

The use of, and outcomes for, inflammatory bowel disease services during the Covid-19 pandemic: a nationwide observational study

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Abstract

Background: Inflammatory bowel disease (IBD) services have been particularly affected by the Covid-19 pandemic. Delays in referral to secondary care and access to investigations and surgery have been exacerbated.

Aims: To investigate the use of and outcomes for emergency IBD care during the Covid-19 pandemic.

Methods: Nationwide observational study using administrative data for England (2015-2020) comparing cohorts admitted from 1 January 2015, to 31 January 2020 (pre-pandemic) and from 1 February 2020, to 31 January 2021 (pandemic). Autoregressive integrated moving average forecast models were run to estimate the counterfactual IBD admissions and procedures for February 2020 to January 2021.

Results: Large decreases in attendances to hospital for emergency treatment were observed for both acute ulcerative colitis (UC, 16.4%) and acute Crohn's disease (CD, 8.7%). The prevalence of concomitant Covid-19 during the same episode was low [391/16 494 (2.4%) and 349/15 613 (2.2%), respectively]. No significant difference in 30-day mortality was observed. A shorter median length of stay by 1 day for acute IBD admissions was observed ($P < 0.0001$). A higher rate of emergency readmission within 28 days for acute UC was observed (14.1% vs 13.4%, $P = 0.012$). All IBD procedures and investigations showed decreases in volume from February 2020 to January 2021 compared with counterfactual estimates. The largest absolute deficit was in endoscopy (17 544 fewer procedures, 35.2% reduction).

Conclusion: There is likely a significant burden of untreated IBD in the community. Patients with IBD may experience clinical harm or protracted decreases in quality of life if care is not prioritised.

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1 | INTRODUCTION

The global covid-19 pandemic caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) virus has disrupted the provision of elective and emergency healthcare services.^{1,2} In response to the pandemic, both patient behaviour and government policy changed quickly. A national lockdown was instituted in the United Kingdom and the public was advised to stay at home.

It is thought that inflammatory bowel disease (IBD) services have been particularly affected. This is because these services fall under the category of providing care for “benign” diseases. The IBD-UK survey has highlighted the needs of these patients and demonstrated delays in referral to secondary care and access to investigations and surgery even before the pandemic occurred.³

In this nationwide observational study, we investigate the process and outcome of secondary and tertiary IBD services during the pandemic in England by:

1. Comparing the outcome (mortality, length of stay and readmission) of emergency medical IBD care (acute ulcerative colitis and flare of Crohn’s disease) in the pandemic with a historical cohort.
2. Estimating the prevalence of Covid-19 during emergency medical admissions for IBD.
3. Quantifying the decrease in provision of elective and emergency IBD investigations and procedures during the pandemic with ARIMA models to predict the counterfactual where the pandemic did not occur.

2 | METHODS

2.1 | Study design and data source

A nationwide observational study of IBD services was performed using Hospital Episode Statistics (HES) Admitted Patient Care database. The use of HES in research has been described previously.⁴ The HES data are the routinely collected administrative inpatient healthcare data for all National Health Service (NHS) patients in England, treated in both NHS and private hospitals. The data include patient demographic and socioeconomic data, coded diagnostic and procedural data, and outcome data such as mortality and length of stay.⁴

2.2 | Study population and time-span

The study population was patients admitted in England between 1 January 2015, and 31 January 2021, aged 18 years and older, and given a coded diagnosis of IBD in keeping with a previous or new diagnosis of IBD. The epidemic was defined as beginning 1 February

2020 to ensure we captured any difference in presentations or outcomes in the period before the national lockdown was announced by the UK government on 23 March 2020.

2.3 | Identification of IBD services

We investigated two types of emergency IBD admission and eight emergency and elective procedures for IBD. These are outlined in Table 1.

Emergency IBD admissions were identified by World Health Organisation International Classification of Disease 10th Revision (ICD-10) codes in the primary diagnosis field admitted as an emergency. IBD procedures were identified by Office of Population Censuses and Surveys Classification of Interventions and Procedures Version 4 (OPCS-4) code in any procedure field with a diagnosis of IBD in any diagnosis field. The specific codes used in each analysis can be found in Supplementary Table S1.

2.4 | Outcomes

Mortality was defined as 30-day all-cause in-hospital mortality. 30-day mortality was evaluated up until February 2021. Readmission was defined as readmission within 28 days of discharge to any NHS hospital for any reason. Length of stay was calculated as the difference between the admission date and discharge date in days.

2.5 | Statistical analysis

Patient characteristics included for analysis were age, sex, ethnicity, Charlson comorbidity score with weights tailored to HES, and social deprivation quintile. Patients with invalid data recorded for age

TABLE 1 Inflammatory bowel disease (IBD) services evaluated in this study

| IBD service | |
|----------------------|--|
| Emergency admissions | Acute UC Acute CD |
| IBD procedures | Emergency colectomy for IBD Elective colectomy for IBD Incision and drainage of perianal CD Fistula surgery for perianal CD Ileal pouch-anal anastomosis for IBD Ileostomy reversals for IBD Right sided or ileal resection or strictureplasty for CD Colonoscopy or flexible sigmoidoscopy for IBD |

Abbreviations: CD, Crohn’s disease; UC, ulcerative colitis.

or sex were excluded. Ethnicity was considered in six major groups: White; Mixed; Asian; Black; Chinese or Other; and Not Known/Not Stated. Comorbidity was categorised as a Charlson score of 0-2 and those with a score of 3 or more. The Charlson score was calculated from secondary diagnosis codes. Social deprivation was categorised into population-weighted quintiles using the Carstairs index, with 1 being the least deprived and 5 being the most deprived (6 represents not assigned).

