Frequency of surgical treatment and related hospital procedures in the United Kingdom: 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 United Kingdom 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 NHS tariffs.

Results

Between 1st April 2009 and 31st March 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, 8,073 and 2,414 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 five-year 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.

Introduction

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 to 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 ten-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 categorised 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 United Kingdom. We used three alternative categorisations 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 categorisations 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 1st April 2009 and 31st March 2014. Data for Northern Ireland were available for the period 1st April 2012 to 31st March 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 1). 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 utilisation of hospital services, including the number of hospital procedures, which are publically available on their websites. 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, 2009-2011 and v4.7, 2011-2014), were manually checked for compatibility and transcription errors prior to analysis. Data were managed using Microsoft Excel (Seattle, USA).

Categories of surgery

All OPCS4 codes for hospital procedures were reviewed. We removed codes that were clearly not surgical in nature, for example 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, for example 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 (TA, AF and TD) independently reviewed all the OPCS4 codes and categorised 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 (RP) for final decision on inclusion.

Number of surgical procedures

We calculated the total number of procedures occurring in each country over the five-year period by summing the number of all procedures included in the respective categories. Since data were not available for Northern Ireland before 2012, we imputed the number of procedures in Northern Ireland for the years 2009-2011 using data from 2012/2013 to provide estimates of the total frequency and cost of surgery for the UK overall.

Mortality

We calculated the total number of deaths within 30, 60 and 90 days after procedures for each category in England, Scotland and Wales. We presented deaths as a proportion of procedures and as a proportion of total national deaths.

Length of hospital stay and day case procedures

The national summary data tables include median hospital length of stay for each OPSC4 code, calculated by subtracting the date of admission from the date of discharge. This excludes admissions with zero days length of stay (i.e. day-case procedures). The total number of day-case admissions for each OPCS4 code is also listed. We calculated the total median hospital length of stay and summarised the total number of day-case admissions for each category of surgery.

Cost

To estimate the total cost of hospital procedures, we applied the NHS Payment by Results (PbR) tariff to the estimates of the number of procedures. Since tariff is indexed using Healthcare Resource Groups (HRG), OPCS4 codes were matched to HRG, first by taking the commonest (mode) HRG for a given OPSC4 code and then by the most appropriate HRG where a modal match was not possible (AF). Matching was independently checked by a second investigator (TA). HRG groups without complication codes were selected to provide a conservative estimate of cost. We multiplied the tariff for each HRG by the number of hospital episodes to estimate the hospital cost of procedures, presented in Pounds Sterling (£) and US Dollars ($) according to the Bank of England conversion rate on the 31st March 2014.

Statistical analysis

We used SPSS version 22 (IBM, New York, USA) to analyse the data. Categorical variables were presented as frequency (%). Continuous variables were presented as mean (SD) for

normally distributed data and median (IQR) for non-normally distributed data. Length of hospital stay, which does not follow a normal distribution, was presented as median (IQR).[13] Missing data were handled by list-wise deletion.

Sensitivity analyses

Firstly, in order to contextualise our categories of surgery we repeated our analysis by categorising our data set using an alternative classification of surgery.[14] We matched OPCS4 codes into the following categories minor, intermediate, major, major plus, and complex major using previously published methods.[14, 15] We repeated the calculation of number of procedures, mortality, length of hospital stay and cost according to this alternative classification. Secondly, in order to evaluate the effect of missing mortality data for Northern Ireland, we estimated the annual total number of post-procedure deaths for the whole UK, including Northern Ireland. We multiplied the average annual procedure mortality for England, Scotland and Wales by the number of procedures for the whole UK (including Northern Ireland). Since procedure frequency in Northern Ireland was not available before 1st April 2012, this analysis was restricted to the period 1st April 2012 – 31st March 2014 and the mean calculated to estimate the annual number of deaths. Thirdly, to account for possible information bias due to retrospective application of the 31st March 2014 currency exchange rate in the cost analysis, we recalculated the conversions using the Bank of England exchange rates on the 31st March each year.

