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# The risk of unexpected hospital admissions and primary care visits after an elective day-case gastroscopy: A cohort study within England

Colin J. Crooks[1,2] | Timothy R. Card[1,3] | Joe West[1,3]

[1]NIHR Nottingham Biomedical Research Centre (BRC), Nottingham University Hospitals NHS Trust and the University of Nottingham, Nottingham, UK

[2]Translational Medical Sciences, Queen's Medical Centre, University of Nottingham, Nottingham, UK

[3]Lifespan and Population Health, School of Medicine, Clinical Sciences Building Phase 2, Nottingham City Hospital, Nottingham, UK

**Correspondence**
Joe West, Lifespan and Population Health, School of Medicine, Clinical Sciences Building phase 2, Nottingham City Hospital, Hucknall Road, Nottingham, NG5 1PB, UK.
Email: joe.west@nottingham.ac.uk

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## Summary

**Aim:** To determine the excess of acute medical contacts following a day-case diagnostic gastroscopy.

**Methods:** Cohort study using English linked primary, secondary care and death registry electronic health data. We included 277,535 diagnostic day-case gastroscopies in 225,304 people between 1998 and 2016 and followed up for 30 days. 1,383,535 30-day periods without a gastroscopy within 991,249 people frequency matched on year, gender and decade of birth. Non-cancer deaths, emergency non-cancer admissions and cardio, vascular or respiratory (CVR) primary care consultations were identified and adjusted for each other as competing risks. Outcomes related to possible indications for gastroscopy were censored.

**Results:** 5.1% of day-case diagnostic gastroscopies were followed by emergency hospital admission, 0.4% for a CVR diagnosis. Adjusted for age, sex, morbidity, time trends, indications and competing risks, there was a 0.1% excess of CVR-related hospital admissions compared to controls. This reduced to 0.05% (95% confidence interval 0.04–0.06%) in people under 40 years without morbidity and increased to 1.1% (0.6%–1.6%) in people over 90 years with high comorbidity. Similarly, by 30 days, 3.8% had a primary care consultation for a CVR problem, with an excess after adjustment ranging from 0.13% (0.11%–0.16%) to 0.31% (0.14%–0.50%). Overall numbers needed to harm ranged from 1 in 294 gastroscopies to 1 in 67 gastroscopies.

**Conclusions:** There was an excess of vascular and respiratory events associated with a diagnostic gastroscopy. In younger patients, this risk manifested as an increase in primary care consultations while in older patients there was an increase in emergency hospital admissions.

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## 1 | INTRODUCTION

Gastrointestinal endoscopy is one of the commonest day-case interventions in secondary care with an ever-increasing demand.[1] There is reported to be inappropriate overuse use of gastroscopy worldwide[2–7] which is worryingly increasing over time.[7] While the majority of endoscopy is perceived as safe,[8,9] more than 10% of procedures are performed in those over 80 years of age,[1] who have increasing levels of frailty and complex co-morbidity which may predispose them to adverse events. This tendency to increasing age of the patient cohort endoscoped is driven not only by the demographics of the population, but also by recognition of the fact that the probability that a procedure will detect major pathology is greater in the elderly who are far more likely to have significant pathology such as neoplasia.[10]

Previous studies of the risks of endoscopy have often focussed on gastrointestinal complications such as bleeding and perforation, particularly in the context of screening colonoscopies.[11] They have for some years largely neglected the non-gastrointestinal risks associated with the more commonly performed diagnostic gastroscopies. For example, the last multi-regional audit in England was over 30 years ago and identified high cardiovascular risks associated with over-sedation.[12,13] Sedation practices have since improved though this may not have improved safety[14] and the population undergoing endoscopy has changed with increasing age and comorbidity,[15] so updated measures are needed. More recent studies suggest that respiratory adverse outcomes are still increased following day-case gastroscopies, particularly in those with existing respiratory disease,[8,16] but can be criticised either for their limited size, or for reliance upon the report of complications back to endoscopists after discharge. Neither of these studies provides data to permit the estimation of risks stratified by age and comorbidity.

The data reported to date, therefore, do not allow us with any confidence to describe to our patients the overall risk of a routine day-case gastroscopy to a person of their own age and comorbidity in the way that we can assess the effect of age upon, for example, cancer risk. We have therefore set out to provide detailed estimates of the risk of this most common endoscopic procedure in a manner which will allow for stratified risk assessment by clinicians and better inform the consent process.

## 2 | METHODS

### 2.1 | Data source

The Clinical Practice Research Datalink (CPRD) contains data from primary care practices in the United Kingdom, of whom 75% have consented to data linkage to secondary care and the death registry from 1 April 1997, representing 3% of the English population.[17] Within this data set patients are labelled as research acceptable only if their data meet basic quality checks and the period for which they are contributing data of acceptable quality is clearly defined, We used the linked Hospital Episode Statistics (HES) procedure coding to identify day-case diagnostic endoscopies, emergency hospital readmissions and pre-existing co-morbidity. This was supplemented with co-morbidity and post-procedure consultation diagnoses in the linked electronic primary care data. We used data from the Office for National Statistics to define date of death, cause of death and socioeconomic status by the Townsend score for the patient's local area of residence.