A concomitant SARS-CoV-2 diagnosis was identified, in any secondary diagnostic field, within the same episode, by the emergency ICD-10 codes: U071 (SARS-CoV-2 infection confirmed by laboratory testing) or U072 (clinical or epidemiological SARS-CoV-2 infection where laboratory confirmation is inconclusive or not available).

Admissions and procedures performed each month were counted. To forecast the counterfactual number of cases that would have happened without the covid-19 pandemic, historical trends for the previous 5 years were plotted with a local smoother to assess for overall trend and seasonality.

Autoregressive integrated moving average (ARIMA) models were run to forecast the counterfactual with the proc arima statement in SAS.⁵ ARIMA models can be used to predict population-level changes and are more suitable than standard regression analysis, which assumes a time series is not autocorrelated.⁶ ARIMA models have been used previously to forecast demand for hospital services.⁷

An ARIMA model consists of three parameters: p , d and q . p refers to the autoregressive (AR) part of the model, d refers to the degree of differencing (I) and q refers to the order of moving average (MA) part of the model.

An autoregressive (AR) model is where the forecasted variable is predicted by one or more observed lagged values. A moving average model is where the predicted variable is predicted by one or more observed lagged values of the error. Differencing is performed to make a non-stationary data series stationary (ie, it removes the pre-existing trend), which is a requirement for an ARIMA model. The method used to build the ARIMA models is detailed in Appendix 1.

The models were used to forecast the counterfactual (the expected number based on pre-pandemic levels) for 12 months and then compared with the observed counts to calculate deficits. Relative deficits were calculated by dividing absolute deficits by the forecast volume and multiplying by 100.

Proportions were compared with the chi-squared test and medians were compared with the Mann-Whitney test.

All statistical analyses were performed in SAS version 9.4.

2.6 | Sensitivity analysis

A sensitivity analysis was conducted where emergency admissions with a code for ulcerative colitis or Crohn's disease in any diagnosis position were included. ARIMA models were constructed for these

analyses, and the deficit based on pre-pandemic trends in admissions was calculated.

2.7 | Ethics statement

We have approval from the Secretary of State and the Health Research Authority under Regulation 5 of the Health Service (Control of Patient Information) Regulations 2002 to hold confidential data and analyse them for research purposes (CAG ref 15/CAG/0005). We have the approval to use them for research and measuring the quality of delivery of healthcare, from the London-South East Ethics Committee (REC ref 20/LO/0611).

3 | RESULTS

3.1 | Medical admission for acute colitis: Patient characteristics and outcomes

16 494 patients were admitted from February 2020 to January 2021 with acute ulcerative colitis, with large decreases in admissions observed in March and April (Figure 1). ARIMA modelling predicted 19,721 admissions from February 2020 to January 2021 giving a shortfall of 3227 admissions (16.4%) compared with the counterfactual. The characteristics of patients admitted during the pandemic were similar to those admitted before (Table 2).

The 30-day in-hospital mortality for acute colitis was not significantly different in the pandemic compared with the historical cohort (1.0% vs 1.0% $P = 0.754$) (Table 4). The median length of stay was statistically shorter by 1 day in the pandemic (6 days vs 7 days, $P < 0.0001$). The 28-day readmission rate was slightly higher during the pandemic (14.1% vs 13.4%, $P = 0.0195$).