Results

There were 1,306 OPCS4 codes for hospital procedures. We included 1,179 codes in the inclusive category of surgery, 1,047 codes in the intermediate category and 553 codes in the restrictive category (supplementary figure 1 and supplementary tables 2 to 5). There was a high rate of reviewer agreement, and only 2.9% (82/2779) were referred for review by a senior author (RP) for arbitration on inclusion. OPCS4 codes are made up of three characters and we provide these in parentheses following the name of the code below.

Number of surgical procedures

There were 39,631,801 (inclusive category) individual patient episodes associated with surgical procedures in the UK between 1st April 2009 and 31st March 2014. This represents an average of 7,926,360 (inclusive category), 5,104,165 (intermediate), 1,526,421 (restrictive) procedures per year, or 12,537, 8,073 and 2,414 respective procedures per 100,000 population per year.[16, 17] We present the frequency of hospital procedures performed in the United Kingdom per 100,000 population in supplementary table 6. The total number of all procedures increased by 5.3% over the five-year period (inclusive category), by 4.2% using the intermediate category and by 6.5% using the restrictive category (table 1). We present the ten most common procedures over the five-year study period for each category in table 2. Four of the most common procedures in the inclusive category were endoscopic, accounting for 7.8 million procedures (19.7%) over five years.

Mortality

Over five years, the mean 30-, 60- and 90-day post-procedure mortality rates in England, Scotland and Wales were: 425,904/38,609,280 (1.1%), 684,657/38,609,280 (1.8%) and 890,201/38,609,280 (2.3%) (inclusive category). Within 30 days after surgery 1.1% of patients died according to the inclusive category, 1.0% according to the intermediate category and 1.5% died according to the restrictive category (table 3). There was a consistent decrease in 30-day postoperative mortality (restrictive category), from 1.7% in

2009/2010 to 1.3% in 2013/2014 (table 3). Similarly, the 90-day mortality rate decreased from 3.1% in 2009/2010 to 2.5% in 2013/2014 (table 3 and figure 2). We present the ten procedures with the highest crude 30-day mortality rate over five years for each category in supplementary table 7. The procedure category with the highest mortality rate was pericardial procedures (L18), which carries a 34.1% risk of death within 30 days of surgery. The mortality rate associated with laparotomy (T30) was 19.0%. There were 169 procedure categories with a mortality rate ≥5%, representing 213,111 deaths over five years. As a proportion of national deaths, mortality within 90 days of a hospital procedure accounted for 32.3% (inclusive), 18.3% (intermediate), and 7.7% (restrictive) of deaths over five years (table 4).[18]

Length of hospital stay and day case procedures

For the period 1st April 2012 to 31st March 2014 median length of stay in England, Wales and Northern Ireland was 1.7 (IQR 1.3-2.0) days (inclusive category), 1.7 (IQR 1.3-2.0) days (intermediate) and 3.8 (IQR 3.6-4.0) days (restrictive). This excluded procedures with length of stay stated as zero days (i.e. day-cases), which accounted for 4,688,661 (62.8%) (inclusive), 2,538,242 (52.8%) (intermediate) and 394,025 (27.2%) (restrictive) procedures per year. Median length of stay in England and Wales (restrictive) reduced from 5.0 (IQR 2.0-8.3) days in 2009/2010 to 4.00 (IQR 2.0-7.8) days in 2013/2014 (20.0%). We present the five procedures with the highest median length of stay for each category in supplementary table 8. Open heart assistance procedures (K54) had the longest length of stay (42.0 [40.0-43.0] days) in the restrictive category.

