Diagnostic accuracy of point of care faecal immunochemical testing using a portable high-speed quantitative analyser for diagnosis in 2-week wait patients

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ORIGINAL ARTICLE

Diagnostic accuracy of point of care faecal immunochemical testing using a portable high-speed quantitative analyser for diagnosis in 2-week wait patients

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Abstract

Aim: Laboratory-based faecal immunochemical testing (FIT) is the gold standard for detecting the presence of blood in the stool. The aim was to perform a diagnostic accuracy study to confirm if a point of care (POC) analyser for FIT could be safely used as an adjunct in the triage and management of 2-week wait (TWW) colorectal patients.

Methods: The Point of Care Faecal Immunochemical Testing (POC FIT) prospective observational cohort study was designed for TWW patients at a regional referral centre. Between July 2019 and March 2020, patients were invited to perform and bring a FIT sample to clinic. FIT was completed within the clinic appointment using a POC quantitative analyser that has a 2-min processing time (QuikRead go®). Patients and clinicians were blinded to results within the clinic appointment. The results were compared with subsequent diagnostic outcomes. Faecal haemoglobin of <10 μg haemoglobin/g of faeces was considered a negative result. Sensitivities for colorectal cancer (CRC) and combined serious bowel disease (SBD) were calculated using this pre-determined cut-off.

Results: A total of 553 patients were included for analytical comparison with diagnostic outcomes. There were 14 (2.5%) patients with CRC and 52 (9.4%) with SBD. The sensitivities for CRC and SBD were 92.9% (95% CI 68.5%–98.7%) and 76.9% (95% CI 63.9%–86.3%) respectively. 379 (68.5%) patients had a negative FIT result (negative predictive value for CRC was 99.7%).

Conclusions: This POC FIT device is a useful adjunct to better manage TWW patients. The high observed sensitivity for CRC offers opportunities, within a single consultation, for improved triage and rationalization of investigation for those with bowel symptoms.

INTRODUCTION

The application of faecal immunochemical testing for haemoglobin (FIT) for colorectal cancer (CRC) screening is well established. However, its use for symptomatic patients is still evolving [1]. Recent large-scale observational studies have confirmed that quantitative FIT results with low cut-off concentrations have high sensitivity for CRC in those with red flag symptoms [2–6]. Typically, FIT samples are processed and analysed in high throughput laboratories. There are three laboratory FIT analysers recommended by the National Institute for Health and Care Excellence (NICE) from 2017 [7].

For 2-week wait (TWW) colorectal patients, FIT can be used to help determine triage urgency [1, 5, 8, 9]. A point of care (POC) system provides the potential for faster decision making and improved risk stratification when assessing TWW patients. However, to ensure clinical utility, POC systems need to be user friendly, accurate, efficient and cost-effective [10, 11]. There are a wide variety of POC devices marketed for FIT [12, 13]. Whilst many are for home-use—and only provide qualitative results (positive or negative)—a number are marketed as suitable for professional use, to offer quantitative results in a consultation setting. These have a CE marking but there are limited analytical evaluations or clinical diagnostic accuracy studies, and none of them is recognized for use by NICE.

Before a POC test can be adopted for widespread clinical use, it must demonstrate the ability to generate analytically valid results and produce acceptable diagnostic accuracy within the context of the clinical pathway. This is outlined by the Point of Care Key Evidence Tool (POCKET) [10]. A recent study evaluated three potential POC quantitative FIT devices [14]. This identified the QuikRead go® (Aidian Oy) as analytically fit for purpose. It also demonstrated high usability as it was portable, simple to use and could generate a result within 2 min.

The Point of Care Faecal Immunochemical Testing (POC FIT) study was designed to establish the diagnostic accuracy of the QuikRead go® in the outpatient setting. Data collection on presenting symptoms and diagnostic outcomes add further understanding of the application of FIT for TWW patients. The objective of POC FIT was to confirm if the QuikRead go® analyser could be safely used in a clinical setting as an adjunct in the triage and management of TWW colorectal patients.

What does this paper add to the literature?

This is the first observational study for a point of care faecal immunochemical testing analyser within a clinic setting to demonstrate sensitivity for colorectal cancer in the 2-week wait cohort. The results demonstrate what potential impact there may be for improved triage and rationalization for investigation resources.

METHODS

Study design

The POC FIT study was designed in line with the updated STARD checklist for reporting diagnostic accuracy studies [15]. Between July 2019 and March 2020, patients referred to the Royal Surrey Foundation Trust (RSFT) on the colorectal TWW pathway were invited to the POC FIT study (REC: 19/LO/0889). This was a prospective observational cohort study comparing the performance of the QuikRead go® device with subsequent diagnostic outcomes. The POC FIT study was approved by the UK Health Research Authority on 9 July 2019 (IRAS: 260384).

Patient intervention

Patients referred to RSFT on the TWW (suspected cancer) pathway were invited to participate in the study by post. On booking a face-to-face appointment, the patients were sent their clinic letter with a study pack. Packs contained the patient information leaflet, a sampling instruction leaflet and the FIT sampling device for the QuikRead go®.

