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Thornhill, M. orcid.org/0000-0003-0681-4083, Crum, A., Campbell, R. et al. (9 more authors) (2023) Temporal association between invasive procedures and infective endocarditis. *Heart*, 109 (3). pp. 223-231. ISSN 1355-6037

<https://doi.org/10.1136/heartjnl-2022-321519>

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Original research

Valvular heart disease

Temporal association between invasive procedures and infective endocarditis

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► Additional supplemental material is published online only. To view, please visit the journal online (<http://dx.doi.org/10.1136/heartjnl-2022-321519>).

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Received 15 June 2022

Accepted 2 September 2022



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To cite: Thornhill MH, Crum A, Campbell R, et al. *Heart* Epub ahead of print. *iplease include Day Month Year*. doi:10.1136/heartjnl-2022-321519

ABSTRACT

Objective Antibiotic prophylaxis has been recommended for patients at increased risk of infective endocarditis (IE) undergoing specific invasive procedures (IPs) despite a lack of data supporting its use. Therefore, antibiotic prophylaxis recommendations ceased in the mid-2000s for all but those at high IE risk undergoing invasive dental procedures. We aimed to quantify any association between IPs and IE.

Methods All 14731 IE hospital admissions in England between April 2010 and March 2016 were identified from national admissions data, and medical records were searched for IP performed during the 15-month period before IE admission. We compared the incidence of IP during the 3 months immediately before IE admission (case period) with the incidence during the preceding 12 months (control period) to determine whether the odds of developing IE were increased in the 3 months after certain IP.

Results The odds of IE were increased following permanent pacemaker and defibrillator implantation (OR 1.54, 95% CI 1.27 to 1.85, $p<0.001$), extractions/surgical tooth removal (OR 2.14, 95% CI 1.22 to 3.76, $p=0.047$), upper (OR 1.58, 95% CI 1.34 to 1.85, $p<0.001$) and lower gastrointestinal endoscopy (OR 1.66, 95% CI 1.35 to 2.04, $p<0.001$) and bone marrow biopsy (OR 1.76, 95% CI 1.16 to 2.69, $p=0.039$). Using an alternative analysis, bronchoscopy (OR 1.33, 95% CI 1.06 to 1.68, $p=0.049$) and blood transfusions/red cell/plasma exchange (OR 1.2, 95% CI 1.07 to 1.35, $p=0.012$) were also associated with IE.

Conclusions This study identifies a significant association between specific IPs (permanent pacemaker and defibrillator implantation, dental extraction, gastrointestinal endoscopy and bronchoscopy) and subsequent IE that warrants re-evaluation of current antibiotic prophylaxis recommendations to prevent IE in high IE risk individuals.

INTRODUCTION

Infective endocarditis (IE) incidence has increased significantly in the last decade in the UK¹ and the rest of Europe.² Responsible factors could include an ageing population, increased intra-cardiac device use (pacemakers, implantable cardioverter-defibrillators, surgical and transcatheter heart valves), vascular interventions (including haemodialysis), injection drug use, greater IE awareness and access to investigations (especially

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Antibiotic prophylaxis (AP) was recommended before various invasive procedures (IPs) to prevent infective endocarditis (IE), but in the mid-2000s, this practice was stopped (except for invasive dental procedures in those at high risk outside the UK), due to an absence of evidence associating these procedures with IE; in the UK, AP stopped altogether. Since then, there has been a significant increase in IE incidence in the UK and the rest of Europe.

WHAT THIS STUDY ADDS

⇒ This study investigated any temporal association between IPs and subsequent IE in England and identified a significant association with IE following implantation of cardiac pacemakers/defibrillators (CIEDs), dental extractions/surgical tooth removal, upper and lower gastrointestinal endoscopy, and bronchoscopy, all previously recommended for AP.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ These findings provide evidence to warrant a re-evaluation of current AP recommendations for IE prevention in those at high IE-risk, particularly with regard to implantation of CIEDs, gastrointestinal endoscopy, dental extractions (in the UK) and bronchoscopy.

echocardiography), and changes in IE prevention guidelines.¹

IE has devastating consequences, and prevention has been the focus of guidelines. Previous UK, European and US guidelines recommended AP for moderate or high IE risk patients undergoing various invasive procedures (IPs), including invasive-dental procedures (IDPs) (online supplemental appendix table S1). With the possible exception of IDPs, however, there is scant evidence linking IPs to IE or evidence that AP prevents IE.³ This, and concerns about adverse drug reactions and the development of antibiotic resistance, led the American Heart Association (AHA)⁴ and European Society for Cardiology (ESC)⁵ to recommend restricting AP use to IDPs in those at high IE risk and the UK National Institute for Health and Care

Box 1 Cardiac conditions used to classify individuals as being at high or moderate infective endocarditis (IE) risk**High IE risk.**

Previous history of IE.

Presence of prosthetic heart valve (including transcatheter valves).

Prosthetic material used for valve repair (including annuloplasty and transcatheter valve procedures).

Unrepaired cyanotic congenital heart disease.

Congenital heart disease treated with palliative shunts or conduits.

Congenital heart defect repaired with surgical or transcatheter technique using prosthetic material or device (first 6 months postprocedure only).

Moderate IE risk

Rheumatic heart disease.

Non-rheumatic valve disease (including mitral valve prolapse).

Congenital valve anomalies (including aortic stenosis).

Hypertrophic cardiomyopathy.

Notes: adapted from the European Society of Cardiology and American Heart Association guidelines.^{7 8 11 12} More extensive details of all diagnoses and procedures (including relevant ICD-10 diagnosis or OPCS-4 procedure codes) included in the definition of those at high or moderate IE risk are provided in online supplemental tables S2 and S3).

Excellence (NICE) to recommend the complete cessation of AP to prevent IE.⁶

This study aimed to investigate any association between specific IPs and subsequent IE in England using a case-crossover methodology during a period when AP prevention of IE was not recommended.

METHODS**IE admissions and IE risk stratification**

All hospital admissions in England are recorded in the Hospital Episode Statistics (HES) database. With UK National Research Ethics Service approval (17/SC/0371) and Confidentiality Advisory Group approval, this resource was used to identify all IE admissions between 1 April 2010 and 31 March 2016. An admission was defined as a single continuous hospital stay (which could comprise several consultant episodes), where an International Classification of Diseases 10th Revision (ICD-10) primary or secondary diagnosis code I33.0, I33.9, I39.0, I39.1, I39.2, I39.3, I39.4 or I39.8, or a primary diagnosis code I38.X, was used for any consultant episode. Patients discharged alive with a <3 day length of hospital stay or elective admission were excluded.⁷ This study is reported according to Strengthening the Reporting of Observational Studies in Epidemiology guidelines.

Each patient's HES record was retrieved from 1 January 2000. To stratify individuals into high, moderate or low/unknown risk of IE (box 1), records were searched for ICD-10 diagnosis or Office of Population Censuses and Surveys Classification of Surgical Operations and Procedures Revision 4 (OPCS-4) procedure codes occurring before IE admission that placed them into these categories based on ESC and AHA guidelines (box 1, online supplemental tables S1 and 2).^{4 5}

New IE admissions were distinguished from readmissions by only accepting IE admissions >180 days apart. Consistent with the guidelines, individuals with congenital heart disease

completely repaired with prosthetic material or a device were considered high-risk for IE for 6 months after the procedure and then considered low risk. Individuals not identified as moderate or high risk were considered at low/unknown risk of IE.

Patient and public involvement

Patients were not directly involved in this study.

Invasive procedures

Each patient's record was searched for OPCS-4 IP codes of interest (online supplemental tables S4 and S5) for each 30-day period over the 15 months before IE admission (ie, between 1 January 2009 and 31 March 2016). IPs of interest were those previously recommended for AP in the 2004 British Cardiac Society and 2006 British Society for Antimicrobial Chemotherapy guidance or identified as associated with an increased risk of IE in a recent Swedish study (online supplemental table S1). To avoid the possibility of reverse causation (procedures being performed as part of the investigation or management of IE), we excluded procedures undertaken during the IE admission. Because some cardiac IPs, for example, coronary artery bypass grafting, may be performed simultaneously with procedures such as valve replacement or repair, we only included them when they occurred alone. Although an association has been reported between dialysis and IE,⁸ the case-crossover methodology is inappropriate for a procedure performed with such regularity, and dialysis was excluded from the study. To ensure we counted the number of individuals exposed to each procedure each month (rather than the number of procedures), we counted the first procedure of each type performed on each individual each month.

Restricting IP data to 1 January 2009 through 31 March 2016, meant all IPs were performed after NICE recommended AP use to prevent IE cease (March 2008)⁶ and before any relaxation of this (April 2016).⁹ Thus, any association between IPs and IE should have been fully exposed.

Case-crossover study**Primary analysis**

Monthly exposure to IPs was quantified over the 15 months before IE-related hospital admissions to determine any temporal association (figures 1 and 2 and online supplemental figure S1). Using a step model case-crossover analysis for each IP,¹⁰ we calculated the period-adjusted OR and its 95% CI of that IP having been undertaken during the 3-month case period before IE admission compared with the preceding 12-month control period (months 4–15), using a mixed-effects logistic regression model with the patient as a random effect and a fixed effect step parameter at 3 months. To account for potential temporal bias of increasing numbers of IPs being performed, we also calculated an adjusted OR for each IP using a mixed-effects logistic regression model adjusted for date of IE admission (see online supplemental appendix methods). Statistical analyses were performed in Stata V.17, using core packages, and all p values were corrected upwards for multiple comparisons using the Benjamini-Hochberg method.¹¹

Secondary analysis

Sensitivity analyses were performed using 4-month and 6-month case periods (online supplemental tables S7 and S8), and an alternative 'hinge-model' case-crossover analysis was performed (see online supplemental appendix), in which instead of fitting a

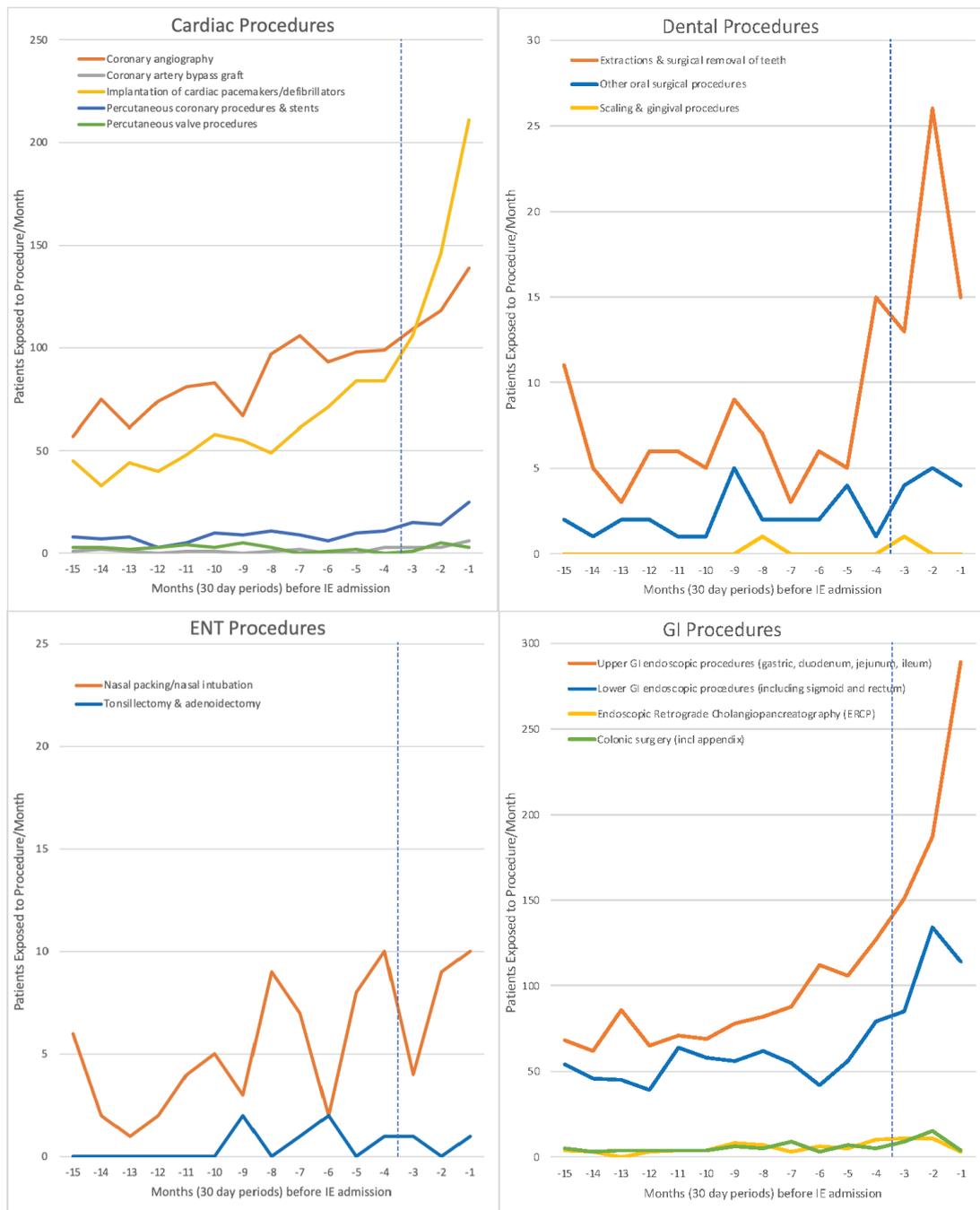


Figure 1 Incidence of different cardiac, dental, ENT and GI invasive procedures over the 15 months before infective endocarditis (IE) hospital admission. Vertical blue dashed line separates case period (months -1 to -3) from control period (months -4 to -15). ENT, ear, nose and throat; GI, gastrointestinal.

step change at 3 months, we fitted a change in the time trend at 3 months before admission (a linear term for months -3 to -1).

Attributable risk

Attributable risk (or absolute risk increase) was defined as the additional number of IE cases per 100 000 procedures) and was estimated for IPs with a significant positive association with IE. The background IE incidence was estimated by dividing the total number of IE cases identified during the study by (duration of study \times 53.4937 million), the latter being the Office of National Statistics figure for the population of England during the middle year of the study (2012). The attributable risk per 100 000 procedures was then calculated as $=100\,000 \times$ background IE

incidence \times (adjusted OR-1)/4, where the adjusted OR from the primary analysis in table 1 and was used to approximate the relative risk for the 3-month case period, and the denominator (4) reflected the case period was one-quarter of a year. The attributable risk was estimated separately for patients at high, moderate or low/unknown risk using previously published prevalence data for these populations (figure 3).^{12 13}

RESULTS

Study population demographics

Between 1 April 2010 and 31 March 2016, there were 14 731 IE admissions (mean age 62.3 years, 66.1% male) in England

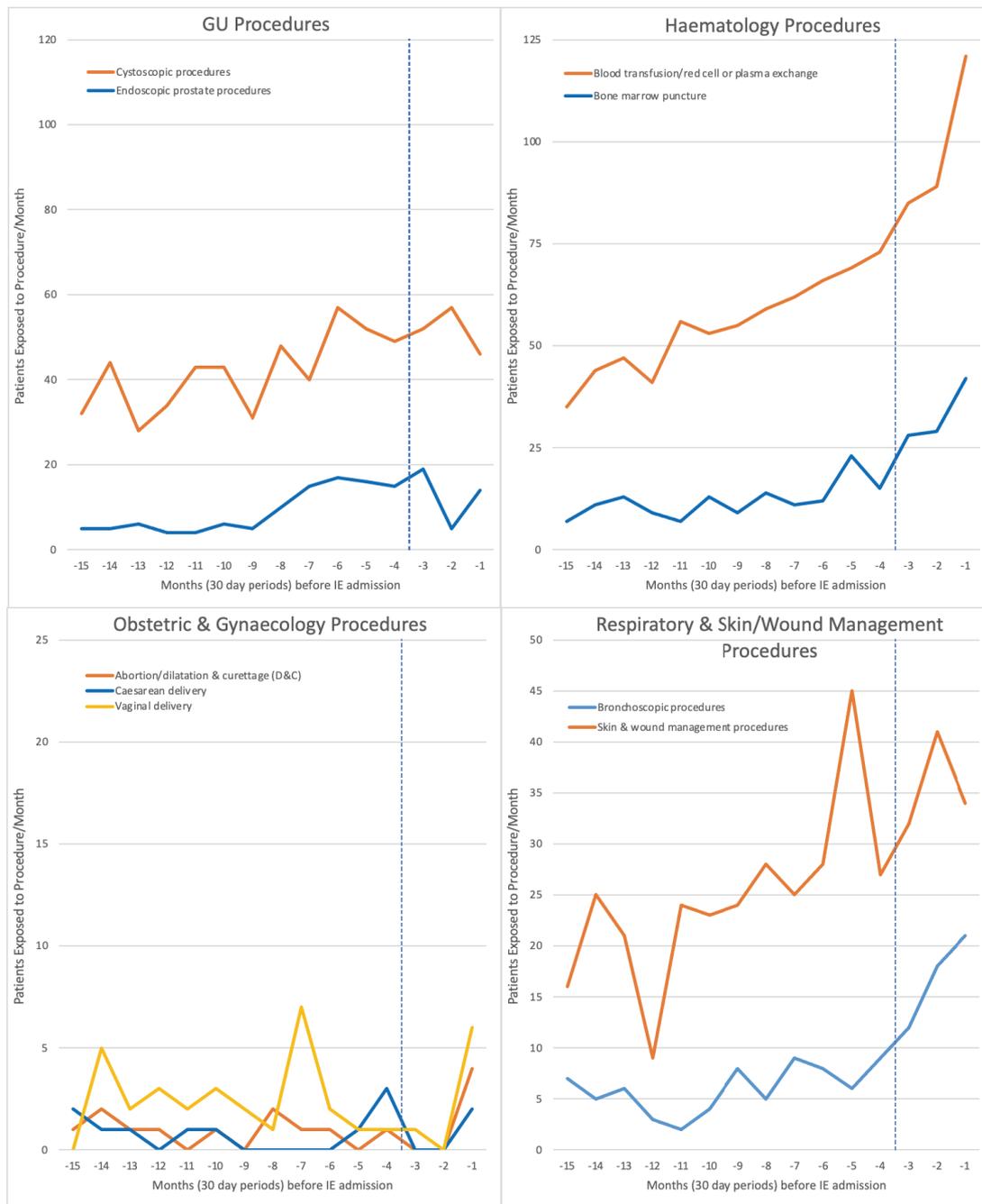


Figure 2 Incidence of different GU, haematology, obstetrics and gynaecology, respiratory and skin/wound management invasive procedures over the 15 months before infective endocarditis (IE) hospital admission. Vertical blue dashed line separates case period (months –1 to –3) from control period (months –4 to –15). GU, genitourinary.

(table 2). Twenty-one per cent occurred in individuals at high IE risk, 17.0% at moderate risk and 61.7% in those at low/unknown risk. Time course studies plotting the monthly incidence of each IP over 15 months before IE admission are shown in figures 1 and 2.

