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Predicting endoscopic activity recovery in England after COVID-19: a national analysis

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Summary
Background The COVID-19 pandemic has led to a substantial reduction in gastrointestinal endoscopies, creating a backlog of procedures. We aimed to quantify this backlog nationally for England and assess how various interventions might mitigate the backlog.

Methods We did a national analysis of data for colonoscopies, flexible sigmoidoscopies, and gastroscopies from National Health Service (NHS) trusts in NHS England’s Monthly Diagnostic Waiting Times and Activity dataset. Trusts were excluded if monthly data were incomplete. To estimate the potential backlog, we used linear logistic regression to project the cumulative deficit between actual procedures performed and expected procedures, based on historical pre-pandemic trends. We then made further estimations of the change to the backlog under three scenarios: recovery to a set level of capacity, ranging from 90% to 130%; further disruption to activity (eg, second pandemic wave); or introduction of faecal immunochemical testing (FIT) triaging.

Findings We included data from Jan 1, 2018, to Oct 31, 2020, from 125 NHS trusts. 10 476 endoscopy procedures were done in April, 2020, representing 9·5% of those done in April, 2019 (n=110 584), before recovering to 105 716 by October, 2020 (84·5% of those done in October, 2019 [n=125 072]). Recovering to 100% capacity on the current trajectory would lead to a projected backlog of 162 735 (95% CI 143 775–181 695) colonoscopies, 119 025 (107 398–130 651) flexible sigmoidoscopies, and 194 087 (172 564–215 611) gastroscopies in January, 2021, attributable to the pandemic. Increasing capacity to 130% would still take up to June, 2022, to eliminate the backlog. A further 2-month interruption would add an extra 15·4%, a 4-month interruption would add an extra 43·8%, and a 6-month interruption would add an extra 82·5% to the potential backlog. FIT triaging of cases that are found to have greater than 10 µg haemoglobin per g would reduce colonoscopy referrals to around 75% of usual levels, with the backlog cleared in early 2022.

Interpretation Our work highlights the impact of the pandemic on endoscopy services nationally. Even with mitigation measures, it could take much longer than a year to eliminate the pandemic-related backlog. Urgent action is required by key stakeholders (ie, individual NHS trusts, Clinical Commissioning Groups, British Society of Gastroenterology, and NHS England) to tackle the backlog and prevent delays to patient management.

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Introduction The COVID-19 pandemic has had a profound effect on the National Health Service (NHS), causing a reorganisation from a comprehensive health-care service to one predominantly focused on treating patients with COVID-19.1 Guidance from the British Society of Gastroenterology issued in March, 2020, recommended a 6-week pause in endoscopic activity, such that all but emergency and absolutely essential endoscopy must stop, including bowel cancer screening, allowing time to refine triage systems.2 Data from the UK National Endoscopy Database (NED), encompassing 79% of endoscopic units in the UK, showed that activity fell to as low as 5% of normal levels in the period affected by COVID-19 from March 23 to May 31, 2020.3 There are substantial concerns for the effect of continued disruption on health-care services, most notably with a backlog of cases caused by delayed and cancelled procedures at a time of reduced capacity, having adverse effects on timely diagnosis and outcomes, especially of cancer.4 This issue was recognised by the British Society of Gastroenterology in late April, 2020, as it recommended restarting endoscopy services safely.5 Early data have shown a reduction in the number of patients on colorectal cancer pathways and significant decreases in the number of cancers detected at endoscopy.6,7 Moreover, it has been postulated that a 1-year restriction on endoscopic services could lead to 28 800 undiagnosed gastrointestinal cancers and a backlog of 1·46 million endoscopic procedures in the UK.7 Several strategies, such as use of faecal immunochemical testing (FIT) for triaging, have been suggested, but there is little information as to how use of this procedure might affect the endoscopy backlog nationally.8
Since December, 2020, the rise in COVID-19 infections associated with the second peak of the pandemic has led to reports of a further reduction in endoscopic services, adding additional pressure to already overstretched services.

We aimed to investigate the effect of the COVID-19 pandemic on endoscopy services and calculate an estimate for the backlog of procedures; present strategies to clear the potential endoscopy backlog related to the COVID-19 pandemic, including a temporary increase in capacity and use of FIT triaging; and estimate the effect of a further reduction in endoscopic capacity on the overall backlog.