Following written consent, the POC analysis was conducted by the consulting physician. Both the patient and clinician were blinded to the results. Patients were assessed and appropriate investigations arranged as per a normal TWW consultation.

Inclusion and exclusion criteria

Patients ≥18 years of age referred on the TWW pathway between July 2019 and March 2020 were included. Patients had to have capacity to consent and have provided the sample from fresh faeces and not a stoma bag. Samples taken from a stoma were not deemed suitable due to the risk of haemoglobin degradation [16].

Index test and reference standard

In order to determine the diagnostic accuracy of colonic pathology, outcomes were compared with the FIT result only where a definitive colonic investigation was made. Colonoscopy and CT colonography were considered the gold standard to investigate for CRC as both are highly sensitive [17]. Cases where the clinician requested a flexible sigmoidoscopy were only included for analysis if they presented with perianal symptoms or anorectal bleeding (bright red blood seen separate to the stool in the pan or on the paper). Other investigations, including standard CT, were not considered as sufficiently sensitive or specific for colonic pathology. Patients having such investigations were excluded for comparison unless further tests or surgery subsequently allowed definitive diagnosis or exclusion of CRC. All cases where other cancers were diagnosed—that is, non-colorectal cancers (non-CRCs)—were included in the analysis. Those without alternative diagnosis and who had not had adequate colonic investigation were excluded.

FIT sample analysis

Specimen collection and handling, analysis, quality management and result recording were undertaken in accordance with the FITTER

checklist [18]. The QuikRead go® samples were analysed by the consulting physician during the clinic appointment using an approved standard operating procedure that was designed for use at the RSFT in accordance with the manufacturer's recommendations. The results were not available to the physician until after the completion of the consultation and further investigation had been arranged. Three doctors were recruited for the study and trained in the use of the QuikRead go® system.

Data

A secure web-based clinical database, approved by the local information governance team, was developed to audit referrals, investigations and outcomes of patients referred under the TWW pathway. Those entered into the POC FIT study were assigned a unique trial number and their FIT results were entered into the database in a pseudonymized fashion. Access to these data was restricted to members of the research team.

Sample size calculation

The sample size estimate was based on the study by Westwood et al. who reported that the sensitivity for CRC of laboratory-based FIT for the OC sensor in symptomatic patients was 92.1% (95% CI 86.9%–95.3%) [19]. Under the assumption that the QuikRead go® operated with the same sensitivity, a margin of error table (defined as the half-width of a 95% CI) was computed. These computations assumed a CRC prevalence rate of 4% in the TWW cohort [8]. The table showed that, with a sample size of 600 subjects to undergo FIT, a sensitivity of 92.5% could be estimated within a margin of error of 10%.

The QuikRead go® displays quantitative faecal haemoglobin (f-Hb) results between 10 and 200 μg haemoglobin/g of faeces (μg/g). The upper threshold to exclude CRC has been considered as 10 μg/g [19]. Therefore f-Hb <10 μg/g was considered negative. The upper limit of quantification is 200 μg/g. Other cut-offs were set at 100 and 150 μg/g to allow for further categorical statistical analysis in line with published data [1, 5]. The point estimate and 95% CI for sensitivity, specificity, positive predictive value, negative predictive value, positive and negative likelihood ratios, diagnostic odds ratio and Youden's index were calculated for each f-Hb threshold [20, 21]. Receiver operating characteristic (ROC) curves were created using Microsoft Excel. Areas under the curve (AUC) were estimated using the DeLong et al. test [22] and were considered significant for $P < 0.05$.

If more than one diagnosis was made, the patients were categorized to the most relevant colorectal diagnosis for the purposes of the results analysis. The hierarchy was pre-determined to rate CRC as the most important diagnosis to achieve the primary objective of the study.

SBDs were identified as CRC, high-risk adenomas and inflammatory bowel disease. High-risk adenomas were defined as any advanced adenoma (≥10 mm, any sessile serrated lesion or adenomas that contained high-risk dysplasia) or if the total number of polyps was ≥5 as per the British Society of Gastroenterology guidelines for surveillance [23]. Low-risk adenomas and other non-neoplastic colorectal diagnoses including other macroscopic colitis, proctitis, microscopic colitis and diverticulosis were classed as not being SBDs along with those with no colonic pathology. A separate category was made for non-CRCs.

RESULTS

In total, 832 patients were invited to the study and 633 provided FIT samples for analysis (76.1%). 80 were excluded from the diagnostic outcome analysis (Figure 1). Of the 80 excluded, two samples were rejected because they were obtained from a stoma and two were excluded as the samples were older than 10 days due to delayed clinic appointments. The remaining 76 did not have gold standard clinical investigations to enable definitive diagnoses. Reasons given for not undergoing these investigations were frailty ($n = 34$), failure to attend or declined recommended investigation ($n = 11$) or lack of clinical indication ($n = 31$).

