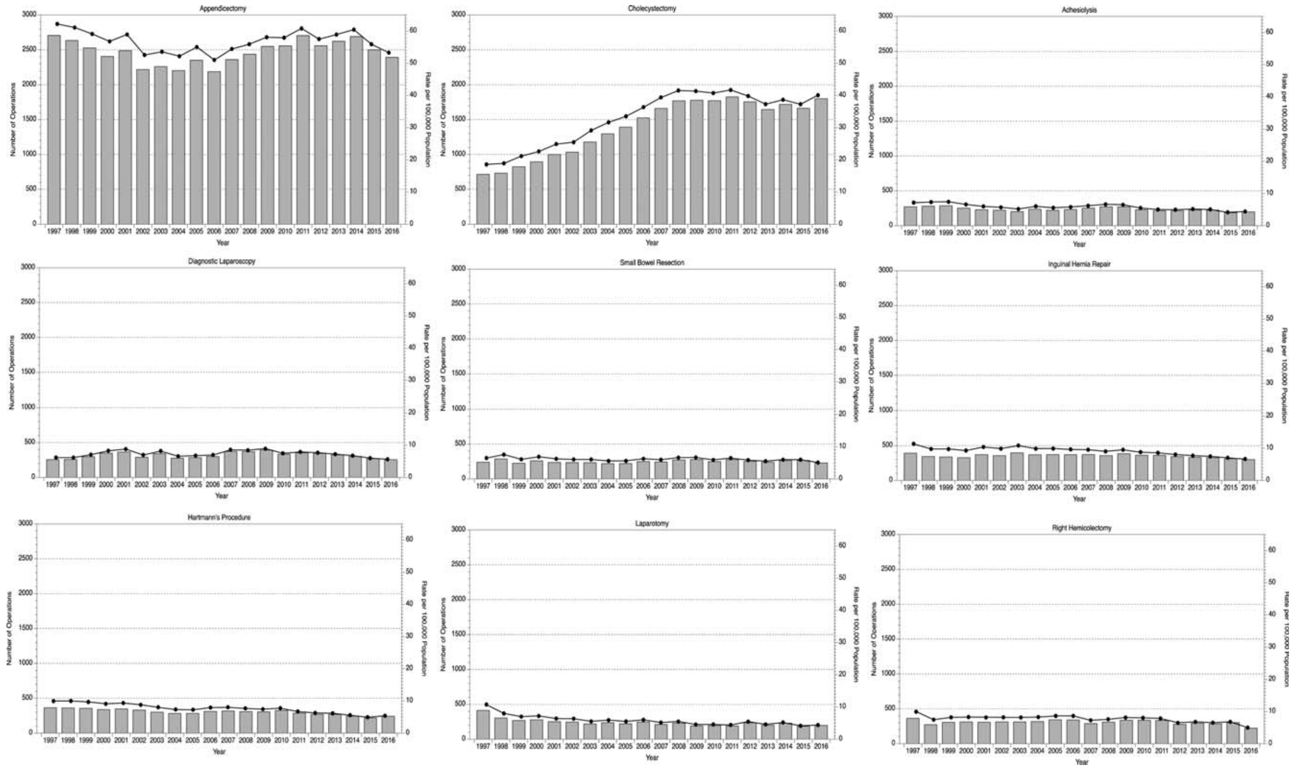

FIGURE 4. Operations: numbers (bars) and age- and sex-standardized rates (line), per 100,000 population.