Methods
Study design and population
We analysed data from NHS England’s Monthly Diagnostic Waiting Times and Activity Data, which is part of National Statistics and is publicly available.15 key diagnostic tests, including endoscopic procedures, non-obstetric ultrasound, and CT are included. NHS England collects data from individual NHS trusts on waiting times and number of procedures done, stratified by urgency (ie, planned or surveillance or unplanned, which included inpatient and emergency procedures) and waiting list (either general practice or hospital referral). Notably, this dataset excludes colonoscopies done under the Bowel Cancer Screening Programme and flexible sigmoidoscopies done under the Bowel Scope Screening Programme. Each NHS trust is also allocated an NHS commissioning region based on their location.

We included colonoscopies, flexible sigmoidoscopies, gastroscopies, and total endoscopic procedures done in 125 NHS trusts in England (figure 1). We excluded procedures done in seven NHS trusts due to incomplete monthly data (see appendix p 2). Several NHS trusts and NHS commissioning regions merged during the study period; pre-merger trusts and regions were aligned with their post-merger counterparts in the final analysis to ensure consistency. Ethical approval was not required as the study uses publicly available non-identifiable data.

Outcomes
The primary outcomes captured were the change in number of endoscopic procedures compared with the same month in 2019, and an estimate of the backlog of procedures associated with the pandemic. Secondary outcomes were to estimate the effect of increasing capacity, a temporary reduction of capacity, and the effect of FIT triaging on the backlog of procedures.

Statistical analysis
We analysed data on a per-month basis using the χ² test to compare the same month in 2019 and 2020 and the Kruskal-Wallis test to compare the overall number of procedures done, the case mix for each individual procedure, and also the number of procedures done in each region. A p value of 0·05 or less was considered significant, with Dunn’s test performed for multiple comparisons. We also created two linear logistic regression models; the first model used data from January, 2018, to January, 2020, to calculate the number of expected procedures in the absence of the pandemic, based on historical demand. The second model used data from April, 2020, to October, 2020, to estimate the recovery of endoscopic capacity. We calculated the potential backlog of procedures by cumulating the difference between the two models. Subsequently, we altered parameters in the second model to simulate different scenarios, including a sustained recovery to plateau at different levels of capacity (ranging from 90% to 130%), a further reduction in endoscopic activity, or a
reduction in colonoscopy referrals through use of FIT triaging. We included 95% CIs in our projections. We assumed these scenarios occurred in December, 2020. Statistical analyses were done using R, version 4.0.2, and GraphPad Prism, version 9.0.0.

Role of the funding source
The funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

Results
We included data from Jan 1, 2018, to Oct 31, 2020, for 125 NHS trusts. In 2018, a mean of 112 680 (SD 6090) endoscopy procedures were done per month (figure 2). This amount increased to a mean of 116 538 (SD 5766) in 2019, a 3·5% rise. The pandemic led to a sudden decrease, to a low point of 104 764 procedures in April, 2020, 9·5% of the procedures done in April, 2019 (n=110 584; table 1). There was a partial recovery, with 105 716 procedures in October, 2020, representing 84·5% of the procedures done in October, 2019 (n=125 072). Although individual endoscopic procedures have all followed the same general trend of a sudden decrease followed by a slow recovery, gastroscopies appeared least affected, with 5642 procedures completed in April, 2020 (11·4% compared with April, 2019), whereas only 1599 flexible sigmoidoscopies were completed (7·0% compared with April, 2019). Individual procedures have also recovered at different rates: in October, 2020, flexible sigmoidoscopy was at 62·2% of October, 2019, levels, compared with 89·6% for gastroscopy and 91·3% for colonoscopy. When analysing actual procedure numbers between January and October, 2020, there was an overall significant difference between the three procedures (p=0·015).

We also investigated whether there was any regional effect on the total number of procedures (appendix p 3). East of England was the most affected region in April, 2020, performing 4·5% of the number of overall procedures compared with April, 2019. By contrast, the corresponding percentage for the Midlands, the least affected region, was 17·6% (p<0·0001 for East of England vs Midlands). Recovery also differed between regions. By October, 2020, North East and Yorkshire (considered together) had recovered least well (75·3% compared with October, 2019), whereas East of England recovered most effectively, to 106·2% (p<0·0001 for East of England vs Midlands). However, when analysing actual procedure numbers between January and October, 2020, there was an overall significant difference between the three procedures (p=0·015).