For those with definitive diagnoses ($n = 553$), the demographics are displayed in Table 1. There were 14 (2.5%) CRC diagnoses and a total of 52 (9.4%) SBD diagnoses. For those patients with CRC, $n = 13$ were identified with f-Hb ≥10 μg/g. For those patients with SBD, $n = 40$ had f-Hb ≥10 μg/g (Figure 2). The calculated sensitivities of the POC analyser were 92.9% for CRC (95% CI 68.5%–98.7%) and 76.9% for SBD (CI 63.9%–86.3%). Of 553 patients, $n = 379$ (68.5%) had a negative FIT result. Negative predictive values for CRC and SBD were 99.7% and 96.9% and positive predictive values were 7.8% and 24.0% respectively (Table 2). The ROC curve for CRC is shown in Figure 3. The AUC for CRC was 0.92 (95% CI 0.83–1.0; $P < 0.01$). The ROC curve for SBD is shown in Figure 4. The AUC for SBD was 0.81 (95% CI 0.74–0.88; $P < 0.01$).

Table 3 displays the breakdown of the diagnostic outcomes after colonic-specific investigation. This demonstrates how the FIT results correspond with these diagnoses using three f-Hb categories (f-Hb <10 μg/g, f-Hb ≥10 and <150 μg/g and f-Hb ≥150 μg/g). Most patients (356/553, 64.3%) with definitive diagnostic outcomes had a normal colon with no cause for presenting complaint or diverticulosis (Table 3). 272 of the 356 (76.4%) patients had an f-Hb of <10 μg/g. Overall, 68.5% of patients had an f-Hb <10 μg/g.

Table 4 shows how the presenting symptoms corresponded with the likelihoods of f-Hb ≥10 μg/g, CRC and overall SBD diagnoses. Patients referred with anaemia were the most likely to have CRC (7.0%). Not all patients with anaemia had confirmed iron deficiency, but those that did had a higher likelihood of CRC (12.0%). Per rectal bleeding was also a high-risk symptom with 4.8% having CRC, and blood described as dark red had a higher risk of CRC (9.1%) making

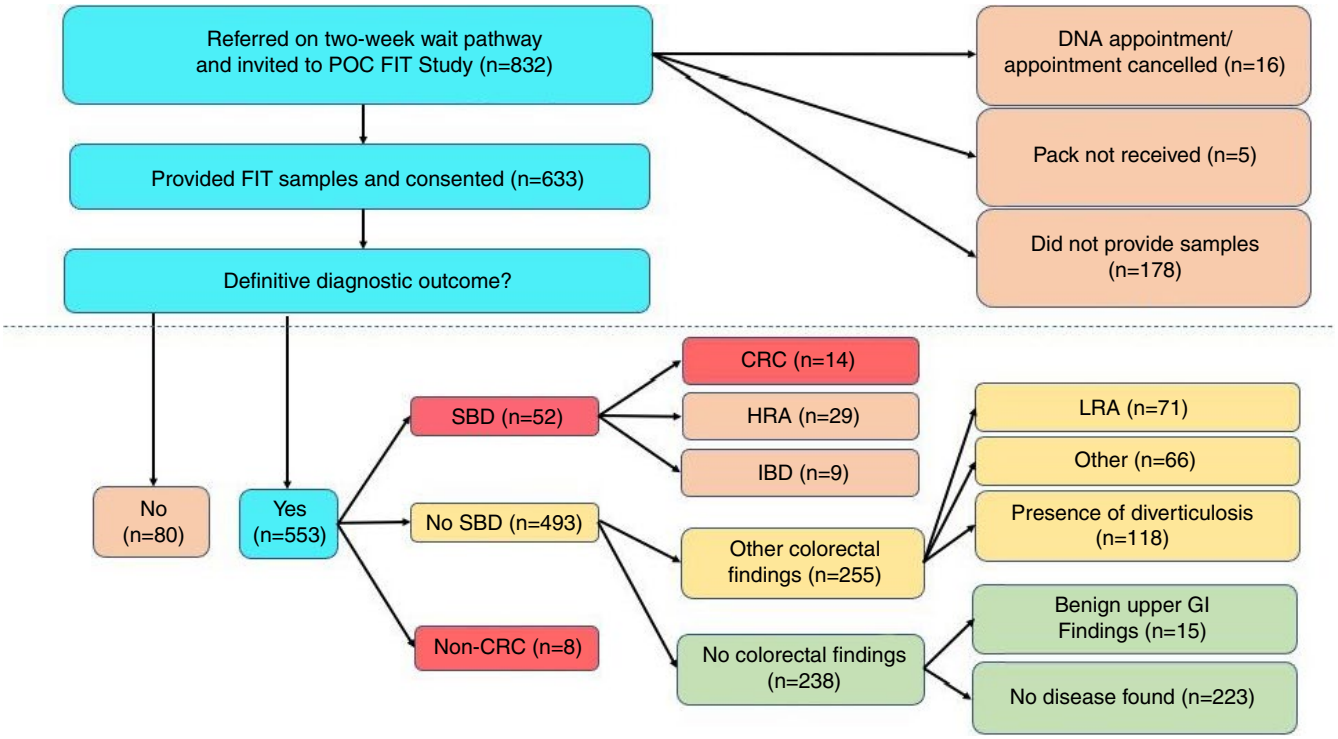

FIGURE 1 Patient pathway showing diagnostic outcomes and pathway to reach diagnostic accuracy analysis

