

QUALITY AND PATIENT SAFETY

Frequency of surgical treatment and related hospital procedures in the UK: a national ecological study using hospital episode statistics

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Abstract

Background: Despite evidence of high activity, the number of surgical procedures performed in UK hospitals, their cost and subsequent mortality remain unclear.

Methods: Time-trend ecological study using hospital episode data from England, Scotland, Wales and Northern Ireland. The primary outcome was the number of in-hospital procedures, grouped using three increasingly specific categories of surgery. Secondary outcomes were all-cause mortality, length of hospital stay and healthcare costs according to standard National Health Service tariffs.

Results: Between April 1, 2009 and March 31, 2014, 39 631 801 surgical patient episodes were recorded. There was an annual average of 7 926 360 procedures (inclusive category), 5 104 165 procedures (intermediate category) and 1 526 421 procedures (restrictive category). This equates to 12 537, 8073 and 2414 procedures per 100 000 population per year, respectively. On average there were 85 181 deaths (1.1%) within 30 days of a procedure each year, rising to 178 040 deaths (2.3%) after 90 days. Approximately 62.8% of all procedures were day cases. Median length of stay for in-patient procedures was 1.7 (1.3–2.0) days. The total cost of surgery over the 5 yr period was £54.6 billion (\$104.4 billion), representing an average annual cost of £10.9 billion (inclusive), £9.5 billion (intermediate) and £5.6 billion (restrictive). For each category, the number of procedures increased each year, while mortality decreased. One-third of all mortalities in national death registers occurred within 90 days of a procedure (inclusive category).

Conclusions: The number of surgical procedures in the UK varies widely according to definition. The number of procedures is slowly increasing whilst the number of deaths is decreasing.

Key words: epidemiology; healthcare costs; surgery; mortality; postoperative care/methods

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Editor's key points

- Cost and other indicators of efficiency of healthcare are needed to better inform health policy and clinician decision-making
- Definitions of 'surgery' and anaesthetic episodes vary widely; these greatly affect the denominator of any estimates of healthcare efficiency.
- In the UK, as with most western countries, approximately one in ten people undergo a surgical procedure each year.
- On average, postoperative mortality is decreasing each year.

Despite advances in pharmacological therapies, the worldwide use of surgical treatments is thought to be increasing.^{1,2} Due to the large volumes of activity, patient outcomes after surgery are a growing public health concern and an important focus of health research and policy.³⁻⁸ However, initiatives to improve the quality of surgical care and subsequent patient outcomes have been hampered by the paucity of reliable audit data. Compared with diseases such as cancer and myocardial infarction, few countries regularly collate data describing the total number of surgical procedures, the associated mortality or healthcare costs. This limited understanding represents a key barrier to improving the safety and effectiveness of surgical treatments, and the planning of future service requirements.

Crude global estimates suggest 312 million major surgical procedures were performed in 2012, an increase of one-third over eight years.¹ However, these worldwide statistics may not be accurate at the individual country level. In England, published estimates of the total volume of surgery using healthcare registry data vary almost 10-fold from 1.6 to 11 million procedures each year.^{7,9,10} Meanwhile, the results of a prospective national census suggest 3 million anaesthetics are administered every year for surgery.¹¹ Importantly, without consensus on the overall denominator of surgical procedures performed, postoperative mortality rates and healthcare costs remain impossible to calculate. This uncertainty is primarily due to wide variations in the definition of surgery used, making comparison difficult. A number of high volume procedures may be categorized very differently. Important examples include pacemaker insertion, endoscopy and interventional radiology procedures.

There is a need for accurate data describing surgical activity, outcomes and cost in order to facilitate healthcare research, policy and delivery. We used National Health Service (NHS) registry data to estimate the annual number of surgical procedures in the UK. We used three alternative categorizations of surgery to demonstrate the effect of different definitions on estimates of surgical volume. Our secondary aims were to describe the all-cause mortality, length of hospital stay and healthcare costs associated with surgical treatments in each category, and the effect of alternative categorizations of surgery on these measures.

Methods**Study design**

This was a time-trend ecological study using summary national-level hospital episode data for the NHS in England, Scotland, Wales and Northern Ireland. Data from England, Wales and

Scotland were available between April 1, 2009 and March 31, 2014. Data for Northern Ireland were available for the period April 1, 2012 to March 31, 2014. Full datasets were obtained for England and Wales. Length of stay data were not available for Scotland and mortality data were not available for Northern Ireland (Supplementary Table S1). The study was subject to institutional review, and was sponsored by Queen Mary University of London. Research ethics approval was not required as the study did not involve analysis of individual patient data.¹²

Data sources

Public bodies in each of the UK nations generate annual anonymous national summary data for utilization of hospital services, including the number of hospital procedures, which are publicly available on their web sites. All episodes in these summary data are either: NHS funded and provided; NHS funded and privately provided; or privately funded and NHS provided. NHS Digital (formerly the Health and Social Care Information Centre) for England, NHS Wales Information Service for Wales and the Information Services Division Scotland for Scotland are able to link patient-level data to Office for National Statistics (ONS) records on request and subsequently provide anonymous national-level summary mortality data grouped by hospital procedure. The Department of Health, Social Services and Public Safety for Northern Ireland is unable to provide ONS-linked mortality data. The median length of hospital stay for each episode of hospital care associated with a procedure was only available for England, Wales and Northern Ireland.