An increase was seen in the proportion of unscheduled procedures, whereas there was a decrease in planned or surveillance and waiting list procedures. This difference was most stark in the month of April, 2020, in which 108 (3·3%) colonoscopies, 361 (22·6%) flexible sigmoidoscopies, and 1501 (26·6%) gastroscopies were unscheduled, compared with 401 (1·0%) of 38 266 colonoscopies, 1187 (5·2%) of 22 877 flexible sigmoidoscopies, and 3532 (7·1%) of 49 441 gastroscopies in April, 2019 (p<0·0001 for all three individual procedures between proportion of unscheduled and scheduled [ie, planned or
|                | Planned or surveillance procedures | Unscheduled procedures | Waiting list procedures | Total procedures |
|----------------|-------------------------------------|------------------------|------------------------|------------------|
|                | n (%)                               | As percentage of 2019  | n (%)                  | As percentage    |
| Colonoscopy*   |                                     |                        |                        | of 2019          |
| January        | 5868 (13.5%)                        | 93.5%                  | 364 (0.8%)             | 57.6%            |
| February       | 5427 (13.2%)                        | 91.4%                  | 389 (0.9%)             | 74.8%            |
| March          | 4930 (12.5%)                        | 62.3%                  | 274 (0.9%)             | 44.6%            |
| April          | 488 (15.1%)                         | 9.2%                   | 108 (3.3%)             | 26.9%            |
| May            | 393 (6.2%)                          | 6.7%                   | 277 (4.3%)             | 60.7%            |
| June           | 1190 (6.9%)                         | 20.1%                  | 384 (2.2%)             | 86.7%            |
| July           | 1897 (7.6%)                         | 31.8%                  | 546 (2.2%)             | 130.0%           |
| August         | 2443 (8.5%)                         | 42.7%                  | 493 (1.7%)             | 70.4%            |
| September      | 3603 (10.1%)                        | 61.4%                  | 570 (1.6%)             | 137.7%           |
| October        | 4467 (10.7%)                        | 69.8%                  | 616 (1.5%)             | 132.2%           |
|                |                                     |                        |                        |                  |
| Flexible sigmoidoscopy* |                   |                        |                        |                  |
| January        | 2878 (11.6%)                        | 91.0%                  | 1222 (4.9%)            | 80.1%            |
| February       | 2610 (11.2%)                        | 91.7%                  | 1098 (4.7%)            | 92.0%            |
| March          | 1829 (10.8%)                        | 57.8%                  | 939 (5.6%)             | 66.8%            |
| April          | 140 (8.8%)                          | 5.5%                   | 361 (22.6%)            | 30.4%            |
| May            | 149 (4.6%)                          | 5.5%                   | 728 (22.4%)            | 55.3%            |
| June           | 394 (5.4%)                          | 14.1%                  | 965 (13.3%)            | 84.9%            |
| July           | 732 (6.8%)                          | 26.5%                  | 1204 (11.1%)           | 96.6%            |
| August         | 810 (6.7%)                          | 32.4%                  | 1108 (9.1%)            | 78.4%            |
| September      | 1054 (7.1%)                         | 39.8%                  | 1242 (8.4%)            | 107.5%           |
| October        | 1233 (7.6%)                         | 39.1%                  | 1370 (7.2%)            | 90.1%            |
| Gastroscopy*   |                                     |                        |                        |                  |
| January        | 6111 (11.2%)                        | 95.9%                  | 3711 (6.8%)            | 94.8%            |
| February       | 5709 (11.3%)                        | 92.1%                  | 3270 (6.5%)            | 94.8%            |
| March          | 3887 (10.3%)                        | 59.2%                  | 3038 (8.1%)            | 77.6%            |
| April          | 507 (9.0%)                          | 9.3%                   | 1501 (26.6%)           | 42.5%            |
| May            | 314 (3.7%)                          | 4.9%                   | 2464 (28.8%)           | 63.7%            |
| June           | 999 (5.2%)                          | 15.8%                  | 3055 (15.9%)           | 87.3%            |
| July           | 1676 (6.0%)                         | 26.4%                  | 3531 (12.7%)           | 91.0%            |
| August         | 2100 (6.5%)                         | 38.1%                  | 3269 (10.1%)           | 86.8%            |
| September      | 3222 (7.6%)                         | 58.8%                  | 3872 (9.1%)            | 112.6%           |
| October        | 3966 (8.3%)                         | 67.8%                  | 3636 (7.6%)            | 97.0%            |
| All procedures*|                                     |                        |                        |                  |
| January        | 14857 (12.1%)                       | 93.9%                  | 5297 (4.3%)            | 87.3%            |
| February       | 13776 (12.0%)                       | 91.8%                  | 4757 (4.1%)            | 92.1%            |
| March          | 9740 (11.2%)                        | 60.2%                  | 4251 (4.9%)            | 71.7%            |
| April          | 1135 (10.8%)                        | 8.5%                   | 1970 (18.8%)           | 38.5%            |
| May            | 856 (4.7%)                          | 5.7%                   | 3469 (19.1%)           | 61.5%            |
| June           | 2583 (5.9%)                         | 17.2%                  | 4404 (10.1%)           | 86.7%            |
| July           | 4305 (6.7%)                         | 28.6%                  | 5281 (8.3%)            | 95.2%            |
| August         | 5533 (7.3%)                         | 39.0%                  | 4870 (6.6%)            | 82.8%            |
| September      | 7879 (8.5%)                         | 56.3%                  | 5629 (6.1%)            | 113.5%           |
| October        | 9273 (10.0%)                        | 60.2%                  | 5422 (5.8%)            | 98.3%            |