### 2.2 | Study population

All research acceptable people with records in the linked CPRD data, undergoing a diagnostic day-case gastroscopy during their observed period in CPRD were identified. These events were defined as the presence of an OPCS-4 code for gastroscopy (Table S1A) during an elective, day-case hospital attendance. Procedures coded as a therapeutic procedure (Table S1B), or within an emergency inpatient stay were excluded. The observed period was defined as running from the later of the start of a subject up to research standard data in their current GP registration or 1 January 1998 (first full year of HES linkage), and until the earlier of 1 January 2016 (last current complete year of HES linkage at time of data extraction) and the end of their up to standard contribution to CPRD. The start of the follow-up was the date the procedure was recorded.

### 2.3 | Comparison population

Within each year of the study, comparison patients were frequently sampled from the CPRD population within strata defined by gender, year of procedure and decade of birth with a ratio of up to 4:1 controls per gastroscopy patient. The comparison population was followed from a pseudo procedure date generated randomly within the calendar year of the matched strata from which they were sampled, within the observed period defined above. Resampling of the at-risk population (controls and cases outside their 60-day follow-up period) meant that patients could be matched to more than one procedure from different years. This ensured the patient sample within each stratum truly represented the general population from which those procedures were performed.

### 2.4 | Outcomes

Outcomes considered were any emergency admission in HES, any death recorded in the Office for National Statistics death registry, and any primary care consultation, all of which had to occur within the 30- or 60-day time periods following a procedure relevant to the individual analysis. Admissions were grouped by ICD 10 codes recorded as the primary admission diagnosis. In order to assess plausibly attributable outcomes, events from both primary and secondary care were categorised hierarchically. The hierarchy is given in

Appendix S1, but in brief, we counted as the relevant outcome a cancer diagnosis if it occurred (as this diagnosis would be likely to be the driver of other adverse outcomes rather than the gastroscopy itself). In the absence of a cancer diagnosis, in the 30 days following the procedure, the electronic admission summary records and primary care records were examined sequentially for GI diagnoses plausibly due to gastroscopy, trauma, cardiorespiratory diagnoses, GI symptoms without a diagnosis, cardiorespiratory symptoms without a diagnosis and finally other admissions or cases of death.

## 2.5 | Study follow-up

Subjects were followed until the earliest of the selected outcome (if any) for the specific analysis, the end of their CPRD record, occurrence of a competing risk (i.e. death or any of the other outcome events), a subsequent procedure, a cancer diagnosis, or 30 days after the index date or procedure date. For selected analyses, this was extended to 60 days to allow time for rates to plateau. Follow-up time was censored if a subsequent procedure was performed, to avoid capturing complications from subsequent procedures.

## 2.6 | Covariates

We considered as potential covariates gender, age at the time of procedure, socioeconomic status (quintile of patient level Townsend index), calendar year and pre-existing co-morbidity. Co-morbidity was measured by the Charlson index (categorised as 0, 1, 2, 3, 4, & ≥5), as defined by coding prior to the procedure or matched index date for each patient in the CPRD and HES diagnosis files using ICD 10 and Read codes previously published.[18] In addition, gastrointestinal, cardiovascular, cerebrovascular or respiratory diagnoses or symptoms prior to the endoscopy were measured.

## 2.7 | Statistical analysis

Demographics for the endoscopy and control patients were cross-tabulated. Then the crude unadjusted proportion of emergency admissions, deaths, cancer diagnoses and primary care events were calculated for the gastroscopy population and their controls. The unit of analysis for all subsequent analyses was at the level of the endoscopic procedure.

To adjust for the competing risks of mortality, cancer diagnoses or related admissions, and subsequent procedures, the respective adjusted cumulative incidence functions were calculated derived from cause-specific Cox proportional hazard models.[19,20] These were fitted for each ICD 10 category from the primary admission diagnosis or cause of death and adjusted by gender, an interaction with age bands (categorised as <65 years 65–79 years, >79 years due to small numbers of events in some admission categories) and the Charlson index (as categorised above). Time was split at 15 and 30 days to allow the risk associated with a procedure to vary during follow-up. These provided the absolute adjusted 30-day risk for each outcome category following gastroscopy, or pseudo-index date for controls. To identify whether there was an excess risk above that expected in the general population, the risks in control periods were subtracted from the respective risks in post-endoscopy time periods to derive the excess risk associated with each procedure.