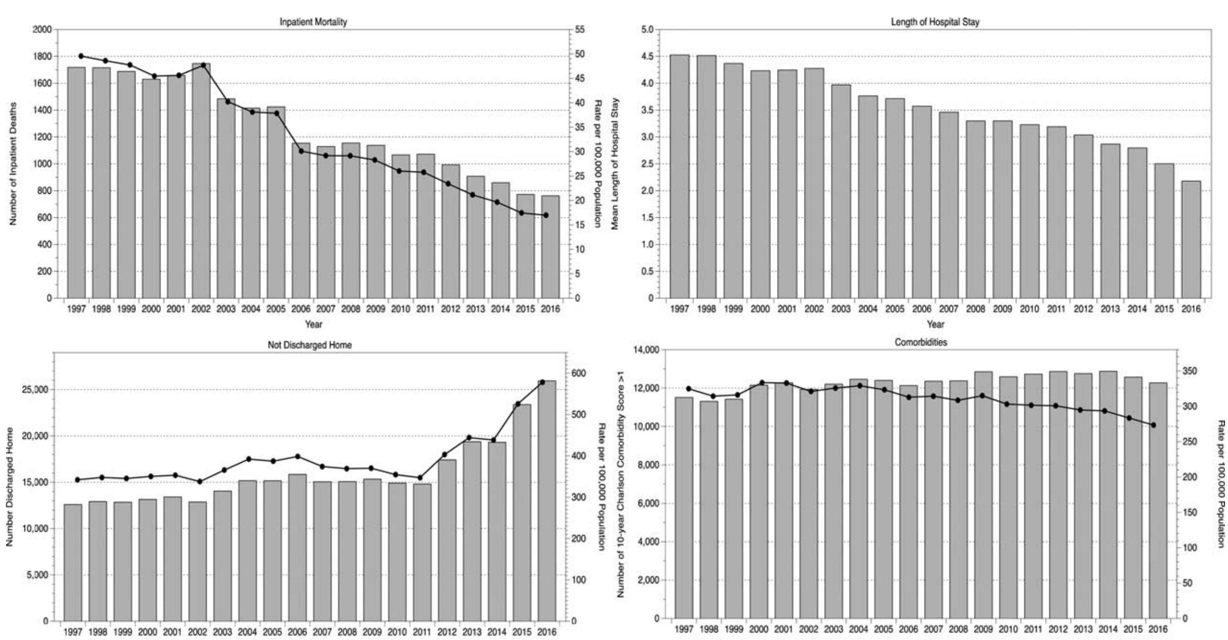

FIGURE 5. Outcomes: numbers (bars*) and age- and sex-standardized rates (lines), per 100,000 population (*length of hospital stay, bars depict the mean).

pronounced in females. The rate per 100,000 population of admissions has remained unchanged in males overall, though it has decreased in the elderly and young. In contrast, the rate per population has increased in females, particularly because of an increase in admissions in young and middle-aged women.

The adult (aged >15) population of Scotland has increased over the study period, from 4.07 to 4.49 million,[17] which may, in part, explain the increase in the number of admissions. However, in women the rate per 100,000 population is increasing, particularly in the young, which suggests that there has either been an increase in the underlying level of disease, or a change in the way our services are delivered. For example, the 2 most common diagnoses—NSAP and biliary pathology—have both increased overall, and the IRR are higher in women than men (1.720 and 1.748, respectively) (Table 2). Perhaps more female patients are being admitted with symptoms of right iliac fossa pain to an EGS service, to rule out appendicitis, rather than to obstetrics and gynecology, to investigate for ovarian pathology or endometriosis.

Evaluation of operations by demographics demonstrates that the number of operations in males and females has decreased overall, with a decrease in number and rate in those aged 61 to 75 and >75 in both sexes (Table 1). The number of operations has decreased in young men also, aside from those aged 46 to 60, but the rate of operations has decreased in all age groups in men, and overall. The number of operations has increased in females aged 16 to 30 and 46 to 60, though the rate of operations in women has remained unchanged in those aged <61, and overall.

The observation of the reduction in the number and rates of operations in the elderly is intriguing. This may be representative of increased nonoperative management of some conditions which would have previously been an indication for surgical intervention (such as sealed perforation of duodenum or diverticulum). Alternatively, this could be explained by an increase in diagnostic cross-sectional imaging (computed tomography and magnetic resonance), which may have previously required diagnostic laparoscopy or laparotomy. Or, an increase in multidisciplinary decision-making may be deeming more patients unfit for surgical intervention, and offering them nonoperative management instead.

Admissions and Diagnoses

We have outlined an overall increase in the number and rates of admission, along with an increased rate of some diagnoses (NSAP, biliary pathology, appendicitis, acute pancreatitis, functional intestinal disorders and diverticular disease, bowel obstruction, and abscess), whereas the diagnoses of head injury and anorectal pathology have decreased.

The reasons for an overall increase in admissions, and in these conditions specifically, are unknown. It could be true that more patients are acutely unwell, and require admission. However, this is not necessarily supported by the fact that patients are requiring fewer acute operations, staying in hospital for fewer days, and have a lower mortality rate. An alternative explanation is that medical practice is becoming increasingly defensive, and thus general practitioners and emergency physicians are more likely to refer/admit patients as inpatients in EGS services rather than provide follow-up and investigations from the community setting. EGS practitioners may also be more apprehensive to decline admission to hospital for medicolegal reasons. If this explanation were true, then the reduction in LOS and mortality could be related to an inpatient population who are not as acutely unwell, and who would have done well whether they were in hospital or not. However, the implication of a higher admission rate, coupled with a decreasing LOS, regardless of explanation, is that demand on EGS services is increasing to provide more rapid assessments, decisions, and prompt discharge of patients. This higher turnover of patients may increase the risk of medical error and professional stress.

Operations and Procedures

There has been an overall reduction in the rate of operative EGS procedures. Individually, some operation rates have increased (cholecystectomy and umbilical hernia repair), whereas most have either remained unchanged (appendicectomy and diagnostic laparoscopy) or decreased (adhesiolysis, small bowel resection, inguinal hernia repair, Hartmann's procedure, laparotomy, and right hemicolectomy) in this population. There was a significant change overall in the rate of superficial operations performed (Table 2).