TABLE 1 Age and sex of patients with definitive diagnosis

Variable	Number (% of total)
Sex	
Male	276 (49.9%)
Female	277 (50.1%)
Age, years	
18–39	18 (3.3%)
40–49	37 (6.7%)
50–59	122 (22.1%)
60–69	141 (25.5%)
70–79	168 (30.4%)
80–89	64 (11.6%)
≥90	3 (0.5%)

up six of the 14 CRCs diagnosed. Referrals for change of bowel habit had the lowest likelihood for CRC (1.6% for any change of bowel habit). None of those with constipation symptoms (less frequent or harder motions) were diagnosed with CRC.

There were no error readings in the 633 patient samples analysed by the QuikRead go®. Had the clinician not been blinded, the result would have been available within consultation time in all cases.

Of all 832 patients reviewed in the TWW clinic, 693 (83.3%) were referred from clinic for further colonic-specific investigation. Of these, 66.8% were referred for colonoscopy, 21.5% were referred for CT colonography and 11.7% were referred for flexible sigmoidoscopy. Of the 832 patients, the overall number of CRCs detected was 18 (2.2%).

DISCUSSION

This is the first study to report the diagnostic accuracy of a POC FIT device in the TWW symptomatic population. The only other POC FIT studies performed have evaluated its use either in the screening population—where the threshold for positivity was altered to match the required referral/positivity rate—or in a population of patients already scheduled for colonoscopy [24, 25]. This study demonstrates that the QuikRead go® POC analyser performs well in identifying those with CRC. A sensitivity of 92.9% for CRC in our cohort is similar to the 92.1% sensitivity reported by Westwood et al. for symptomatic patients using laboratory-based FIT [19]. Furthermore, this is comparable to the more recent, large-scale, multicentre prospective observational NICE FIT study that used laboratory-based FIT. NICE FIT demonstrated a sensitivity of 90.9% (CI 87.2%–93.8%) using f-Hb ≥10 μg/g as a cut-off in the high-risk symptomatic population [2]. In our study, the sensitivity of the POC FIT device for SBD also performed well at 76.9% and this was higher than that seen in the NICE FIT study of 62.6% [2].

The POC system used within an outpatient setting for the symptomatic patient removes the need for laboratory sample delivery and processing time. Avoiding the wait for a result enables decision making for referral or investigation choice within