For the more detailed stratified analysis of potentially attributable primary and secondary care diagnoses and symptoms, the cause-specific Cox models were refitted adjusted for gender, year of procedure, prior cardio, vascular or respiratory events, Charlson index, age (as a continuous variable centred on the mean) and a quadratic and cubic term for age (to more flexibly model the association of age with each of the cause-specific outcomes). To allow the risk of a procedure to vary by age and co-morbidity there was power in these models to include an interaction between age and co-morbidity as well as the interaction with days after procedure. These models were bootstrapped to provide 95% confidence intervals stratified by age and co-morbidity.[21]

To assess the effect of socioeconomic status and region, an interaction between procedure and Townsend quintile, and between procedure and region was introduced. To assess whether complication rates are changing over time, an interaction was introduced for each procedure with year as a continuous variable. All analyses were repeated extending the exposure period for events to 60 days and a Joinpoint analysis was used to assess when events returned to baseline.[22]

Finally, we calculated a number needed to harm (NNH), for each adverse event. For the purposes of interpretation, this assumes that the gastroscopy caused the adverse event in question and the NNH is therefore the number of gastroscopies required to "cause" each adverse outcome. Further sensitivity analyses were performed restricting follow-up to 3 and 7 days, and excluding all procedures with an ICD 10 coding for a general anaesthetic.

## 2.8 | Approvals

The study protocol was approved by the Independent Scientific Advisory Committee for the CPRD prior to the study (protocol number 17_021).

## 2.9 | Patients and public involvement

Patients and public were not involved in the study design and analysis.

# 3 | RESULTS

277,535 day-case diagnostic gastroscopies among 225,304 people were frequency matched to 1,383,535 60-day time periods in

991,249 patients not undergoing endoscopy. Baseline demographics for the respective cohorts after matching are shown in Table 1, and numbers of patients resampled as controls in Table S2. Eighty-eight percent of procedures had an indication inferred from pre-procedure diagnostic coding in primary or secondary care, with the most common coding for acid-related symptoms and peptic disease (57%), then other GI symptoms including weight loss (15%), anaemia (6%), IBD (1%), liver disease (2%) and other GI diagnosis (5%).

### 3.1 | Overall crude 30-day events

Table 2, shows the crude unadjusted risks of subsequent events following gastroscopies and in controls. 5.1% of day-case diagnostic gastroscopies had an emergency hospital admission within 30 days of the procedure, 1.4% of these were unrelated to a gastrointestinal or cancer diagnosis and 0.4% had a cardio, vascular or respiratory cause. In addition, 3.8% of procedures were followed by a primary care (GP) consultation within 30 days for a cardio, vascular or respiratory diagnosis or symptoms. The 20 most frequent cardio, vascular or respiratory ICD 10 and Read codes are shown in Table S3A,B. Pneumonia was the most frequent cardiovascular or respiratory diagnosis in an emergency hospital admission after an endoscopy, whereas in primary care this was a symptom code for cough.

### 3.2 | Adjusted excess 30-day events of all emergency admissions

The excess risks adjusted for censoring, age, gender, year and Charlson morbidity of any emergency hospital admission are shown in Table 3 stratified by admission diagnosis and age. There was an overall adjusted excess risk of 0.08% for an emergency hospital admission from cardio, vascular or respiratory causes according to ICD 10 categories. This increased with age from 0.06% (<65 years) to 0.31% (>79 years). In contrast, in primary care, the adjusted excess risk of a cardio, vascular or respiratory diagnosis in a consultation had minimal change with age from 0.4% (<65 years) to 0.3% (>79 years). Including additional consultations for related cardiovascular symptoms without a diagnosis, an overall 0.4% of patients across all ages experienced an excess cardiac, vascular or respiratory event necessitating medical consultation or admission within 30 days of gastroscopy.

### 3.3 | 30-day and 60-day excess risks of potentially attributable gastrointestinal, cardio, vascular and respiratory events

Figures for excess risks stratified by all outcomes, ages and morbidities following our hierarchical coding of outcomes are represented in Figures S1 and S2 with the underlying Cox models in Tables S4–S9. For younger patients following a gastroscopy, there was an excess risk of a cardio, vascular and respiratory symptoms and diagnoses within primary care compared to the background population. With older age and co-morbidity this translated into an excess of cardio, vascular and respiratory hospital admissions. The total 30-day risk of an emergency cardio, vascular or respiratory hospital admission following gastroscopies increased 30-fold with age for those without co-morbidity from 0.03% to 0.9% (20–29 year old versus 90–99 years old). For those with high co-morbidity (Charlson = 4) the total 30-day risk increased across the same age range from 0.1% to 2.7%. The corresponding excess risk increased from 0.02% (20–29 years with no Charlson morbidity) to 1.1% (90–99 years with Charlson = 4).

For primary care consultations, the excess risk of cardio, vascular or respiratory diagnosis increased from 0.13% (0.11%–0.16%) (in 40-year olds with no co-morbidity) to 0.31% (0.14%–0.50%) (in 90-year olds with Charlson = 4). For consultations for cardio, vascular or respiratory symptoms without a diagnosis the excess risk did not have the same gradient; 0.16% (0.13%–0.19%) to 0.11% (0%–0.25%), respectively, for the same patient groups.

Figure 1 shows the daily additional excess risk for 60 days of follow-up. This demonstrates a reduction to a background level after the first time split at 15 days. When this was assessed as a Joinpoint analysis, there was evidence to support this reduction occurring between 14 and 17 days ($P = 0.005$, 22].