Data are n (%) unless specified. *The differences in proportions of planned or surveillance, unscheduled, and waiting list procedures were significant for each individual endoscopic procedure between January and October, 2020 (colonoscopy p<0.0001, flexible sigmoidoscopy p=0.0005; gastroscopy p=0.0003; and all procedures p=0.0001).

Table 1: Number of endoscopy procedures, with percentages, compared with same month in 2019 from January to October, 2020
surveillance and waiting list combined\] procedures in April, 2019, and April, 2020). As endoscopy services started to recover, there was a reversal of this trend (table 1). Recovery for planned or surveillance procedures was slower than waiting list procedures. For all procedures in April, 2020, planned or surveillance and waiting list procedures were at 8-5% of April, 2019, levels for planned or surveillance procedures and 8-0% for waiting list procedures. However, in October, 2020, planned or surveillance procedures were at 60-2% of October, 2019, levels, compared with 87-0% for waiting list procedures. The differences between the monthly proportions of unscheduled, planned or surveillance, and waiting list procedures were significant for all endoscopic procedures combined (planned vs unscheduled \( p = 0.0041 \); unscheduled vs waiting list \( p = 0.0002 \)).

Figure 3 shows the number of patients on the waiting list at the end of each month for each endoscopic procedure. A marked increase was observed in the number of patients on the overall waiting list since March, 2020, increasing from 102 891 patients to a peak of 177 557 patients in September, 2020 (72-6% increase). The most recent data from October, 2020, suggest that the waiting lists for all three procedures have started to decrease.

We developed some future projections for potential strategies and solutions. For scenario 1, which predicts a sustained recovery to a plateau, we created five hypothetical scenarios whereby endoscopic capacity would recover at a steady rate based on the trajectory during the study period, until plateauing at a fixed capacity. These were set at 90%, 100%, 110%, 120%, and 130% of what would be expected capacity in the absence of COVID-19. These states would represent a less severe slowdown in services, with units having learnt from their previous experience and improved contingency planning (appendix p 5). We estimate that a 2-month lockdown could add an additional 15·4% (73 359 cases [95% CI 68 404–78 314]) to the total backlog, while a 4-month lockdown could add 43·8% (208 269 cases [193 797–222 740]), and a 6-month lockdown could add 82-5% (392 796 cases [364 768–420 825]) to the total backlog (table 2).

For scenario 3, we propose using FIT triaging for colonoscopy. Loveday and colleagues suggested that using a FIT cutoff of 10 µg haemoglobin per g could reduce urgent 2-week-wait suspected cancer endoscopies to 18% of usual requirements, if we assume the remaining 82% of patients are not offered endoscopy.\(^6\) NHS England has recommended that a threshold of more than 10 µg haemoglobin per g is used to proceed to colonoscopy, with patients who have concentrations less than the threshold offered safety netting.\(^7\) Data for the proportion of procedures that were on a 2-week-wait pathway was unavailable, but we estimated this proportion using data for indications for colonoscopy. Data from the Dutch Gastrointestinal Endoscopy Audit registry showed that 29% of all colonoscopy referrals had an indication of changes in bowel habit, iron deficiency, chronic diarrhoea, or abdominal complaints.\(^8\) Furthermore, data provided by NED comprising 92 879 colonoscopies in 2019 showed that 31-8% of
Figure 4: Estimation of potential procedural backlog related to first pandemic wave in March, 2020

Estimation of colonoscopy (A), flexible sigmoidoscopy (B), and gastroscopy (C) procedural backlog based on trajectory from October, 2020, before reaching a plateau at a set capacity level, with estimated backlog in January, 2021; January, 2022; and January, 2023, shown in the tables. Data in tables are n (95% CI).