Case-crossover analysis

Case-crossover analysis (table 1) showed that many IPs had no significant IE association. However, our primary step model analysis identified a significant IE association following implantation of cardiac pacemakers/defibrillators (CIEDs) (OR 1.54, 95% CI 1.27 to 1.85, $p < 0.001$), extractions/surgical tooth removal (OR 2.14, 95% CI 1.22 to 3.76, $p = 0.047$), upper GI (OR

1.58, 95% CI 1.34 to 1.85, $p < 0.001$) and lower GI endoscopic procedures (OR 1.66, 95% CI 1.35 to 2.04, $p < 0.001$) and bone marrow biopsy (OR 1.76, 95% CI 1.16 to 2.69, $p = 0.039$). All except extractions/surgical tooth removal were also significantly associated with IE using the alternative hinge model analysis. Hinge model analysis also demonstrated a significant association with IE following blood transfusion/red cell or plasma exchange (OR 1.2, 95% CI 1.07 to 1.35, $p = 0.012$) and bronchoscopic procedures (OR 1.33, 95% CI 1.06 to 1.68, $p = 0.049$). In the sensitivity analyses, extractions and upper and lower gastrointestinal (GI) endoscopy remained significantly associated with IE when a 4-month (but not a 6 month) case period was used (online supplemental tables S6 and S7). The remaining procedures were

Table 1 Case-crossover analysis comparing the incidence of invasive procedures (IPs) in the 3-month case period and the preceding 12-month control period for 14 731 patients admitted with IE

| Invasive procedures (ISPs) | Case period (3 m) | | Control period (12 m) | | Unadjusted step model† | | Adjusted step model‡ | | | Adjusted hinge model§ | | |
|--|-------------------|---------|-----------------------|---------|------------------------|---------------|----------------------|----------------|---------|-----------------------|--------------|---------|
| | Total proc* | Proc/m* | Total proc* | Proc/m* | OR | 95% CI | OR | 95% CI | P value | OR | 95% CI | P value |
| Cardiac procedures | | | | | | | | | | | | |
| Coronary angiography | 366 | 122 | 991 | 82.6 | 1.48 | 1.31 to 1.67 | 1.05 | 0.88 to 1.25 | 0.776 | 1.04 | 0.97 to 1.12 | 0.403 |
| Coronary artery bypass graft (CABG) | 12 | 4 | 12 | 1 | 4 | 1.80 to 8.91 | 2.99 | 0.75 to 11.96 | 0.253 | 1.62 | 0.96 to 2.73 | 0.132 |
| Percutaneous coronary procedures and stent implantation | 54 | 18 | 97 | 8.1 | 2.25 | 1.61 to 3.15 | 1.59 | 0.94 to 2.68 | 0.211 | 1.28 | 1.03 to 1.58 | 0.066 |
| Implantation of cardiac pacemakers/defibrillators | 463 | 154.3 | 672 | 56 | 2.81 | 2.50 to 3.17 | 1.54 | 1.27 to 1.85 | <0.001 | 1.29 | 1.19 to 1.39 | <0.001 |
| Percutaneous valve procedures | 9 | 3 | 29 | 2.4 | 1.25 | 0.59 to 2.66 | 2.57 | 0.78 to 8.45 | 0.278 | 1.61 | 0.99 to 2.60 | 0.115 |
| Dental procedures | | | | | | | | | | | | |
| Extractions or surgical removal of teeth | 54 | 18 | 81 | 6.8 | 2.68 | 1.90 to 3.78 | 2.14 | 1.22 to 3.76 | 0.047 | 1.27 | 1.02 to 1.59 | 0.082 |
| Other oral surgical procedures | 13 | 4.3 | 25 | 2.1 | 2.10 | 1.07 to 4.12 | 1.59 | 0.56 to 4.53 | 0.590 | 1.14 | 0.75 to 1.75 | 0.687 |
| Scaling and gingival procedures | 1 | 0.3 | 1 | 0.1 | 4 | 0.25 to 63.92 | 2.99 | 0.02 to 363.52 | 0.753 | 0.55 | 0.08 to 4.04 | 0.611 |
| ENT procedures | | | | | | | | | | | | |
| Tonsillectomy and adenoidectomy | 2 | 0.7 | 6 | 0.5 | 1.33 | 0.27 to 6.61 | 0.28 | 0.03 to 2.39 | 0.472 | 0.58 | 0.21 to 1.56 | 0.376 |
| Nasal packing/nasal intubation | 23 | 7.7 | 59 | 4.9 | 1.60 | 0.97 to 2.64 | 0.71 | 0.35 to 1.44 | 0.572 | 0.99 | 0.73 to 1.33 | 0.925 |
| GI procedures | | | | | | | | | | | | |
| Upper GI endoscopic procedures (gastric, duodenum, jejunum, ileum) | 627 | 209 | 1014 | 84.5 | 2.59 | 2.34 to 2.87 | 1.58 | 1.34 to 1.85 | <0.001 | 1.30 | 1.22 to 1.39 | <0.001 |
| Lower GI endoscopic procedures (including sigmoid and rectum) | 333 | 111 | 656 | 54.7 | 2.07 | 1.81 to 2.37 | 1.66 | 1.35 to 2.04 | <0.001 | 1.23 | 1.13 to 1.34 | <0.001 |
| Colonic surgery (including appendectomy) | 28 | 9.3 | 59 | 4.9 | 1.9 | 1.21 to 2.98 | 1.48 | 0.74 to 2.95 | 0.467 | 1.01 | 0.76 to 1.35 | 0.911 |
| Endoscopic retrograde cholangio-pancreatic procedures | 25 | 8.3 | 57 | 4.8 | 1.81 | 1.12 to 2.94 | 0.94 | 0.46 to 1.89 | 0.853 | 0.78 | 0.57 to 1.06 | 0.198 |
| GU procedures | | | | | | | | | | | | |
| Cystoscopy procedures | 155 | 51.7 | 501 | 41.8 | 1.26 | 1.05 to 1.53 | 0.92 | 0.70 to 1.20 | 0.775 | 0.94 | 0.83 to 1.05 | 0.391 |
| Endoscopic prostate procedures | 38 | 12.7 | 108 | 9 | 1.41 | 0.97 to 2.05 | 0.55 | 0.33 to 0.92 | 0.084 | 0.72 | 0.57 to 0.91 | 0.019 |
| Haematology procedures | | | | | | | | | | | | |
| Blood transfusion/red cell/plasma exchange | 295 | 98.3 | 660 | 55 | 2.84 | 2.35 to 3.43 | 1.33 | 1.01 to 1.76 | 0.129 | 1.2 | 1.07 to 1.35 | 0.012 |
| Bone marrow puncture | 99 | 33 | 144 | 12 | 2.96 | 2.27 to 3.87 | 1.76 | 1.16 to 2.69 | 0.039 | 1.28 | 1.08 to 1.52 | 0.018 |
| Obstetric and gynaecological procedures | | | | | | | | | | | | |
| Abortion/dilatation and curettage | 4 | 1.3 | 11 | 0.9 | 1.46 | 0.46 to 4.63 | 1.69 | 0.29 to 9.72 | 0.754 | 2.07 | 0.99 to 4.33 | 0.120 |
| Vaginal delivery | 7 | 2.3 | 29 | 2.4 | 0.97 | 0.42 to 2.20 | 0.96 | 0.31 to 2.98 | 0.898 | 1.34 | 0.83 to 2.15 | 0.380 |
| Caesarean delivery | 2 | 0.7 | 10 | 0.8 | 0.8 | 0.18 to 3.65 | 0.71 | 0.10 to 5.24 | 0.805 | 1.28 | 0.56 to 2.94 | 0.639 |
| Respiratory procedures | | | | | | | | | | | | |
| Bronchoscopic procedures | 51 | 17 | 72 | 6 | 2.88 | 2.00 to 4.13 | 1.87 | 1.04 to 3.34 | 0.118 | 1.33 | 1.06 to 1.68 | 0.049 |
| Skin procedures | | | | | | | | | | | | |
| Skin and wound management procedures | 107 | 35.7 | 295 | 24.6 | 1.46 | 1.17 to 1.83 | 0.92 | 0.67 to 1.27 | 0.765 | 0.96 | 0.84 to 1.10 | 0.600 |

P values in red=significant positive association between the ISP and subsequent IE after Benjamini-Hochberg correction. P values in purple=significant negative association between ISP and subsequent IE after Benjamini-Hochberg correction.
 *A maximum of one procedure of each type per patient was counted each month.
 †Period-adjusted OR of ISPs in case period (3 months prior to IE admission) compared with the 12 month control period (15 to 4 months prior to IE admission) calculated using a mixed-effects logistic regression model with the patient as the random effect.
 ‡OR of ISPs in case period (3 months prior to IE admission) compared with control period (15 to 4 months prior to IE admission) calculated using a mixed-effects logistic regression model adjusted for the month (1–15) and date of IE admission (with the patient as the random effect).
 §OR of ISPs for each month increase in the case period (3 to 1 months prior to IE admission) compared with control period (15 to 4 months prior to IE admission) calculated using a mixed-effects logistic regression model adjusted for month and date of IE admission (with patient as the random effect).
 IE, infective endocarditis; ISPs, invasive procedures; m, month; proc, procedures.

neither statistically nor clinically significant, comprising small effects (OR below 1.05) and/or infrequent procedures (<10 per month in control periods).

For IPs with evidence of an association with IE, the absolute risk increase (attributable risk) was small for low/unknown risk and moderate risk patients, with estimated attributable risk below 1 per 100 000 procedures for those at low/unknown IE risk and below 4 per 100 000 for those at moderate IE risk (figure 3). The absolute risk was greatest for those at high IE

risk, with the absolute risk being highest for those at high IE risk undergoing dental extractions/surgical removal of teeth (49.5 per 100 000 procedures).

DISCUSSION

Previous IE guidelines recommended AP before various IPs (online supplemental table S1). These recommendations have been successively abandoned due to lack of evidence to support

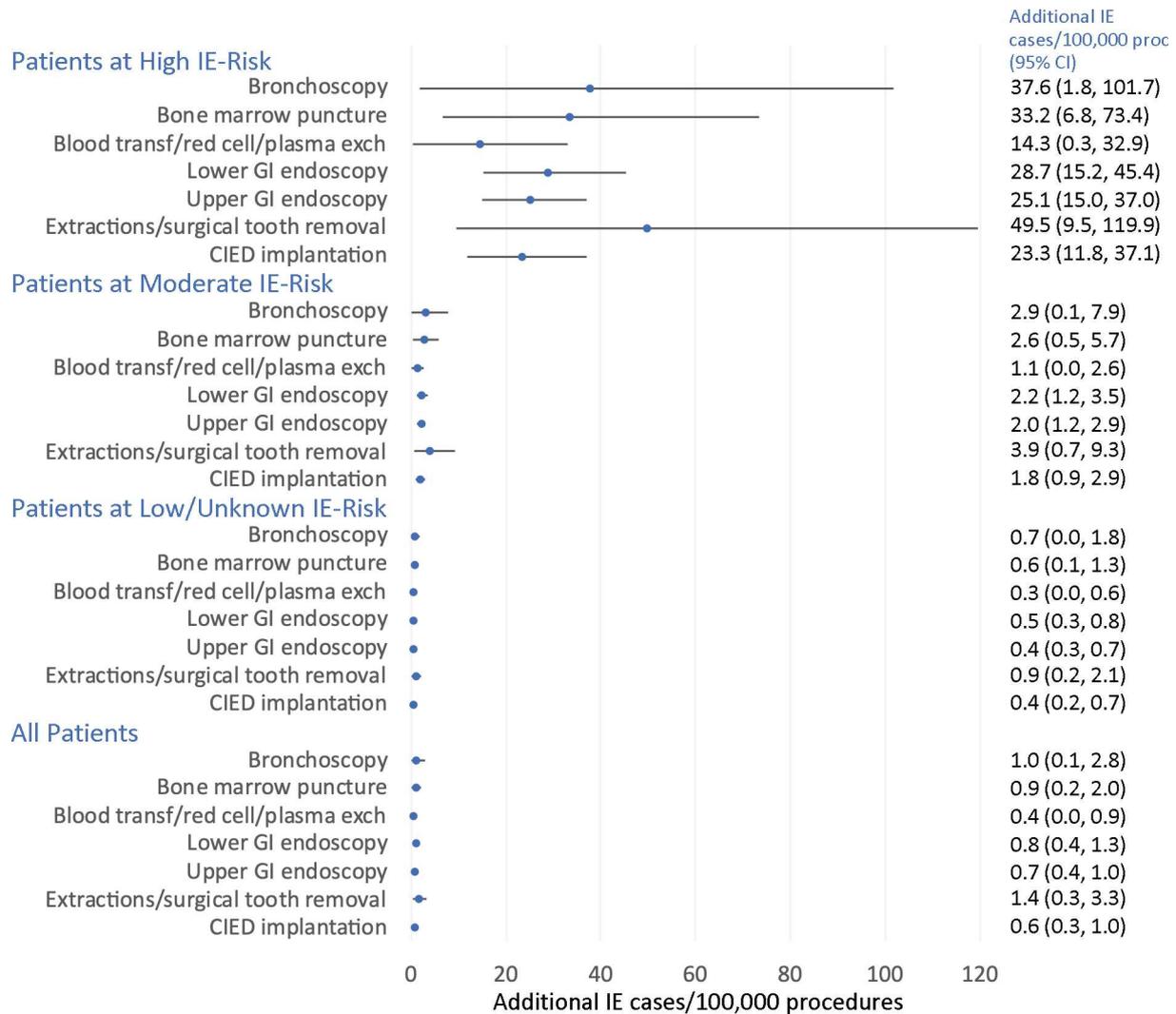


Figure 3 Attributable risk – the predicted additional IE cases per 100 000 procedures by patient risk group. The attributable risk is presented for IPS with a significant positive temporal association with subsequent IE and is expressed as the predicted additional number of IE cases per 100 000 procedures. The population at risk was estimated using the population of England during the middle year of the study (2012–2023) and estimates for the proportion of the population at high, moderate or low/unknown risk. Baseline risk was calculated as the average 3 monthly risk of being subject to each procedure for each population over the study period (March 2010–December 2015, excluding the last 3 months of data). The attributable risk was calculated by multiplying the baseline risk with the adjusted or estimate from table 1. CIED, cardiac implantable electronic devices; exch, exchange; GI, gastrointestinal; IE, infective endocarditis; IPS, invasive procedures; transf, transfusion.

an association between them and subsequent IE. The exception is AP before IDPs in high-risk individuals, which is still recommended outside the UK.^{14 15} A recent Swedish national study, which will be referred to throughout this discussion, found an association between IE and many IPs previously recommended for AP cover, raising the possibility that withdrawal of AP for these may have been premature.⁸ To explore this, we performed a case-crossover study to determine any temporal association between these IPs and subsequent IE.

Cardiac procedures

Device infection is a well-recognised complication of CIED implantation, and surveys suggest that most CIED implantations in England were AP covered.^{16 17} Nonetheless, there was considerable variation in the AP regimens used.^{16 17} Concerns about this led to the first UK CIED infection prevention guidelines in 2015.¹⁸ The incidence of IE following CIED insertion has been calculated at 550 cases/million procedures per year.¹⁹ Despite

it being likely that most CIED implantations were covered by AP, we identified a significantly increased risk of IE in the first 3 months after CIED implantation. The attributable risk was 23.8 per 100 000 procedures for those at high IE risk and 1.8 per 100 000 procedures for those at moderate IE risk. These data suggest that AP cover of CIED implantation was not complete at the time of the study and more may need to be done to improve the effectiveness of CIED infection prevention protocols. It is notable that despite the introduction of UK-wide CIED infection prevention guidelines shortly before the end of this study,¹⁸ current UK IE prevention guidelines contradict these by recommending against the use of AP to prevent IE and failing to mention the IE risk posed by CIED implantation.²⁰

Dental procedures

During the study period, 294 034 IDPs were performed in English hospitals (of which 70.2% were extractions/surgical tooth removal, 23.8% other surgical procedures and 5.6%

Table 2 Clinical characteristics of patients requiring IE admission

| Characteristics | Statistics | All IE admissions |
|--------------------------------------|---|---------------------------------|
| Age | N | 14 722 |
| | Mean (SD) | 62.3 (19.9) |
| | Median (min, max) | 67.0 (0, 103) |
| Sex | N | 14 731 |
| | Male, n (%) | 9734 (66.1) |
| | Female, n (%) | 4997 (33.9) |
| Level of IE risk before admission | N | 14 731 |
| | High risk, n (%) | 3145 (21.3) |
| | Moderate risk, n (%) | 2503 (17.0) |
| | Low/unknown risk, n (%) | 9083 (61.7) |
| Reason for high-risk stratification* | Previous IE, n (%) | 154 (4.9) |
| | Previous IE - I38X, n (%) | 67 (2.1) |
| | Replacement heart valve, n (%) | 2416 (76.8) |
| | Repaired heart valve, n (%) | 311 (9.9) |
| | Cyanotic congenital heart disease, n (%) | 150 (4.8) |
| | Repaired congenital heart disease, n (%) | 3 (0.1) |
| | Palliative shunt or conduit, n (%) | 37 (1.2) |
| | Prosthetic heart/ventricular assist device, n (%) | 7 (0.2) |
| | Reason for moderate-risk stratification* | Previous rheumatic fever, n (%) |
| Non-rheumatic valve disease, n (%) | | 1571 (62.8) |
| Congenital valve anomalies, n (%) | | 58 (2.3) |
| Hypertrophic cardiomyopathy, n (%) | | 66 (2.6) |
| Admission date | N | 14 731 |
| | Min | 01 Apr 2010 |
| | Max | 28 Mar 2016 |
| Discharge date | N | 14 297 |
| | Min | 6 April 2010 |
| | Max | 31 March 2016 |
| Hospital length of stay (days)* | N | 14 297 |
| | Mean (SD) | 33.0 (27.3) |
| | Median (min, max) | 28 (0, 410) |
| Discharged alive? | N | 14 275 |
| | No, n (%) | 2677 (18.8) |
| | Yes, n (%) | 11 598 (81.2) |

*Length of stay is from admission to discharge alive or until in hospital death. Although we excluded patients discharged alive with a length of stay <3 days, a length of stay <3 days is possible if the patient died within the first 3 days of the IE hospital admission.
IE, infective endocarditis.

scaling procedures). We identified a significant association between extractions/surgical tooth removal and IE. Although no association was identified for other IDPs, the number of these performed in hospital settings was probably too low to detect a significant association. The increase in attributable risk per 100 000 extractions/surgical tooth removal was 49.5 for those at high risk and 3.9 for those at moderate risk. A large recent study of US dentists also demonstrated a significant association between IDPs (particularly extractions and surgical procedures) and IE that was significantly reduced by AP.²¹ Regrettably, a similar study of dentists in England proved impossible due to inadequacies in data recording. Consistent with the previous observations, most guidelines (except NICE) currently recommend AP in high IE risk patients before IDPs.^{9 14 15}

GI procedures

We identified a statistically significant association between upper (gastric, duodenum, jejunum, ileum) and lower (colon, sigmoid,

rectum) GI endoscopic procedures and IE. The increase in attributable risk was, respectively, 25.1 and 28.7 per 100 000 procedures for those at high IE risk undergoing upper or lower GI endoscopy and 2.0 and 2.2 per 100 000 procedures for those at moderate risk. A subanalysis identified no significant difference in the association between upper and lower GI endoscopy and subsequent IE between endoscopic procedures that involved an intervention, for example, a biopsy, and those that did not.

AP was previously recommended before GI endoscopy procedures, and they were also significantly associated with IE in the Swedish study.⁸

Two case series have identified IE following endoscopy,^{22 23} and elevated IE incidence has been noted in elderly high IE risk patients following colonoscopy.²⁴ Nonetheless, current IE prevention guidelines do not recommend AP in these settings. One explanation for an association between colonoscopy and IE is that *Streptococcus gallolyticus* IE is associated with colorectal cancer in the elderly or immunocompromised. Indeed, clinicians are advised to exclude colorectal cancer in patients with *Streptococcus gallolyticus* bacteraemia.²⁵ However, this does not explain the strong association between upper GI endoscopy and IE and could only explain a small proportion of lower GI endoscopy-associated IE.

We found no association between endoscopic retrograde cholangio-pancreatic (ERCP) and IE. This could be because ERCP patients are frequently already receiving antibiotics for cholangitis or because AP to prevent local infection is recommended in several situations for UK patients undergoing ERCP.²⁶

Haematology procedures

There was a significant association in both the primary step and alternative hinge-model analyses between bone marrow biopsy and IE. There was also an association between blood transfusion, red cell or plasma exchange and IE in the hinge analysis. Neither procedure has previously been recommended for AP cover (online supplemental table S1). We included them because the Swedish study found both significantly associated with IE (RR 4.67, 95% CI 1.34 to 16.24, and RR 6.69, 95% CI 4.43 to 10.11, respectively).⁸

Although these associations may be valid, they could also be explained by diagnostic bone marrow biopsy or therapeutic transfusions, particularly if haematological malignancy is suspected in the weeks before an IE diagnosis is confirmed. This is not uncommon since IE may present with features similar to haematological malignancy. Further investigation into this possible association is essential before drawing any conclusions.