There was no statistically significant interaction in the risk of cardio, vascular or respiratory events by socioeconomic quintile, region or by calendar year (likelihood ratio test with all $P > 0.05$). Results are therefore presented without stratifying on these variables.

### 3.4 | Number of procedures per event

Overall one in every 1238 gastrocopies (0.08%) was followed by an excess non-cancer emergency admission for a gastrointestinal diagnosis after adjusting for the effect of age, sex, gender, co-morbidity and competing risks. Table 4 shows this number needed to harm broken down by age and co-morbidity. The risk increased with age and morbidity from 1 adverse event every 5000 procedures to 1 every 385.

Table 5 shows the equivalent NNHs for an excess cardio, vascular or respiratory emergency hospital admission increasing from one every 5000 procedures to less than 1 every 100 as age and comorbidity increased. The overall NNH for an excess cardio, vascular or respiratory emergency hospital admission was 1 in 769 after adjusting for the effect of age, sex, gender, co-morbidity and competing risks. Including primary care and cardio, vascular or respiratory diagnosis or symptom consultations this NNH reduced to an average 1 in 245 gastroscopies across all ages and co-morbidities.

Additional Tables S10A,B and S11A,B show a sensitivity analysis of the 3-and 7-day NNH for gastrointestinal and cardio, vascular or respiratory emergency admissions. Tables S12A,B show a sensitivity analysis excluding any procedures with an ICD 10 code for a general anaesthetic ($n = 108$ excluded, 0.04% of all gastroscopies).

**TABLE 1** Demographics of matching characteristics (number and percentage of each cohort)

| Category | Demographic | Controls—no event | Controls—any event | Gastroscopies—no event | Gastroscopies—any event |
|---|---|---|---|---|---|
| Total | | 1,265,632 | 117,903 | 230,800 | 46,735 |
| Gender | Men | 575,086 (45.4%) | 50,374 (42.7%) | 103,620 (44.9%) | 21,833 (46.7%) |
| | Women | 690,546 (54.6%) | 67,529 (57.3%) | 127,180 (55.1%) | 24,902 (53.3%) |
| Age band (years) | 20–29 | 60,572 (4.8%) | 2411 (2.0%) | 10,860 (4.7%) | 1193 (2.6%) |
| | 30–39 | 115,880 (9.2%) | 5015 (4.3%) | 21,286 (9.2%) | 2265 (4.8%) |
| | 40–49 | 200,609 (15.9%) | 10,023 (8.5%) | 37,520 (16.3%) | 4736 (10.1%) |
| | 50–59 | 260,433 (20.6%) | 17,151 (14.5%) | 47,920 (20.8%) | 7398 (15.8%) |
| | 60–69 | 279,539 (22.1%) | 28,064 (23.8%) | 51,794 (22.4%) | 11,047 (23.6%) |
| | 70–79 | 228,049 (18.0%) | 32,856 (27.9%) | 40,989 (17.8%) | 12,073 (25.8%) |
| | >79 | 120,550 (9.5%) | 22,383 (19.0%) | 20,431 (8.9%) | 8023 (17.2%) |
| Year matched | 1998 | 39,271 (3.1%) | 2646 (2.2%) | 7381 (3.2%) | 1003 (2.1%) |
| | 1999 | 49,681 (3.9%) | 3384 (2.9%) | 9301 (4.0%) | 1312 (2.8%) |
| | 2000 | 57,541 (4.5%) | 3860 (3.3%) | 10,747 (4.7%) | 1537 (3.3%) |
| | 2001 | 62,157 (4.9%) | 4446 (3.8%) | 11,572 (5.0%) | 1761 (3.8%) |
| | 2002 | 69,576 (5.5%) | 4998 (4.2%) | 12,921 (5.6%) | 2005 (4.3%) |
| | 2003 | 68,610 (5.4%) | 5420 (4.6%) | 12,626 (5.5%) | 2180 (4.7%) |
| | 2004 | 65,647 (5.2%) | 5748 (4.9%) | 11,932 (5.2%) | 2347 (5.0%) |
| | 2005 | 64,103 (5.1%) | 6092 (5.2%) | 11,669 (5.1%) | 2370 (5.1%) |
| | 2006 | 68,627 (5.4%) | 6453 (5.5%) | 12,430 (5.4%) | 2586 (5.5%) |
| | 2007 | 73,124 (5.8%) | 7281 (6.2%) | 13,137 (5.7%) | 2944 (6.3%) |
| | 2008 | 80,586 (6.4%) | 8354 (7.1%) | 14,455 (6.3%) | 3333 (7.1%) |
| | 2009 | 84,117 (6.6%) | 8458 (7.2%) | 15,110 (6.5%) | 3405 (7.3%) |
| | 2010 | 82,935 (6.6%) | 8688 (7.4%) | 14,934 (6.5%) | 3399 (7.3%) |
| | 2011 | 83,075 (6.6%) | 8657 (7.3%) | 15,029 (6.5%) | 3334 (7.1%) |
| | 2012 | 86,214 (6.8%) | 9606 (8.1%) | 15,440 (6.7%) | 3724 (8.0%) |
| | 2013 | 82,057 (6.5%) | 8713 (7.4%) | 14,646 (6.3%) | 3508 (7.5%) |
| | 2014 | 75,308 (6.0%) | 7932 (6.7%) | 13,600 (5.9%) | 3048 (6.5%) |
| | 2015 | 67,448 (5.3%) | 6622 (5.6%) | 12,147 (5.3%) | 2667 (5.7%) |
| | 2016 | 5555 (0.4%) | 545 (0.5%) | 1723 (0.7%) | 272 (0.6%) |
| Charlson | 0 | 856,630 (67.7%) | 37,973 (32.2%) | 126,625 (54.9%) | 13,240 (28.3%) |
| | 1 | 173,649 (13.7%) | 23,588 (20.0%) | 42,427 (18.4%) | 8208 (17.6%) |
| | 2 | 89,815 (7.1%) | 16,304 (13.8%) | 21,687 (9.4%) | 7605 (16.3%) |
| | 3 | 39,509 (3.1%) | 9433 (8.0%) | 10,506 (4.6%) | 4081 (8.7%) |
| | 4 | 30,813 (2.4%) | 7135 (6.1%) | 7761 (3.4%) | 3341 (7.1%) |
| | 5 | 75,216 (5.9%) | 23,470 (19.9%) | 21,794 (9.4%) | 10,260 (22.0%) |
| Pre procedure diagnoses: | Previous admission with cardio, vascular respiratory diagnoses | 197,971 (2.5%) | 22,517 (8.1%) | 51,319 (3.3%) | 9375 (7.5%) |
| | Previous admission with cardio, vascular respiratory symptoms | 199,565 (20.6%) | 23,907 (33.3%) | 51,846 (22.5%) | 9710 (27.5%) |
| | Previous primary care coding with cardio, vascular respiratory diagnoses | 175,392 (22.6%) | 23,005 (42.4%) | 48,048 (24.3%) | 9684 (34.8%) |