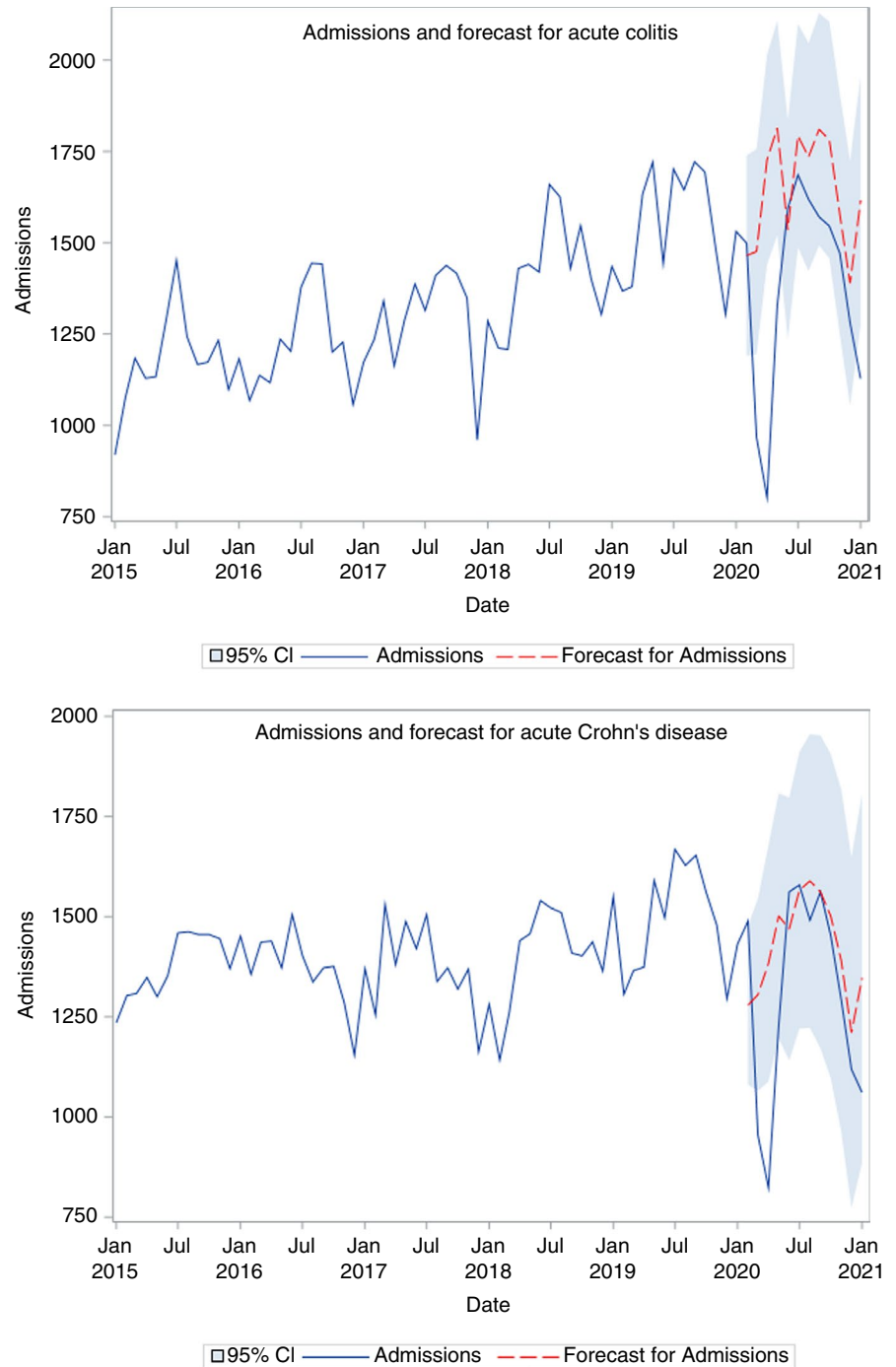
A flowchart of the initial ulcerative colitis admissions identified and subsequent exclusions are displayed in Figure 2.

3.2 | Medical admission for flare of Crohn's disease: Patient characteristics and outcomes

A total of 15,613 patients were admitted from February 2020 to January 2021 with a flare of Crohn's disease. Again, the largest decreases in attendances were seen in March and April 2021 (Figure 1). ARIMA modelling predicted 17,102 admissions from February 2020 to January 2021 and there was a shortfall of 1489 (8.7%) admissions compared with the counterfactual. The characteristics of patients admitted during the pandemic were similar to those admitted historically (Table 3).

The 30-day mortality was not significantly different during the pandemic when compared with the historical cohort (0.5% vs 0.6% $P = 0.408$) (Table 4). The median length of stay was statistically shorter by 1 day in the pandemic (5 days vs 6 days, $P < 0.0001$). The 28-day readmission rate was 16.0% during the pandemic and this

FIGURE 1 Admission time series and forecast for acute ulcerative colitis and acute Crohn's disease (January 2015 to January 2021)



was not significantly different compared with the historical cohort ($P = 0.821$).

A flowchart of the initial Crohn's disease admissions identified and subsequent exclusions are displayed in Figure 3.

3.3 | Prevalence of Covid-19 during emergency medical IBD admissions

A total of 391/16 494 (2.4%) patients admitted for acute ulcerative colitis after 1 February 2020, until 31 January 2021 had a concomitant secondary diagnosis of Covid-19. A total of 349/15 613 (2.2%) patients

admitted for a flare of Crohn's disease after 1 February 2020, until 31 January 2021 had a concomitant secondary diagnosis of covid-19.

3.4 | IBD investigations and procedures

All IBD investigations and procedures analysed demonstrated a decrease in frequency recorded compared with the central estimate of the forecast. Table 5 shows the central estimate of the decrease in volume from February 2020 to January 2021 with an accompanying 95% CI. The three largest absolute deficits were observed for diagnostic or therapeutic colonoscopy or flexible sigmoidoscopy;

| | | Pre-pandemic cohort | Pandemic cohort |
|----------------|--------------------|---------------------|-----------------|
| Total | | 81 302 | 16 494 |
| Age | Mean (SD) | 45.2 (19.3) | 46.1 (19.4) |
| Sex | Male | 41,300 (50.8%) | 8348 (50.6%) |
| | Female | 40,002 (49.2%) | 8146 (49.4%) |
| Ethnicity | White | 63,809 (78.5%) | 12,791 (77.6%) |
| | Mixed | 756 (0.9%) | 181 (1.1%) |
| | Asian | 7420 (9.1%) | 1335 (8.1%) |
| | Black | 1553 (1.9%) | 273 (1.7%) |
| | Other | 1765 (2.2%) | 411 (2.5%) |
| | Unknown | 5999 (7.4%) | 1503 (9.1%) |
| Deprivation | 1 (least deprived) | 14 683 (18.1%) | 3084 (18.7%) |
| | 2 | 16 129 (19.9%) | 3595 (21.8%) |
| | 3 | 16 613 (20.4%) | 3182 (19.3%) |
| | 4 | 16 653 (20.5%) | 3305 (20.0%) |
| | 5 (most deprived) | 16 780 (20.6%) | 3181 (19.3%) |
| | 6 (not assigned) | 444 (0.6%) | 147 (0.9%) |
| Charlson Score | <=2 | 59 732 (73.5%) | 11 746 (71.2%) |
| | >2 | 21 570 (26.5%) | 4748 (28.8%) |