Respiratory procedures

Most early guidelines recommended AP before bronchoscopy, and our alternative hinge analysis and the Swedish study⁸ identified an association between bronchoscopy and subsequent IE. Furthermore, our attributable risk estimate was 38 additional IE cases per 100 000 procedures for those at high IE risk. Bacteraemia is a recognised complication of bronchoscopy.²⁷ Nonetheless, consistent with NICE guidance,²⁰ current British Thoracic Society guidelines recommend against the use of AP to prevent IE in those undergoing flexible bronchoscopy.²⁸

Other procedures

We detected no association between ENT, skin or obstetrics and gynaecology procedures and IE. Indeed, the number of these procedures was extremely low over the 15 months before IE admission.

Although cystoscopy and endoscopic prostate procedures were previously recommended for AP cover, and the Swedish study found a significant association between these procedures and IE,⁸ we found no significant association. Antibiotic use to prevent postprocedural urinary tract infections is common and could have masked any relationship in our study. Indeed, another UK study identified a significant association between urological procedures and IE,²⁹ so further investigation is warranted.

Sensitivity analysis

Sensitivity analysis showed the association between extractions, upper or lower GI endoscopy and subsequent IE was sustained for 4 (but not 6) months. The hinge model analysis confirmed the associations identified with the primary step model analysis but identified two more (bronchoscopy and transfusion/red cell/plasma exchange).

The Swedish study did not investigate IDPs, but most IPs we identified as significantly associated with IE were also identified in the Swedish study.⁸ We could not, however, confirm all associations identified in the Swedish study, and the relative risk values they identified were higher than the comparable ORs we found. The reasons for this are: first, the Swedish study screened all inpatient and outpatient IPs to identify associations with IE; we only studied those previously recommended for AP or identified with a positive association in the Swedish study. Second, although both studies used a case-crossover methodology and a 3-month case period, different control periods were used. The Swedish study used a 3-month control period, 1 year before the case period, while we used the preceding 12 months. Sampling the control frequency over an entire year is twice as efficient as sampling equal duration case and control periods.¹⁰ Finally, with increasing numbers of IPs being performed, using a 1-year control period, and adjusting the ORs to take account of the date of each procedure, allowed us to correct for trends in procedure numbers. This means our adjusted ORs are often smaller but may better reflect any actual association between these IP and IE.

Study limitations

Misclassification is possible in administrative databases, particularly for challenging diagnoses such as IE. Nonetheless, a recent analysis of English IE admissions showed that the IE definition we used had the best overall balance between sensitivity, positive predictive value (PPV) and negative predictive value (NPV) for identifying modified Duke criteria positive IE cases (sensitivity 0.65, specificity 0.91, PPV 0.80, NPV 0.82).⁷ Administrative databases also afford larger sample sizes, and this study captured the entire spectrum of IE-related hospitalisations in England, removing the potential for referral bias. Furthermore, case-crossover analysis with constant intrasubject characteristics (eg, age, sex, comorbidities), and each individual serving as their control, eliminated control selection bias and confounding.³⁰

Although our study recorded all IPs performed, this was not the case for IDPs. Most dental procedures are performed in general dental practice and only a minority in hospitals. This may explain our failure to detect an association between some IDPs and IE and could underestimate any association. Nonetheless, we demonstrated a significant association between extractions (including surgical tooth removal) and subsequent IE.

Our study used ICD-10 and OPCS-4 codes to stratify IE cases into those previously at high, moderate or low/unknown IE risk. However, records of predisposing procedures or conditions were incomplete before January 2000, resulting in the potential

misclassification of some high-risk or moderate-risk individuals as low/unknown risk.

Although we wanted to provide details of the causal organisms for IE cases, this proved impossible since there is no requirement to record secondary or supplemental ICD-10 codes on which causal organism data depend and were missing in many cases. This, and the lack of specific ICD-10 codes for oral viridans group streptococci, enterococci and other organisms, made the accurate evaluation of IE microbiology impossible.

CONCLUSIONS

We report a significant association between implantation of CIEDs, upper and lower GI endoscopy, bronchoscopy, and dental extractions (including surgical tooth removal), and subsequent IE. These procedures resulted in an additional 14.3–49.5 IE cases/100 000 procedures in those at high IE risk and an additional 1.1–3.9 IE cases/100 000 procedures in those at moderate risk. These data support a reconsideration of the possible role of preprocedural AP for these procedures in those at high IE risk.

Contributors MHT and JN conceived the idea of the study and formulated the study design. MD, BDP, PL and LB provided the clinical input needed to identify the data to extract. AC, RC and TS undertook data extraction. JN, MB and ECL performed the statistical analysis. JN and MB supervised the analysis. MHT, JN, MD, BDP, PL and LB interpreted the findings. VF provided logistical coordination and support. MT drafted the manuscript. JN, AC, RC, TS, VF, MD, BDP, PL and LB critically reviewed the manuscript, and MT revised the manuscript for final submission. All authors have approved the final draft of the manuscript. MT is the guarantor. MT and JN accept full responsibility for the work and the conduct of the study, had access to the data and controlled the decision to publish. The corresponding author attests that all listed authors meet the authorship criteria and that no others meeting the criteria have been omitted.

Funding This work was supported by a British Heart Foundation Project Grant (PG/20/10410).

Competing interests MHT, AC, RC, TS, ECL, MB, VF and JN all received salary support from the British Heart Foundation (Project Grant PG/20/10410) for this study. MHT, PL and JN report other grant support from the National Institutes for Health (USA) or the National Institute for Health Research (UK). BDP reports unrestricted educational and research grants from Edwards Lifesciences, and personal speaker/consultancy fees from Medtronic, Abbott, Microport, Anteris and Edwards Lifesciences. LB reports consulting for Boston Scientific and Roivant Sciences, and royalty payments from UpToDate, Inc. MD reports payment for expert testimony from Bevan Brittan, honoraria for presentations and support for attending meetings from Biotronik. JN reports being chair of the REPHILL trial data monitoring committee from (National Institute for Health and Care Research (NIHR)), chair of research commissioning panels for COVID research (CSO Scotland), member of the UKRI-DHSC COVID-19 Vaccine trial commissioning panel and member of the NIHR commissioning panel for emergency care procedures research.

Patient and public involvement 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 Not applicable.

Ethics approval This study involves human participants and was approved by UK National Research Ethics Service. Reference No: 17/SC/0371. Data were obtained from a national database – NHS Digital, and we had both ethics (national research ethics) and Confidentiality Advisory Group permission to use non-identifiable data from the NHS Digital database for this project without the need to seek individual patient consent.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement No data are available. The original data (from which the aggregated data shown in this report are derived) are the subject of data sharing agreements between the University of Sheffield and NHS Digital. These agreements restrict data sharing and require its destruction after study completion. We are therefore unable to share the original data, but they may be obtained by application to NHS Digital (<https://digital.nhs.uk>) after appropriate regulatory approval.

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Supplementary Appendix

Temporal Association Between Invasive Procedures and Infective Endocarditis

Brief Title – Endocarditis and invasive procedures

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Abbreviations:

AHA = American Heart Association

AP = Antibiotic prophylaxis

BCS = British Cardiac Society

BSAC = British Society for Antimicrobial Chemotherapy

CABG = Coronary artery bypass graft

CI = Confidence interval

ENT = Ear nose and throat

ESC = European Society for Cardiology

ERCP = Endoscopic retrograde cholangio-pancreatic procedures

IDPs = Invasive-dental procedures

IPs = Invasive procedures

IE = Infective endocarditis

NICE = National Institute for Health and Care Excellence

OR = Odds ratio

RR = Relative risk

UK = United Kingdom

US = United States of America

Supplementary Methods

Analyses:

Case-Crossover studies compare exposure to possible trigger events (in this case the incidence of invasive procedures [IP]) for an outcome (in this case admission for infective endocarditis [IE]) during an exposure window (in this case the 3-month case-period before hospital admission for infective endocarditis [IE]) when exposure may lead to the outcome and compares this with the exposure in an earlier control-period (in this case the incidence of IP in the 12 months preceding the case-period). In its simplest form this involves comparing the monthly incidence of the IP in the case-period with the incidence in the control period. If a causal relationship exists between the IP and the outcome IE, then one would expect the mean IP incidence in the case-period to exceed the mean IP incidence in the control-period i.e., there would be a step increase in the IP incidence in the control period on transitioning into the case period. Hence the term “step-model”. This is depicted in the figure below by the graph labelled ‘Sep-Model’. The step increase between the control and case period means can be seen. This is what we describe as the unadjusted “step-model”.

Unadjusted step-model analysis:

For each procedure, the binary outcome (procedure occurred, yes/no) was modelled longitudinally. Whilst it is possible to have multiple procedures within the same month, the vast majority of procedures considered here occur only once if at all. Furthermore, multiple procedures within the same month are likely to relate to one episode for these procedures. For both of these reasons, (simplicity and avoidance of double counting) we chose to limit analysis to yes/no incidence. The unadjusted model considers the probability of an invasive procedure during a month within the “case period” (3 months prior to IE), compared to the probability of an invasive procedure in the remaining months of the study (4-15 prior to IE). This is referred to as a “step-model” as the proportion of patients undergoing a procedure is assumed to follow a step-change once the patient enters the case period:

$$\text{logit}(p_{it}) = \alpha + \beta_{\text{case}} \times I_{(t)} + \gamma_i$$

Where p_{it} denotes the probability that the i^{th} patient recorded a procedure in time-period t (1 to 15), $I_{(t)}$ is equal to 1 if the current timepoint is within 3 months of the IE and 0 otherwise, β_{case} is the coefficient (log-odds) for the procedure in the case period compared to the non-case period, γ_i is a Normally distributed random effect γ_i specific to the patient. This analysis compares monthly occurrence during “case” periods to “control” periods but is biased (exaggerated) if the incidence of procedures increases with time.

To address this, we defined an adjusted ‘step model’ as our primary outcome. This corrected for the background increase in IP incidence and is represented in the figure below by the graph labelled ‘Adjusted Step-Model’. Despite adjusting for the background increase in IP incidence, there is still a step increase in the incidence between the case- and control-periods caused by any association between the IP and subsequent IE (hence the term adjusted “step-model”). The important thing to note is that the unadjusted “step-model” (that represents most case-crossover studies on this subject e.g., the Janszky study (Janszky et al, J. Am. Coll.

Cardiol. (2018) 71(24)2744-2752)) will tend to exaggerate or overestimate the Odds or RR in a situation where the incidence of the potential trigger (IP in this case) is increasing over time. Whereas the adjusted “step-model” (our primary outcome) helps to correct for this but results in a lower OR/RR, – as discussed in the last two sentences of the Discussion section on ‘Sensitivity Analysis’.

Adjusted step-model analysis:

The adjusted model builds on the unadjusted model which also incorporates the association between procedure and calendar time:

$$\text{logit}(p_{it}) = \alpha + \beta_{\text{case}} \times I_{(t)} + \beta_{\text{time}} \times d_t + \gamma_i$$

Where d_t is the calendar date (1st April 2010 to 31st March 2016), β_{time} is the coefficient (log-odds) for the temporal association, and p_{it} , $I_{(t)}$ and γ_i are as above. This analysis models associations both temporally and with procedure but models the change as a jump at three months prior to IE and was chosen as our primary analysis.

An alternative approach is to consider the slope of the IP incidence in the case- and control-periods as continuous (i.e., without a step change) but with a change of slope (or trajectory) occurring at the point of transition from the control- to the case-period (i.e., with a hinge point in the slope). This is depicted in the figure below by the graph labelled ‘Hinge-model’.

Hinge-model analysis:

The hinge-model analysis allows a gradual separation of the curves during the case period, as opposed to the step (or “jump”) the previous two models. Like the adjusted step-model, this also incorporates the association between procedure and calendar time:

$$\text{logit}(p_{it}) = \alpha + \beta_{\text{case}} \times I_{(t)} \times t^* + \beta_{\text{time}} \times d_t + \gamma_i$$

Where t^* equal to the study month. This analysis is more biologically plausible and most sensitive to detecting an association where one exists but cannot directly estimate the attributable risk. Since we wanted to estimate this, and since the incidence of many procedures appeared to increase with time, the adjusted step-model analysis was selected as our primary analysis.

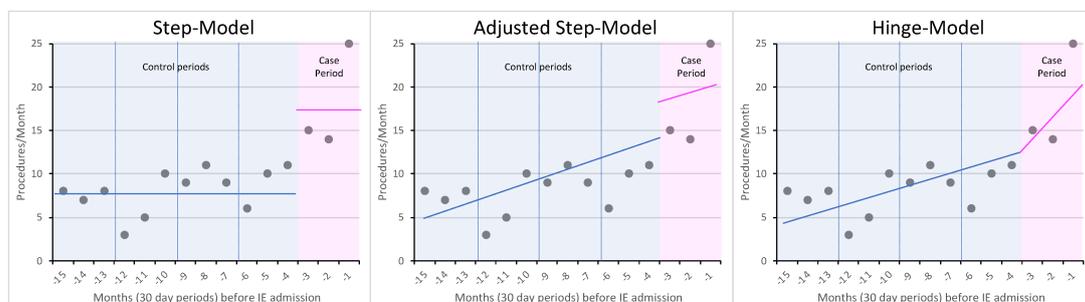


Table S1. Invasive procedures identified for antibiotic prophylaxis by previous guidelines or with positive association with subsequent infective endocarditis

| Invasive Procedures (IPs) | BCS 2004[1] | ESC 2004² | AHA 1997³ | Janszky et al. 2018⁴ Inpatient IPs RR (95% CI) |
|--|--------------------|-----------------------------|-----------------------------|--|
| GI Procedures | | | | |
| Upper GI Endoscopy with/without biopsy | ✓ | - | ✓† | 3.97 (2.68-5.88) |
| Lower GI Endoscopy with/without biopsy | ✓ | - | ✓† | 2.82 (1.42-5.61) |
| ERCP (Endoscopic Retrograde Cholangio-Pancreatography) | ✓ | ✓ | ✓ | 3.60 (1.34-9.70) |
| Colonic Surgery | ✓ | - | ✓ | - |
| GU Procedures | | | | |
| Endoscopic prostate procedures | ✓ | ✓ | ✓ | - |
| Cystoscopy and endoscopic urological procedures | ✓ | ✓ | ✓ | 4.40 (1.67-11.62) |
| Obstetric & Gynaecological Procedures | | | | |
| Caesarean section | ✓ | - | - | - |
| Vaginal delivery | ✓ | ✓§ | ✓† | - |
| Abortion/dilatation and curettage (D&C) | ✓ | ✓§ | - | 3.00 (1.81-4.98) |
| Respiratory Procedures | | | | |
| Bronchoscopic procedures (esp. rigid) | ✓ | ✓ | ✓ | 16.00 (2.12-120.65) |
| Cardiac Procedures | | | | |
| Implantation of pacemakers/defibrillators | ✓ | - | - | 9.75 (3.48-27.28) |
| Percutaneous valve procedures | ✓ | - | - | - |
| Percutaneous coronary procedures/stents | ✓ | - | - | 3.50 (1.41-8.67) |
| Coronary artery bypass graft (CABG) | - | - | - | 13.8 (5.57-34.21) |
| Coronary angiography | | - | - | 4.23 (2.93-6.11) |
| ENT Procedures | | | | |
| Tonsillectomy/adenoidectomy | ✓ | ✓ | ✓ | 2.33 (0.60-9.02) |
| Nasal packing/nasal intubation | ✓ | - | - | - |
| Dermatological Procedures | | | | |
| Skin suturing, drainage or wound management | ✓ | - | - | 7.00 (0.86-56.89) |
| Haematological Procedures | | | | |
| Blood transfusion/red cell/plasma exchange | - | - | - | 6.69 (4.43-10.11) |
| Bone marrow puncture | - | - | - | 4.67 (1.34-16.24) |
| Dental Procedures | | | | |
| Dental extractions | ✓ | ✓ | ✓ | - |
| Other oral surgical procedures | ✓ | ✓ | ✓ | - |
| Scaling of teeth | ✓ | ✓ | ✓ | - |
| Endodontic treatment | ✓ | ✓ | ✓ | - |

Notes: This table shows those invasive procedures (IPs) for which antibiotic prophylaxis (AP) was recommended for those at moderate- or high-risk of infective endocarditis (IE) (i) by the 2004 British Cardiac Society (BCS) guidance,[1] (ii) by the 2004 European Society for Cardiology (ESC) guidance,[2] or (iii) the 1997 American Heart Association (AHA) guidelines.[3] It also shows the increased relative risk (RR), with 95% Confidence Intervals, of developing IE after different types of IP that was identified in the 2018 analysis of Swedish national data for hospital admissions between January 1998 and December 2011 by Janszky et al.[4] The 2009 ESC guidelines[5] and the 2007 AHA guidelines[6] recommended against the use of AP for all IPs in those at moderate-IE-risk and for all IPs, except dental IPs, in those at high-IE-risk. The 2008 NICE guidelines in the UK recommended the complete cessation of AP for all IPs, including dental procedures.[7] TOE= Transoesophageal echocardiography, ✓ = antibiotic prophylaxis recommended, ✓† = prophylaxis recommended as optional for high-risk patients, ✓§ = antibiotic prophylaxis recommended in the presence of infection.

Table S2.

Codes used to identify those at high-risk of IE. Primary and secondary codes used (except I38X for which primary diagnosis code only was used).

| Cardiac Condition | ICD-10 Diagnosis Codes and OPCS-4 Procedure codes For Identifying Those at High-Risk of IE ¹ |
|--|--|
| Previous IE | <p>ICD-10 Diagnosis Codes:</p> <p>I330 Acute and subacute infective endocarditis I339 Acute endocarditis, unspecified I38X Endocarditis, valve unspecified I390 Endocarditis and mitral valve disorders in disease classified elsewhere I391 Endocarditis and aortic valve disorders in disease classified elsewhere I392 Endocarditis and tricuspid valve disorders in disease classified elsewhere I393 Endocarditis and pulmonary valve disorders in disease classified elsewhere I394 Endocarditis and multiple valve disorders in disease classified elsewhere I398 Endocarditis, valve unspecified in disease classified elsewhere B376 Candidal endocarditis T826 Infection and inflammatory reaction due to cardiac valve prosthesis</p> |
| Prosthetic replacement of heart valve | <p>OPCS-4 Procedure Codes:</p> <p>K251 Allograft replacement of mitral valve K252 Xenograft replacement of mitral valve K253 Prosthetic replacement of mitral valve K254 Replacement of mitral valve NEC K261 Allograft replacement of aortic valve K262 Xenograft replacement of aortic valve K263 Prosthetic replacement of aortic valve K264 Replacement of aortic valve NEC K271 Allograft replacement of mitral valve K272 Xenograft replacement of mitral valve K273 Prosthetic replacement of mitral valve K274 Replacement of mitral valve NEC K281 Allograft replacement of pulmonary valve K282 Xenograft replacement of pulmonary valve K283 Prosthetic replacement of pulmonary valve K284 Replacement of pulmonary valve NEC K291 Allograft replacement of valve of heart NEC K292 Xenograft replacement of valve of heart NEC K293 Prosthetic replacement of valve of heart NEC K294 Replacement of valve of heart NEC K297 Replacement of truncal valve K331 Aortic root replacement using pulmonary valve autograft with right ventricle to pulmonary artery valved conduit K332 Aortic root replacement using pulmonary valve autograft with right ventricle to pulmonary artery valved conduit and aortoventriculoplasty K333 Aortic root replacement using homograft K334 Aortic root replacement using mechanical prosthesis K336 Aortoventriculoplasty with pulmonary valve autograft K357 Percutaneous transluminal pulmonary valve replacement</p> |
| Valve repair using prosthetic material | <p>OPCS-4 Procedure Codes:</p> <p>K255 Mitral valve repair NEC K258 Other specified plastic repair of mitral valve K259 Unspecified plastic repair of mitral valve K265 Aortic valve repair NEC K268 Other specified plastic repair of aortic valve K269 Unspecified plastic repair of aortic valve K275 Repositioning of tricuspid valve</p> |