(Continues)

TABLE 1 (Continued)

| Category | Demographic | Controls—no event | Controls—any event | Gastroscopies—no event | Gastroscopies—any event |
|---|---|---|---|---|---|
| | Previous admission with gastrointestinal symptoms[a] | 159,071 (0.0%) | 22,666 (0.2%) | 46,875 (0.5%) | 10,276 (0.6%) |
| | Previous gastrointestinal diagnosis related to an unexpected outcome[b] | 101,500 (2.5%) | 15,829 (4.9%) | 32,547 (4.9%) | 7649 (6.2%) |

[a]Including gastrointestinal perforation, bleeding, peritonitis, coded procedural complications or over sedation coded in the primary diagnoses coded for an emergency admission or primary care records.

[b]Including perforation, bleeding, peritonitis, coded procedural complications or over sedation coded in the primary diagnoses coded for an emergency admission or primary care records.

TABLE 2 Unadjusted overall risks post-diagnostic gastroscopy (rows are mutually exclusive, conditional on events in prior rows not being present)

| | 30 days | | 60 days | |
|---|---|---|---|---|
| Event category | Controls | OGD | Controls | OGD |
| No event | 1,343,558 (97.1%) | 258,705 (93.2%) | 1312,148 (94.8%) | 246,566 (88.8%) |
| Gastrointestinal cancer death | 8 (0.0%) | 132 (0.0%) | 44 (0.0%) | 456 (0.2%) |
| Other cancer death | 92 (0.0%) | 187 (0.1%) | 208 (0.0%) | 544 (0.2%) |
| Other death | 1441 (0.1%) | 480 (0.2%) | 2742 (0.2%) | 1059 (0.4%) |
| Gastrointestinal cancer diagnosis (primary care or emergency admission) | 86 (0.0%) | 773 (0.3%) | 164 (0.0%) | 1025 (0.4%) |
| Cancer diagnosis (primary care or emergency admission) | 1928 (0.1%) | 4715 (1.7%) | 3677 (0.3%) | 6651 (2.4%) |
| Emergency admission with pain, vomiting, peritonitis, bleeding or perforation | 1737 (0.1%) | 1256 (0.5%) | 3323 (0.2%) | 2190 (0.8%) |
| Other gastrointestinal emergency admission | 907 (0.1%) | 831 (0.3%) | 1630 (0.1%) | 1294 (0.5%) |
| Cardio, vascular, respiratory emergency admission | 3113 (0.2%) | 1163 (0.4%) | 5635 (0.4%) | 1943 (0.7%) |
| Other emergency admission | 5973 (0.4%) | 2607 (0.9%) | 11,078 (0.8%) | 4310 (1.6%) |
| Primary care consultation for cardio, vascular, respiratory diagnoses | 38,778 (2.8%) | 10,452 (3.8%) | 42,886 (3.1%) | 11,497 (4.1%) |