### A Colonoscopy

| Month, year | January, 2021 | January, 2022 | January, 2023 |
|-------------|----------------|----------------|----------------|
| 90%         | 176 387 (156 222 to 196 251) | 233 219 (208 668 to 257 890) | 293 682 (262 641 to 324 723) |
| 100%        | 167 735 (143 775 to 181 695) | 167 735 (143 775 to 181 695) | 167 735 (143 775 to 181 695) |
| 110%        | 147 736 (132 568 to 166 904) | 92 884 (80 422 to 105 347) | 37 443 (26 450 to 48 433) |
| 120%        | 140 610 (124 057 to 157 163) | 26 906 (19 764 to 34 048) | Backlog cleared |
| 130%        | 134 880 (119 927 to 149 833) | Backlog cleared | Backlog cleared |

| Month, year | April, 2020 | October, 2020 | April, 2021 | October, 2021 | April, 2022 | October, 2022 |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| April, 2020 | 47 574 (35 060 to 57 447) | 47 574 (35 060 to 57 447) | | | |
| October, 2020 | 134 880 (119 927 to 149 833) | 134 880 (119 927 to 149 833) | | | |
| April, 2021 | Backlog cleared | Backlog cleared | | | |
| October, 2021 | Backlog cleared | Backlog cleared | | | |
| April, 2022 | Backlog cleared | Backlog cleared | | | |
| October, 2022 | Backlog cleared | Backlog cleared | | | |

### B Flexible sigmoidoscopy

| Month, year | January, 2021 | January, 2022 | January, 2023 |
|-------------|----------------|----------------|----------------|
| 90%         | 121 689 (109 233 to 134 158) | 119 025 (107 398 to 130 651) | 119 025 (107 398 to 130 651) |
| 100%        | 118 727 (107 888 to 129 567) | 89 054 (81 240 to 96 868) | 58 991 (55 339 to 62 644) |
| 110%        | 118 727 (107 888 to 129 567) | 61 459 (57 386 to 65 532) | 133 4 (-29 160 to 55 83) |
| 120%        | 118 727 (107 888 to 129 567) | 36 247 (35 823 to 36 670) | Backlog cleared |
| 130%        | 118 727 (107 888 to 129 567) | Backlog cleared | Backlog cleared |

### C Gastroscopy

| Month, year | January, 2021 | January, 2022 | January, 2023 |
|-------------|----------------|----------------|----------------|
| 90%         | 209 726 (187 175 to 232 276) | 272 619 (244 727 to 300 511) | 326 955 (300 817 to 371 293) |
| 100%        | 194 087 (172 564 to 215 611) | 194 087 (172 564 to 215 611) | 194 087 (172 564 to 215 611) |
| 110%        | 179 969 (159 894 to 200 045) | 117 076 (102 343 to 131 810) | 51 640 (46 252 to 61 028) |
| 120%        | 163 410 (150 163 to 188 917) | 43 754 (35 823 to 52 447) | Backlog cleared |
| 130%        | 163 709 (145 442 to 181 976) | Backlog cleared | Backlog cleared |

| Month, year | April, 2020 | October, 2020 | April, 2021 | October, 2021 | April, 2022 | October, 2022 |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| April, 2020 | 35 823 (35 060 to 36 670) | 35 823 (35 060 to 36 670) | | | |
| October, 2020 | 163 709 (145 442 to 181 976) | 163 709 (145 442 to 181 976) | | | |
| April, 2021 | Backlog cleared | Backlog cleared | | | |
| October, 2021 | Backlog cleared | Backlog cleared | | | |
| April, 2022 | Backlog cleared | Backlog cleared | | | |
| October, 2022 | Backlog cleared | Backlog cleared | | | |
procedures had at least one indication of acute or chronic changes in bowel habit, anaemia, abdominal pain, or weight loss, although the true figure might be lower, as around 27,000 procedures had more than one indication recorded.\textsuperscript{12} Assuming these referrals would be suitable for FIT triaging at 10 µg haemoglobin per g, FIT triaging showed a drop to 29\% for colonoscopy and 37\% for gastroscopy when comparing between January and April, 2020.\textsuperscript{13} Meanwhile, a global web-based survey done between April and May, 2020, covering 252 centres from 55 countries suggested an average of 83\% reduction when comparing activity between baseline and during the COVID-19 pandemic.\textsuperscript{14} These results would suggest that endoscopy in England might have been affected to a greater degree than in other countries around the world, even though there was broad consensus among worldwide guidelines.\textsuperscript{15} A host of reasons, ranging from decision making at the local level, hesitancy at accessing cancer services, preserving personal protective equipment (PPE), and staffing issues might be the cause of this difference.\textsuperscript{4,16}

Discussion

For the first time, to our knowledge, we present an analysis of national data to show an urgent gap in endoscopy service provision as an indirect effect of the COVID-19 pandemic. We have shown that the pandemic directly led to a decrease in the number of endoscopic procedures done, with a partial recovery as COVID-19 infections and hospital admissions started to fall. Furthermore, potential solutions are challenging even if greater than normal capacity is achieved or FIT triaging can be fully implemented.