Hospital procedures are identified by staff at respective hospitals who assign an Office of Population Censuses and Surveys version 4 (OPCS4) code prior to entering the procedure into the dataset. Two very similar versions of OPCS4 codes (v4.6, 2009–11 and v4.7, 2011–4), were manually checked for compatibility and transcription errors prior to analysis. Data were managed using Microsoft Excel (Seattle, WA, USA).

Categories of surgery

All OPCS4 codes for hospital procedures were reviewed. We removed codes that were clearly not surgical in nature (e.g. radiotherapy, diagnostic imaging or oxygen therapy), and stratified the remaining codes according to three increasingly strict categories. The first 'inclusive' category comprised procedures that might be considered surgery, including minor surgery, interventional radiology procedures and diagnostic endoscopies, but excluding non-invasive diagnostic procedures (e.g. diagnostic imaging). The second 'intermediate' category included procedures routinely undertaken in an operating theatre and/or under general or regional anaesthesia. The third 'restrictive' category included major procedures that due to duration or complexity may often result in tissue injury. Three investigators (T.E.F.A., A.J.F., T.D.D.) independently reviewed all the OPCS4 codes and categorized them according to each category. Where unanimous agreement was not reached, a second round of independent review was carried out. Where agreement was not reached after two rounds, each code was discussed and referred to the senior investigator (R.M.P.) for final decision on inclusion.

Number of surgical procedures

We calculated the total number of procedures occurring in each country over the 5 yr period by summing the number of all procedures included in the respective categories. As data were not available for Northern Ireland before 2012, we imputed the

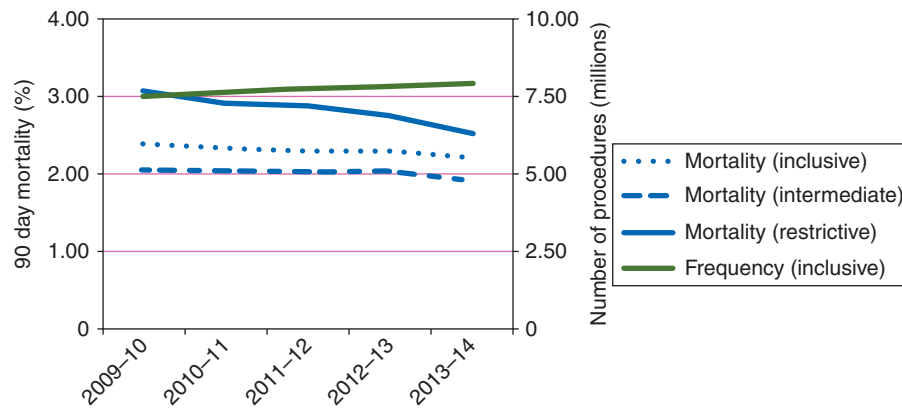


Fig 2 Crude 90 day post-procedure mortality for England, Scotland and Wales during the period April 1, 2009–March 31, 2014, stratified by inclusive, intermediate and restrictive categories of surgery and shown in % on the left axis. Procedure frequency using the inclusive category shown on the right axis in multiples of 1 000 000 procedures. It is unclear whether the observed reduction in mortality rates between 2009 and 2014 reflect improvements in perioperative care or are an artefact of the increasing frequency of procedures.

Table 4 Post-procedure mortality as a proportion of National deaths. The combined number of in-hospital and out of hospital deaths following hospital procedures in England, Scotland and Wales per financial year as a proportion of the total number of deaths nationally (%), stratified according to three categories of surgery. Data are presented as n (%) for 30-day, 60-day and 90-day mortality are presented separately, with a total across the five-year study period. Mortality data were not available for Northern Ireland

	2014-2013	2013-2012	2012-2011	2011-2010	2010-2009	Total
National deaths	555 663	561 490	554 268	538 028	547 209	2 756 658
Within 30 days after surgery, n (%)						
Inclusive	82 979 (14.93)	85 522 (15.23)	85 357 (15.40)	85 944 (15.97)	86 102 (15.73)	425 904 (15.45)
Intermediate	49 356 (9.12)	51 208 (9.12)	50 999 (9.20)	51 966 (9.66)	51 457 (9.40)	254 986 (9.25)
Restrictive	20 408 (3.92)	22 021 (3.92)	22 331 (4.03)	23 403 (4.35)	23 897 (4.37)	112 060 (4.07)
Within 60 days after surgery n (%)						
Inclusive	133 900 (24.10)	137 749 (24.53)	137 264 (24.76)	137 793 (25.61)	137 951 (25.21)	684 657 (24.84)
Intermediate	76 639 (13.79)	79 146 (14.10)	78 491 (14.16)	79 272 (14.73)	78 483 (14.34)	392 031 (14.22)
Restrictive	30 758 (5.54)	33 113 (5.90)	33 233 (6.00)	34 615 (6.43)	35 326 (6.46)	167 045 (6.06)
Within 90 days after surgery n (%)						
Inclusive	174 620 (31.43)	179 465 (31.96)	178 378 (32.18)	178 794 (33.23)	178 944 (32.70)	890 201 (32.29)
Intermediate	99 195 (17.85)	101 940 (18.16)	100 759 (18.18)	101 148 (18.80)	100 356 (18.34)	503 398 (18.26)
Restrictive	39 222 (7.06)	41 871 (7.46)	41 942 (7.57)	43 426 (8.07)	44 443 (8.12)	210 904 (7.65)