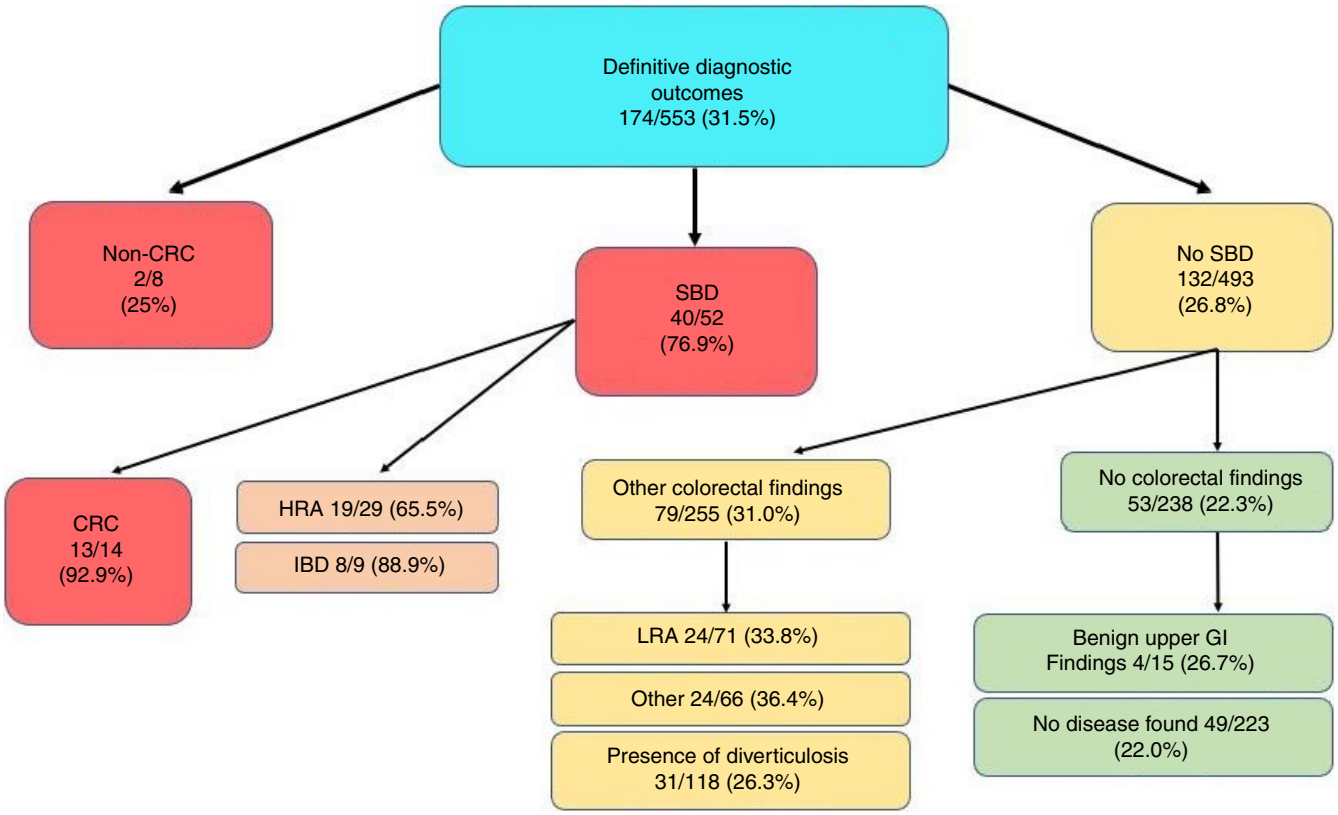

FIGURE 2 Definitive diagnostic outcomes and proportion with FIT ≥10 μg/g

one consultation. The study demonstrates that results would be available within the timeframe of a clinic consultation and usability was consistent with that reported within the analytical validation study of the device at RSFT [14]. FIT has not yet been advocated in the secondary care setting, possibly due to the lead time to result. Such delays negatively impact on the 28-day diagnostic target that TWW patients must meet from the point of referral from primary care. As such, a POC FIT device that gives the result in one clinic assessment would not add to this time pressure. Sample requests may be posted with appointment letters (as performed in this study) or be given to patients from primary care at the point of referral.

The application of FIT in the symptomatic population for detecting CRC has broadened recently. In 2017, NICE updated the NG12 TWW guidelines for the use of FIT for patients with low-risk symptoms in primary care [7]. With the COVID-19 pandemic reducing access to endoscopy, FIT was recommended for triage by NHS England for those within the higher risk groups [26]. The RSFT demonstrated that using FIT enabled safety-netting with a watch and wait approach, but also reduced overall colonoscopy from 62% to 34% of TWW patients [27].

This study has demonstrated a method where POC FIT could have been used in a secondary care clinic. As with most screening methods, the most appropriate utilization for POC FIT is likely to be early in the diagnostic pathway. A negative result from a POC FIT device used in primary care could identify those who would be unlikely to benefit from colonic investigation. For those with positive results, it may enable 'straight to test' or telephone triage appointments for fast track colonoscopy. Public Health England have previously reported that the TWW pathway is the commonest route to CRC diagnosis. However, this still only accounted for 30% of CRC diagnoses and routine referrals still made up 23% of CRC diagnoses [28]. FIT may rationalize those that would better benefit from referral on the TWW pathway.

The RSFT reported a two-fold increase in TWW colorectal referrals in recent years, but no increase in the number of CRCs diagnosed [29]. Of those invited to participate in this study there was an overall pick-up rate for CRC of only 2.2%, which is below the NHS England 3% target. A POC device could assist general practitioners to appropriately filter and triage referrals at source. Mowat et al. reported that using FIT can reduce referrals by 15.1% from primary care [30]. As FIT has been shown to have such a high sensitivity, this is not likely to reduce total CRC diagnoses. Addition of a sensitive POC analyser could reduce this even further as a clinician may decide not to make the referral if an instant negative result was to hand in the same consultation.

In practical terms, use of POC FIT in primary care may still require two appointments, as a patient would need to take the kit home from initial consultation to collect their sample. Screening presenting complaints prior to appointments can identify those with bowel symptoms. These patients could be asked to pick up an FIT kit and perform sampling prior to the initial appointment, allowing the need for only one consultation. Alternatively, the second consultation could be avoided if the clinician took the sample for FIT

TABLE 2 Colorectal cancer (CRC), high-risk adenomas (HRA), inflammatory bowel disease (IBD) and combined serious bowel disease (SBD) diagnoses according to faecal haemoglobin (f-Hb) cut-off

Diagnosis	≥Cut-off value (μg/g)	Sensitivity (%)	Confidence intervals for sensitivity	Specificity (%)	Confidence intervals for specificity	PPV (%)	NPV (%)	Likelihood ratio (+)	Likelihood ratio (−)	Odds ratio	Youden's index
CRC ($n = 14$)	10	92.9	68.5–98.7	70.1	66.1–73.8	7.5	99.7	3.11	0.10	30.52	0.63
	100	71.4	45.4–88.3	94.6	92.4–96.2	25.6	99.2	13.28	0.30	43.97	0.66
	150	57.1	32.6–78.6	95.9	93.9–97.3	26.7	98.9	14.00	0.45	31.33	0.53
HRA ($n = 29$)	10	65.5	47.3–80.1	70.4	66.4–74.2	10.9	97.4	2.21	0.49	4.52	0.36
	100	20.7	9.8–38.4	93.7	91.3–95.5	15.4	95.5	3.29	0.85	3.88	0.14
	150	13.8	5.5–30.6	95.0	92.8–96.6	13.3	95.2	2.78	0.91	3.07	0.09
IBD ($n = 9$)	10	88.9	56.5–98.0	69.5	65.5–73.2	4.6	99.7	2.91	0.16	18.22	0.58
	100	44.4	18.9–73.3	93.6	91.2–95.3	10.3	99.0	6.91	0.59	11.63	0.38
	150	33.3	12.1–64.6	95.0	92.9–96.6	10.0	98.9	6.72	0.70	9.57	0.28
SBD ($n = 52$)	10	76.9	63.9–86.3	73.3	69.2–76.9	12.0	96.8	2.88	0.32	9.13	0.50
	100	38.5	26.5–52.0	96.2	94.2–97.6	51.3	93.8	10.14	0.64	15.86	0.35
	150	28.8	18.3–42.3	97.0	95.1–98.2	50.0	92.9	9.63	0.73	13.14	0.26