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| | <p>K276 Tricuspid valve repair NEC K278 Other specified plastic repair of tricuspid valve K279 Unspecified plastic repair of tricuspid valve K285 Pulmonary valve repair NEC K288 Other specified plastic repair of pulmonary valve K289 Unspecified plastic repair of pulmonary valve K295 Repair of valve of heart NEC K296 Truncal valve repair K298 Other specified plastic repair of unspecified valve of heart K299 Unspecified plastic repair of unspecified valve of heart K301 Revision of plastic repair of mitral valve K302 Revision of plastic repair of aortic valve K303 Revision of plastic repair of tricuspid valve K304 Revision of plastic repair of pulmonary valve K305 Revision of plastic repair of truncal valve K308 Other specified revision of plastic repair of valve of heart K309 Unspecified revision of plastic repair of valve of heart K335 Aortic root replacement NEC K341 Annuloplasty of mitral valve K342 Annuloplasty of tricuspid valve K343 Annuloplasty of valve of heart NEC K358 Other specified therapeutic transluminal operations on valve of heart K359 Unspecified therapeutic transluminal operations on valve of heart</p> |
| Prosthetic heart or ventricular assist device | <p>OPCS-4 Procedure Codes: K023 Implantation of prosthetic heart K025 Revision of implantation of prosthetic heart K541 Open implantation of ventricular assist device</p> |
| Congenital Heart Condition (CHC) in whom a palliative shunt or conduit has been used | <p>OPCS-4 Procedure Codes: K041 Repair of tetralogy of Fallot using valved right ventricular outflow conduit K042 Repair of tetralogy of Fallot using right ventricular outflow conduit NEC K063 Left ventricle to aorta tunnel with right ventricle to pulmonary artery valved conduit K171 Total cavopulmonary connection with extracardiac inferior caval vein to pulmonary artery conduit K173 Aortopulmonary reconstruction with systemic to pulmonary arterial shunt K174 Aortopulmonary reconstruction with right ventricle to pulmonary arterial valveless conduit K181 Creation of valved conduit between atrium and ventricle of heart K182 Creation of valved conduit between right atrium and pulmonary artery K183 Creation of valved conduit between right ventricle of heart and pulmonary artery K184 Creation of valved conduit between left ventricle of heart and aorta K185 Revision of valved cardiac conduit K186 Creation of valved conduit between left ventricle of heart pulmonary artery K187 Replacement of valved cardiac conduit K188 Other specified creation of valved cardiac conduit K189 Unspecified creation of valved cardiac conduit K191 Creation of conduit between atrium and ventricle of heart NEC K192 Creation of conduit between right atrium and pulmonary artery NEC K193 Creation of conduit between right ventricle of heart and pulmonary artery NEC K194 Creation of conduit between right ventricle of heart and vena cava K195 Creation of conduit between left ventricle of heart and aorta NEC K196 Revision of cardiac conduit NEC K198 Other specified creation of other cardiac conduit K199 Unspecified creation of other cardiac conduit K761 Percutaneous transluminal balloon dilatation of cardiac conduit K768 Other specified transluminal operations on cardiac conduit K769 Unspecified transluminal operations on cardiac conduit L051 Creation of shunt to main pulmonary artery from ascending aorta using interposition tube prosthesis</p> |

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| | <p>L052 Creation of shunt to right pulmonary artery from ascending aorta using interposition tube prosthesis</p> <p>L053 Creation of shunt to left pulmonary artery from ascending aorta using interposition tube prosthesis</p> <p>L054 Percutaneous transluminal balloon dilatation of interposition tube prosthesis between pulmonary artery and aorta</p> <p>L058 Other specified creation of shunt to pulmonary artery from aorta using interposition tube prosthesis</p> <p>L059 Unspecified creation of shunt to pulmonary artery from aorta using interposition tube prosthesis</p> <p>L071 Creation of shunt to right pulmonary artery from right subclavian artery using interposition tube prosthesis</p> <p>L072 Creation of shunt to left pulmonary artery from left subclavian artery using interposition tube prosthesis</p> <p>L074 Percutaneous transluminal balloon dilatation of interposition tube prosthesis between pulmonary artery and subclavian artery</p> <p>L078 Other specified creation of shunt to pulmonary artery from subclavian artery using interposition tube prosthesis</p> <p>L079 Unspecified creation of shunt to pulmonary artery from subclavian artery using interposition tube prosthesis</p> |
| Unrepaired cyanotic congenital heart condition (CHC) ² | <p>ICD-10 Diagnosis Codes:</p> <p>Q200 Common arterial trunk</p> <p>Q201 Double outlet right ventricle</p> <p>Q202 Double outlet left ventricle</p> <p>Q203 Discordant ventriculoarterial connection</p> <p>Q204 Double inlet ventricle</p> <p>Q205 Discordant atrioventricular connection</p> <p>Q212 Atrioventricular septal defect</p> <p>Q213 Tetralogy of Fallot</p> <p>Q214 Aortopulmonary septal defect</p> <p>Q262 Total anomalous pulmonary venous connection</p> |
| Completely repaired CHC defect with prosthetic material or device, whether placed by surgery or catheter intervention, during first 6 months after the procedure only. ³ | <p>OPCS-4 Procedure Codes:</p> <p>K091 Repair of defect of atrioventricular septum using dual prosthetic patches</p> <p>K092 Repair of defect of atrioventricular septum using prosthetic patch NEC</p> <p>K101 Repair of defect of interatrial septum using prosthetic patch</p> <p>K111 Repair of defect of interventricular septum using prosthetic patch</p> <p>K117 Repair of defect of inter ventricular septal defect using intraoperative transluminal prosthesis</p> <p>K121 Repair of defect of septum of heart using prosthetic patch NEC</p> <p>K131 Percutaneous transluminal repair of defect of interventricular septum using prosthesis</p> <p>K132 Percutaneous transluminal repair of defect of interventricular septum NEC</p> <p>K133 Percutaneous transluminal repair of defect of interatrial septum using prosthesis</p> <p>K134 Percutaneous transluminal repair of defect of interatrial septum NEC</p> <p>K135 Percutaneous transluminal repair of defect of unspecified septum using prosthesis</p> <p>K138 Other specified transluminal repair of defect of interatrial septum</p> <p>K139 Unspecified transluminal repair of defect of interatrial septum</p> <p>K163 Percutaneous transluminal atrial septum fenestration closure with prosthesis</p> <p>K165 Percutaneous transluminal closure of patent oval foramen with prosthesis</p> <p>L031 Percutaneous transluminal prosthetic occlusion of patent ductus arteriosus</p> <p>L101 Repair of pulmonary artery using prosthesis</p> <p>L233 Plastic repair of aorta using patch graft</p> |

Table S3.

Codes used to identify those at moderate-risk of IE

| Cardiac Condition | ICD-10 Diagnosis Codes and OPCS-4 Procedure codes For Identifying Those at High-Risk of IE ¹ |
|-----------------------------|---|
| Previous Rheumatic Fever | <p>ICD-10 Diagnosis Codes:</p> <p>I011 Acute rheumatic endocarditis I018 Other acute rheumatic heart disease I019 Acute rheumatic heart disease, unspecified I020 Rheumatic chorea with heart involvement I050 Rheumatic mitral stenosis I051 Rheumatic mitral insufficiency I052 Rheumatic mitral stenosis with insufficiency I058 Other mitral valve disease I059 Rheumatic mitral valve disease, unspecified I060 Rheumatic aortic stenosis I061 Rheumatic aortic insufficiency I062 Rheumatic aortic stenosis with insufficiency I068 Other rheumatic aortic valve disease I069 Rheumatic aortic valve disease, unspecified I070 Rheumatic tricuspid stenosis I071 Rheumatic tricuspid insufficiency I072 Rheumatic tricuspid stenosis with insufficiency I078 Other rheumatic tricuspid valve disease I079 Rheumatic tricuspid valve disease, unspecified I080 Disorders of both mitral and aortic valves I081 Disorders of both mitral and tricuspid valves I082 Disorders of both aortic and tricuspid valves I083 Combined disorders of mitral, aortic and tricuspid valves I088 Other multiple valve disease I089 Multiple valve diseases, unspecified I090 Rheumatic myocarditis I091 Rheumatic disease of the endocardium, valve unspecified I098 Other specified rheumatic heart disease I099 Rheumatic heart disease, unspecified</p> |
| Non-Rheumatic Valve Disease | <p>ICD-10 Diagnosis Codes:</p> <p>I340 Mitral valve insufficiency I341 Mitral valve prolapse I342 Nonrheumatic mitral valve stenosis I348 Other nonrheumatic mitral valve disorders I349 Nonrheumatic mitral valve disorder, unspecified I350 Aortic valve stenosis I351 Aortic valve insufficiency I352 Aortic valve stenosis with insufficiency I358 Other nonrheumatic aortic valve disorders I359 Nonrheumatic aortic valve disorder, unspecified I360 Tricuspid valve stenosis I361 Tricuspid valve insufficiency I362 Tricuspid valve stenosis with insufficiency I368 Other nonrheumatic tricuspid valve disorders I369 Nonrheumatic tricuspid valve disorder, unspecified I370 Pulmonary valve stenosis I371 Pulmonary valve insufficiency I372 Pulmonary valve stenosis with insufficiency I378 Other nonrheumatic pulmonary valve disorders I379 Nonrheumatic pulmonary valve disorder, unspecified</p> |

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| Hypertrophic cardiomyopathy | ICD-10 Diagnosis Codes: I421 Obstructive hypertrophic cardiomyopathy I422 Other hypertrophic cardiomyopathy |
| Congenital valve anomalies | ICD-10 Diagnosis Codes: Q221 Congenital pulmonary valve stenosis Q222 Congenital pulmonary valve insufficiency Q223 Other congenital malformations of pulmonary valve Q224 Congenital tricuspid valve stenosis Q225 Ebstein anomaly Q228 Other congenital malformations of tricuspid valve Q229 Congenital malformations of tricuspid valve, unspecified Q230 Congenital stenosis of aortic valve Q231 Congenital insufficiency of aortic valve Q232 Congenital mitral valve stenosis Q233 Congenital mitral valve insufficiency Q238 Other congenital malformations of aortic and mitral valves Q239 Congenital malformations of aortic and mitral valves, unspecified |

Table S4

Summary of Invasive Procedure (IPs) OPCS-4 Codes

| Procedures | Paper (RR)* | OPCS-4 Codes | Most Likely Organisms |
|---|-------------|--|-----------------------|
| Haematology Procedures | | | |
| Blood transfusion/red cell or plasma exchange | 7 | X32.1-X34.9 (3 Character – X32–X34) | Staph |
| Bone marrow puncture | 16 | W36.5, Y66.7 (Must use 4 character codes) | Staph |
| GI Procedures | | | |
| Oesophageal endoscopic procedures (all) | | G14.1-G20.9 U20.2 (3 Character – G14–G20 + U20.2) | |
| - Transoesophageal echocardiography (TOE) | | U20.2 | |
| - Oesophageal endoscopic procedures (excluding TOE) | | G14.1-G20.9 (3 Character – G14–G20) | |
| Upper GI endoscopic procedures (gastric, jejunum, ileum) | 4 | G42.1-G46.9 G54.1-G55.9 G64.1-G65.9 G79.1-G79.9 G80.1-G80.9 (3 Character – G42-G46, G54-G55, G64-G65 + G79-G80) | Enterococci |
| Lower GI endoscopic procedures (including sigmoid and rectum) | 3 | H20.1-28.9 (3 Character – H20–H28) | Enterococci |
| Colonic surgery (incl appendix) | | H01.1-19.9 H29.1-29.9 (3 Character – H01-03 (Appendix), H04–H19 and H29 (Colonic surgery)) | |
| Endoscopic Retrograde Cholangio-pancreatic Procedures (ERCP) | | J40-1 - J45.9 (3 Character – J40 - J45) | Enterococci |
| GU Procedures | | | |
| Cystoscopic procedures | 4 | M09.1-M11.9 M27.1-M30.9 M42.1-M45.9 (3 Character – M09–M11, M27–M30, M42-M45) | Enterococci |
| Endoscopic prostate procedures | | M65.1-M68.9 M70.1-M71.9 (3 Character – M65-M68 and M70-M71) | |
| Respiratory Procedures | | | |
| Bronchoscopic procedures | | E48.1-51.9 | ? |

| | | | |
|---|-----|---|-------|
| | | (3 Character – E48-E51) | |
| ENT procedures | | | ? |
| Tonsillectomy & Adenoidectomy | 2 | E20.1–E20.9 F34.1-34.9, F36.1-F36.9 (3 Character – E20, F34, F36) | ? |
| Nasal packing/nasal intubation | | E06.1-E06.9 + X56.1 (3 Character – E06 + 4 char X56.1) | |
| Obstetric & gynae procedures | | | ? |
| Abortion/dilatation & curettage (D&C) | 3 | Q10.1-11.9 (3 Character – Q10, Q11) | |
| Vaginal delivery | | R19.1-24.9 (3 Character – R19-R24) | |
| Caesarean delivery | | R17.1-18.9 (3 Character – R17, R18) | |
| Cardiac Procedures | | | |
| Coronary angiography | 4 | K63.1-63.9, K65.1-K65.9. (3 Character – K63, K65) | Staph |
| Coronary artery bypass | 14 | K40.1-46.9 (3 Character – K40-K46) | Staph |
| Percutaneous coronary procedures and stents | | K49.1-K51.9, K75.1-75.9 (3 Character – K49-51 & K75) | Staph |
| Implantation of cardiac pacemakers/defibrillators | | K59.1-K61.9, K73.1-K73.9 (3 Character – K59-61 & K73) | |
| Percutaneous valve procedures/heart catheterisation | | K35.1-K35.9 (3 Character – K35) | |
| Skin and wound management procedures | 7 | S41.1-S42.9, S47.1-S47.9, S54.1-S57.9 (3 Character – S41-42, S47 & S54-57) | Staph |
| Dental Procedures | N/A | | |
| Extractions & surgical removal of teeth | | F09.1-F10.9 (3 Character F09-F10) | OVGS |
| Other oral surgical procedures | | 3 Character F01, F02, F03, F04, F05, F06, F08, F11, F18, F22, F23, F24, F26, F28, F29, F30, F32, F38, F39, F40 and 4 Character F42.1-42.3 | OVGS |
| Endodontic procedures | | F12.1-F12.9 (3 Character F12) | OVGS |
| Scaling and gingival procedures | | F16.4, F20.1-F20.9 (3 Character F20 + 4 Character F16.4) | OVGS |
| Restorative Dental Procedures | | F13.1-F13.5, F13.8-F13.9 F17.1, F17.6 (Use 4-character codes) | |

* Increased relative risk of developing IE within 3 months of this procedure being performed according to the data published by Janszky et al. 2018[4]

Table S5
Individual OPCS-4 Invasive Procedure (IPs) Code Descriptions

| Procedure | Code | OPCS-4 Code Description | |
|---------------------------|--|--|---|
| Cardiac Procedures | | | |
| Coronary angiography | K63 | Contrast radiology of heart | |
| | K63.1 | Angiocardiology of combination of right and left side of heart | |
| | K63.2 | Angiocardiology of right side of heart NEC | |
| | K63.3 | Angiocardiology of left side of heart NEC | |
| | K63.4 | Coronary arteriography using two catheters | |
| | K63.5 | Coronary arteriography using single catheter | |
| | K63.6 | Coronary arteriography NEC | |
| | K63.8 | Other specified contrast radiology of heart | |
| | K63.9 | Unspecified contrast radiology of heart | |
| | K65 | Catheterisation of heart | |
| | K65.1 | Catheterisation of combination of right and left side of heart NEC | |
| | K65.2 | Catheterisation of right side of heart NEC | |
| | K65.3 | Catheterisation of left side of heart NEC | |
| | K65.4 | Catheterisation of left side of heart via atrial transeptal puncture | |
| | K65.8 | Other specified catheterisation of heart | |
| | K65.9 | Unspecified catheterisation of heart | |
| | Coronary artery bypass | K40 | Saphenous vein graft replacement of coronary artery |
| | | K40.1 | Saphenous vein graft replacement of one coronary artery |
| | | K40.2 | Saphenous vein graft replacement of two coronary arteries |
| K40.3 | | Saphenous vein graft replacement of three coronary arteries | |
| K40.4 | | Saphenous vein graft replacement of four or more coronary arteries | |
| K40.8 | | Other specified saphenous vein graft replacement of coronary artery | |
| K40.9 | | Unspecified saphenous vein graft replacement of coronary artery | |
| K41 | | Other autograft replacement of coronary artery | |
| K41.1 | | Autograft replacement of one coronary artery NEC | |
| K41.2 | | Autograft replacement of two coronary arteries NEC | |
| K41.3 | | Autograft replacement of three coronary arteries NEC | |
| K41.4 | | Autograft replacement of four or more coronary arteries NEC | |
| K41.8 | | Other specified other autograft replacement of coronary artery | |
| K41.9 | | Unspecified other autograft replacement of coronary artery | |
| K42 | | Allograft replacement of coronary artery | |
| K42.1 | | Allograft replacement of one coronary artery | |
| K42.2 | | Allograft replacement of two coronary arteries | |
| K42.3 | | Allograft replacement of three coronary arteries | |
| K42.4 | | Allograft replacement of four or more coronary arteries | |
| K42.8 | | Other specified allograft replacement of coronary artery | |
| K42.9 | | Unspecified allograft replacement of coronary artery | |
| K43 | | Prosthetic replacement of coronary artery | |
| K43.1 | | Prosthetic replacement of one coronary artery | |
| K43.2 | | Prosthetic replacement of two coronary arteries | |
| K43.3 | | Prosthetic replacement of three coronary arteries | |
| K43.4 | | Prosthetic replacement of four or more coronary arteries | |
| K43.8 | | Other specified prosthetic replacement of coronary artery | |
| K43.9 | | Unspecified prosthetic replacement of coronary artery | |
| K44 | | Other replacement of coronary artery | |
| K44.1 | | Replacement of coronary arteries using multiple methods | |
| K44.2 | | Revision of replacement of coronary artery | |
| K44.8 | | Other specified other replacement of coronary artery | |
| K44.9 | Unspecified other replacement of coronary artery | | |
| K45 | Connection of thoracic artery to coronary artery | | |
| K45.1 | Double anastomosis of mammary arteries to coronary arteries | | |
| K45.2 | Double anastomosis of thoracic arteries to coronary arteries NEC | | |

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| | K45.3 | Anastomosis of mammary artery to left anterior descending coronary artery |
| | K45.4 | Anastomosis of mammary artery to coronary artery NEC |
| | K45.5 | Anastomosis of thoracic artery to coronary artery NEC |
| | K45.6 | Revision of connection of thoracic artery to coronary artery |
| | K45.8 | Other specified connection of thoracic artery to coronary artery |
| | K45.9 | Unspecified connection of thoracic artery to coronary artery |
| | K46 | Other bypass of coronary artery |
| | K46.1 | Double implantation of mammary arteries into heart |
| | K46.2 | Double implantation of thoracic arteries into heart NEC |
| | K46.3 | Implantation of mammary artery into heart NEC |
| | K46.4 | Implantation of thoracic artery into heart NEC |
| | K46.5 | Revision of implantation of thoracic artery into heart |
| | K46.8 | Other specified other bypass of coronary artery |
| | K46.9 | Unspecified other bypass of coronary artery |
| | Percutaneous coronary procedures and stents | K49 |
| K49.1 | | Percutaneous transluminal balloon angioplasty of one coronary artery |
| K49.2 | | Percutaneous transluminal balloon angioplasty of multiple coronary arteries |
| K49.3 | | Percutaneous transluminal balloon angioplasty of bypass graft of coronary artery |
| K49.4 | | Percutaneous transluminal cutting balloon angioplasty of coronary artery |
| K49.8 | | Other specified transluminal balloon angioplasty of coronary artery |
| K49.9 | | Unspecified transluminal balloon angioplasty of coronary artery |
| K50 | | Other therapeutic transluminal operations on coronary artery |
| K50.1 | | Percutaneous transluminal laser coronary angioplasty |
| K50.2 | | Percutaneous transluminal coronary thrombolysis using streptokinase |
| K50.3 | | Percutaneous transluminal injection of therapeutic substance into coronary artery NEC |
| K50.4 | | Percutaneous transluminal atherectomy of coronary artery |
| K50.8 | | Other specified other therapeutic transluminal operations on coronary artery |
| K50.9 | | Unspecified other therapeutic transluminal operations on coronary artery |
| K51 | | Diagnostic transluminal operations on coronary artery |
| K51.1 | | Percutaneous transluminal angiography |
| K51.2 | | Intravascular ultrasound of coronary artery |
| K51.8 | | Other specified diagnostic transluminal operations on coronary artery |
| K51.9 | | Unspecified diagnostic transluminal operations on coronary artery |
| K75 | | Percutaneous transluminal balloon angioplasty and insertion of stent into coronary artery |
| K75.1 | | Percutaneous transluminal balloon angioplasty and insertion of 1-2 drug-eluting stents into coronary artery |
| K75.2 | | Percutaneous transluminal balloon angioplasty and insertion of 3 or more drug-eluting stents into coronary artery |
| K75.3 | Percutaneous transluminal balloon angioplasty and insertion of 1-2 stents into coronary artery | |
| K75.4 | Percutaneous transluminal balloon angioplasty and insertion of 3 or more stents into coronary artery NEC | |
| K75.8 | Other specified percutaneous transluminal balloon angioplasty and insertion of stent into coronary artery | |
| K75.9 | Unspecified percutaneous transluminal balloon angioplasty and insertion of stent into coronary artery | |
| Implantation of cardiac pacemakers/defibrillators | K59 | Cardioverter defibrillator introduced through the vein |
| | K59.1 | Implantation of cardioverter defibrillator using one electrode lead |
| | K59.2 | Implantation of cardioverter defibrillator using two electrode leads |
| | K59.3 | Resiting of lead of cardioverter defibrillator |
| | K59.4 | Renewal of cardioverter defibrillator NEC |
| | K59.5 | Removal of cardioverter defibrillator |
| | K59.6 | Implantation of cardioverter defibrillator using three electrode leads |
| | K59.7 | Renewal of cardioverter defibrillator using three electrode leads |
| | K59.8 | Other specified cardioverter defibrillator introduced through the vein |
| | K59.9 | Unspecified cardioverter defibrillator introduced through the vein |