The increase in cholecystectomy operations may have been affected by guidelines outlining a shift toward "hot gallbladder" procedures, performed within approximately 1 week from symptoms.[20,21] Indeed, some view that the delivery of laparoscopic cholecystectomy procedures in a timely manner is a key measure indicative of an efficient EGS service framework.[22]

Interestingly, the authors had expected appendicectomy rates to have decreased given the increasing literature demonstrating successful treatment of uncomplicated acute appendicitis nonoperatively, with antibiotics.[23,24] However, many of these studies are not practicable as they depend on computed tomography diagnosis, which many surgeons feel is not required compared with clinical examination for appendicitis, and therefore confers an unnecessary dose of ionizing radiation to patients.[25]

Most noteworthy is the decrease in the rate of major operations, including Hartmann's procedure, laparotomy, and right hemicolectomy. The reasons for this are also not clear. It may be that clinicians are encountering patients who are not fit for surgical intervention, so are treated with chemotherapy, radiotherapy, colorectal stenting, or palliation instead. Alternatively, it could be that these operations are simply being performed as "urgent" cases, whereby patients are worked up on an urgent outpatient basis, discussed at multidisciplinary meetings, and brought back on elective operative lists instead of remaining in hospital until their operation. Unfortunately, we do not have data on elective operations or elective inpatient admissions to further augment this data.

The reduction in rate of emergency operating will have significant implications on surgical training, which will need to be addressed. Training units will need to maximize opportunities for operative training while ensuring compliance with the New Deal and European Working Time Directive.[26]

Outcomes

Reassuringly, there has been a significant reduction in inpatient mortality over time. As mentioned, the reasons for this are not clear, and it is beyond the scope of this paper to explore this in more depth, and thus will be the subject of further work.

There has also been a reduced length of hospital stay (LOS) over time. This may be due to more utilization of inpatient cross-sectional imaging to aid in diagnosis, which may lead to more prompt decisions and thus treatment and recovery.[27] The decreased LOS may also be related to the increasingly management-driven bed utilization policies in hospitals.[28] There has also been an increase in patients not discharged directly home from hospital. We did not perform a subgroup analysis to examine precisely where these patients are being discharged to instead of home, but may be a subject of further work.

An unexpected finding was a decreased 10-year lookback Charlson Comorbidity Score of $\geq$2 over time. Upon closer inspection of the Poisson, the IRR of comorbidities increases with age as expected (Table 2). The IRR of comorbidity is significantly lower in females than males, and we know from Figure 2 and Table 1 that there is a significant increase in admissions of young women (aged

16–60 y), whereas there is a more significant increase in admissions of older men (aged 46 to >75 y). So perhaps this overall decrease of comorbidity merely represents the changing demographics.

Limitations

As with all large epidemiological studies, our study depends on the accuracy of the source database (ISD), and specifically of ICD-10 diagnosis codes, and of OPCS-4 procedure codes. This was a retrospective study design; however, the data have been prospectively collected. A key methodological and conceptual limitation of this study is the fact that changes in healthcare service organizational factors may skew or confound the results. For example, we cannot control for overall changes in healthcare service provision, such as if an operation or procedure is increasingly done as an outpatient, or elective list instead of on an emergency operative list as part of the EGS admission. These operations would not be counted in this study design, and thus it would appear as a decrease in operation rate when it is in fact shifting to an elective procedure, and may be similar or even increasing in number and/or rate annually. Other changes which took place during the study period include vascular surgery becoming its own specialty in the United Kingdom as of 1 March 16, 2012,[29] and an increased use of laparoscopy for cavity surgery.[30]

Implications and Further Study

Our findings have many implications. The demand for EGS services is continuing to rise, and will have to be met. Given the increase in nonoperative treatment, the question arises as to whether some or all of these patients need to be admitted under the care of a surgeon. If so, then work patterns will have to take this increased workload into account. Dealing with comorbidity in elderly patients might benefit from more geriatric medical input. Surgical training programs will need to account for the decreased number of EGS operations performed, both in allowing for this during intraprogram evaluations, as well as recognizing the need for competent delivery of nonoperative management. Training programs in the United Kingdom are already lengthy, as a result of working time regulations, and further increases are probably not feasible. A projection of future admissions and operations may be a valuable area for further study. In addition, though our data fit the basic assumptions of Poisson regression (Table 2), some of these relationships may be nonlinear. This is an area of further work, where we can then attempt to correlate changes in admission/operative trends with changes in service provision, in the context of strategic shifts of planning and educational resources in the Scottish National Health Service.

RECOMMENDATIONS

This 20-year epidemiological study of all emergency general surgery hospital episodes in Scotland has enhanced our understanding of secular trends of EGS, including demographics, diagnoses, operations, and outcomes. These data will help inform stakeholders in EGS service planning and delivery, as well as in surgical training, what has occurred in recent history. We must adapt to accommodate an increasingly aged population, fewer of which will require an operation, but may remain longer in hospital. Further modeling to predict admissions or operations may aid workforce planning to facilitate the future demand of emergency care delivery.

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