Abbreviations: NPV, negative predictive value; PPV, positive predictive value.

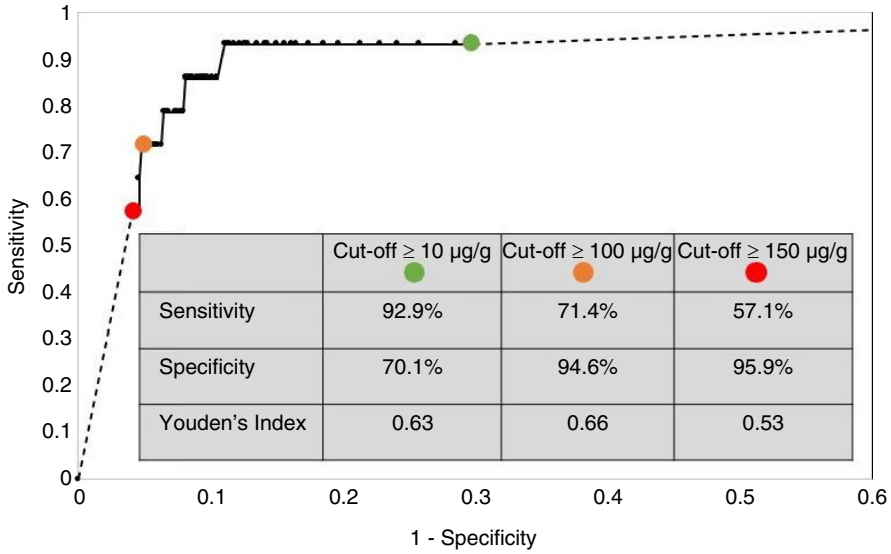

FIGURE 3 CRC ($n = 14$) ROC curve for QuikRead go®. Area under the curve (AUC) for CRC = 0.92 (95% confidence interval 0.83–1.0; $P < 0.01$)

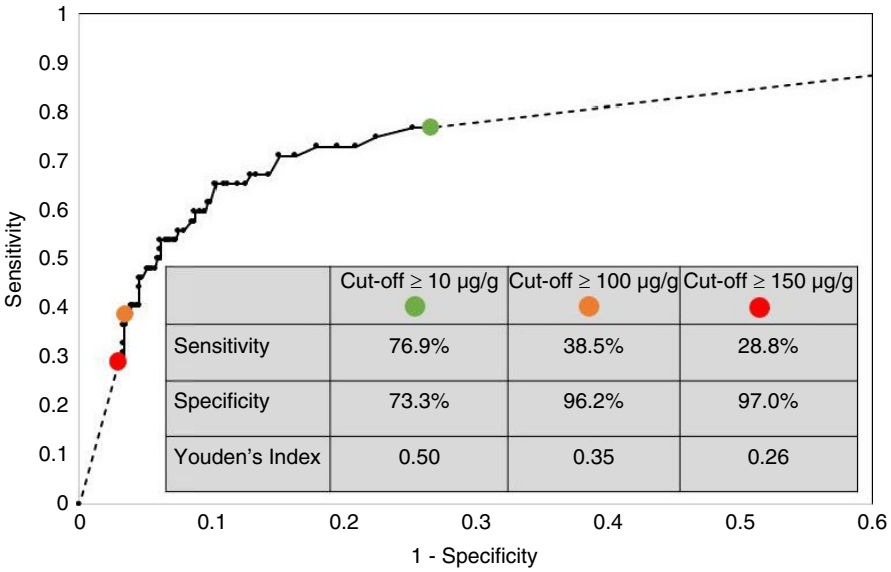

FIGURE 4 SBD ($n = 52$) ROC curve for QuikRead go®. Area under the curve (AUC) for SBD = 0.81 (95% confidence interval 0.74–0.88; $P < 0.01$)

via a digital rectal examination. Two studies have used this method for subsequent laboratory analysis [31, 32] and therefore in the POC scenario the analysis could be immediately after the clinical examination.