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| | K60 | Cardiac pacemaker system introduced through vein |
| | K60.1 | Implantation of intravenous cardiac pacemaker system NEC |
| | K60.2 | Resiting of lead of intravenous cardiac pacemaker system |
| | K60.3 | Renewal of intravenous cardiac pacemaker system NEC |
| | K60.4 | Removal of intravenous cardiac pacemaker system |
| | K60.5 | Implantation of intravenous single chamber cardiac pacemaker system |
| | K60.6 | Implantation of intravenous dual chamber cardiac pacemaker system |
| | K60.7 | Implantation of intravenous biventricular cardiac pacemaker system |
| | K60.8 | Other specified cardiac pacemaker system introduced through vein |
| | K60.9 | Unspecified cardiac pacemaker system introduced through vein |
| | K61 | Other cardiac pacemaker system |
| | K61.1 | Implantation of cardiac pacemaker system NEC |
| | K61.2 | Resiting of lead of cardiac pacemaker system NEC |
| | K61.3 | Renewal of cardiac pacemaker system NEC |
| | K61.4 | Removal of cardiac pacemaker system NEC |
| | K61.5 | Implantation of single chamber cardiac pacemaker system |
| | K61.6 | Implantation of dual chamber cardiac pacemaker system |
| | K61.7 | Implantation of biventricular cardiac pacemaker system |
| | K61.8 | Other specified other cardiac pacemaker system |
| | K61.9 | Unspecified other cardiac pacemaker system |
| | K73 | Other cardiac pacemaker system introduced through vein |
| | K73.1 | Renewal of intravenous single chamber cardiac pacemaker system |
| | K73.2 | Renewal of intravenous dual chamber cardiac pacemaker system |
| | K73.3 | Renewal of intravenous biventricular cardiac pacemaker |
| | K73.8 | Other specified other cardiac pacemaker system introduced through vein |
| | K73.9 | Unspecified other cardiac pacemaker system introduced through vein |
| Percutaneous valve procedures/heart catheterisation | K35 | Therapeutic transluminal operations on valve of heart |
| | K35.1 | Percutaneous transluminal mitral valvotomy |
| | K35.2 | Percutaneous transluminal aortic valvotomy |
| | K35.3 | Percutaneous transluminal tricuspid valvotomy |
| | K35.4 | Percutaneous transluminal pulmonary valvotomy |
| | K35.5 | Percutaneous transluminal valvuloplasty |
| | K35.6 | Percutaneous transluminal pulmonary valve perforation and dilation |
| | K35.7 | Percutaneous transluminal pulmonary valve replacement |
| | K35.8 | Other specified therapeutic transluminal operations on valve of heart |
| | K35.9 | Unspecified therapeutic transluminal operations on valve of heart |
| GI Procedures | | |
| Trans oesophageal echo (TOE) procedures | U20.2 | Transoesophageal echocardiography |
| Other oesophageal endoscopic procedures | G14 | Fibreoptic endoscopic extirpation of lesion of oesophagus |
| | G14.1 | Fibreoptic endoscopic snare resection of lesion of oesophagus |
| | G14.2 | Fibreoptic endoscopic laser destruction of lesion of oesophagus |
| | G14.3 | Fibreoptic endoscopic cauterisation of lesion of oesophagus |
| | G14.4 | Fibreoptic endoscopic injection sclerotherapy to varices of oesophagus |
| | G14.5 | Fibreoptic endoscopic destruction of lesion of oesophagus NEC |
| | G14.6 | Fibreoptic endoscopic submucosal resection of lesion of oesophagus |
| | G14.7 | Fibreoptic endoscopic photodynamic therapy of lesion of oesophagus |
| | G14.8 | Other specified fibreoptic endoscopic extirpation of lesion of oesophagus |
| | G14.9 | Unspecified fibreoptic endoscopic extirpation of lesion of oesophagus |
| | G15 | Other therapeutic fibreoptic endoscopic operations on oesophagus |
| | G15.1 | Fibreoptic endoscopic removal of foreign body from oesophagus |
| | G15.2 | Fibreoptic endoscopic balloon dilation of oesophagus |
| | G15.3 | Fibreoptic endoscopic dilation of oesophagus NEC |
| | G15.4 | Fibreoptic endoscopic insertion of tubal prosthesis into oesophagus |
| | G15.5 | Fibreoptic endoscopic dilation of web of oesophagus |
| | G15.6 | Fibreoptic endoscopic insertion of expanding metal stent into oesophagus NEC |
| | G15.7 | Fibreoptic endoscopic insertion of expanding covered metal stent into oesophagus |
| | G15.8 | Other specified other therapeutic fibreoptic endoscopic operations on oesophagus |

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|--|--------|---|
| | G15.9 | Unspecified other therapeutic fibreoptic endoscopic operations on oesophagus |
| | G16 | Diagnostic fibreoptic endoscopic examination of oesophagus |
| | G16.1 | Diagnostic fibreoptic endoscopic examination of oesophagus and biopsy of lesion of oesophagus |
| | G16.2 | Diagnostic fibreoptic endoscopic ultrasound examination of oesophagus |
| | G16.3 | Diagnostic fibreoptic insertion of Bravo pH capsule into oesophagus |
| | G16.8 | Other specified diagnostic fibreoptic endoscopic examination of oesophagus |
| | G16.9 | Unspecified diagnostic fibreoptic endoscopic examination of oesophagus |
| | G17 | Endoscopic extirpation of lesion of oesophagus using rigid oesophagoscope |
| | G17.1 | Endoscopic snare resection of lesion of oesophagus using rigid oesophagoscope |
| | G17.2 | Endoscopic laser destruction of lesion of oesophagus using rigid oesophagoscope |
| | G17.3 | Endoscopic cauterisation of lesion of oesophagus using rigid oesophagoscope |
| | G17.4 | Endoscopic injection sclerotherapy to varices of oesophagus using rigid oesophagoscope |
| | G17.8 | Other specified endoscopic extirpation of lesion of oesophagus using rigid oesophagoscope |
| | G17.9 | Unspecified endoscopic extirpation of lesion of oesophagus using rigid oesophagoscope |
| | G18 | Other therapeutic endoscopic operations on oesophagus using rigid oesophagoscope |
| | G18.1 | Endoscopic removal of foreign body from oesophagus using rigid oesophagoscope |
| | G18.2 | Endoscopic balloon dilation of oesophagus using rigid oesophagoscope |
| | G18.3 | Endoscopic dilation of oesophagus using rigid oesophagoscope NEC |
| | G18.4 | Endoscopic insertion of tubal prosthesis into oesophagus using rigid oesophagoscope |
| | G18.5 | Dilation of web of oesophagus using rigid oesophagoscope |
| | G18.8 | Other specified other therapeutic endoscopic operations on oesophagus using rigid oesophagoscope |
| | G18.9 | Unspecified other therapeutic endoscopic operations on oesophagus using rigid oesophagoscope |
| | G19 | Diagnostic endoscopic examination of oesophagus using rigid oesophagoscope |
| | G19.1 | Diagnostic endoscopic examination of oesophagus and biopsy of lesion of oesophagus using rigid oesophagoscope |
| | G19.2 | Diagnostic endoscopic insertion of Bravo pH capsule using rigid oesophagoscope |
| | G19.8 | Other specified diagnostic endoscopic examination of oesophagus using rigid oesophagoscope |
| | G19.9 | Unspecified diagnostic endoscopic examination of oesophagus using rigid oesophagoscope |
| | G20 | Therapeutic fibreoptic endoscopic operations on oesophagus |
| | G20.1 | Fibreoptic endoscopic coagulation of bleeding lesion of oesophagus |
| | G20.8 | Other specified therapeutic fibreoptic endoscopic operations on oesophagus |
| | G20.9 | Unspecified therapeutic fibreoptic endoscopic operations on oesophagus |
| Upper GI endoscopic procedures (gastric, jejunum, ileum) | G42* | Other fibreoptic endoscopic extirpation of lesion of upper gastrointestinal tract |
| | G42.1* | Fibreoptic endoscopic submucosal resection of lesion of upper gastrointestinal tract |
| | G42.2* | Fibreoptic endoscopic photodynamic therapy of lesion of upper gastrointestinal tract |
| | G42.3* | Fibreoptic endoscopic mucosal resection of lesion of upper gastrointestinal tract |
| | G42.8* | Other specified other fibreoptic endoscopic extirpation of lesion of upper gastrointestinal tract |
| | G42.9* | Unspecified other fibreoptic endoscopic extirpation of lesion of upper gastrointestinal tract |
| | G43* | Fibreoptic endoscopic extirpation of lesion of upper gastrointestinal tract |
| | G43.1* | Fibreoptic endoscopic snare resection of lesion of upper gastrointestinal tract |
| | G43.2* | Fibreoptic endoscopic laser destruction of lesion of upper gastrointestinal tract |
| | G43.3* | Fibreoptic endoscopic cauterisation of lesion of upper gastrointestinal tract |
| | G43.4* | Fibreoptic endoscopic sclerotherapy to lesion of upper gastrointestinal tract |
| | G43.5* | Fibreoptic endoscopic destruction of lesion of upper gastrointestinal tract NEC |
| | G43.6* | Fibreoptic endoscopic injection therapy to lesion of upper gastrointestinal tract NEC |
| | G43.7* | Fibreoptic endoscopic rubber band ligation of upper gastrointestinal tract varices |

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| G43.8* | Other specified fibreoptic endoscopic extirpation of lesion of upper gastrointestinal tract |
| G43.9* | Unspecified fibreoptic endoscopic extirpation of lesion of upper gastrointestinal tract |
| G44* | Other therapeutic fibreoptic endoscopic operations on upper gastrointestinal tract |
| G44.1* | Fibreoptic endoscopic insertion of prosthesis into upper gastrointestinal tract |
| G44.2# | Fibreoptic endoscopic removal of foreign body from upper gastrointestinal tract |
| G44.3* | Fibreoptic endoscopic dilation of upper gastrointestinal tract NEC |
| G44.4# | Fibreoptic endoscopic reduction of intussusception of gastroenterostomy |
| G44.5* | Fibreoptic endoscopic percutaneous insertion of gastrostomy |
| G44.6* | Fibreoptic endoscopic pressure controlled balloon dilation of lower oesophageal sphincter |
| G44.7# | Fibreoptic endoscopic removal of gastrostomy tube |
| G44.8* | Other specified other therapeutic fibreoptic endoscopic operations on upper gastrointestinal tract |
| G44.9* | Unspecified other therapeutic fibreoptic endoscopic operations on upper gastrointestinal tract |
| G45# | Diagnostic fibreoptic endoscopic examination of upper gastrointestinal tract |
| G45.1* | Fibreoptic endoscopic examination of upper gastrointestinal tract and biopsy of lesion of upper gastrointestinal tract |
| G45.2# | Fibreoptic endoscopic ultrasound examination of upper gastrointestinal tract |
| G45.3# | Fibreoptic endoscopic insertion of Bravo pH capsule into upper gastrointestinal tract |
| G45.4# | Fibreoptic endoscopic examination of upper gastrointestinal tract and staining of gastric mucosa |
| G45.8# | Other specified diagnostic fibreoptic endoscopic examination of upper gastrointestinal tract |
| G45.9# | Unspecified diagnostic fibreoptic endoscopic examination of upper gastrointestinal tract |
| G46* | Therapeutic fibreoptic endoscopic operations on upper gastrointestinal tract |
| G46.1* | Fibreoptic endoscopic endoluminal plication of gastro-oesophageal junction |
| G46.2* | Fibreoptic endoscopic coagulation of bleeding lesion of upper gastrointestinal tract |
| G46.8* | Other specified therapeutic fibreoptic endoscopic operations on upper gastrointestinal tract |
| G46.9* | Unspecified therapeutic fibreoptic endoscopic operations on upper gastrointestinal tract |
| G54* | Therapeutic endoscopic operations on duodenum |
| G54.1* | Endoscopic extirpation of lesion of duodenum |
| G54.2* | Endoscopic dilation of duodenum |
| G54.3* | Endoscopic insertion of tubal prosthesis into duodenum |
| G54.8* | Other specified therapeutic endoscopic operations on duodenum |
| G54.9* | Unspecified therapeutic endoscopic operations on duodenum |
| G55# | Diagnostic endoscopic examination of duodenum |
| G55.1* | Diagnostic endoscopic examination of duodenum and biopsy of lesion of duodenum |
| G55.8# | Other specified diagnostic endoscopic examination of duodenum |
| G55.9# | Unspecified diagnostic endoscopic examination of duodenum |
| G64* | Therapeutic endoscopic operations on jejunum |
| G64.1* | Endoscopic extirpation of lesion of jejunum |
| G64.2* | Endoscopic dilation of jejunum |
| G64.3* | Endoscopic insertion of tubal prosthesis into jejunum |
| G64.8* | Other specified therapeutic endoscopic operations on jejunum |
| G64.9* | Unspecified therapeutic endoscopic operations on jejunum |
| G65# | Diagnostic endoscopic examination of jejunum |
| G65.1* | Diagnostic endoscopic examination of jejunum and biopsy of lesion of jejunum |
| G65.8# | Other specified diagnostic endoscopic examination of jejunum |
| G65.9# | Unspecified diagnostic endoscopic examination of jejunum |
| G79* | Therapeutic endoscopic operations on ileum |
| G79.1* | Endoscopic extirpation of lesion of ileum |
| G79.2* | Endoscopic dilation of ileum |

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| | G79.3* | Endoscopic insertion of tubal prosthesis into ileum |
| | G79.8* | Other specified therapeutic endoscopic operations on ileum |
| | G79.9* | Unspecified therapeutic endoscopic operations on ileum |
| | G80 [#] | Diagnostic endoscopic examination of ileum |
| | G80.1* | Diagnostic endoscopic examination of ileum and biopsy of lesion of ileum |
| | G80.2 [#] | Wireless capsule endoscopy |
| | G80.3 [#] | Diagnostic endoscopic balloon examination of ileum |
| | G80.8 [#] | Other specified diagnostic endoscopic examination of ileum |
| | G80.9 [#] | Unspecified diagnostic examination of ileum |
| Lower GI endoscopic procedures (including sigmoid and rectum) | H20* | Endoscopic extirpation of lesion of colon |
| | H20.1* | Fibreoptic endoscopic snare resection of lesion of colon |
| | H20.2* | Fibreoptic endoscopic cauterisation of lesion of colon |
| | H20.3* | Fibreoptic endoscopic laser destruction of lesion of colon |
| | H20.4* | Fibreoptic endoscopic destruction of lesion of colon NEC |
| | H20.5* | Fibreoptic endoscopic submucosal resection of lesion of colon |
| | H20.6* | Fibreoptic endoscopic resection of lesion of colon NEC |
| | H20.7* | Fibreoptic endoscopic mucosal resection of lesion of colon |
| | H20.8* | Other specified endoscopic extirpation of lesion of colon |
| | H20.9* | Unspecified endoscopic extirpation of lesion of colon |
| | H21* | Other therapeutic endoscopic operations on colon |
| | H21.1* | Fibreoptic endoscopic dilation of colon |
| | H21.2* | Fibreoptic endoscopic coagulation of blood vessel of colon |
| | H21.3 [#] | Fibreoptic endoscopic removal of foreign body from colon |
| | H21.4* | Fibreoptic endoscopic insertion of expanding metal stent into colon |
| | H21.5 [#] | Fibreoptic endoscopic decompression of colon |
| | H21.8* | Other specified other therapeutic endoscopic operations on colon |
| | H21.9* | Unspecified other therapeutic endoscopic operations on colon |
| | H22 [#] | Diagnostic endoscopic examination of colon |
| | H22.1* | Diagnostic fibreoptic endoscopic examination of colon and biopsy of lesion of colon |
| | H22.8 [#] | Other specified diagnostic endoscopic examination of colon |
| | H22.9 [#] | Unspecified diagnostic endoscopic examination of colon |
| | H23* | Endoscopic extirpation of lesion of lower bowel using fibreoptic sigmoidoscope |
| | H23.1* | Endoscopic snare resection of lesion of lower bowel using fibreoptic sigmoidoscope |
| | H23.2* | Endoscopic cauterisation of lesion of lower bowel using fibreoptic sigmoidoscope |
| | H23.3* | Endoscopic laser destruction of lesion of lower bowel using fibreoptic sigmoidoscope |
| | H23.4* | Endoscopic destruction of lesion of lower bowel using fibreoptic sigmoidoscope NEC |
| | H23.5* | Endoscopic submucosal resection of lesion of lower bowel using fibreoptic sigmoidoscope |
| | H23.6* | Endoscopic resection of lesion of lower bowel using fibreoptic sigmoidoscope NEC |
| | H23.7* | Endoscopic mucosal resection of lesion of lower bowel using fibreoptic sigmoidoscope |
| | H23.8* | Other specified endoscopic extirpation of lesion of lower bowel using fibreoptic sigmoidoscope |
| | H23.9* | Unspecified endoscopic extirpation of lesion of lower bowel using fibreoptic sigmoidoscope |
| | H24* | Other therapeutic endoscopic operations on lower bowel using fibreoptic sigmoidoscope |
| | H24.1* | Endoscopic dilation of lower bowel using fibreoptic sigmoidoscope |
| | H24.2* | Endoscopic coagulation of blood vessel of lower bowel using fibreoptic sigmoidoscope |
| | H24.3* | Endoscopic insertion of tubal prosthesis into lower bowel using fibreoptic sigmoidoscope |
| | H24.4* | Endoscopic insertion of expanding metal stent into lower bowel using fibreoptic sigmoidoscope |
| | H24.5 [#] | Endoscopic decompression of lower bowel using fibreoptic sigmoidoscope |
| | H24.8* | Other specified other therapeutic endoscopic operations on lower bowel using fibreoptic sigmoidoscope |

