Efficacy of digital health technologies in the management of inflammatory bowel disease: an umbrella review

Marco Gasparetto, Priya Narula, Charlotte Wong, James Ashton, Jochen Kammermeier, Marieke Pierik, Uri Kopylov, Naila Arebi

Lancet Digit Health 2025; 7: 100843

Published Online May 14, 2025 https://doi.org/10.1016/j.landig.2024.12.007

Norfolk and Norwich University Hospitals, Jenny Lind Children's Hospital, Norwich, Norfolk, UK (M Gasparetto MD); **Norwich Medical School, Faculty of Medicine and Health Sciences, University of East Anglia (UEA), Norwich, Norfolk, UK** (M Gasparetto); **Department of Paediatric Gastroenterology, Sheffield Children's NHS Foundation Trust, Sheffield, South Yorkshire, UK** (P Narula MD); **Department of Inflammatory Bowel Disease, St Mark's National Bowel Hospital, London, UK** (C Wong MBBS MSc, Prof N Arebi MD PhD); **Department of Metabolism, Digestion and Reproduction, Imperial College London, London, UK** (C Wong, Prof N Arebi); **Department of Paediatric Gastroenterology, Southampton Children's Hospital, Southampton, UK** (J Ashton MD PhD); **Human Genetics and Genomic Medicine, Faculty of Medicine, University of Southampton, Southampton, UK** (J Ashton); **Department of Paediatric Gastroenterology, Evelina London Children's Hospital, London, UK** (J Kammermeier MD PhD); **Department of Gastroenterology-Hepatology, Maastricht University Medical Center, Maastricht, Netherlands** (Prof M Pierik MD PhD); **School of Nutrition and Translational Research in Metabolism, Maastricht University, Maastricht, Netherlands** (Prof M Pierik); **IBD service, Department of Gastroenterology, Sheba Medical Center, Tel Hashomer, Israel** (Prof U Kopylov MD)

Correspondence to: Prof Naila Arebi, Department of Inflammatory Bowel Disease, St Mark's National Bowel Hospital, London NW10 7NS, UK **naila.arebi@imperial.ac.uk**

The use of digital health technology (DHT) is increasing worldwide. Clinical trials assessing available health tools for the management of patients with inflammatory bowel disease (IBD) are sparse, with limited evidence-based outcome data. In this umbrella review, we investigated the effectiveness of DHT in the care of patients with IBD and identified areas for future research following the Joanna Briggs Institute methodology. Systematic reviews published between January, 2012, and September, 2024, were identified through searches across nine databases (Ovid Embase, Ovid MEDLINE, ProQuest PsycINFO, Epistemonikos, Cochrane, Health Evidence, DoPHER, PROSPERO, and CINAHL via EBSCO), and the results were imported into Covidence software. Inclusion criteria included systematic reviews of randomised controlled trials (RCTs) involving patients of all ages with Crohn's disease or ulcerative colitis, using DHT for diagnostics, treatment support, monitoring, self-management, or increasing participation in research studies, compared with standard care or alternative interventions. Outcomes included the efficacy and effectiveness of digital interventions, as reported in the studies. The primary outcome was clinical efficacy reported as one or more of the following: clinical response or remission, disease activity, flare-ups or relapses, and quality of life. Secondary outcomes included medication adherence, number of health-care visits, patient engagement (satisfaction and adherence or compliance with interventions), attendance for all terms of engagement, rate of interactions, knowledge improvement, psychological outcomes, and cost or cost–time effectiveness. The review protocol was registered in PROSPERO (registration number: CRD42023417525). AMSTAR-2 was used for methodological quality assessment. Nine relevant reviews were included, including five with meta-analyses comprising 13–19 RCTs in each review; four reviews were rated as high quality and five as critically low quality. DHT was not directly beneficial in achieving or maintaining clinical remission in IBD. In four trials, DHT use was associated with a reduced number of hospital attendances and increased treatment adherence, supporting its role as an adjuvant to standard clinical practice in IBD. Although current evidence from several RCTs and systematic reviews does not indicate better clinical outcomes with DHT in maintaining IBD remission and reducing relapse rates, DHT could be used as an adjuvant resource contributing towards treatment adherence and reducing hospital visits.

Introduction

Digital health technologies (DHTs) are increasingly used to support clinical care, increase accessibility to health care, and improve health outcomes in many chronic diseases, including inflammatory bowel disease (IBD).[1] Technologies accessible to patients, parents, caregivers, and health-care professionals can facilitate seamless care and innovative ways of delivering and improving care.

Digital technology in health care refers to digital products intended to benefit people or the wider health and social care systems. These digital products include smartphone apps; standalone software; online tools for treating or diagnosing conditions, preventing ill health, and improving system efficiencies; and programmes that can be used to analyse data from medical devices, such as scanners, sensors, and monitors.[2] The term telemedicine or telehealth encompasses interactions between patients and health-care providers using one or more such tools.