Cost of surgery

The estimated total cost of hospital procedures in the UK over five years was £54,631,317,163 ($104,389,947,396), representing an average annual cost of £10,926,263,433 (inclusive), £9,508,213,884 (intermediate) and £5,550,530,996 (restrictive). We present the five procedures attracting the largest aggregate payments over five years,

and the number of procedures performed in supplemental table 9. Orthopaedic procedures, including spinal surgery (V54), total knee (W40) replacement, and open (W20, W19) and closed (W24) reduction of fractures accounted for £8,785,890,035/54,631,317,163 (16.1%) of the total cost of surgery. The estimated total cost of procedures in the inclusive category in 2009/2010 was £10,471,024,463 ($15,848,942,627) compared to £11,056,095,814 ($18,424,983,674) for 2013/2014. 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 + 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 United Kingdom 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 inclusive category to 1.5 million per year for the most restrictive. This is less than the largest previous estimates of national surgical volume.[9, 10] Equivalent to one in ten members of the UK population undergo a surgical procedure every year, and equivalent to one third of all UK deaths occur within the three months following a hospital procedure.[16] Post-procedure mortality rates appear to be decreasing year on year, however this still represents almost nine hundred thousand deaths over five years. We are unable to say whether these deaths are attributable to surgery or if they are preventable since these data represent all-cause mortality. However, it raises questions about whether there are opportunities to intervene in the perioperative care pathway to further patient benefit, and to what degree life expectancy influences the decision of doctors and patients to proceed with invasive procedures. Given the high procedure volume, total annual cost of surgery (£11 billion) accounts for a substantial portion (9.4%) of the total NHS budget (£117 billion for 2013/2014).[19-22] This estimate does not include spending on associated outpatient appointments, investigations or treatment for post-procedure complications.

This is the first investigation, of which we are aware, to estimate the total number of surgical procedures across all four nations of the United Kingdom. Our findings are consistent with previous reports, which suggest that between 1.6 million and 11 million procedures are performed in England each year.[7, 9, 10] However, these studies were probably targeted at different patient populations, for example the estimate of 1.6 million procedures was likely focused on major surgery according to our restrictive category.[7] Three million general anaesthetics were administered during the NAP-4 audit of airway management and this would account for around two thirds of the intermediate category, which included procedures

typically performed under regional or general anaesthesia.[11] Similarly, accepted global estimates of the frequency of surgery suggest that in high-income countries over 11,000 procedures are performed annually per 100,000 head of population.[1, 2] When considered in the context of our data, many procedures included in these estimates may not be considered as surgery by many clinicians. The term 'surgery' may mean very different things to different stakeholders, such as clinicians, researchers, policy makers and patients. The absence of a standard vocabulary is unhelpful and promotes confusion. There may be international differences in what is considered 'surgery'. For example, in some countries, regional analgesia for non-instrumental delivery during childbirth would be considered a surgical procedure whilst in other countries it would not. We did not include non-instrumental delivery in any category. Our estimates of procedural mortality are consistent with previous estimates (0.5-4.0%) and are likely to be amongst the most accurate estimates of postoperative mortality in the UK.[7, 8, 23-25] The mortality rate for laparotomies was 19%, which is consistent with other observations for this patient group.[26-30] We identified a consistent decreasing trend in mortality rates over five years. However, it is unclear whether this represents a true reduction in mortality, due to improved patient care and perioperative risk assessment, or whether this is a statistical artefact of an increased number of low-risk procedures (denominator).[31, 32] The magnitude of the difference between 30-day and 90-day mortality rates is striking, suggesting much greater emphasis should be placed on 90-day postoperative mortality as a clinical outcome measure. The median length of hospital stay (restrictive category) was 3.8 days, with a reducing trend over five years. We were unable to investigate the influence of complications on hospital length of stay in this study.

This study has several strengths. We used summary data for all hospital procedures undertaken by NHS providers across the UK. Therefore our results represent the majority of surgery undertaken nationally over the five-year period of interest, which makes these data generalisable to the entire UK population. In contrast to previous reports using similar source data, we adopted three transparent consensus categories of surgery to reflect the variety of

opinions regarding what constitutes surgery. Our categories of surgery are available in the supplementary files (supplementary tables 2 to 5) and we hope others will expand on this work. The mortality data were generated through linkage to the Office for National Statistics death register. Therefore the mortality rates represent all deaths in the UK within the allotted time period, not just in-hospital mortality, which has been a key limitation of previous epidemiological studies.[8, 24]

This study also has several limitations. This was an ecological study using group-level data. We were not able to undertake patient-level multivariable statistical modelling or risk adjustment.[33, 34] Hospital episode data rely on clinicians and coders at each hospital to record details about individual patient admissions. The accuracy and completeness of data coding, as well as clinical care, is likely to vary between hospitals and between individuals at each hospital, which may introduce information bias.[35, 36] There is a possibility that a patient who had multiple admissions for procedures and died may be double counted in the mortality estimate. Where multiple procedures occur in one admission, the hospital episode is coded according to the predominant procedure, so this analysis may underestimate the total number of procedures. The source data represent all 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 categorised 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 generalisability 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 standardisation. Since 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.