Within this study there were a total of 14 CRCs and eight non-CRCs from the included cohort of 553 patients. Although CRC diagnoses were lower than expected, 36% of the total cancers being non-CRCs is a concern. Given that FIT is validated for CRC, it is unsurprising that, of the non-CRC group, six of eight patients had a negative FIT. Lower gastrointestinal endoscopy cannot identify non-CRC diagnoses and therefore this poses an issue for such patients referred on the CRC pathway [1, 33]. The application of FIT could aid a clinician when considering clinical symptoms and which investigation pathway to select. This approach—to combine FIT results with clinical assessment—is recommended by Mowat et al. to better determine individual CRC risks for patients [34]. The availability of FIT during the initial assessment of symptoms would help prevent non-CRC patients from moving down the CRC pathway and delaying their diagnosis. In the knowledge that the negative predictive value of POC FIT is 99.7%, GPs could be confident in selecting alternative investigation pathways for their patients.

Although the sensitivity in this study was determined as high, the test will still have some false negative results. Safety-netting of those with negative FIT is encouraged, particularly as for many patients symptoms are short-lived. More than 50% of patients suffer with moderate to severe anxiety related to colonoscopy [35]. Those who have a negative FIT with resolved symptoms may avoid referral and ultimately avoid the anxiety of an unpleasant, potentially risky and costly colonoscopy. Symptoms of constipation (harder or less frequent stools) may also be seen as lower risk, as we found only one SBD and no CRCs in this group. If symptoms persist after safety-netting and remain concerning, referral to secondary care should still be made.

The lowest reportable value displayed by the QuikRead go® is currently 10 µg/g, which is recognized as the lower threshold to be used for symptomatic patients both in the DG30 update by NICE [7] and by NHS England in response to COVID-19 [26]. The NICE FIT study demonstrated better sensitivity of 97.0% for CRC when

TABLE 3 Primary definitive diagnoses with faecal haemoglobin (f-Hb) results categorised.

Diagnosis	Number (% of Subtotal)	f-Hb <10 μg/g (% within diagnosis)	f-Hb ≥10 and <150 μg/g (% within diagnosis)	f-Hb ≥150 μg/g (% within diagnosis)
Most important				
Serious Bowel Disease	52 (9.4%)	12 (23.1%)	25 (48.1%)	15 (28.8%)
Non-colorectal cancers	8 (1.4%)	6 (75.0%)	2 (25.0%)	0 (0%)
Minor neoplastic				
Low risk adenoma(s)	71 (12.8%)	47 (66.2%)	22 (31.0%)	2 (2.8%)
Inflammatory				
Other Colitis	13 (2.4%)	4 (30.8%)	6 (46.2%)	3 (23.1%)
Radiation Proctitis	9 (1.6%)	5 (55.6%)	3 (33.3%)	1 (11%)
Microscopic Colitis	6 (1.1%)	5 (83.3%)	1 (17%)	0 (0%)
Diverticulitis/Diverticular Stricture	10 (1.8%)	8 (80.0%)	2 (20.0%)	0 (0%)
Appendicitis	1 (0.2%)	1 (100%)	0 (0%)	0 (0%)
Perianal				
Haemorrhoids	21 (3.8%)	13 (61.9%)	6 (28.6%)	2 (15%)
Fibroepithelial Polyp	2 (0.4%)	2 (100%)	0 (0%)	0 (0%)
Miscellaneous				
Threadworm / spirochetosis / melanosis coli / rectocele	4 (0.7%)	4 (100%)	0 (0%)	0 (0%)
Diverticulosis	118 (21.3%)	87 (73.7%)	28 (23.7%)	3 (3%)
Normal colon, but benign upper gastrointestinal findings	15 (2.7%)	11 (73.3%)	4 (26.7%)	0 (0%)
Normal colon and no cause found for presenting complaint	223 (40.3%)	174 (78.0%)	45 (20.2%)	4 (2%)
Subtotal	553	379 (68.5%)	144 (26.0%)	30 (5%)
No definitive diagnostic outcome	76	60 (78.9%)	14 (18.4%)	2 (2.6%)
Total	629	439 (69.8%)	158 (25.1%)	32 (5.1%)

setting the cut-off threshold to 2 μg/g [2]. This came with the drawback of decreasing the specificity. For current guidelines, 10 μg/g as the lowest reported value is sufficient. We can see from Table 1 and Figure 3 that, if a cut-off were set at 10, 100 or 150 μg/g, the sensitivity for CRC of the QuikRead go® is reduced from 92.9% to 71.4% or 57.1% respectively. Under normal circumstances, these lower levels of sensitivity (using f-Hb 100 or 150 μg/g as cut-offs) would be unacceptable for detecting CRCs in the symptomatic population. However, where resources are very limited, as during the COVID-19 pandemic, the use of higher concentrations as a method of triage may have a role [1, 26].

Study limitations

This study was powered to report the diagnostic accuracy of the QuikRead go® POC analyser for CRC. A larger cohort with more CRC diagnoses would have offered a more precise confidence interval for the sensitivity of FIT in detecting CRC. Our study cohort had a lower number of CRCs than expected—2.5% in the included group and an overall detection rate from all those invited to the study of 2.2%. This further demonstrates the need for a better filter and triage of referrals to the TWW pathway from primary care [29]. Our sensitivity evaluation of SBD demonstrated a more precise confidence interval, and the diagnostic accuracy was comparable to expected values.