Endoscopic activity was at its lowest in April, 2020, decreasing to 9\%-5\% of procedures compared with 1 year earlier. We also noted regional differences in endoscopy provision as well as changes in the case mix of procedures. A similar overall pattern was seen in the NED database, which recorded the trough in the week beginning March 30, 2020, although no regional differences were seen.\textsuperscript{1} This result is probably because the NED analysis only included data up until May 31, 2020, and regional differences might not have been apparent then.

As a comparison, a national study from the Netherlands, which entered a nationwide lockdown on March 12, 2020, showed a drop to 29\% for colonoscopy and 37\% for gastroscopy when comparing between January and April, 2020.\textsuperscript{16} Meanwhile, a global web-based survey done between April and May, 2020, covering 252 centres from 55 countries suggested an average of 83\% reduction when comparing activity between baseline and during the COVID-19 pandemic.\textsuperscript{14} These results would suggest that endoscopy in England might have been affected to a greater degree than in other countries around the world, even though there was broad consensus among worldwide guidelines.\textsuperscript{15} A host of reasons, ranging from decision making at the local level, hesitancy at accessing cancer services, preserving personal protective equipment (PPE), and staffing issues might be the cause of this difference.\textsuperscript{4,16}

Our data also show that recovery has been somewhat slow and that there are some substantial inter-regional differences. 6 months on from the start of the first peak of the pandemic in March, 2020, the number of patients on waiting lists had started to fall, but approximately 50\% of patients were on a waiting list in October, 2020, than in the previous year. Meanwhile, capacity in October, 2020, remained at 84\%-5\% compared with the previous year, with a slower recovery for planned or surveillance procedures (60\% of October, 2019, levels) compared with waiting list procedures (87\% of October, 2019, levels). Conversely, there have been more unscheduled procedures than in the previous year: this finding might be a manifestation of altered health behaviour during the first peak of the pandemic, with delayed presentation of medical conditions subsequently leading to emergency complications.\textsuperscript{1} These findings show the need for a targeted approach regionally to aid recovery with appropriate resource allocation. Equally, there should be a dedicated strategy to ensure that planned or surveillance procedures do not lag far behind waiting list procedures during the recovery.

Endoscopy services face further challenges in increasing capacity back to pre-pandemic levels. Staffing remains a key concern: redeployment, staff absence due to self-isolation or shielding, and additional administrative burden due to COVID-19 mitigation measures such as telephone

Table 2: Estimated additional procedures added to the backlog by months of reduced activity

|             | Estimated additional procedures | Percentage of potential backlog (%)(n=162,735) |
|-------------|---------------------------------|-----------------------------------------------|
| 2 months    | 27,354                          | 16.8%                                          |
|             | (25,521–29,187)                 |                                               |
| 3 months    | 50,257                          | 30.9%                                          |
|             | (46,844–53,669)                 |                                               |
| 4 months    | 77,835                          | 47.8%                                          |
|             | (72,482–83,188)                 |                                               |
| 5 months    | 110,113                         | 67.7%                                          |
|             | (102,446–117,781)               |                                               |
| 6 months    | 147,117                         | 90.4%                                          |
|             | (136,749–157,485)               |                                               |

Data are estimate (95\% CI) or percentage.

|             | Estimated additional procedures | Percentage of potential backlog (%)(n=194,087) |
|-------------|---------------------------------|-----------------------------------------------|
| 2 months    | 14,721                          | 12.4%                                          |
|             | (13,542–15,899)                 |                                               |
| 3 months    | 26,999                          | 22.7%                                          |
|             | (24,805–29,194)                 |                                               |
| 4 months    | 41,744                          | 35.1%                                          |
|             | (38,302–45,187)                 |                                               |
| 5 months    | 58,958                          | 49.5%                                          |
|             | (54,027–63,899)                 |                                               |
| 6 months    | 78,643                          | 66.1%                                          |
|             | (71,975–85,310)                 |                                               |

|             | Estimated additional procedures | Percentage of potential backlog (%)(n=194,087) |
|-------------|---------------------------------|-----------------------------------------------|
| 2 months    | 31,284                          | 16.1%                                          |
|             | (29,204–33,365)                 |                                               |
| 3 months    | 57,371                          | 29.6%                                          |
|             | (53,498–61,245)                 |                                               |
| 4 months    | 88,690                          | 45.7%                                          |
|             | (82,613–94,766)                 |                                               |
| 5 months    | 125,243                         | 64.5%                                          |
|             | (119,559–133,948)               |                                               |
| 6 months    | 167,037                         | 86.1%                                          |
|             | (155,267–178,806)               |                                               |