TABLE 2 Characteristics of 97 796 patients admitted with acute ulcerative colitis before and after the pandemic (defined as 1 February 2020)

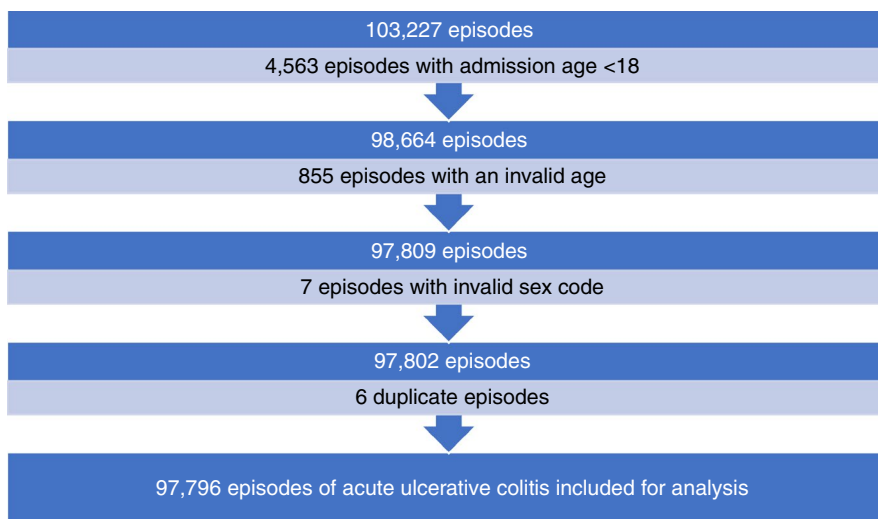


FIGURE 2 Flowchart of initial included episodes and subsequent exclusions for acute ulcerative colitis

ileostomy reversals; and ileal resection/strictureplasty or ileocecal resection for Crohn's disease. The three largest relative estimated deficits were seen in ileostomy reversals (40.8%, 1819 fewer procedures), perianal CD fistula surgery (36.9%, 322 fewer procedures) and lower GI endoscopy (35.2%, 17 544 fewer procedures). The forecast for IPAA surgery included negative values in the 95% confidence intervals meaning the forecast model was not reliable for prediction and so further calculation of the deficit was not possible.

Figure 4 shows an array of time series plots for selected IBD procedures and investigations from January 2015 to January 2021. The forecasts for the counterfactual scenario where the Covid-19 pandemic had not occurred are shown with plots in red with 95% confidence bands. Observing the plots shows clear patterns: colonoscopy and flexible sigmoidoscopy, ileostomy reversals, perianal CD fistula surgery and

right-sided or ileal resection or strictureplasty for Crohn's disease showed large decreases in volume in the first wave of the pandemic especially in March and April 2020. Most procedures showed a recovery in volume recorded after April. Less dramatic decreases in volume were observed for drainage of perianal sepsis in Crohn's disease, emergency and elective colectomy (with a larger decrease in elective colectomy), and pouch surgery (Figure 4) but a deficit was observed for all procedures when comparing observed volume with the central estimate of the forecast (Table 5).

3.5 | Sensitivity analysis

When the diagnostic code for ulcerative colitis was in a secondary position a large range of primary diagnosis codes were observed. The

TABLE 3 Characteristics of 101 259 patients admitted with acute Crohn's disease before and after the pandemic (defined as 1 February 2020)

| Variable | Level | Pre-pandemic cohort | Pandemic cohort |
|----------------|--------------------|---------------------|-----------------|
| Total | | 85 646 | 15 613 |
| Age | Mean (SD) | 41.7 (17.6) | 43.0 (17.9) |
| Sex | Male | 38 115 (44.5%) | 6958 (44.6%) |
| | Female | 47 531 (55.5%) | 8655 (55.4%) |
| Ethnicity | White | 71 886 (83.9%) | 12 878 (82.5%) |
| | Mixed | 990 (1.2%) | 249 (1.6%) |
| | Asian | 5185 (6.1%) | 813 (5.2%) |
| | Black | 1367 (1.6%) | 315 (2.0%) |
| | Other | 1445 (1.7%) | 244 (1.6%) |
| | Unknown | 4773 (5.6%) | 1114 (7.1%) |
| Deprivation | 1 (least deprived) | 13 185 (15.4%) | 2100 (14.9%) |
| | 2 | 15 777 (18.4%) | 2705 (19.2%) |
| | 3 | 17 903 (20.9%) | 1988 (21.2%) |
| | 4 | 18 177 (21.2%) | 3162 (22.4%) |
| | 5 (most deprived) | 20 094 (23.5%) | 3112 (22.0%) |
| | 6 (not assigned) | 510 (0.6%) | 59 (0.42%) |
| Charlson Score | <=2 | 64 181 (74.9%) | 11 310 (72.4%) |
| | >2 | 21 465 (25.1%) | 4303 (27.6%) |