## 4 | DISCUSSION

We have demonstrated that following day-case diagnostic gastroscopy, there are more deaths, emergency hospital admissions and GP consultations than would be expected for people with the same age and level of co-morbidity not undergoing gastroscopy. Some of this excess is likely to be due to the diseases that might have led to investigation by gastroscopy, for example, GI malignancies. However, after censoring and adjustment for events related to endoscopic indications, a considerable excess in admissions for non-GI causes and particularly cardiovascular and respiratory remained. Overall 1 in 245 patients undergoing day-case gastroscopy experienced an unexpected cardio, vascular or respiratory hospital admission or GP consultation, however this average masked a wide variation in the excess risk depending on age and co-morbidity. For the elderly with co-morbidity, an additional cardio, vascular or respiratory admission was associated with between ½ and 1% of gastroscopies, and most of this excess risk occurred in the first 15 days after a procedure. This temporal relationship suggests that the increased risk is causally related to gastroscopies rather than merely an effect of the background risk of the patients who undergo them.

Some of the strengths of our study are that we have adjusted in multiple ways for case mix, prior risk, and competing risks in our detailed analyses. Furthermore, the population-based data we have used provided an unbiased and unselected capture of all events due to the national recording of all hospital admissions, deaths and primary care events and ensures that our findings should be generalisable to the UK population. We have been able to do this over a time period far longer than the day-case admissions we are studying and can therefore comment upon adverse events which may be attributable to the gastroscopy but occur only after discharge from the day-case unit in which the procedure was done. Not only have we ascertained hospital admissions but also medically attended primary

**TABLE 3** Adjusted excess risk of 30-day emergency admission following gastroscopy compared to controls compared to excess primary care consultations

| Age group | <65 years (%) | 65–79 years (%) | >79 years (%) |
|---|---|---|---|
| Admissions by cause | | | |
| Any malignancy | 0.098 | 0.280 | 0.550 |
| Upper GI | 0.076 | 0.065 | 0.120 |
| Lower GI | 0.017 | 0.019 | 0.030 |
| HPB | 0.093 | 0.049 | 0.037 |
| Respiratory infections | 0.009 | 0.016 | 0.039 |
| Chronic airway disease | 0.001 | 0.001 | 0.001 |
| Other respiratory | 0.013 | 0.024 | 0.066 |
| Ischaemic heart disease | 0.014 | 0.029 | 0.053 |
| Other cardiac disease | 0.013 | 0.043 | 0.088 |
| Cerebrovascular disease | 0.004 | 0.007 | 0.030 |
| Other circulatory disease | 0.009 | 0.015 | 0.034 |
| Any Cardiovascular/ Respiratory | 0.063 | 0.135 | 0.310 |
| Other infections | 0.008 | 0.012 | 0.007 |
| Endocrine | 0.004 | 0.002 | 0.005 |
| Psychiatric | 0.007 | 0.000 | 0.003 |
| Neurological | 0.006 | 0.003 | 0.001 |
| Dermatological | 0.002 | −0.003 | −0.002 |
| Musculoskeletal | 0.011 | 0.004 | 0.015 |
| Genitourinary | 0.014 | 0.018 | 0.022 |
| Symptoms | 0.127 | 0.114 | 0.171 |
| Poisoning | 0.010 | 0.004 | 0.001 |
| Other | 0.002 | 0.001 | 0.001 |
| Trauma | 0.005 | 0.004 | 0.003 |
| Death without admission | 0.009 | 0.006 | −0.020 |
| Any Cardiovascular/ Respiratory Primary Care Consultation | 0.82 | 0.66 | 0.47 |
| Total | 0.552 | 0.713 | 1.253 |
| Total excluding cancer | 0.454 | 0.433 | 0.704 |

care events. We are therefore able to provide estimates that allow a global measurement of the risks of endoscopy in a way that has not previously been possible.

It is possible that nonspecific cardiac or respiratory symptoms might be mistaken for gastrointestinal symptoms leading to an endoscopy. However, this is unlikely for the secondary care emergency admissions that were most frequently for pneumonia which is unlikely to have triggered a referral for an endoscopy. In primary care, the most frequent codes were for cough which might have been associated with reflux symptoms. However, these were followed closely by codes for chest infection which suggests the symptoms were more likely to have indicated an infection as well. We have used a number of approaches to minimise post-procedure events being due to an expected attendance after the endoscopy:

1. First, we only included acute gastrointestinal events rather than disease diagnoses: for example, GI emergency hospital admissions potentially attributable to complications of gastroscopy (perforation, bleeding, peritonitis, coded procedural complications or over sedation), or primary care consultations or emergency hospital admission with GI symptoms (abdominal pain, nausea or vomiting).
2. Second, to avoid mixing up reattendance at primary care or hospital for a GI symptom that was the indication for the procedure, we only included acute gastrointestinal events or symptoms that had no coding prior to the procedure.
3. Third, we split out all diagnosed cancers as a separate category from any GI events and these were not classified as unexpected events.
4. Finally for the final detailed results in Table 4 we only focused on emergency admissions for these excess gastrointestinal events. Outpatients' follow-up appointments for diagnoses related to the endoscopy or other routine attendances are not included in this study, as these would be in secondary care outpatient diagnosis data that is not currently available to us, not the inpatient or primary care data sets.