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| | H24.9* | Unspecified other therapeutic endoscopic operations on lower bowel using fiberoptic sigmoidoscope |
| | H25 [#] | Diagnostic endoscopic examination of lower bowel using fiberoptic sigmoidoscope |
| | H25.1* | Diagnostic endoscopic examination of lower bowel and biopsy of lesion of lower bowel using fiberoptic sigmoidoscope |
| | H25.2 [#] | Diagnostic endoscopic examination of lower bowel and sampling for bacterial overgrowth using fiberoptic sigmoidoscope |
| | H25.8 [#] | Other specified diagnostic endoscopic examination of lower bowel using fiberoptic sigmoidoscope |
| | H25.9 [#] | Unspecified diagnostic endoscopic examination of lower bowel using fiberoptic sigmoidoscope |
| | H26* | Endoscopic extirpation of lesion of sigmoid colon using rigid sigmoidoscope |
| | H26.1* | Endoscopic snare resection of lesion of sigmoid colon using rigid sigmoidoscope |
| | H26.2* | Endoscopic cauterisation of lesion of sigmoid colon using rigid sigmoidoscope |
| | H26.3* | Endoscopic laser destruction of lesion of sigmoid colon using rigid sigmoidoscope |
| | H26.4* | Endoscopic cryotherapy to lesion of sigmoid colon using rigid sigmoidoscope |
| | H26.5* | Endoscopic destruction of lesion of sigmoid colon using rigid sigmoidoscope NEC |
| | H26.6* | Endoscopic submucosal resection of lesion of sigmoid colon using rigid sigmoidoscope |
| | H26.7* | Endoscopic resection of lesion of sigmoid colon using rigid sigmoidoscope NEC |
| | H26.8* | Other specified endoscopic extirpation of lesion of sigmoid colon using rigid sigmoidoscope |
| | H26.9* | Unspecified endoscopic extirpation of lesion of sigmoid colon using rigid sigmoidoscope |
| | H27* | Other therapeutic endoscopic operations on sigmoid colon using rigid sigmoidoscope |
| | H27.1* | Endoscopic dilation of sigmoid colon using rigid sigmoidoscope |
| | H27.2 [#] | Endoscopic removal of foreign body from sigmoid colon using rigid sigmoidoscope |
| | H27.3 [†] | Endoscopic insertion of tubal prosthesis into sigmoid colon using rigid sigmoidoscope |
| | H27.4* | Endoscopic insertion of expanding metal stent into sigmoid colon using rigid sigmoidoscope |
| | H27.5 [#] | Endoscopic decompression of sigmoid colon using rigid sigmoidoscope |
| | H27.8* | Other specified other therapeutic endoscopic operations on sigmoid colon using rigid sigmoidoscope |
| | H27.9* | Unspecified other therapeutic endoscopic operations on sigmoid colon using rigid sigmoidoscope |
| | H28 [#] | Diagnostic endoscopic examination of sigmoid colon using rigid sigmoidoscope |
| | H28.1* | Diagnostic endoscopic examination of sigmoid colon and biopsy of lesion of sigmoid colon using rigid sigmoidoscope |
| | H28.8 [#] | Other specified diagnostic endoscopic examination of sigmoid colon using rigid sigmoidoscope |
| | H28.9 [#] | Unspecified diagnostic endoscopic examination of sigmoid colon using rigid sigmoidoscope |
| Colonic surgery (incl. appendix) | H01 | Emergency excision of appendix |
| | H01.1 | Emergency excision of abnormal appendix and drainage HFQ |
| | H01.2 | Emergency excision of abnormal appendix NEC |
| | H01.3 | Emergency excision of normal appendix |
| | H01.8 | Other specified emergency excision of appendix |
| | H01.9 | Unspecified emergency excision of appendix |
| | H02 | Other excision of appendix |
| | H02.1 | Interval appendicectomy |
| | H02.2 | Planned delayed appendicectomy NEC |
| | H02.3 | Prophylactic appendicectomy NEC |
| | H02.4 | Incidental appendicectomy |
| | H02.8 | Other specified other excision of appendix |
| | H02.9 | Unspecified other excision of appendix |
| | H03 | Other operations on appendix |

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| H03.1 | Drainage of abscess of appendix |
| H03.2 | Drainage of appendix NEC |
| H03.3 | Exteriorisation of appendix |
| H03.8 | Other specified other operations on appendix |
| H03.9 | Unspecified other operations on appendix |
| H04 | Total excision of colon and rectum |
| H04.1 | Panproctocolectomy and ileostomy |
| H04.2 | Panproctocolectomy and anastomosis of ileum to anus and creation of pouch HFQ |
| H04.3 | Panproctocolectomy and anastomosis of ileum to anus NEC |
| H04.8 | Other specified total excision of colon and rectum |
| H04.9 | Unspecified total excision of colon and rectum |
| H05 | Total excision of colon |
| H05.1 | Total colectomy and anastomosis of ileum to rectum |
| H05.2 | Total colectomy and ileostomy and creation of rectal fistula HFQ |
| H05.3 | Total colectomy and ileostomy NEC |
| H05.8 | Other specified total excision of colon |
| H05.9 | Unspecified total excision of colon |
| H06 | Extended excision of right hemicolon |
| H06.1 | Extended right hemicolectomy and end to end anastomosis |
| H06.2 | Extended right hemicolectomy and anastomosis of ileum to colon |
| H06.3 | Extended right hemicolectomy and anastomosis NEC |
| H06.4 | Extended right hemicolectomy and ileostomy HFQ |
| H06.5 | Extended right hemicolectomy and end to side anastomosis |
| H06.8 | Other specified extended excision of right hemicolon |
| H06.9 | Unspecified extended excision of right hemicolon |
| H07 | Other excision of right hemicolon |
| H07.1 | Right hemicolectomy and end to end anastomosis of ileum to colon |
| H07.2 | Right hemicolectomy and side to side anastomosis of ileum to transverse colon |
| H07.3 | Right hemicolectomy and anastomosis NEC |
| H07.4 | Right hemicolectomy and ileostomy HFQ |
| H07.5 | Right hemicolectomy and end to side anastomosis |
| H07.8 | Other specified other excision of right hemicolon |
| H07.9 | Unspecified other excision of right hemicolon |
| H08 | Excision of transverse colon |
| H08.1 | Transverse colectomy and end to end anastomosis |
| H08.2 | Transverse colectomy and anastomosis of ileum to colon |
| H08.3 | Transverse colectomy and anastomosis NEC |
| H08.4 | Transverse colectomy and ileostomy HFQ |
| H08.5 | Transverse colectomy and exteriorisation of bowel NEC |
| H08.6 | Transverse colectomy and end to side anastomosis |
| H08.8 | Other specified excision of transverse colon |
| H08.9 | Unspecified excision of transverse colon |
| H09 | Excision of left hemicolon |
| H09.1 | Left hemicolectomy and end to end anastomosis of colon to rectum |
| H09.2 | Left hemicolectomy and end to end anastomosis of colon to colon |
| H09.3 | Left hemicolectomy and anastomosis NEC |
| H09.4 | Left hemicolectomy and ileostomy HFQ |
| H09.5 | Left hemicolectomy and exteriorisation of bowel NEC |
| H09.6 | Left hemicolectomy and end to side anastomosis |
| H09.8 | Other specified excision of left hemicolon |
| H09.9 | Unspecified excision of left hemicolon |
| H10 | Excision of sigmoid colon |
| H10.1 | Sigmoid colectomy and end to end anastomosis of ileum to rectum |
| H10.2 | Sigmoid colectomy and anastomosis of colon to rectum |
| H10.3 | Sigmoid colectomy and anastomosis NEC |
| H10.4 | Sigmoid colectomy and ileostomy HFQ |
| H10.5 | Sigmoid colectomy and exteriorisation of bowel NEC |
| H10.6 | Sigmoid colectomy and end to side anastomosis |

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| H10.8 | Other specified excision of sigmoid colon |
| H10.9 | Unspecified excision of sigmoid colon |
| H11 | Other excision of colon |
| H11.1 | Colectomy and end to end anastomosis of colon to colon NEC |
| H11.2 | Colectomy and side to side anastomosis of ileum to colon NEC |
| H11.3 | Colectomy and anastomosis NEC |
| H11.4 | Colectomy and ileostomy NEC |
| H11.5 | Colectomy and exteriorisation of bowel NEC |
| H11.6 | Colectomy and end to side anastomosis NEC |
| H11.8 | Other specified other excision of colon |
| H11.9 | Unspecified other excision of colon |
| H12 | Extirpation of lesion of colon |
| H12.1 | Excision of diverticulum of colon |
| H12.2 | Excision of lesion of colon NEC |
| H12.3 | Destruction of lesion of colon NEC |
| H12.8 | Other specified extirpation of lesion of colon |
| H12.9 | Unspecified extirpation of lesion of colon |
| H13 | Bypass of colon |
| H13.1 | Bypass of colon by anastomosis of ileum to colon |
| H13.2 | Bypass of colon by anastomosis of caecum to sigmoid colon |
| H13.3 | Bypass of colon by anastomosis of transverse colon to sigmoid colon |
| H13.4 | Bypass of colon by anastomosis of transverse colon to rectum |
| H13.5 | Bypass of colon by anastomosis of colon to rectum NEC |
| H13.8 | Other specified bypass of colon |
| H13.9 | Unspecified bypass of colon |
| H14 | Exteriorisation of caecum |
| H14.1 | Tube caecostomy |
| H14.2 | Refashioning of caecostomy |
| H14.3 | Closure of caecostomy |
| H14.4 | Appendicocaecostomy |
| H14.8 | Other specified exteriorisation of caecum |
| H14.9 | Unspecified exteriorisation of caecum |
| H15 | Other exteriorisation of colon |
| H15.1 | Loop colostomy |
| H15.2 | End colostomy |
| H15.3 | Refashioning of colostomy |
| H15.4 | Closure of colostomy |
| H15.5 | Dilation of colostomy |
| H15.6 | Reduction of prolapse of colostomy |
| H15.7 | Percutaneous endoscopic sigmoid colostomy |
| H15.8 | Other specified other exteriorisation of colon |
| H15.9 | Unspecified other exteriorisation of colon |
| H16 | Incision of colon |
| H16.1 | Drainage of colon |
| H16.2 | Caecotomy |
| H16.3 | Colotomy |
| H16.8 | Other specified incision of colon |
| H16.9 | Unspecified incision of colon |
| H17 | Intra-abdominal manipulation of colon |
| H17.1 | Open reduction of intussusception of colon |
| H17.2 | Open reduction of volvulus of caecum |
| H17.3 | Open reduction of volvulus of sigmoid colon |
| H17.4 | Open reduction of volvulus of colon NEC |
| H17.5 | Open relief of strangulation of colon |
| H17.6 | Open relief of obstruction of colon NEC |
| H17.8 | Other specified intra-abdominal manipulation of colon |
| H17.9 | Unspecified intra-abdominal manipulation of colon |
| H18 | Open endoscopic operations on colon |

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| | H18.1 | Open colonoscopy |
| | H18.8 | Other specified open endoscopic operations on colon |
| | H18.9 | Unspecified open endoscopic operations on colon |
| | H19 | Other open operations on colon |
| | H19.1 | Open biopsy of lesion of colon |
| | H19.2 | Fixation of colon |
| | H19.3 | Enterorrhaphy of colon |
| | H19.4 | Open removal of foreign body from colon |
| | H19.8 | Other specified other open operations on colon |
| | H19.9 | Unspecified other open operations on colon |
| | H29 | Subtotal excision of colon |
| | H29.1 | Subtotal excision of colon and rectum and creation of colonic pouch and anastomosis of colon to anus |
| | H29.2 | Subtotal excision of colon and rectum and creation of colonic pouch NEC |
| | H29.3 | Subtotal excision of colon and creation of colonic pouch and anastomosis of colon to rectum |
| | H29.4 | Subtotal excision of colon and creation of colonic pouch NEC |
| | H29.5 | Subtotal excision of colon and anastomosis of colon to ileum |
| | H29.8 | Other specified subtotal excision of colon |
| | H29.9 | Unspecified subtotal excision of colon |
| | Endoscopic Retrograde Cholangio-pancreatic Procedures (ERCP) | J40 |
| J40.1 | | Endoscopic retrograde insertion of tubal prosthesis into both hepatic ducts |
| J40.2 | | Endoscopic retrograde insertion of tubal prosthesis into bile duct NEC |
| J40.3 | | Endoscopic retrograde renewal of tubal prosthesis in bile duct NEC |
| J40.4 | | Endoscopic retrograde removal of tubal prosthesis from bile duct |
| J40.5 | | Endoscopic retrograde insertion of expanding covered metal stent into bile duct |
| J40.6 | | Endoscopic retrograde insertion of expanding metal stent into bile duct NEC |
| J40.7 | | Endoscopic retrograde renewal of expanding metal stent in bile duct |
| J40.8 | | Other specified endoscopic retrograde placement of prosthesis in bile duct |
| J40.9 | | Unspecified endoscopic retrograde placement of prosthesis in bile duct |
| J41 | | Other therapeutic endoscopic retrograde operations on bile duct |
| J41.1 | | Endoscopic retrograde extraction of calculus from bile duct |
| J41.2 | | Endoscopic dilation of bile duct NEC |
| J41.3 | | Endoscopic retrograde lithotripsy of calculus of bile duct |
| J41.4 | | Endoscopic retrograde photodynamic laser therapy of lesion of bile duct |
| J41.8 | | Other specified other therapeutic endoscopic retrograde operations on bile duct |
| J41.9 | | Unspecified other therapeutic endoscopic retrograde operations on bile duct |
| J42 | | Therapeutic endoscopic retrograde operations on pancreatic duct |
| J42.1 | | Endoscopic retrograde insertion of tubal prosthesis into pancreatic duct |
| J42.2 | | Endoscopic retrograde renewal of tubal prosthesis in pancreatic duct |
| J42.3 | | Endoscopic retrograde removal of calculus from pancreatic duct |
| J42.4 | | Endoscopic retrograde drainage of lesion of pancreas |
| J42.5 | | Endoscopic retrograde dilation of pancreatic duct |
| J42.8 | | Other specified therapeutic endoscopic retrograde operations on pancreatic duct |
| J42.9 | | Unspecified therapeutic endoscopic retrograde operations on pancreatic duct |
| J43 | | Diagnostic endoscopic retrograde examination of bile duct and pancreatic duct |
| J43.1 | | Endoscopic retrograde cholangiopancreatography and biopsy of lesion of ampulla of Vater |
| J43.2 | | Endoscopic retrograde cholangiopancreatography and biopsy of lesion of biliary or pancreatic system NEC |
| J43.3 | | Endoscopic retrograde cholangiopancreatography and collection of bile |
| J43.8 | | Other specified diagnostic endoscopic retrograde examination of bile duct and pancreatic duct |
| J43.9 | | Unspecified diagnostic endoscopic retrograde examination of bile duct and pancreatic duct |
| J44 | | Diagnostic endoscopic retrograde examination of bile duct |
| J44.1 | Endoscopic retrograde cholangiography and biopsy of lesion of bile duct | |
| J44.8 | Other specified diagnostic endoscopic retrograde examination of bile duct | |

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| | J44.9 | Unspecified diagnostic endoscopic retrograde examination of bile duct |
| | J45 | Diagnostic endoscopic retrograde examination of pancreatic duct |
| | J45.1 | Endoscopic retrograde pancreatography and biopsy of lesion of pancreas |
| | J45.2 | Endoscopic retrograde pancreatography and collection of pancreatic juice |
| | J45.3 | Endoscopic retrograde pancreatography through accessory ampulla of Vater |
| | J45.8 | Other specified diagnostic endoscopic retrograde examination of pancreatic duct |
| | J45.9 | Unspecified diagnostic endoscopic retrograde examination of pancreatic duct |
| GU Procedures | | |
| Cystoscopic procedures | M09 | Therapeutic endoscopic operations on calculus of kidney |
| | M09.1 | Endoscopic ultrasound fragmentation of calculus of kidney |
| | M09.2 | Endoscopic electrohydraulic shockwave fragmentation of calculus of kidney |
| | M09.3 | Endoscopic laser fragmentation of calculus of kidney |
| | M09.4 | Endoscopic extraction of calculus of kidney NEC |
| | M09.8 | Other specified therapeutic endoscopic operations on calculus of kidney |
| | M09.9 | Unspecified therapeutic endoscopic operations on calculus of kidney |
| | M10 | Other therapeutic endoscopic operations on kidney |
| | M10.1 | Endoscopic extirpation of lesion of kidney NEC |
| | M10.2 | Endoscopic pyeloplasty |
| | M10.3 | Endoscopic deroofing of multiple cysts of kidney |
| | M10.4 | Endoscopic cryoablation of lesion of kidney |
| | M10.5 | Endoscopic endoluminal balloon rupture of stenosis of pelviureteric junction of kidney |
| | M10.8 | Other specified other therapeutic endoscopic operations on kidney |
| | M10.9 | Unspecified other therapeutic endoscopic operations on kidney |
| | M11 | Diagnostic endoscopic examination of kidney |
| | M11.1 | Diagnostic endoscopic examination of kidney and biopsy of lesion of kidney NEC |
| | M11.2 | Diagnostic endoscopic retrograde examination of kidney and biopsy of lesion of kidney |
| | M11.3 | Diagnostic endoscopic retrograde examination of kidney NEC |
| | M11.8 | Other specified diagnostic endoscopic examination of kidney |
| | M11.9 | Unspecified diagnostic endoscopic examination of kidney |
| | M27 | Therapeutic ureteroscopic operations on ureter |
| | M27.1 | Ureteroscopic laser fragmentation of calculus of ureter |
| | M27.2 | Ureteroscopic fragmentation of calculus of ureter NEC |
| | M27.3 | Ureteroscopic extraction of calculus of ureter |
| | M27.4 | Ureteroscopic insertion of ureteric stent |
| | M27.5 | Ureteroscopic removal of ureteric stent |
| | M27.6 | Ureteroscopic endoluminal balloon rupture of stenosis of ureter |
| | M27.7 | Ureteroscopic dilation of ureter |
| | M27.8 | Other specified therapeutic ureteroscopic operations on ureter |
| | M27.9 | Unspecified therapeutic ureteroscopic operations on ureter |
| | M28 | Other endoscopic removal of calculus from ureter |
| | M28.1 | Code retired - refer to introduction |
| | M28.2 | Code retired - refer to introduction |
| | M28.3 | Code retired - refer to introduction |
| | M28.4 | Endoscopic catheter drainage of calculus of ureter |
| | M28.5 | Endoscopic drainage of calculus of ureter by dilation of ureter |
| | M28.8 | Other specified other endoscopic removal of calculus from ureter |
| | M28.9 | Unspecified other endoscopic removal of calculus from ureter |
| | M29 | Other therapeutic endoscopic operations on ureter |
| | M29.1 | Endoscopic extirpation of lesion of ureter |
| | M29.2 | Endoscopic insertion of tubal prosthesis into ureter NEC |
| | M29.3 | Endoscopic removal of tubal prosthesis from ureter |
| | M29.4 | Endoscopic dilation of ureter |
| | M29.5 | Endoscopic renewal of tubal prosthesis into ureter |
| | M29.8 | Other specified other therapeutic endoscopic operations on ureter |
| | M29.9 | Unspecified other therapeutic endoscopic operations on ureter |