TABLE 4 Crude outcomes after admission for acute ulcerative colitis and acute Crohn's disease before and after the pandemic (defined as 1 February 2020)

| Diagnosis | Outcome | Pre-pandemic | Pandemic | P |
|-----------|----------------------------------|-----------------------|----------------------|----------------|
| Acute UC | 30-day mortality (%) | 787/81 302 (1.0%) | 164/16 494 (1.0%) | 0.754 (chisq) |
| | Median LOS (interquartile range) | 7 (4-12) | 6 (4-11) | <0.0001 (MW) |
| | Readmission within 28 days (%) | 10 930/81 302 (13.4%) | 2 330/16 494 (14.1%) | 0.0195 (chisq) |
| Acute CD | 30-day mortality (%) | 502/85 646 (0.6%) | 83/15 613 (0.5%) | 0.408 (chisq) |
| | Median LOS (interquartile range) | 6 (2-10) | 5 (2-10) | <0.0001 (MW) |
| | Readmission within 28 days (%) | 13 663/85 646 (16.0%) | 2 502/15 613 (16.0%) | 0.821 (chisq) |

most frequent codes used were: J181 lobar pneumonia, unspecified (3.7% of all primary diagnosis codes); N390 urinary tract infection, site not specified (2.7%); A419 sepsis, unspecified (2.7%) and A099 gastroenteritis and colitis of unspecified origin (2.5%). There were 78,101 admissions forecast with a diagnosis of ulcerative colitis in any position from February 2020 to January 2021 compared with an observed 65,058 admissions (16.7% deficit).

When Crohn's disease was coded for in a secondary diagnosis position a large range of primary diagnosis codes were observed. The most frequent codes were: R104 Other and unspecified abdominal pain (3.2% of all primary diagnosis codes); J181 lobar pneumonia, unspecified (3.1%); K566 Other and unspecified intestinal obstruction (2.9%), and A099 gastroenteritis and colitis of unspecified origin (2.7%). There were 79,987 admissions forecast with a diagnosis of Crohn's disease in any position from February 2020 to January 2021 compared with an observed 67,263 admissions (15.9% deficit).

4 | DISCUSSION

This study has found large decreases in emergency and elective activity for IBD services on a national scale during the pandemic. Most striking amongst these data are the reductions in the frequency of attendance to secondary care for emergency IBD care and reductions in procedures and investigations for IBD. It is concerning that thousands of fewer patients have attended hospital for acute IBD during the first year of the pandemic. Diagnostic and therapeutic lower GI endoscopy, ileostomy reversals and operations for ileal Crohn's disease were particularly affected. There has been a significant change in the treatment of perianal Crohn's disease, with less drainage of sepsis and fewer operations for perianal fistula. Surgery for ulcerative colitis has been affected, with fewer elective and emergency colectomies and fewer IPAA operations. A shorter length of stay by 1 day was observed for both acute UC and CD

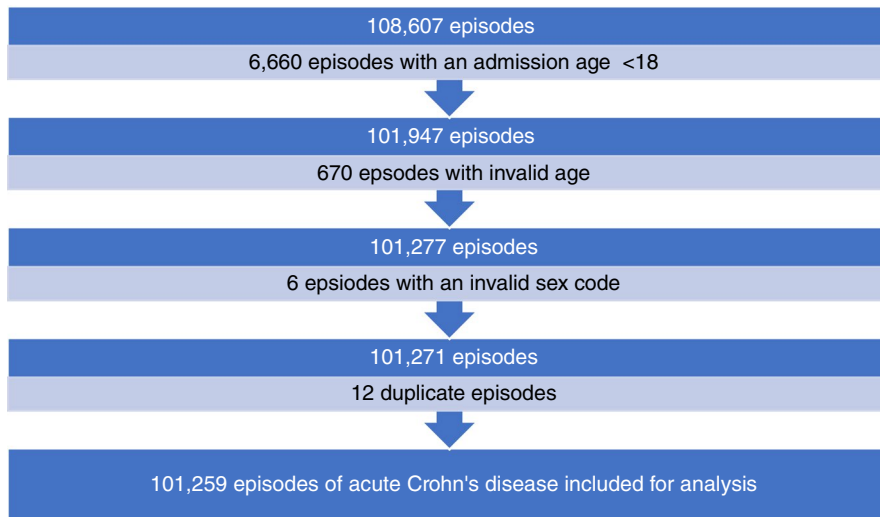


FIGURE 3 Flowchart of initial included episodes and subsequent exclusions for acute Crohn's disease

TABLE 5 Sum of observed and forecasted volume of procedures from February 2020 to January 2021 ordered by descending observed volume

| Procedure | Observed volume | Forecast volume (95% CI) | Deficit to December 2020 (95% CI) | Estimated deficit (%) |
|---------------------------------|-----------------|---------------------------|-----------------------------------|-----------------------|
| Lower GI endoscopy | 32 348 | 49 892 (43 694 to 56 089) | 17 544 (11 346 to 23 741) | 35.2 |
| Ileostomy reversal | 2637 | 4456 (3144 to 5767) | 1819 (507 to 3130) | 40.8 |
| CD resection or strictureplasty | 946 | 1085 (573 to 1596) | 138 (-373 to 650) | 12.7 |
| Emergency colectomy | 629 | 715 (238 to 1192) | 86 (-391 to 563) | 12.1 |
| Elective colectomy | 553 | 674 (163 to 1 185) | 121 (-390 to 632) | 18.0 |
| CD fistula surgery | 551 | 873 (568 to 1 179) | 322 (17 to 628) | 36.9 |
| I&D for perianal CD | 502 | 557 (265 to 849) | 55 (-237 to 347) | 9.9 |

admissions. There was a slightly higher rate of emergency readmission within 28 days for acute UC admissions. Finally, the prevalence of concomitant covid-19 infection was low in the emergency admissions for UC and CD during the first year of the pandemic.