|             | Estimated additional procedures | Percentage of potential backlog (%)(N=475,847) |
|-------------|---------------------------------|-----------------------------------------------|
| 2 months    | 73,359                          | 15.4%                                          |
|             | (68,404–78,314)                 |                                               |
| 3 months    | 134,627                         | 28.3%                                          |
|             | (125,403–143,852)               |                                               |
| 4 months    | 208,269                         | 43.8%                                          |
|             | (193,797–222,740)               |                                               |
| 5 months    | 294,345                         | 61.9%                                          |
|             | (273,526–315,043)               |                                               |
| 6 months    | 392,796                         | 82.5%                                          |
|             | (364,768–420,825)               |                                               |
triaging and pre-procedural SARS-CoV-2 testing all create additional barriers in service recovery.\textsuperscript{1,16} In addition, the requirement for PPE, especially with gastroscopy (an aerosol-generating procedure) and infection control measures such as deep cleaning and leaving a time gap between procedures all lead to decreased room use and efficiency.\textsuperscript{1,17}

Our work on future projections, based on extrapolation of historical pre-pandemic demand, also shows that there could be a backlog of nearly half a million endoscopic procedures attributable to the pandemic. We also quantified the scale of the challenge faced in the recovery phase: if only 90% capacity is reached, which might well be realistic given the current constraints, each month will add an additional 12 217 (95% CI 11 401–13 031) endoscopic procedures to the potential backlog. Furthermore, following the surge in COVID-19 cases since December, 2020, it is likely that endoscopy services have been curtailed, and even a short 2-month disruption could add an additional 73 359 (95% CI 68 404–78 314) cases to the potential backlog. There is therefore a need to preserve progress made on recovery and catch up by increasing capacity to above normal levels.\textsuperscript{1,18} One option is to use the private sector to provide this additional capacity for a short period to catch up, or to create additional capacity during evenings and weekends. However, a UK study from 2017 showed that only 55% of endoscopy units were meeting cancer wait targets, with shortages of endoscopists and nursing staff cited as reasons for missing the target.\textsuperscript{19} 82% of English NHS trusts already do ad-hoc weekend work, hence increasing capacity further for a sustained period might not be possible.\textsuperscript{19}

Temporary increases in waiting list and unscheduled capacity could be achieved by reducing cancer screening programmes and reallocating this capacity. As an example, it was expected for the Bowel Scope Screening Programme to have done 256 000 flexible sigmoidoscopies in 2020.\textsuperscript{18} Under our projections, reallocating this capacity could create an additional 87% capacity per month, eliminating the pandemic-related backlog by May, 2021. However, this reallocation of screening capacity for other purposes must be balanced against the risk of an overall increase in preventable deaths.\textsuperscript{19} Furthermore, the latest British Society of Gastroenterology guidelines for post-polypectomy surveillance suggest that adoption would lead to a decrease to 20% of the level of polyp surveillance workload in 2019.\textsuperscript{20} 10–4% of colonoscopies in a Dutch series had an indication of adenoma surveillance, so theoretically, adherence to these guidelines could generate an extra 8–3% of capacity.\textsuperscript{20}

Strategies to enhance triaging could also be used to reduce the rate of additional cases being added to the backlog. Enhanced vetting of referrals has been used in 77% of recovery plans and has helped to reduce demand.\textsuperscript{21} FIT has increasingly been used across the NHS to triage patients for lower gastrointestinal investigation, and recommendations were released in March, 2020, for FIT triaging to be used for patients who were symptomatic in primary care.\textsuperscript{22,23} We show here that FIT could reduce the colonoscopy backlog, if patients with haemoglobin concentrations less than a set FIT threshold are not offered endoscopy. Studies have found that FIT with 10 µg or less haemoglobin per g has a negative predictive value of greater than 99%, with the colorectal cancer risk in patients who are symptomatic similar to the baseline risk.\textsuperscript{24–26} However, it has also been argued that FIT should be used as a triaging rather than a diagnostic tool, to guide timing of the procedure rather than replace it.\textsuperscript{27} If used in this way, it might have limited effect in the long term to reduce colonoscopy demand. In addition, there remains debate as to how patients with a FIT of 10 µg or less haemoglobin per g ought to be followed up.\textsuperscript{28} Cytosponge and colon capsule endoscopy in lieu of gastroscopy and colonoscopy have both been touted as possible alternatives, although neither are used in routine clinical practice.\textsuperscript{29,30}