Declaration of competing interests

EH has served on an advisory board for GSK. RP 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.

Details of contributions

TA, AF, MG, and RP developed the analysis plan. TA, AF and TD extracted the data. TA performed the data analysis with input from AF and RP. The manuscript was drafted by TA, AF and RP, and revised following critical review by all authors.

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Patient and public involvement

This paper 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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Table 1. Frequency of hospital procedures in the United Kingdom between 1st April 2009 and 31st March 2014

The number of procedures per year stratified by financial year and country for three categories of surgery: 'inclusive', 'intermediate' and 'restrictive'. Data regarding the number of procedures were not available in Northern Ireland before 1st April 2012, so values for 2013-2012 were used to estimate annual UK totals from 2009-2012. Numbers in parentheses are imputed.

Year	2014-2013	2013-2012	2012-2011	2011-2010	2010-2009	Total
			England			
Inclusive	7,025,974	6,915,380	6,845,202	6,755,316	6,597,897	34,139,769
Intermediate	4,540,371	4,418,792	4,376,982	4,402,195	4,315,158	22,053,498
Restrictive	1,366,868	1,338,358	1,276,686	1,304,241	1,267,000	6,553,153
			Wales			
Inclusive	339,946	337,663	336,665	332,601	348,341	1,695,216
Intermediate	211,175	211,368	214,645	210,883	223,962	1,072,033
Restrictive	64,222	65,411	66,675	64,220	67,606	328,134
			Scotland			
Inclusive	554,259	551,953	551,946	552,589	563,548	2,774,295
Intermediate	366,659	362,901	358,595	360,851	368,214	1,817,220
Restrictive	116,485	115,704	116,178	117,646	117,154	583,167
			Northern Ireland			
Inclusive	205,745	204,194	(204,194)	(204,194)	(204,194)	1,022,521
Intermediate	116,470	115,401	(115,401)	(115,401)	(115,401)	578,074
Restrictive	33,903	33,437	(33,437)	(33,437)	(33,437)	167,651
			Total for England, Scotland and Wales			
Inclusive	7,920,179	7,804,996	7,733,813	7,640,506	7,509,786	38,609,280
Intermediate	5,118,205	4,993,061	4,950,222	4,973,929	4,907,334	24,942,751
Restrictive	1,547,575	1,519,473	1,459,539	1,486,107	1,451,760	7,464,454
			Total for United Kingdom			
Inclusive	8,125,924	8,009,190	7,938,007	7,844,700	7,713,980	39,631,801
Intermediate	5,234,675	5,108,462	5,065,623	5,089,330	5,022,735	25,520,825
Restrictive	1,581,478	1,552,910	1,492,976	1,519,544	1,485,197	7,632,105

Table 2. The ten most frequent procedures included in each category (inclusive, intermediate, restrictive) over five years. Procedure code, total frequency shown and proportion of total volume over five years (%) are shown in parentheses.