IBD services, especially for surgery and endoscopy, have been negatively impacted globally. Most evidence for this comes in the form of cross-sectional and survey data at the height of the pandemic. For example, cross-sectional data from a single centre in Spain found that rates of emergency department visits and admissions for IBD fell by 58% and 50% respectively in March and April 2020.⁸ In the UK, paediatric IBD services have been negatively affected with over half of patients unable to access diagnostic endoscopy at the peak of the first wave.⁹ Extrapolating from nationwide histopathology registry data in the Netherlands, there are large estimated falls in endoscopy (59.7%) and surgery (14.2%).¹⁰ Survey data from China also suggest delayed diagnostic procedures, biologic therapy and elective surgery.¹¹ Lastly, survey data from Canada show evidence of delays in care with a median delay of 10 weeks for surgery.¹² Most of these data come from developed countries affected during 2020. The ongoing impact after the first wave and in developing countries is not well described.

How IBD and its medical treatment are risk factors for contracting Sars-CoV-2 and the resulting outcome for patients has been investigated previously in cohort studies and case reports. Two systematic

reviews of these studies from earlier in the pandemic (2020) concluded that IBD patients were not at greater risk of being infected with SARS-CoV-2 than the general population.^{13,14} However, there is evidence that steroids may be associated with a worse prognosis and there are mixed findings for immunomodulators.¹³ The risk of adverse outcomes may be higher in ulcerative colitis.¹³ The latest data from the SECURE-IBD international registry suggested that combination therapy and thiopurines may be associated with an increased risk of severe Covid-19 infection.¹⁵ Lastly, a recent nationwide registry study of patients with inflammatory disease in Denmark found that IBD patients with Covid-19 were not at higher risk of requiring invasive ventilation, longer hospital stay or death.¹⁶ Our study adds evidence that IBD patients admitted as emergencies had similar outcomes for 30-day in-hospital mortality and readmission within 28 days when compared with historical cohorts during the first wave of the pandemic in England. The decrease in length of stay we observed for acute IBD admissions may reflect the zeal of clinicians to keep acute admissions as short as possible during the pandemic.

This is also consistent with a previous large multi-centre observational study (PROTECT-ASUC) for outcomes for acute colitis during the pandemic.¹⁷ This is reassuring: despite resources being stretched, healthcare services were able to manage the emergency patients well. This study has shown a similarly reassuring finding for acute CD admissions.