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| | M30 | Diagnostic endoscopic examination of ureter |
| | M30.1 | Endoscopic retrograde pyelography |
| | M30.2 | Endoscopic catheterisation of ureter |
| | M30.3 | Endoscopic ureteric urine sampling |
| | M30.4 | Nephroscopic ureteroscopy |
| | M30.5 | Diagnostic endoscopic examination of ureter and biopsy of lesion of ureter NEC |
| | M30.6 | Diagnostic endoscopic examination of ureter and biopsy of lesion of ureter using rigid ureteroscope |
| | M30.8 | Other specified diagnostic endoscopic examination of ureter |
| | M30.9 | Unspecified diagnostic endoscopic examination of ureter |
| | M42 | Endoscopic extirpation of lesion of bladder |
| | M42.1 | Endoscopic resection of lesion of bladder |
| | M42.2 | Endoscopic cauterisation of lesion of bladder |
| | M42.3 | Endoscopic destruction of lesion of bladder NEC |
| | M42.8 | Other specified endoscopic extirpation of lesion of bladder |
| | M42.9 | Unspecified endoscopic extirpation of lesion of bladder |
| | M43 | Endoscopic operations to increase capacity of bladder |
| | M43.1 | Endoscopic transection of bladder |
| | M43.2 | Endoscopic hydrostatic distension of bladder |
| | M43.3 | Endoscopic overdistension of bladder NEC |
| | M43.4 | Endoscopic injection of neurolytic substance into nerve of bladder |
| | M43.8 | Other specified endoscopic operations to increase capacity of bladder |
| | M43.9 | Unspecified endoscopic operations to increase capacity of bladder |
| | M44 | Other therapeutic endoscopic operations on bladder |
| | M44.1 | Endoscopic lithopaxy |
| | M44.2 | Endoscopic extraction of calculus of bladder NEC |
| | M44.3 | Endoscopic removal of foreign body from bladder |
| | M44.4 | Endoscopic removal of blood clot from bladder |
| | M44.8 | Other specified other therapeutic endoscopic operations on bladder |
| | M44.9 | Unspecified other therapeutic endoscopic operations on bladder |
| | M45 | Diagnostic endoscopic examination of bladder |
| | M45.1 | Diagnostic endoscopic examination of bladder and biopsy of lesion of bladder NEC |
| | M45.2 | Diagnostic endoscopic examination of bladder and biopsy of lesion of prostate NEC |
| | M45.3 | Diagnostic endoscopic examination of bladder and biopsy of lesion of bladder using rigid cystoscope |
| | M45.4 | Diagnostic endoscopic examination of bladder and biopsy of lesion of prostate using rigid cystoscope |
| | M45.5 | Diagnostic endoscopic examination of bladder using rigid cystoscope |
| | M45.8 | Other specified diagnostic endoscopic examination of bladder |
| | M45.9 | Unspecified diagnostic endoscopic examination of bladder |
| Endoscopic prostate procedures | M65 | Endoscopic resection of outlet of male bladder |
| | M65.1 | Endoscopic resection of prostate using electrotome |
| | M65.2 | Endoscopic resection of prostate using punch |
| | M65.3 | Endoscopic resection of prostate NEC |
| | M65.4 | Endoscopic resection of prostate using laser |
| | M65.5 | Endoscopic resection of prostate using vapotrode |
| | M65.6 | Endoscopic ablation of prostate using steam |
| | M65.8 | Other specified endoscopic resection of outlet of male bladder |
| | M65.9 | Unspecified endoscopic resection of outlet of male bladder |
| | M66 | Other therapeutic endoscopic operations on outlet of male bladder |
| | M66.1 | Endoscopic sphincterotomy of external sphincter of male bladder |
| | M66.2 | Endoscopic incision of outlet of male bladder NEC |
| | M66.3 | Endoscopic injection of inert substance into outlet of male bladder |
| | M66.8 | Other specified other therapeutic endoscopic operations on outlet of male bladder |
| | M66.9 | Unspecified other therapeutic endoscopic operations on outlet of male bladder |
| | M67 | Other therapeutic endoscopic operations on prostate |
| | M67.1 | Endoscopic cryotherapy to lesion of prostate |
| | M67.2 | Endoscopic destruction of lesion of prostate NEC |

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| | M67.3 | Endoscopic drainage of prostate |
| | M67.4 | Endoscopic removal of calculus from prostate |
| | M67.5 | Endoscopic microwave destruction of lesion of prostate |
| | M67.6 | Endoscopic radiofrequency ablation of lesion of prostate |
| | M67.8 | Other specified other therapeutic endoscopic operations on prostate |
| | M67.9 | Unspecified other therapeutic endoscopic operations on prostate |
| | M68 | Endoscopic insertion of prosthesis into prostate |
| | M68.1 | Endoscopic insertion of prostatic stent |
| | M68.2 | Endoscopic removal of prostatic stent |
| | M68.3 | Endoscopic insertion of prosthesis to compress lobe of prostate |
| | M68.8 | Other specified endoscopic insertion of prosthesis into prostate |
| | M68.9 | Unspecified endoscopic insertion of prosthesis into prostate |
| | M70.1 | Aspiration of prostate NEC |
| | M70.2 | Perineal needle biopsy of prostate |
| | M70.3 | Rectal needle biopsy of prostate |
| | M70.4 | Balloon dilation of prostate |
| | M70.5 | Massage of prostate |
| | M70.6 | Radioactive seed implantation into prostate |
| | M70.7 | Transurethral radiofrequency needle ablation of prostate |
| | M70.8 | Other specified other operations on outlet of male bladder |
| | M70.9 | Unspecified other operations on outlet of male bladder |
| | M71 | Other operations on prostate |
| | M71.1 | High intensity focused ultrasound of prostate |
| | M71.2 | Implantation of radioactive substance into prostate |
| | M71.8 | Other specified other operations on prostate |
| | M71.9 | Unspecified other operations on prostate |
| Respiratory Procedures | | |
| Bronchoscopic procedures | E48 | Therapeutic fiberoptic endoscopic operations on lower respiratory tract |
| | E48.1 | Fiberoptic endoscopic snare resection of lesion of lower respiratory tract |
| | E48.2 | Fiberoptic endoscopic laser destruction of lesion of lower respiratory tract |
| | E48.3 | Fiberoptic endoscopic destruction of lesion of lower respiratory tract NEC |
| | E48.4 | Fiberoptic endoscopic aspiration of lower respiratory tract |
| | E48.5 | Fiberoptic endoscopic removal of foreign body from lower respiratory tract |
| | E48.6 | Fiberoptic endoscopic irrigation of lower respiratory tract |
| | E48.7 | Fiberoptic endoscopic photodynamic therapy of lesion of lower respiratory tract |
| | E48.8 | Other specified therapeutic fiberoptic endoscopic operations on lower respiratory tract |
| | E48.9 | Unspecified therapeutic fiberoptic endoscopic operations on lower respiratory tract |
| | E49 | Diagnostic fiberoptic endoscopic examination of lower respiratory tract |
| | E49.1 | Diagnostic fiberoptic endoscopic examination of lower respiratory tract and biopsy of lesion of lower respiratory tract |
| | E49.2 | Diagnostic fiberoptic endoscopic examination of lower respiratory tract and lavage of lesion of lower respiratory tract |
| | E49.3 | Diagnostic fiberoptic endoscopic examination of lower respiratory tract and brush cytology of lesion of lower respiratory tract |
| | E49.4 | Diagnostic fiberoptic endoscopic examination of lower respiratory tract with lavage and brush cytology of lesion of lower respiratory tract |
| | E49.5 | Diagnostic fiberoptic endoscopic examination of lower respiratory tract with biopsy, lavage and brush cytology of lesion of lower respiratory tract |
| | E49.8 | Other specified diagnostic fiberoptic endoscopic examination of lower respiratory tract |
| | E49.9 | Unspecified diagnostic fiberoptic endoscopic examination of lower respiratory tract |
| | E50 | Therapeutic endoscopic operations on lower respiratory tract using rigid bronchoscope |
| | E50.1 | Endoscopic snare resection of lesion of lower respiratory tract using rigid bronchoscope |
| | E50.2 | Endoscopic laser destruction of lesion of lower respiratory tract using rigid bronchoscope |

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| | E50.3 | Endoscopic destruction of lesion of lower respiratory tract using rigid bronchoscope NEC |
| | E50.4 | Endoscopic aspiration of lower respiratory tract using rigid bronchoscope |
| | E50.5 | Endoscopic removal of foreign body from lower respiratory tract using rigid bronchoscope |
| | E50.6 | Endoscopic irrigation of lower respiratory tract using rigid bronchoscope |
| | E50.8 | Other specified therapeutic endoscopic operations on lower respiratory tract using rigid bronchoscope |
| | E50.9 | Unspecified therapeutic endoscopic operations on lower respiratory tract using rigid bronchoscope |
| | E51 | Diagnostic endoscopic examination of lower respiratory tract using rigid bronchoscope |
| | E51.1 | Diagnostic endoscopic examination of lower respiratory tract and biopsy of lesion of lower respiratory tract using rigid bronchoscope |
| | E51.8 | Other specified diagnostic endoscopic examination of lower respiratory tract using rigid bronchoscope |
| | E51.9 | Unspecified diagnostic endoscopic examination of lower respiratory tract using rigid bronchoscope |
| ENT procedures | | |
| Tonsillectomy & Adenoidectomy | E20 | Operations on adenoid |
| | E20.1 | Total adenoidectomy |
| | E20.2 | Biopsy of adenoid |
| | E20.3 | Surgical arrest of postoperative bleeding of adenoid |
| | E20.4 | Suction diathermy adenoidectomy |
| | E20.8 | Other specified operations on adenoid |
| | E20.9 | Unspecified operations on adenoid |
| | F34 | Excision of tonsil |
| | F34.1 | Bilateral dissection tonsillectomy |
| | F34.2 | Bilateral guillotine tonsillectomy |
| | F34.3 | Bilateral laser tonsillectomy |
| | F34.4 | Bilateral excision of tonsil NEC |
| | F34.5 | Excision of remnant of tonsil |
| | F34.6 | Excision of lingual tonsil |
| | F34.7 | Bilateral coblation tonsillectomy |
| | F34.8 | Other specified excision of tonsil |
| | F34.9 | Unspecified excision of tonsil |
| | F36 | Other operations on tonsil |
| | F36.1 | Destruction of tonsil |
| | F36.2 | Biopsy of lesion of tonsil |
| | F36.3 | Drainage of abscess of peritonsillar region |
| F36.4 | Removal of foreign body from tonsil | |
| F36.5 | Surgical arrest of postoperative bleeding from tonsillar bed | |
| F36.6 | Excision of lesion of tonsil | |
| F36.8 | Other specified other operations on tonsil | |
| F36.9 | Unspecified other operations on tonsil | |
| Nasal packing/nasal intubation | E06 | Packing of cavity of nose |
| | E06.1 | Packing of posterior cavity of nose NEC |
| | E06.2 | Packing of anterior cavity of nose NEC |
| | E06.3 | Removal of packing from cavity of nose |
| | E06.4 | Balloon packing of cavity of nose |
| | E06.8 | Other specified packing of cavity of nose |
| | E06.9 | Unspecified packing of cavity of nose |
| | X56.1 | Nasotracheal intubation |
| Haematology Procedures | | |
| Blood transfusion/red cell or plasma exchange | X32 | Exchange blood transfusion |
| | X32.1 | Neonatal exchange blood transfusion |
| | X32.2 | Exchange of plasma (single) |

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| | X32.3 | Exchange of plasma (2-9) |
| | X32.4 | Exchange of plasma (10-19) |
| | X32.5 | Exchange of plasma (>19) |
| | X32.6 | Red cell exchange |
| | X32.7 | Leucopheresis |
| | X32.8 | Other specified exchange blood transfusion |
| | X32.9 | Unspecified exchange blood transfusion |
| | X33 | Other blood transfusion |
| | X33.1 | Intra-arterial blood transfusion |
| | X33.2 | Intravenous blood transfusion of packed cells |
| | X33.3 | Intravenous blood transfusion of platelets |
| | X33.4 | Autologous peripheral blood stem cell transplant |
| | X33.5 | Syngeneic peripheral blood stem cell transplant |
| | X33.6 | Allogeneic peripheral blood stem cell transplant |
| | X33.7 | Autologous transfusion of red blood cells |
| | X33.8 | Other specified other blood transfusion |
| | X33.9 | Unspecified other blood transfusion |
| | X34 | Other intravenous transfusion |
| | X34.1 | Transfusion of coagulation factor |
| | X34.2 | Transfusion of plasma NEC |
| | X34.3 | Transfusion of serum NEC |
| | X34.4 | Transfusion of blood expander |
| | X34.8 | Other specified other intravenous transfusion |
| | X34.9 | Unspecified other intravenous transfusion |
| Bone marrow puncture | W36.5 | Diagnostic extraction of bone marrow NEC |
| | Y66.7 | Harvest of bone marrow |
| Obstetric & gynae procedures | | |
| Abortion/dilatation & curettage | Q10 | Curettage of uterus |
| | Q10.1 | Dilation of cervix uteri and curettage of products of conception from uterus |
| | Q10.2 | Curettage of products of conception from uterus NEC |
| | Q10.3 | Dilation of cervix uteri and curettage of uterus NEC |
| | Q10.8 | Other specified curettage of uterus |
| | Q10.9 | Unspecified curettage of uterus |
| | Q11 | Other evacuation of contents of uterus |
| | Q11.1 | Vacuum aspiration of products of conception from uterus NEC |
| | Q11.2 | Dilation of cervix uteri and evacuation of products of conception from uterus NEC |
| | Q11.3 | Evacuation of products of conception from uterus NEC |
| | Q11.4 | Extraction of menses |
| | Q11.5 | Vacuum aspiration of products of conception from uterus using rigid cannula |
| | Q11.6 | Vacuum aspiration of products of conception from uterus using flexible cannula |
| | Q11.8 | Other specified other evacuation of contents of uterus |
| | Q11.9 | Unspecified other evacuation of contents of uterus |
| Vaginal delivery | R19 | Breech extraction delivery |
| | R19.1 | Breech extraction delivery with version |
| | R19.8 | Other specified breech extraction delivery |
| | R19.9 | Unspecified breech extraction delivery |
| | R20 | Other breech delivery |
| | R20.1 | Spontaneous breech delivery |
| | R20.2 | Assisted breech delivery |
| | R20.8 | Other specified other breech delivery |
| | R20.9 | Unspecified other breech delivery |
| | R21 | Forceps cephalic delivery |
| | R21.1 | High forceps cephalic delivery with rotation |
| | R21.2 | High forceps cephalic delivery NEC |
| | R21.3 | Mid forceps cephalic delivery with rotation |
| | R21.4 | Mid forceps cephalic delivery NEC |
| | R21.5 | Low forceps cephalic delivery |

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| | R21.8 | Other specified forceps cephalic delivery |
| | R21.9 | Unspecified forceps cephalic delivery |
| | R22 | Vacuum delivery |
| | R22.1 | High vacuum delivery |
| | R22.2 | Low vacuum delivery |
| | R22.3 | Vacuum delivery before full dilation of cervix |
| | R22.8 | Other specified vacuum delivery |
| | R22.9 | Unspecified vacuum delivery |
| | R23 | Cephalic vaginal delivery with abnormal presentation of head at delivery without instrument |
| | R23.1 | Manipulative cephalic vaginal delivery with abnormal presentation of head at delivery without instrument |
| | R23.2 | Non-manipulative cephalic vaginal delivery with abnormal presentation of head at delivery without instrument |
| | R23.8 | Other specified cephalic vaginal delivery with abnormal presentation of head at delivery without instrument |
| | R23.9 | Unspecified cephalic vaginal delivery with abnormal presentation of head at delivery without instrument |
| | R24 | Normal delivery |
| | R24.9 | All normal delivery |
| Caesarean delivery | R17 | Elective caesarean delivery |
| | R17.1 | Elective upper uterine segment caesarean delivery |
| | R17.2 | Elective lower uterine segment caesarean delivery |
| | R17.8 | Other specified elective caesarean delivery |
| | R17.9 | Unspecified elective caesarean delivery |
| | R18 | Other caesarean delivery |
| | R18.1 | Upper uterine segment caesarean delivery NEC |
| | R18.2 | Lower uterine segment caesarean delivery NEC |
| | R18.8 | Other specified other caesarean delivery |
| | R18.9 | Unspecified other caesarean delivery |
| Skin Procedures | | |
| Skin and wound management procedures | S41 | Suture of skin of head or neck |
| | S41.1 | Primary suture of skin of head or neck NEC |
| | S41.2 | Delayed primary suture of skin of head or neck |
| | S41.3 | Secondary suture of skin of head or neck |
| | S41.4 | Resuture of skin of head or neck |
| | S41.8 | Other specified suture of skin of head or neck |
| | S41.9 | Unspecified suture of skin of head or neck |
| | S42 | Suture of skin of other site |
| | S42.1 | Primary suture of skin NEC |
| | S42.2 | Delayed primary suture of skin NEC |
| | S42.3 | Secondary suture of skin NEC |
| | S42.4 | Resuture of skin NEC |
| | S42.8 | Other specified suture of skin of other site |
| | S42.9 | Unspecified suture of skin of other site |
| | S47 | Opening of skin |
| | S47.1 | Drainage of lesion of skin of head or neck |
| | S47.2 | Drainage of lesion of skin NEC |
| | S47.3 | Incision of lesion of skin of head or neck |
| | S47.4 | Incision of lesion of skin NEC |
| | S47.5 | Incision of skin of head or neck |
| | S47.6 | Incision of skin NEC |
| | S47.8 | Other specified opening of skin |
| | S47.9 | Unspecified opening of skin |
| | S54 | Exploration of burnt skin of head or neck |
| | S54.1 | Debridement of burnt skin of head or neck |
| | S54.2 | Removal of slough from burnt skin of head or neck |
| | S54.3 | Toilet to burnt skin of head or neck NEC |

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| | S54.4 | Dressing of burnt skin of head or neck NEC |
| | S54.5 | Attention to dressing of burnt skin of head or neck |
| | S54.6 | Cleansing and sterilisation of burnt skin of head or neck |
| | S54.7 | Dressing of burnt skin of head or neck using vacuum assisted closure device |
| | S54.8 | Other specified exploration of burnt skin of head or neck |
| | S54.9 | Unspecified exploration of burnt skin of head or neck |
| | S55 | Exploration of burnt skin of other site |
| | S55.1 | Debridement of burnt skin NEC |
| | S55.2 | Removal of slough from burnt skin NEC |
| | S55.3 | Toilet to burnt skin NEC |
| | S55.4 | Dressing of burnt skin NEC |
| | S55.5 | Attention to dressing of burnt skin NEC |
| | S55.6 | Cleansing and sterilisation of burnt skin NEC |
| | S55.7 | Dressing of burnt skin using vacuum assisted closure device NEC |
| | S55.8 | Other specified exploration of burnt skin of other site |
| | S55.9 | Unspecified exploration of burnt skin of other site |
| | S56 | Exploration of other skin of head or neck |
| | S56.1 | Debridement of skin of head or neck NEC |
| | S56.2 | Removal of slough from skin of head or neck NEC |
| | S56.3 | Toilet to skin of head or neck NEC |
| | S56.4 | Dressing of skin of head or neck NEC |
| | S56.5 | Attention to dressing of skin of head or neck NEC |
| | S56.6 | Cleansing and sterilisation of skin of head or neck NEC |
| | S56.7 | Dressing of skin of head or neck using vacuum assisted closure device NEC |
| | S56.8 | Other specified exploration of other skin of head or neck |
| | S56.9 | Unspecified exploration of other skin of head or neck |
| | S57 | Exploration of other skin of other site |
| | S57.1 | Debridement of skin NEC |
| | S57.2 | Removal of slough from skin NEC |
| | S57.3 | Toilet of skin NEC |
| | S57.4 | Dressing of skin NEC |
| | S57.5 | Attention to dressing of skin NEC |
| | S57.6 | Cleansing and sterilisation of skin NEC |
| | S57.7 | Dressing of skin using vacuum assisted closure device NEC |
| | S57.8 | Other specified exploration of other skin of other site |
| | S57.9 | Unspecified exploration of other skin of other site |
| Dental Procedures | | |
| Extractions & surgical removal of teeth | F09 | Surgical removal of tooth |
| | F09.1 | Surgical removal of impacted wisdom tooth |
| | F09.2 | Surgical removal of impacted tooth NEC |
| | F09.3 | Surgical removal of wisdom tooth NEC |
| | F09.4 | Surgical removal of tooth NEC |
| | F09.5 | Surgical removal of retained root of tooth |
| | F09.8 | Other specified surgical removal of tooth |
| | F09.9 | Unspecified surgical removal of tooth |
| | F10 | Simple extraction of tooth |
| | F10.1 | Full dental clearance |
| | F10.2 | Upper dental clearance |
| | F10.3 | Lower dental clearance |
| | F10.4 | Extraction of multiple teeth NEC |
| | F10.8 | Other specified simple extraction of tooth |
| F10.9 | Unspecified simple extraction of tooth | |
| Other oral surgical procedures | F01 | Partial excision of lip |
| | F01.1 | Excision of vermilion border of lip and advancement of mucosa of lip |
| | F01.8 | Other specified partial excision of lip |
| | F01.9 | Unspecified partial excision of lip |
| | F02 | Extirpation of lesion of lip |
| F02.1 | Excision of lesion of lip | |