Rank	Inclusive	Intermediate	Restrictive
1	Diagnostic upper gastrointestinal endoscopy (G45; 3,273,173; 8.3%)	Prosthesis of lens (C75; 1,906,986; 7.5%)	Cholecystectomy (J18; 409,612; 5.4%)
2	Prosthesis of lens (C75; 1,906,986; 4.8%)	Excision of skin lesion (S06; 1,076,599; 4.2%)	Total knee replacement with cement (W40; 390,309; 5.1%)
3	Diagnostic colonoscopy (H22; 1,835,537; 4.6%)	Surgical removal of tooth (F09; 592,073; 2.3%)	Spinal operations (V54; 287,629; 3.8%)
4	Diagnostic cystoscopy (M45; 1,510,160; 3.8%)	Vitreous body procedures (C79; 514,780; 1.0%)	Open reduction of fracture with extra-medullary fixation (W20; 261,500; 3.4%)
5	Diagnostic sigmoidoscopy (H25; 1,180,286; 3.0%)	Caesarean section (R18; 505,495; 2.0%)	Closed reduction of fracture with internal fixation (W24; 251,509; 3.3%)
6	Excision of skin lesion (S06; 1,076,599; 2.7%)	Therapeutic endoscopy of semilunar cartilage (W82; 422,891; 1.7%)	Excision of breast tissue (B28; 239,148; 3.1%)
7	Therapeutic colonoscopy (H20; 621,916; 1.6%)	Cholecystectomy (J18; 409,612; 1.6%)	Internal fixation of bone (W28; 213,096; 2.8%)
8	Surgical removal of tooth (F09; 592,073; 1.5%)	Inguinal hernia repair (T20; 392,462; 1.5%)	Emergency appendicectomy (H01; 210,691; 2.8%)
9	Joint aspiration (W90; 540,218; 1.4%)	Angioplasty with stent insertion (K75; 391,724; 1.5%)	Total hip replacement with cement (W37; 193,739; 2.5%)
10	Vitreous body procedures (C79; 514,780; 1.3%)	Total knee replacement with cement (W40; 390,309; 1.5%)	Hysterectomy (Q07; 184,072; 2.4%)

Table 3. Aggregate post-procedure mortality in England, Scotland and Wales between 1st April 2009 and 31st March 2014

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

Year	2014-2013	2013-2012	2012-2011	2011-2010	2010-2009	Total
			30-day mortality, n (%)			
Inclusive	82,979 (1.05)	85,522 (1.10)	85,357 (1.10)	85,944 (1.12)	86,102 (1.15)	425,904 (1.10)
Intermediate	49,356 (0.96)	51,208 (1.03)	50,999 (1.03)	51,966 (1.04)	51,457 (1.05)	254,986 (1.02)
Restrictive	20,408 (1.32)	22,021 (1.45)	22,331 (1.53)	23,403 (1.57)	23,897 (1.65)	112,060 (1.50)
			60-day mortality, n (%)			
Inclusive	133,900 (1.69)	137,749 (1.76)	137,264 (1.77)	137,793 (1.80)	137,951 (1.84)	684,657 (1.77)
Intermediate	76,639 (1.50)	79,146 (1.59)	78,491 (1.59)	79,272 (1.59)	78,483 (1.60)	392,031 (1.57)
Restrictive	30,758 (1.99)	33,113 (2.18)	33,233 (2.28)	34,615 (2.33)	35,326 (2.43)	167,045 (2.24)
			90-day mortality, n (%)			
Inclusive	174,620 (2.20)	179,465 (2.30)	178,378 (2.31)	178,794 (2.34)	178,944 (2.38)	890,201 (2.31)
Intermediate	99,195 (1.94)	101,940 (2.04)	100,759 (2.04)	101,148 (2.03)	100,356 (2.05)	503,398 (2.02)
Restrictive	39,222 (2.53)	41,871 (2.76)	41,942 (2.87)	43,426 (2.92)	44,443 (3.06)	210,904 (2.83)

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)

Table 5. Summary of hospital procedure frequency, mortality (%), median length of hospital stay (days) and cost to NHS providers (£) stratified by British United Provident Association (BUPA) procedure severity grading. Office of Population Censuses and Surveys version 4 (OPCS4) codes were matched to BUPA codes. Frequency and cost were presented as total over five years and average annual total for the United Kingdom. Deaths within 30 days of surgery presented as total over five years with average percentage mortality for England, Scotland and Wales. Length of stay presented as annual median for England, Wales and Northern Ireland.