We recognize that colonoscopy, CT colonography and flexible sigmoidoscopy are themselves not 100% sensitive for CRC. The performance of these investigations is often operator dependent, and as a single-centre study this may affect translatability of the study outcomes. The caecal intubation success for our endoscopy unit during the study period was 94.83%, and reported inadequate bowel preparation ranged between 1.71% and 4.25% in the monthly reports. At the time of writing, it has been 10 months following the last recruitment date. No cancers have yet been identified that were not detected within the study. However, with regard to colonoscopy, missed CRCs can be reported up to 3 years later and the estimated false negative rate in England has been estimated as 7.4% [36].

CONCLUSIONS

This study has demonstrated the clinical utility of using FIT at the point of care to risk stratify patients. POC FIT may be used in

TABLE 4 Presenting complaints with f-Hb ≥10 μg/g, colorectal cancer (CRC) and combined serious bowel disease (SBD) likelihoods

Presenting complaint	Frequency (% of cases out of 553)	f-Hb ≥10 μg/g (% within presenting complaint)	Frequency of CRC (% within presenting complaint)	Frequency of SBD (% within presenting complaint)
All	553	174 (31.5%)	14 (2.5%)	52 (9.4%)
Anaemia (<13.5 g/l in men and <12 g/l in women)	71 (12.8%)	31 (43.7%)	5 (7.0%)	10 (14.1%)
Anaemia with confirmed low ferritin (<12 ng/l) or low iron (<15 μmol/l)	25 (4.5%)	10 (40.0%)	3 (12.0%)	6 (24%)
Per rectal bleeding	189 (34.2%)	76 (40.2%)	9 (4.8%)	25 (13.2%)
Any dark per rectal bleeding	22 (4.0%)	11 (50.0%)	6 (9.1%)	8 (36.4%)
Any mixed in stool	76 (13.7%)	35 (46.1%)	5 (6.6%)	13 (17.1%)
Separate to stool/on paper	113 (20.4%)	41 (36.3%)	4 (3.5%)	12 (10.6%)
Bright red only	167 (30.2%)	65 (38.9%)	3 (1.8%)	17 (10.2%)
Abdominal pain	146 (26.4%)	44 (30.8%)	6 (4.1%)	15 (10.3%)
Weight loss	81 (14.6)	23 (28.4%)	3 (3.7%)	8 (9.9%)
Change of bowel frequency	325 (58.8%)	89 (27.4%)	6 (1.8%)	27 (8.3%)
Alternating	53 (9.6%)	16 (30.2%)	2 (3.8%)	6 (11.3%)
More frequent	223 (40.3%)	62 (27.8%)	4 (1.8%)	20 (9.0%)
Less frequent	49 (8.9%)	11 (22.4%)	0 (0%)	1 (2.0%)
Change of consistency	344 (62.2%)	96 (27.9%)	6 (1.7%)	26 (7.6%)
Alternating	37 (6.7%)	11 (29.7%)	1 (2.7%)	3 (8.1%)
Looser/diarrhoea	257 (46.5%)	76 (29.6%)	5 (1.9%)	22 (8.6%)
Harder	50 (9.0%)	10 (20.0%)	0 (0%)	1 (2.0%)
Any change of bowel habit	368 (66.5%)	102 (27.7%)	6 (1.6%)	29 (7.9%)
More than 6 weeks	291(52.6%)	69 (23.7%)	5 (1.7%)	22 (7.6%)
Less than 6 weeks	77 (13.9%)	33 (42.9%)	1 (1.3%)	7 (9.1)
Mucus	22 (4.0%)	9 (40.1%)	1 (4.5%)	5 (22.7%)
Incontinence/leakage	32 (5.8%)	12 (37.5%)	1 (3.1%)	4 (12.5%)
Positive faecal occult blood test from primary care	38 (6.9%)	18 (47.4%)	1 (2.6%)	6 (15.9%)
Bloating/flatulence	46 (8.3%)	12 (26.1%)	1 (2.2%)	2 (4.3%)
Miscellaneous	87 (15.7%)	27 (31.0%)	2 (2.3%)	8 (9.2%)

conjunction with clinical assessment. Such application can effectively filter and triage referrals, rationalize investigations, protect endoscopy and radiology capacity, cut costs and improve efficiency within the TWW pathway.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

ETHICS APPROVAL

Ethics for the project were approved by the London South East Research Ethics Committee on 28 May 2019 (REC reference 19/LO/0889, IRAS ID: 260384).

PATIENT CONSENT

Patients were invited by post to participate. If they wished to do so, written consent was obtained from all participants.

REPRODUCTION FROM OTHER SOURCES

No other data sources were used that are not referenced in the paper.

CLINICAL TRIAL REGISTRATION

The study was registered on clinicaltrials.gov (identifier NCT04402424). The study was adopted onto the NIHR portfolio.

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SUPPORTING INFORMATION

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

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