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| F02.2 | Destruction of lesion of lip |
| F02.8 | Other specified extirpation of lesion of lip |
| F02.9 | Unspecified extirpation of lesion of lip |
| F03 | Correction of deformity of lip |
| F03.1 | Primary closure of cleft lip |
| F03.2 | Revision of primary closure of cleft lip |
| F03.3 | Adjustment to vermilion border of lip NEC |
| F03.8 | Other specified correction of deformity of lip |
| F03.9 | Unspecified correction of deformity of lip |
| F04 | Other reconstruction of lip |
| F04.1 | Reconstruction of lip using tongue flap |
| F04.2 | Reconstruction of lip using skin flap |
| F04.8 | Other specified other reconstruction of lip |
| F04.9 | Unspecified other reconstruction of lip |
| F05 | Other repair of lip |
| F05.1 | Excision of excess mucosa from lip |
| F05.2 | Advancement of mucosa of lip NEC |
| F05.3 | Suture of lip |
| F05.4 | Removal of suture from lip |
| F05.8 | Other specified other repair of lip |
| F05.9 | Unspecified other repair of lip |
| F06 | Other operations on lip |
| F06.1 | Division of adhesions of lip |
| F06.2 | Biopsy of lesion of lip |
| F06.3 | Shave of lip |
| F06.8 | Other specified other operations on lip |
| F06.9 | Unspecified other operations on lip |
| F08 | Implantation of tooth |
| F08.1 | Allotransplantation of tooth |
| F08.2 | Autotransplantation of tooth |
| F08.3 | Replantation of tooth |
| F08.4 | Repositioning of tooth |
| F08.8 | Other specified implantation of tooth |
| F08.9 | Unspecified implantation of tooth |
| F11 | Preprosthetic oral surgery |
| F11.1 | Oral alveoplasty |
| F11.2 | Augmentation of alveolar ridge using autobone graft |
| F11.3 | Augmentation of alveolar ridge NEC |
| F11.4 | Vestibuloplasty of mouth |
| F11.5 | Endosseous implantation into jaw |
| F11.6 | Subperiosteal implantation into jaw |
| F11.8 | Other specified preprosthetic oral surgery |
| F11.9 | Unspecified preprosthetic oral surgery |
| F18 | Excision of dental lesion of jaw |
| F18.1 | Enucleation of dental cyst of jaw |
| F18.2 | Marsupialisation of dental lesion of jaw |
| F18.8 | Other specified excision of dental lesion of jaw |
| F18.9 | Unspecified excision of dental lesion of jaw |
| F22 | Excision of tongue |
| F22.1 | Total glossectomy |
| F22.2 | Partial glossectomy |
| F22.8 | Other specified excision of tongue |
| F22.9 | Unspecified excision of tongue |
| F23 | Extirpation of lesion of tongue |
| F23.1 | Excision of lesion of tongue |
| F23.2 | Destruction of lesion of tongue |
| F23.8 | Other specified extirpation of lesion of tongue |
| F23.9 | Unspecified extirpation of lesion of tongue |

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| F24 | Incision of tongue |
| F24.1 | Biopsy of lesion of tongue |
| F24.2 | Removal of foreign body from tongue |
| F24.3 | Glossotomy |
| F24.8 | Other specified incision of tongue |
| F24.9 | Unspecified incision of tongue |
| F26 | Other operations on tongue |
| F26.1 | Commissurectomy of tongue |
| F26.2 | Excision of frenulum of tongue |
| F26.3 | Incision of frenulum of tongue |
| F26.4 | Freeing of adhesions of tongue |
| F26.5 | Suture of tongue |
| F26.8 | Other specified other operations on tongue |
| F26.9 | Unspecified other operations on tongue |
| F28 | Extirpation of lesions of palate |
| F28.1 | Excision of lesion of palate |
| F28.2 | Destruction of lesion of palate |
| F28.8 | Other specified extirpation of lesion of palate |
| F28.9 | Unspecified extirpation of lesion of palate |
| F29 | Correction of deformity of palate |
| F29.1 | Primary repair of cleft palate |
| F29.2 | Revision of repair of cleft palate |
| F29.8 | Other specified correction of deformity of cleft palate |
| F29.9 | Unspecified correction of deformity of palate |
| F30 | Other repair of palate |
| F30.1 | Plastic repair of palate using flap of palate |
| F30.2 | Plastic repair of palate using flap of skin |
| F30.3 | Plastic repair of palate using flap of tongue |
| F30.4 | Plastic repair of palate using graft of skin |
| F30.5 | Plastic repair of palate using flap of mucosa |
| F30.6 | Plastic repair of palate using graft of mucosa |
| F30.7 | Suture of palate |
| F30.8 | Other specified other repair of palate |
| F30.9 | Unspecified other repair of palate |
| F32 | Other operations on palate |
| F32.1 | Biopsy of lesion of palate |
| F32.2 | Removal of foreign body from palate |
| F32.3 | Incision of palate |
| F32.4 | Operations on uvula NEC |
| F32.5 | Uvulopalatopharyngoplasty |
| F32.6 | Uvulopalatoplasty |
| F32.8 | Other specified other operations on palate |
| F32.9 | Unspecified other operations on palate |
| F38 | Extirpation of lesion of other part of mouth |
| F38.1 | Excision of lesion of floor of mouth |
| F38.2 | Excision of lesion of mouth NEC |
| F38.3 | Destruction of lesion of floor of mouth |
| F38.4 | Destruction of lesion of mouth NEC |
| F38.8 | Other specified extirpation of lesion of other part of mouth |
| F38.9 | Unspecified extirpation of lesion of other part of mouth |
| F39 | Reconstruction of other part of mouth |
| F39.1 | Reconstruction of mouth using flap NEC |
| F39.2 | Reconstruction of mouth using graft NEC |
| F39.8 | Other specified reconstruction of other part of mouth |
| F39.9 | Unspecified reconstruction of other part of mouth |
| F40 | Other repair of other part of mouth |
| F40.1 | Revision of repair of mouth NEC |
| F40.2 | Graft of skin to mouth NEC |

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| | F40.3 | Graft of mucosa to mouth NEC |
| | F40.4 | Suture of mouth NEC |
| | F40.5 | Removal of suture from mouth NEC |
| | F40.8 | Other specified other repair of other part of mouth |
| | F40.9 | Unspecified other repair of other part of mouth |
| | F42.1 | Biopsy of lesion of mouth NEC |
| | F42.2 | Incision of mouth NEC |
| Endodontic procedures | F42.3 | Removal of excess mucosa from mouth NEC |
| | F12 | Surgery on apex of tooth |
| | F12.1 | Apicectomy of tooth |
| | F12.2 | Root canal therapy to tooth |
| | F12.8 | Other specified surgery on apex of tooth |
| Scaling and gingival procedures | F12.9 | Unspecified surgery on apex of tooth |
| | F16.4 | Scaling of tooth |
| | F20 | Operations on gingiva |
| | F20.1 | Excision of gingiva |
| | F20.2 | Excision of lesion of gingiva |
| | F20.3 | Biopsy of lesion of gingiva |
| | F20.4 | Gingivoplasty |
| | F20.5 | Suture of gingiva |
| | F20.8 | Other specified operations on gingiva |
| | F20.9 | Unspecified operations on gingiva |
| Restorative Dental Procedures | F13.1 | Full restoration of crown of tooth |
| | F13.2 | Partial restoration of crown of tooth |
| | F13.3 | Restoration of crown of tooth NEC |
| | F13.4 | Restoration of part of using inlay NEC |
| | F13.5 | Restoration of part of tooth using filling NEC |
| | F13.8 | Other specified restoration of tooth |
| | F13.9 | Unspecified restoration of tooth |
| | F17.1 | Preparation of tooth for dental crown |
| F17.6 | Preparation of teeth for bridge | |

Note: * = endoscopic GI procedures treated as interventional in sub analysis of upper and lower GI endoscopic procedures, # = endoscopic GI procedures treated as non-interventional

Table S6. Case-crossover step-analysis comparing the incidence of invasive procedures (IPs) using a 4-month case period and preceding 11-month control period for 14,731 patients admitted with IE.

| Invasive Procedures (IPs) | Case Period (4m) | | Control Period (11m) | | Unadjusted step model ^b | | Adjusted step-model ^c | | |
|--|-------------------------|---------------------|-------------------------|---------------------|------------------------------------|---------------|----------------------------------|----------------|---------|
| | Total proc ^a | Proc/m ^a | Total proc ^a | Proc/m ^a | OR | 95% CI | OR | 95% CI | p-value |
| Cardiac Procedures | | | | | | | | | |
| Coronary angiography | 465 | 116.3 | 892 | 81.1 | 1.44 | 1.28 to 1.61 | 0.97 | 0.81 to 1.16 | 0.897 |
| Coronary artery bypass graft (CABG) | 15 | 3.8 | 9 | 0.8 | 4.58 | 2.01 to 10.48 | 6.31 | 1.14 to 34.48 | 0.156 |
| Percutaneous coronary procedures and stents | 65 | 16.3 | 86 | 7.8 | 2.1 | 1.52 to 2.90 | 1.42 | 0.81 to 2.49 | 0.497 |
| Implantation of cardiac pacemakers/defibrillators | 547 | 136.8 | 588 | 53.5 | 2.6 | 2.32 to 2.93 | 1.29 | 1.05 to 1.58 | 0.086 |
| Percutaneous valve procedures | 9 | 2.3 | 29 | 2.6 | 0.85 | 0.40 to 1.81 | 1.15 | 0.35 to 3.72 | 0.895 |
| | | | | | | | | | |
| Dental Procedures | | | | | | | | | |
| Extractions or surgical removal of teeth | 69 | 17.3 | 66 | 6 | 2.89 | 2.06 to 4.05 | 3.35 | 1.75 to 6.39 | 0.021 |
| Other oral surgical procedures | 14 | 3.5 | 24 | 2.2 | 1.61 | 0.83 to 3.13 | 0.84 | 0.29 to 2.46 | 0.865 |
| Scaling and gingival procedures | 1 | 0.3 | 1 | 0.1 | 2.75 | 0.17 to 43.90 | 1.06 | 0.01 to 126.76 | 0.981 |
| | | | | | | | | | |
| ENT procedures | | | | | | | | | |
| Tonsillectomy & Adenoidectomy | 3 | 0.8 | 5 | 0.5 | 1.65 | 0.39 to 6.90 | 0.31 | 0.03 to 2.95 | 0.588 |
| Nasal packing/nasal intubation | 33 | 8.3 | 49 | 4.5 | 1.93 | 1.22 to 3.04 | 1.03 | 0.48 to 2.02 | 0.979 |
| | | | | | | | | | |
| GI Procedures | | | | | | | | | |
| Upper GI endoscopic procedures (gastric, duodenum, jejunum, ileum) | 754 | 188.5 | 887 | 80.6 | 2.43 | 2.20 to 2.69 | 1.43 | 1.20 to 1.69 | 0.007 |
| Lower GI endoscopic procedures (including sigmoid and rectum) | 412 | 103 | 577 | 52.5 | 2 | 1.76 to 2.27 | 1.69 | 1.35 to 2.12 | 0.010 |
| Colonic surgery (incl appendix) | 33 | 8.3 | 54 | 4.9 | 1.68 | 1.09 to 2.59 | 1.15 | 0.56 to 2.36 | 0.910 |
| Endoscopic Retrograde Cholangio-pancreatic Procedures (ERCP) | 35 | 8.8 | 47 | 4.3 | 2.13 | 1.36 to 3.35 | 1.42 | 0.65 to 3.07 | 0.577 |
| | | | | | | | | | |
| GU Procedures | | | | | | | | | |
| Cystoscopic procedures | 204 | 51 | 452 | 41.1 | 1.27 | 1.07 to 1.51 | 0.9 | 0.69 to 1.19 | 0.670 |
| Endoscopic prostate procedures | 53 | 13.3 | 93 | 8.5 | 1.57 | 1.12 to 2.21 | 0.59 | 0.35 to 1.02 | 0.222 |

| Haematology Procedures | | | | | | | | | |
|--|-----|------|-----|------|------|--------------|-------|----------------|-------|
| Blood transfusion/red cell or plasma exchange | 368 | 92 | 587 | 53.4 | 2.7 | 2.26 to 3.24 | 1.15 | 0.86 to 1.54 | 0.633 |
| Bone marrow puncture | 114 | 28.5 | 129 | 11.7 | 2.58 | 1.99 to 3.35 | 1.29 | 0.82 to 2.02 | 0.562 |
| Obstetric & gynaecological procedures | | | | | | | | | |
| Abortion/dilatation & curettage | 5 | 1.3 | 10 | 0.9 | 1.38 | 0.47 to 4.07 | 1.66 | 0.27 to 10.32 | 0.797 |
| Vaginal delivery | 8 | 2 | 28 | 2.5 | 0.79 | 0.36 to 1.72 | 0.59 | 0.19 to 1.86 | 0.611 |
| Caesarean delivery | 5 | 1.3 | 7 | 0.6 | 1.96 | 0.62 to 6.19 | 10.86 | 0.84 to 140.64 | 0.223 |
| Respiratory Procedures | | | | | | | | | |
| Bronchoscopic procedures | 60 | 15 | 63 | 5.7 | 2.65 | 1.86 to 3.79 | 1.63 | 0.87 to 3.05 | 0.374 |
| Skin Procedures | | | | | | | | | |
| Skin and wound management procedures | 134 | 33.5 | 268 | 24.4 | 1.39 | 1.12 to 1.71 | 0.78 | 0.56 to 1.09 | 0.355 |

Notes: a, a maximum of one procedure of each type per patient was counted each month. b, period-adjusted OR of IPs in case period (4 months prior to IE admission) compared to control period (15 to 5 months prior to IE admission) calculated using a mixed effects logistic regression model with the patient as the random effect. c, OR of IPs in case period (4 months prior to IE admission) compared to control period (15 to 5 months prior to IE admission) calculated using a mixed effects logistic regression model adjusted for month and date of IE admission with the patient as the random effect. m=month, proc=procedures, OR=odds ratio, CI=confidence interval, IE=infective endocarditis, IPs=invasive procedures. **P values in red** = significant positive association between the IP and subsequent IE following Benjamini-Hochberg correction. **P values in purple** = significant negative association between IP and subsequent IE following Benjamini-Hochberg correction.

Table S7. Case-crossover step-analysis comparing the incidence of invasive procedures (IPs) using a 6-month case period and preceding 9-month control period for 14,731 patients admitted with IE.

| Invasive Procedures (IPs) | Case Period (4m) | | Control Period (11m) | | Unadjusted step model ^b | | Adjusted step-model ^c | | |
|--|-------------------------|---------------------|-------------------------|---------------------|------------------------------------|---------------|----------------------------------|---------------|---------|
| | Total proc ^a | Proc/m ^a | Total proc ^a | Proc/m ^a | OR | 95% CI | OR | 95% CI | p-value |
| Cardiac Procedures | | | | | | | | | |
| Coronary angiography | 656 | 109.3 | 701 | 77.9 | 1.41 | 1.26 to 1.57 | 0.86 | 0.70 to 1.06 | 0.909 |
| Coronary artery bypass graft (CABG) | 15 | 2.5 | 9 | 1 | 2.5 | 1.09 to 5.72 | 0.62 | 0.12 to 3.12 | 0.806 |
| Percutaneous coronary procedures and stents | 81 | 13.5 | 70 | 7.8 | 1.75 | 1.27 to 2.41 | 0.74 | 0.40 to 1.39 | 1.000 |
| Implantation of cardiac pacemakers/defibrillators | 702 | 117 | 433 | 48.1 | 2.47 | 2.19 to 2.79 | 0.98 | 0.78 to 1.24 | 0.878 |
| Percutaneous valve procedures | 12 | 2 | 26 | 2.9 | 0.69 | 0.34 to 1.37 | 0.59 | 0.17 to 2.04 | 0.718 |
| | | | | | | | | | |
| Dental Procedures | | | | | | | | | |
| Extractions or surgical removal of teeth | 80 | 13.3 | 55 | 6.1 | 2.19 | 1.55 to 3.09 | 1.37 | 0.69 to 2.69 | 0.940 |
| Other oral surgical procedures | 20 | 3.3 | 18 | 2 | 1.68 | 0.88 to 3.18 | 0.86 | 0.25 to 2.99 | 0.930 |
| Scaling and gingival procedures | 1 | 0.2 | 1 | 0.1 | 1.5 | 0.09 to 23.94 | 0.08 | 0.00 to 27.91 | 0.755 |
| | | | | | | | | | |
| ENT procedures | | | | | | | | | |
| Tonsillectomy & Adenoidectomy | 5 | 0.8 | 3 | 0.3 | 2.5 | 0.60 to 10.46 | 0.77 | 0.05 to 12.62 | 0.894 |
| Nasal packing/nasal intubation | 43 | 7.2 | 39 | 4.3 | 1.71 | 1.09 to 2.67 | 0.61 | 0.26 to 1.45 | 0.874 |
| | | | | | | | | | |
| GI Procedures | | | | | | | | | |
| Upper GI endoscopic procedures (gastric, duodenum, jejunum, ileum) | 972 | 162 | 669 | 74.3 | 2.25 | 2.04 to 2.49 | 1.07 | 0.88 to 1.31 | 0.747 |
| Lower GI Endoscopic procedures (including sigmoid and rectum) | 510 | 85 | 479 | 53.2 | 1.62 | 1.42 to 1.83 | 0.86 | 0.67 to 1.09 | 0.980 |
| Colonic surgery (incl appendix) | 43 | 7.2 | 44 | 4.9 | 1.47 | 0.96 to 2.23 | 0.69 | 0.31 to 1.56 | 0.860 |
| Endoscopic Retrograde Cholangio-pancreatic Procedures (ERCP) | 46 | 7.7 | 36 | 4 | 1.98 | 1.27 to 3.10 | 1.13 | 0.47 to 2.73 | 0.947 |
| | | | | | | | | | |
| GU Procedures | | | | | | | | | |
| Cystoscopic procedures | 313 | 52.2 | 343 | 38.1 | 1.41 | 1.20 to 1.66 | 1.27 | 0.93 to 1.74 | 1.000 |
| Endoscopic prostate procedures | 86 | 14.3 | 60 | 6.7 | 2.17 | 1.55 to 3.02 | 1.48 | 0.77 to 2.85 | 0.924 |

| Haematology Procedures | | | | | | | | | |
|--|-----|------|-----|------|------|--------------|------|---------------|-------|
| Blood transfusion/red cell or plasma exchange | 503 | 83.8 | 452 | 50.2 | 2.54 | 2.13 to 3.02 | 0.88 | 0.63 to 1.23 | 0.731 |
| Bone marrow puncture | 149 | 24.8 | 94 | 10.4 | 2.51 | 1.92 to 3.27 | 1.1 | 0.65 to 1.86 | 0.912 |
| Obstetric & gynaecological procedures | | | | | | | | | |
| Abortion/dilatation & curettage | 6 | 1 | 9 | 1 | 1 | 0.35 to 2.83 | 0.62 | 0.09 to 4.29 | 0.846 |
| Vaginal delivery | 11 | 1.8 | 25 | 2.8 | 0.66 | 0.32 to 1.34 | 0.26 | 0.08 to 0.91 | 0.805 |
| Caesarean delivery | 6 | 1 | 6 | 0.7 | 1.5 | 0.48 to 4.65 | 6.15 | 0.51 to 74.18 | 1.000 |
| Respiratory Procedures | | | | | | | | | |
| Bronchoscopic procedures | 74 | 12.3 | 49 | 5.4 | 2.29 | 1.59 to 3.29 | 0.93 | 0.46 to 1.90 | 0.932 |
| Skin Procedures | | | | | | | | | |
| Skin and wound management procedures | 207 | 34.5 | 195 | 21.7 | 1.61 | 1.32 to 1.96 | 1.19 | 0.80 to 1.75 | 0.815 |

Notes: a, a maximum of one procedure of each type per patient was counted each month. b, period-adjusted OR of IPs in case period (6 months prior to IE admission) compared to control period (15 to 7 months prior to IE admission) calculated using a mixed effects logistic regression model with the patient as the random effect. c, OR of IPs in case period (6 months prior to IE admission) compared to control period (15 to 7 months prior to IE admission) calculated using a mixed effects logistic regression model adjusted for month and date of IE admission with the patient as the random effect. m=month, proc=procedures, OR=odds ratio, CI=confidence interval, IE=infective endocarditis, IPs=invasive procedures. **P values in red** = significant positive association between the IP and subsequent IE following Benjamini-Hochberg correction. **P values in purple** = significant negative association between IP and subsequent IE following Benjamini-Hochberg correction.

Figure S1. Incidence of different invasive procedures (IPs) over the 15 months before infective endocarditis (IE) hospital admission.



Figure S1. Continued.



Notes: ENT = Ear, nose and throat, GI = gastrointestinal, GU = genitourinary, IE = infective endocarditis, Obs & Gynae = Obstetrics and gynaecology, Procs = procedures. Cyan bars represent the control-period (months -4 to -15). Magenta bars represent the case-period (months -1 to -3), IE admission - day zero.

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