BUPA grading	Frequency (total)	Frequency (annual)	Total deaths (%)	Median length of stay	Cost (total) £	Cost (annual) £
Minor	11,414,356.0	2,282,871	185,907 (1.7)	1.0	6,297,244,674	1,259,448,935
Intermediate	14,045,849.0	2,809,170	128,529 (0.9)	1.0	12,298,560,462	2,459,712,092
Major	8,909,387.0	1,781,877	68,008 (0.8)	2.0	15,213,166,652	3,042,633,330
Major +	2,041,560.0	408,312	20,225 (1.0)	3.0	10,207,671,696	2,041,534,339
Complex Major	1,190,126.0	238,025	24,428 (2.1)	7.0	4,985,396,319	997,079,264
Total	37,601,278.0	7,520,256	427,097 (1.2)	-	49,002,039,803	9,800,407,961

Figure Legends

Figure 1. Flow diagram showing Office of Population Censuses and Surveys version 4 (OPCS4) codes included in each category of surgery (inclusive, intermediate or restrictive).

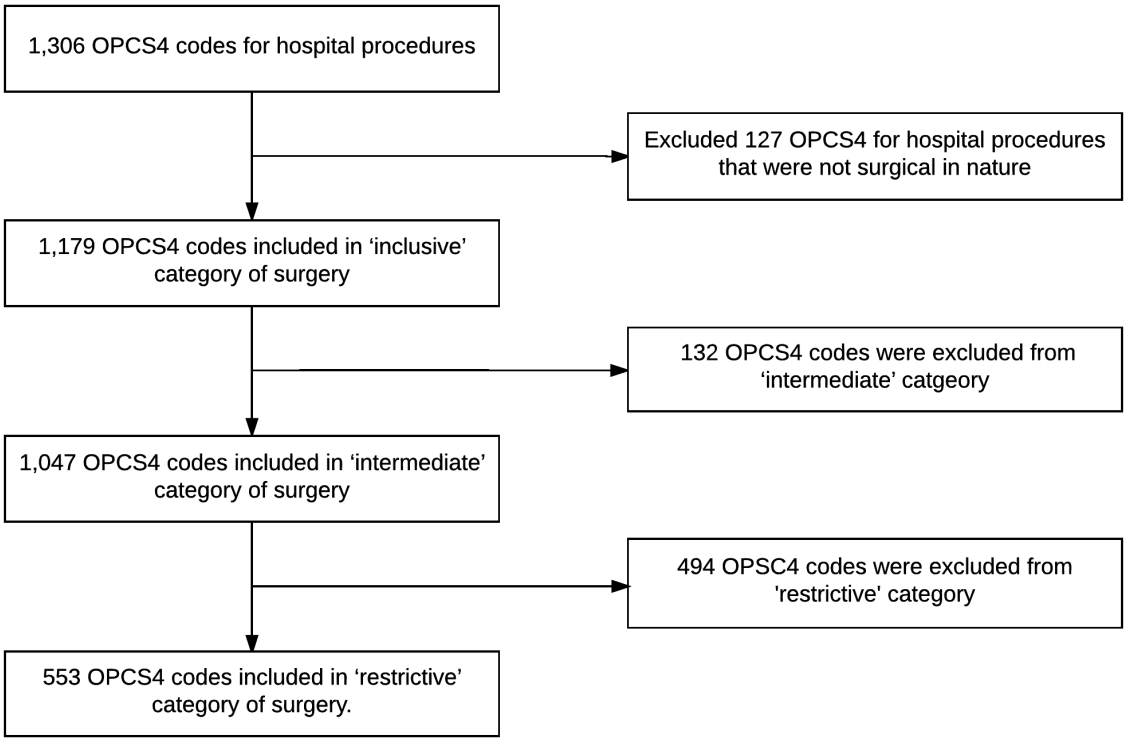

Figure 2. Crude 90-day post-procedure mortality for England, Scotland and Wales during the period 1st April 2009 – 31st March 2014, stratified by inclusive, intermediate and restrictive categories of surgery and shown in percent (%) on left axis. Procedure frequency using the inclusive category shown on right axis in multiples of 1,000,000 procedures. It is unclear whether reduction in mortality rates are a true effect or an artefact of the increasing frequency of procedures.