total cost of surgery. The estimated total cost of procedures in the inclusive category in 2009–10 was £10 471 024 463 (\$15 848 942 627) compared with £11 056 095 814 (\$18 424 983 674) for 2013–4. This represents a 5.6% increase over five years.

Sensitivity analysis

We matched OPCS4 codes to British United Provident Association (BUPA) codes using a previously published method.¹⁵ We were unable to match 371 codes. There were 171 minor procedure codes, 219 intermediate, 272 major, 108 major plus and 159 complex major. We applied BUPA codes to the national NHS dataset. Using this classification there were a total of 7 520 256 procedures and 85 419 (1.2%) deaths within 30 days of a procedure per year. The average median length of stay was 2.8 days and average total cost was £9 800 407 961 per year (Table 5). When

we applied the average 30 day post-procedure mortality rate for England, Scotland and Wales to the average UK frequency estimate, the mean annual number of deaths was 86 231 (inclusive), 51 305 (intermediate) and 21 710 (restrictive). When we repeated the currency conversions using the Bank of England exchange for each financial year, the results were similar.

Discussion

The principal finding of this study was that surgery accounts for more than 39 million individual patient episodes in the UK over five years and the annual number of procedures is increasing year on year. The number of procedures is dependent on the definition used, ranging from 7.9 million per year for the most

hospital procedures provided or funded through the NHS, but does not include procedures provided and paid for privately. We approached private providers in order to estimate the volume of private surgery in the UK, but this was unsuccessful. We prospectively created three categories of surgery and categorized OPCS4 codes by consensus. This is inherently subjective and not all clinicians or researchers will agree with our interpretation. Restrictions regarding public availability of hospital episode data in Northern Ireland mean that the primary analysis did not include data from Northern Ireland before 2012 and the mortality analysis did not include deaths in Northern Ireland. However, we do not believe this has a significant effect on the generalizability of the results to the UK population. Cost data were generated by linking OPCS4 codes to the commonest (modal) HRG code for that procedure and multiplying these by the PbR tariff. Standard methodology for health economic analysis uses PbR tariff.³⁷ However, tariff represents the payment to the provider (hospital), which is not necessarily the same as the actual cost.³⁸ Payments to hospitals can be increased through the use of postoperative complications codes and through national or local adjustment of tariff.³⁹ We did not attempt to attribute an excess cost to patients with complications codes, and our approach therefore provides a conservative estimate of income to hospitals for care provided. Finally, we presented the mortality data as crude (unadjusted) incidence rates because we did not have access to mortality data stratified by age in order to perform age standardization. As it was not our intention to make comparisons between countries, or make inferences regarding exposures that might influence postoperative mortality, we do not think this influences our interpretation.

Conclusions

A very large number of hospital procedures are performed in the UK every year, representing a significant proportion of NHS activity, expenditure and mortality. However, the total number of procedures is sensitive to the definition of surgery used. Universal and clinically relevant definitions of surgery are required for coordinated research, healthcare policy and planning. Further research is needed to better understand the population undergoing major surgery, who are the primary focus of perioperative medicine, and procedures undertaken in the last year of life.

Authors' contributions

Developed the analysis plan: T.E.F.A., A.J.F., M.A.G., R.M.P.
 Extracted the data: T.E.F.A., A.J.F., T.D.D.
 T.E.F.A. performed the data analysis with input from A.J.F., R.M.P.
 The manuscript was drafted by T.E.F.A., A.J.F., R.M.P., and revised following critical review by all authors.

Supplementary material

Supplementary material is available at *British Journal of Anaesthesia* online.

Declaration of interest

E.M.H. has served on an advisory board for GSK. R.M.P. holds research grants, and has given lectures and/or performed consultancy work for GSK, Nestle Health Sciences, BBraun,

Medtronic and Edwards Lifesciences, and is a member of the Associate editorial board of the *British Journal of Anaesthesia*; there are no other relationships or activities that could appear to have influenced the submitted work. All other authors declare no conflict of interests.

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Patient and public involvement

This article addresses several key research areas identified in the recent James Lind Alliance Priority Setting Partnership for perioperative medicine, in which patients played an active role. The research proposal was reviewed by the Patient, Public and Carer Involvement group at the Royal College of Anaesthetists Health Services Research Centre, which provided feedback during both development and design phases.

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