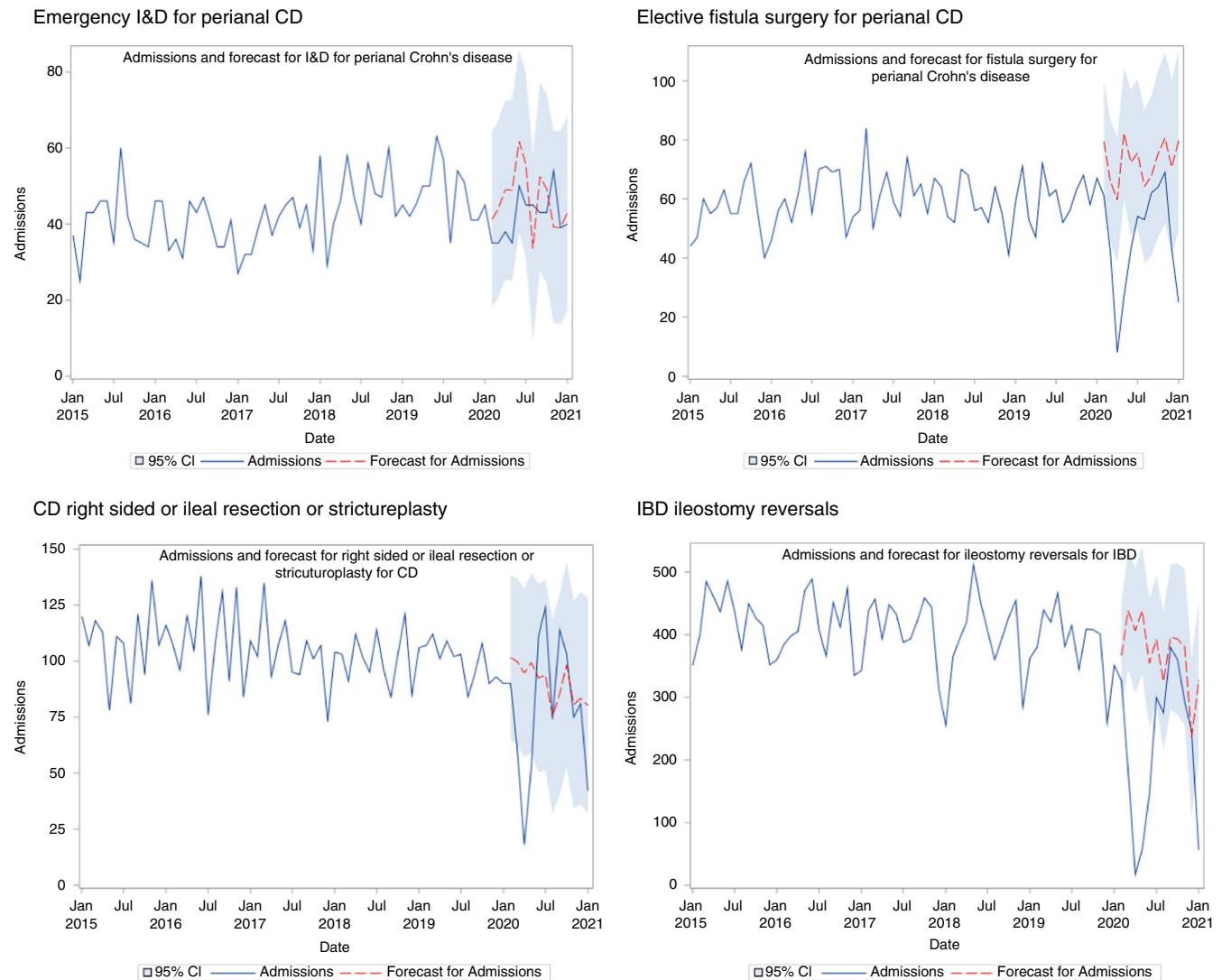


FIGURE 4 Admission time series and forecasts for eight different procedures for IBD

However, there is likely a burden of unmeasured morbidity in the community that this study can only indirectly measure. Exactly how large this burden is and whether it has led to complications should be the focus of future research. Excess mortality has been demonstrated in England and Wales for the population as a whole, and up to a fifth of this is due to non-covid-19 causes.¹⁸ It is unclear if IBD patients had excess mortality in the community during the first wave. Admissions for ischaemic heart disease and high-risk emergency general surgery did decrease during the first wave of the pandemic, giving indirect evidence that out of hospital deaths may have increased.^{1,2}

The evidence regarding UC colectomy rates in recent years is conflicting. Some studies suggest that colectomy rate is decreasing in the era of access to biologic medications.^{19,20} However, HES analysis of emergency admissions for UC before the pandemic has demonstrated a decrease in short-term colectomy rate in recent years that does not persist long-term.²⁰ The PROTECT-ASUC found that the practice of gastroenterologists and colorectal surgeons had changed, with more patients receiving rescue therapy in the form of

biologicals, ciclosporin or tofacitinib.¹⁷ This study suggests the trend to delay colectomy for patients undergoing emergency admission for ulcerative colitis has been exacerbated due to the pandemic. The ensuing effect on the quality of life of patients is hard to quantify and needs to be investigated.

Restorative surgery with IPAA is an important viable option for patients who have had colectomy for UC and would like to live without an ileostomy.²¹ This study was unable to produce a reliable model of the counterfactual IPAA procedures as the confidence intervals crossed zero. What we do know is that the volume of IPAA in England has dropped to a low likely not seen since the 1980s.²² This study has shown that along with the decrease in restorative surgery after colectomy, a significant number of ileostomies were not reversed during the pandemic. Again, there may be an ensuing decrease in the quality of life of IBD patients because of increasing time living with an ileostomy.

These data also show we are now treating fewer CD patients with surgery than before. It has been demonstrated that laparoscopic ileocaecal resection is a reasonable alternative to infliximab