An alternative to colonoscopy could be to use CT colonography. We attempted to assess data for changes to CT colonography use during the pandemic. Unfortunately, these data are not collected by NHS England. Advantages of CT colonography include decreased PPE use, improved ability to socially distance compared with colonoscopy, and shorter patient visit times.\textsuperscript{30} However, ensuring adequate CT capacity and expertise to perform and report the procedures might be barriers to implementation.\textsuperscript{30}

There are also wider implications for our work; although we have quantified the effect of the pandemic on endoscopy, other procedure-heavy specialties such as cardiology and surgery have also faced similar challenges.\textsuperscript{32,33} Of particular concern is the effect on cancer waiting lists and pathways; it has been estimated that diagnostic delays might lead to a 16% increase in colorectal cancer deaths and 5–9% increase in oesophageal cancer deaths over 5 years.\textsuperscript{34} Furthermore, diagnostic delays due to a further lockdown could lead to 1231 additional cancer-related deaths and 22 635 life-years lost.\textsuperscript{35} This possibility is especially pertinent as countries experience subsequent waves of the pandemic, leading to increased health-care resource use and further risking the recovery of hospital services. The focus on cancer might very much be a small part of a much wider problem; we might not fully know the effect of the pandemic on other gastrointestinal diseases, other health services, and health outcomes for some years, not only in England but also globally. However, given that this issue is global and inter-disciplinary, it could afford novel opportunities for collaboration going forward.

The first important limitation of the study relates to the size of the waiting list. Although endoscopic activity remains less than expected levels, endoscopy waiting lists started to decrease as of October, 2020. This finding suggests that deferred patients might have already been
referred or might no longer require endoscopic investigation. An alternative explanation is that this result is a reflection of both a reduction in general practice consultations by a third and reduction in referrals to secondary care by half.4,5 With COVID-19 being a dynamic situation with a resurgence of cases from December, 2020, the full effect on endoscopic waiting lists might still not be fully known and potentially be worse than feared. A second limitation is that in our backlog calculation we have assumed that endoscopy will eventually return to pre-pandemic levels of practice and demand, and that over time, referral patterns will even out back to pre-pandemic trends. Some recovery plans, such as enhanced vetting of referrals or changes in referral pathways could be retained long term and continue to reduce demand for endoscopy services. This situation would mean that the estimated backlog figures presented here might be an overestimate of the actual backlog of procedures. However, any excess capacity could easily be filled by expansion of cancer screening or surveillance programmes.6 Third, our study excludes endoscopic retrograde cholangiopancreatographies and procedures done as part of the Bowel Cancer Screening Programme and the Bowel Scope Screening Programme, which were suspended in the first wave of the pandemic. Fourth, data for the number of referrals to endoscopy were unavailable, which would have been a better measure of demand. Although data for the number of patients on the waiting list is available per procedure, these data only provide a snapshot of the number of people at the end of a month at a given timepoint, and also exclude unscheduled or planned or surveillance procedures; hence it was not used as a surrogate for referrals. Also, our scenarios for a further slowdown are hypothetical in nature and might not reflect real-world practice. Finally, we made assumptions on the number of colonoscopy referrals, which might be amenable to FIT triaging by using data for endoscopic indications. In addition, guidelines for FIT triaging were introduced from March, 2020, onwards within different regions, hence the effect of FIT triaging as predicted in our model might be less pronounced.

Our research shows the enormous strain the COVID-19 pandemic has put on NHS endoscopy in England. This issue has become even more pertinent with the rapid rise of COVID-19 hospital admissions in December, 2020, and January, 2021, leading to further disruption of endoscopic services. Without major structural reforms, this disruption will lead to a growing backlog of cases. Strategies to increase endoscopy capacity and preserve endoscopy services in the event of subsequent waves of infection must be implemented immediately. Triaging with FIT testing should be implemented, with further urgent research deployed to ensure risk stratification of patients reduces unnecessary demand but also provides a safety net for those at highest risk.

Contributors
KMAH was responsible for study conception, data analysis, and manuscript preparation. MDR was responsible for collection of data, manuscript preparation, and supervisory oversight. AB, ML, and LBL were responsible for study conception, data analysis, manuscript preparation, and supervisory oversight. KMAH, AB, ML, and LBL verified data. All authors had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Declaration of interests
KMAH has received a British Society of Gastroenterology-Norgine travel award for travel and conference expenses unrelated to this work. ML has received an unrestricted educational grant from Pfizer for research unrelated to this work. ML has also received honoraria from Pfizer, EMD Serono, Roche, and Bristol Myers Squibb unrelated to this work. All other authors declare no competing interests.

Data sharing
Data used in this study are openly available from NHS England.

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