One obvious weakness of the study is that by excluding all cardio, vascular, and respiratory events in patients who also had cancer, a directly gastrointestinal or procedure-related event or a traumatic event we might underestimate their burden. Similarly, our estimates of adverse gastrointestinal events are likely to be conservative as we excluded events that had also occurred prior to the procedure or in those people with a cancer diagnosis. We were not able to examine the variation between providers as provider information was not available in the CPRD linked data due to anonymisation. Finally, since we did not have access to sedation related to these procedures, we are unable to comment upon the role of this important risk factor. However, as this is usually a decision made on the day of the procedure it is an unknown factor at the time of requesting the procedure and so the risks we describe are based upon those factors the requester (and patient) can reasonably take into consideration at the time of the decision to request a gastroscopy. Furthermore, modern sedation practices are associated with a much lower risk of attributable complications than previously.[23,24] In the United Kingdom, a diagnostic gastroscopy would not routinely be performed by an anaesthetist administrating a general anaesthetic, but under conscious sedation by the endoscopist.[25] This is confirmed within this study with only 0.04% of diagnostic gastroscopies having an OPCS code for a general anaesthetic (and excluding these procedures did not reduce the risk of unexpected events). An audit of the sedation practice in England sampled consecutive cases in each hospital prior to any procedures with a 30-day death, reported 15% gastroscopies

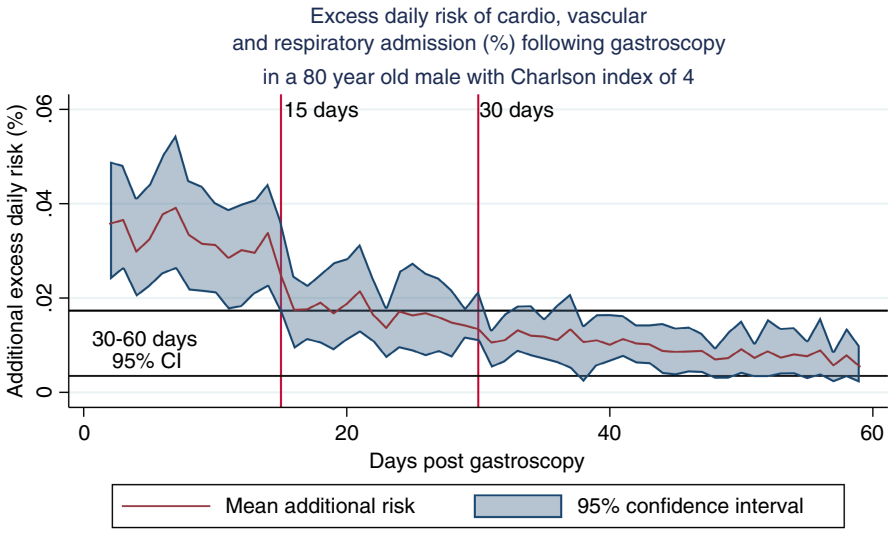


**FIGURE 1** Additional daily excess risk of emergency cardio, vascular or respiratory hospital admission in people having a gastroscopy

**TABLE 4** Number of day-case diagnostic gastroscopies needed to harm with an excess emergency gastrointestinal admission by 30 days

| Number of procedures for one event (green is low risk, red is high risk) | Charlson index | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 |
| Age (years) | | | | | | |
| 20–29 | 5000 | 3333 | 2500 | 2500 | 2000 | 1429 |
| 30–39 | 2500 | 2000 | 1429 | 1250 | 1000 | 769 |
| 40–49 | 2000 | 1429 | 909 | 833 | 714 | 556 |
| 50–59 | 1667 | 1250 | 833 | 769 | 667 | 500 |
| 60–69 | 2000 | 1250 | 909 | 769 | 714 | 526 |
| 70–79 | 2000 | 1429 | 1000 | 833 | 714 | 588 |
| 80–89 | 1667 | 1250 | 909 | 769 | 625 | 526 |
| >89 | 1111 | 833 | 625 | 556 | 455 | 385 |

**TABLE 5** Number of day-case diagnostic gastroscopies needed to harm with an excess emergency admission with a cardio, vascular or respiratory diagnosis by 30 days

| Number of procedures for one event (green is low risk, red is high risk) | Charlson index | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 |
| Age (years) | | | | | | |
| 20–29 | 5000 | 3333 | 3333 | 2500 | 2000 | 2000 |
| 30–39 | 3333 | 2000 | 2000 | 1429 | 1111 | 1250 |
| 40–49 | 2000 | 1250 | 1250 | 909 | 769 | 833 |
| 50–59 | 1250 | 833 | 833 | 588 | 476 | 556 |
| 60–69 | 833 | 556 | 556 | 385 | 323 | 370 |
| 70–79 | 556 | 357 | 370 | 263 | 213 | 256 |
| 80–89 | 357 | 233 | 256 | 172 | 143 | 175 |
| >89 | 227 | 152 | 172 | 116 | 93 | 120 |

performed without sedation, and 84% receiving IV sedation (of which 87% midazolam), and 20% combining benzodiazepine and opioid (83% pethidine)).[26] The recent national endoscopy database has not yet fully reported the current sedation practice, but an initial abstract reports 49% of gastroscopy procedures are now performed unsedated.[27]