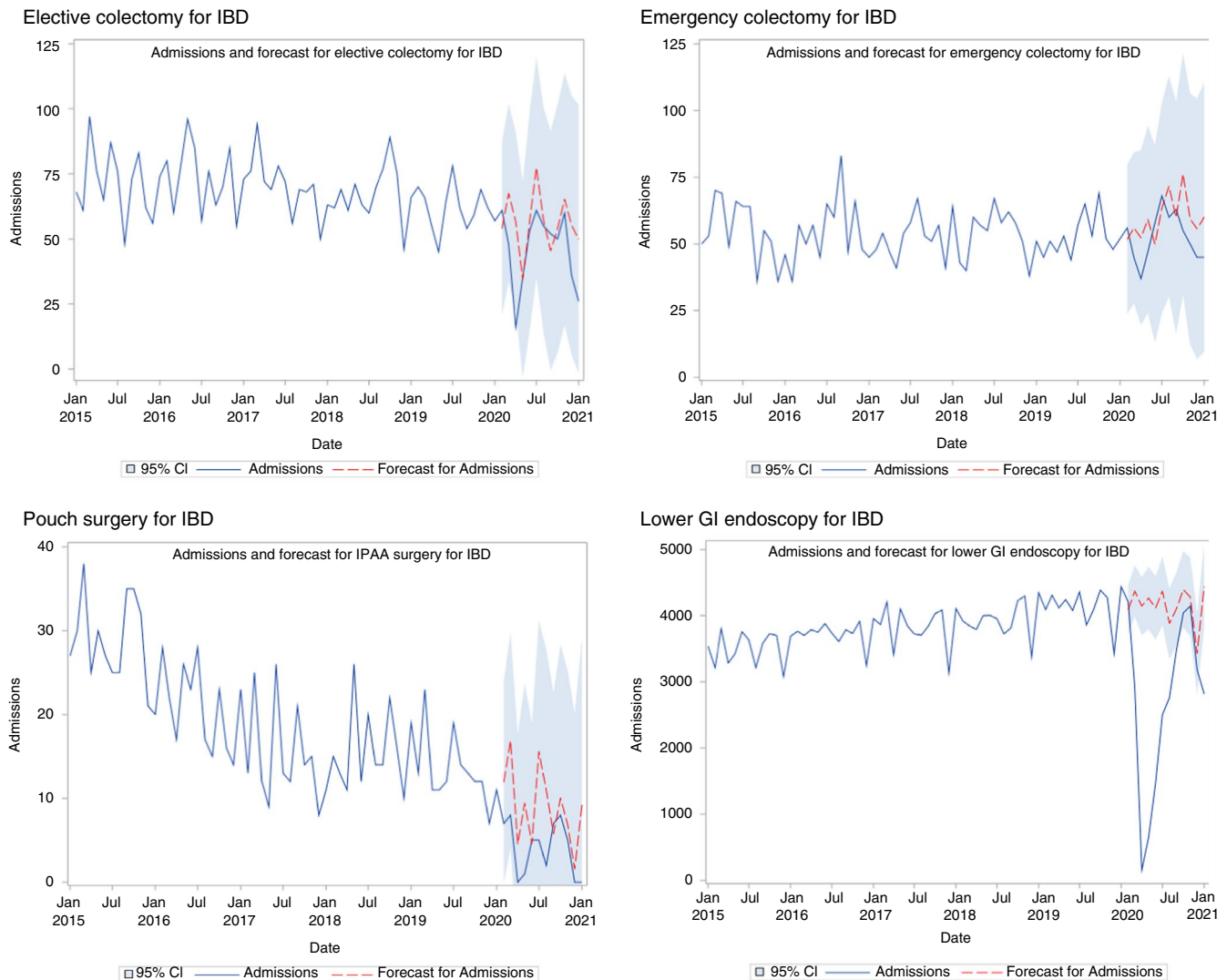


FIGURE 4 (Continued)

therapy in a randomised control trial.²³ The pandemic has meant that Crohn's disease patients in England were less likely to be offered this operation in 2020 according to these data.

The decreases in procedures for perianal CD are concerning. It is known that patients with perianal Crohn's disease have a much lower quality of life.²⁴ Surgical drainage of sepsis is a key part of the management of perianal CD, and the observed decrease in surgical drainage in this study is concerning for a burden of untreated complicated disease in this population.²⁵

There are stark decreases in lower GI endoscopy demonstrated in this study. IBD may not be prioritised as urgently, and these patients may have their procedures postponed. This study included both diagnostic and therapeutic colonoscopy and flexible sigmoidoscopy in the procedure count. IBD patients require endoscopy for diagnosis, monitoring, surveillance and treatment.²⁶ The long-term impact of this deficit is difficult to unpick. In future more patients will be triaged with non-invasive investigations that mitigate the need for endoscopy or they may be investigated in other ways such as

with CT colonography. The impact on training future endoscopists will be significant, and measures have been taken to improve this.²⁷

Taken as a whole, the postponement and cancellation of these procedures could represent a decrease in quality of life for IBD patients. This is a secondary harm of a pandemic and exacerbated by what was a necessary response from government and healthcare providers. We recommend that when planning surgical theatre lists, those IBD cases where the quality of life is significantly impacted should be taken into account.

The main strength of this study is the use of routinely collected administrative data that covers all NHS care in hospitals in England. This gives a count of all activity and is not subject to selection bias. Our sensitivity analyses used admissions where ulcerative colitis or Crohn's disease were recorded in any diagnosis position. Some of these admissions could be where the ulcerative colitis or Crohn's disease is recorded as comorbidity. However, a proportion would be admissions due to acute IBD such as those with sepsis, unspecified abdominal pain or unspecified bowel obstruction. Accounting for

these admissions, similar decreases in admissions were observed in 2020 as in our main analysis.

There are limitations to this study. The accuracy of the clinical coding underlying the diagnostic and procedural coding can be a concern but accuracy rates are improving and the routinely collected data are robust for research.²⁸ Secondary diagnoses are likely under-recorded but are accurate when included.^{29,30} This study is unable to quantify the morbidity of untreated disease outside of hospital. Some of the procedures that have not been performed due to the pandemic may no longer be indicated and the deficits are overestimated.

This study has demonstrated large decreases in medical admissions and procedures for IBD. There is likely a large burden of untreated IBD disease that must be addressed as we emerge from the covid-19 pandemic.

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AUTHORSHIP

Guarantor of the article: Professor Omar Faiz.

Author contributions: MD, KS, GW, KP, OF designed the study. MD and VB performed the data extraction and analysis and constructed the prediction models. All authors wrote and edited the manuscript. All authors approved the final version of the manuscript.

CONFLICT OF INTEREST

None.

DATA AVAILABILITY STATEMENT

The data that support these findings are available from NHS Digital

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SUPPORTING INFORMATION

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

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APPENDIX 1

ARIMA models were built using the following steps:

1. Assessing for stationarity and seasonality by observing the trend of the time series plots
2. Differencing the time series to make non-stationary data stationary
3. Accounting for seasonality with seasonal differencing
4. Assessing for stationarity with the augmented Dicky Fuller test and observing the autocorrelation function (ACF) plot decay quickly
5. Estimating the p and q terms by assessing ACF plots and partial ACF plots if possible
6. Using the $minic$ and $esacf$ functions in SAS to select p and q that gave the smallest Akaike information criterion (AIC) and Schwarz-Bayesian Criterion (SBC)
7. Checking the residuals of the model are normally distributed
8. Performing the Ljung-Box test for white noise