### 4.1 | Existing literature on 30-day unplanned events

Previous studies often have not followed up with patients after they leave the endoscopy unit[28] or are only secondary care based and so will have missed events presenting in primary care.[29] Nevertheless, our study concurs with the available literature in identifying an important increased risk of adverse events after endoscopy. For example, a 1% rate of hospital admission with events related to endoscopic procedures has previously been shown in a study which observed that only 22% of these were captured by the standard reporting of endoscopic complications.[16] This study though was from a single centre and therefore examined far lower numbers of procedures than does the current study. Another study with telephone follow-up within 24 h found respiratory symptoms occurred in 5% of patients within 24 h after endoscopy, and 0.1% developed infections requiring antibiotics.[30] For diagnostic gastroscopy, gastrointestinal bleeding is perceived as a rare adverse event,[31] and gastrointestinal complications including perforation are reported at rates of 1 in 2000[12] to 1 in 100,000, with bleeding rates of 1 in 50,000.[8] Our study found a similar overall 30-day emergency excess gastrointestinal admission risk of under 1 in 2000 for the youngest and healthiest, but this risk increased to about 1 in 500 with co-morbidity and age. In addition, our estimate of 30-day overall cardio, vascular and respiratory medical consultations following diagnostic gastroscopies at 1 in 154 is far higher than previously accepted.[8,12,31] This reflects the unselected population-based follow-up of our study and far more complete ascertainment of outcomes in comparison to previous attempts to quantify this problem.

Recently, a multistate study in the USA found 3.5% of gastroscopies had an unplanned admissions or A&E attendances and 0.3% had an infection-related admission.[32] This was lower than bronchoscopy, but higher than less invasive screening tests like mammography. Our study, did not have access to microbiology samples to assess infection-related admissions or emergency department attendances, but our overall emergency admission rates are of a similar magnitude to the American study, and we also found clear risks of respiratory and other infections.

### 4.2 | Interpretation

When requesting or undergoing a gastroscopy the risk of an excess adverse event needs to be weighed against the expected diagnostic yield of the investigation. Studies from 20 to 30 years ago reported that 7% of patients with iron deficiency anaemia have an upper GI cancer, 5% have coeliac disease, 8% have peptic ulceration/oesophagitis and 6% have vascular lesions.[33] In those with dyspepsia and alarm symptoms 1.4% had an upper GI cancer when <35 years, compared to 22.4% in those 65 years and over.[34] In those without alarm symptoms less than 3% had GI cancer overall.[35] However, in our study only 0.5% overall had a gastrointestinal cancer recorded in the 60 days after the procedure (Table 2). Partly this is because not all diagnostic gastroscopies are performed to rule out cancer, but also because, as a recent meta-analysis showed, real-world endoscopies are frequently not performed in line with any guidelines,[4] and in these patients less than 1 in 1000 found an upper GI cancer compared to 1 in 34 in those following guidelines. This is supported with our population-based study of unselected gastroscopies, and suggests that in the real world there is a more delicate balance between risk of excess events and utility of carrying out the procedure in terms of diagnostic yield.

## 5 | CONCLUSION

We have shown that 1 in 245 day-case diagnostic gastroscopies were followed by an unexpected medically attended cardio, vascular or respiratory event resulting in either primary care consultation or emergency admission to hospital. However, this risk varies in magnitude and consequence depending on age and morbidity of the patient undergoing the gastroscopy. The excess risk is related to primary care consultations and symptoms in younger patients and emergency hospital admissions in older patients. It is important for clinicians to weigh up these risks against the expected benefits of a diagnostic gastroscopy when planning to do this test and in consenting their patients.

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### AUTHOR CONTRIBUTIONS

**Colin J Crooks:** Conceptualization (equal); data curation (equal); formal analysis (lead); investigation (lead); methodology (lead); project administration (equal); supervision (equal); visualization (equal); writing – original draft (lead); writing – review and editing (equal). **Tim Card:** Conceptualization (equal); data curation (equal); formal analysis (supporting); investigation (supporting); methodology (supporting); supervision (equal); visualization (equal); writing – original draft (supporting); writing – review and editing (equal). **Joe West:** Conceptualization (equal); data curation (supporting); formal analysis (supporting); investigation (supporting); methodology (supporting); project administration (supporting); supervision (equal); visualization (supporting); writing – original draft (supporting); writing – review and editing (equal).

## AUTHORSHIP

*Guarantor of the article:* Colin Crooks.

## ORCID

*Colin J. Crooks* https://orcid.org/0000-0002-6794-6621
*Timothy R. Card* https://orcid.org/0000-0003-2555-2250
*Joe West* https://orcid.org/0000-0002-1135-9356

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## SUPPORTING INFORMATION

Additional supporting information will be found online in the Supporting Information section.

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