The rising global prevalence of IBD has placed a huge burden on health-care systems owing to the increasing use of health-care resources by patients.[3] In recognition of the challenges in delivering affordable health care, the *Lancet* Commission on the cost of IBD in high-income settings[3] identified a pressing need to include complementary methods, such as electronic tools, to deliver health care. One advantage of digital technology in supporting patient–provider communication and disease monitoring is the facilitation of task shifting of care, allowing increased involvement of nurses and pharmacists in treatment monitoring.[3] Furthermore, youth born in the era of rapid technological advances have an inherent aptitude for digital technology, making digital health an acceptable and attractive option for health-care access. Some digital health interventions have been partly adopted despite the speculative evidence supporting their role in improving outcomes in IBD.[4] The diverse types of interventions and outcomes studied might account for the uncertainty of benefits. For instance, in an early multicentre study with a web-based intervention to guide treatment in ulcerative colitis, quality of life (QoL) improved only in patients living in Denmark and not in Ireland.[5] In a large Dutch study using a telemedicine system called myIBDcoach, the QoL at 1 year was similar to that of the standard care group.[6] Despite the growing adoption and breadth of research using DHT, evidence supporting the clinical effectiveness of DHT in IBD management remains inconclusive.

In this umbrella review of systematic reviews, we aimed to evaluate the effectiveness of DHT in the management of IBD by summarising the benefits and limitations reported in existing systematic reviews as a mixed-method review (narrative and quantitative). We included study interventions, tools, and services covering the patient journey, including

diagnostics, treatment support, monitoring, self-management, and participation in research studies; use of transformative approaches, such as virtual reality; and use of information communication technologies, including mobile applications, social media, chatbots, and electronic portals, with the perspective of patients as stakeholders. We believe that this evidence will help to identify research gaps in DHT for IBD, guiding future studies.

Methods

Review question(s)

The primary research question was to evaluate the effectiveness of DHT on clinical outcomes in IBD. The secondary questions were related to understanding the nature and effects of DHT in IBD, including the types of DHT studied, frequency and duration of use, types of clinical outcomes studied, and potential differences in the effectiveness of DHT related to different specific types of DHTs, such as web-based portal or mobile applications, and different IBD groups such as Crohn's disease versus ulcerative colitis, young versus older adults, and presence or absence of involvement of health-care professionals.

Inclusion criteria

This umbrella review was conducted following the Joanna Briggs Institute (JBI) methodology,[7,8] and the study protocol was aligned with the PRISMA-P 2015 statement.[9–11] The inclusion criteria were established using the population, intervention, comparator, outcomes, and study design framework to define the scope of this review.[7–15] The study population included patients of all ages diagnosed with Crohn's disease, ulcerative colitis, or IBD. In terms of intervention, the search terms were selected to capture digital technology applications within the review scope, including diagnostics, treatment support, monitoring, self-management, participation in research studies, virtual reality, mobile applications, social media, chatbots, and electronic portals; the complete list of search terms is provided in the appendix (pp 10–18). The comparator included standard care or alternative interventions—namely, self-management guidance or educational interventions. Outcomes related to efficacy and effectiveness in digital interventions were assessed as reported in the included studies. Primary efficacy outcomes included QoL, clinical response or remission, disease activity, and flare-ups or relapses. Secondary outcomes included medication adherence, number of health-care visits, patient engagement (satisfaction and adherence or compliance with interventions), attendance across engagement terms, rate of interactions, knowledge improvement, psychological outcomes, and cost or cost–time effectiveness, such as incremental cost-effectiveness ratios, average cost-effectiveness ratios, benefit–cost ratios, and unit costs. Qualitative outcomes describing the nature of interventions were included only for studies that reported quantitative meta-analysis results with effect sizes. Reviews in which references to conditions other than IBD could not be distinguished were excluded. Meta-analyses that lacked specific study data (eg, number of incident events, study population, follow-up period, relative risks, and 95% CIs) and for which missing data could not be retrieved from the original studies were included only in the narrative review.

See Online for appendix

Exclusion criteria

We excluded technologies solely used by health-care professionals, such as radiology and endoscopy technologies for lesion differentiation or diagnostic outcomes, electronic health records, and health-care administrative systems. We also excluded reviews examining artificial intelligence algorithms.

Study screening

Relevant publications were identified through a series of electronic searches across nine databases from January, 2012, to September, 2024. Search results were imported into Covidence software. Duplicates were removed automatically and manually based on an exact match of title, date, author, and result. Two reviewers (NA and MG) independently screened titles and abstracts of the retrieved articles according to the inclusion and exclusion criteria. When eligibility could not be determined based on the title or abstract, full texts were assessed. Disagreements between reviewers were resolved through consensus or by consulting a third reviewer (PN). The third reviewer (PN) independently assessed titles, abstracts, and full texts of studies with unresolved discrepancies between the two primary screeners (NA and MG). A final decision regarding inclusion or exclusion was made following a discussion among all three screeners.

Data extraction

Standardised extraction forms were developed in Microsoft Excel. Two reviewers (NA and MG) independently extracted data from each eligible systematic review. The data extraction form is provided in the appendix (p 22). Ambiguities in data extraction were resolved through discussion or consultation with a third reviewer (PN) when consensus could not be reached.

The following data were extracted: characteristics of included reviews (eg, first author, publication year, number and type of studies included in each review, and total sample size), population characteristics (disease conditions), intervention and control descriptions (type of digital intervention or control, sample size of each group, intervention details, and follow-up duration), and outcomes (name and definition of outcome, summary effect size with corresponding 95% CI, and number of participants included in outcome assessments). All extracted data were available in text format, which eliminated the need to estimate effect sizes from plots using Ycasd software, as initially planned.[16]

Quality of study assessments

The methodological quality of the included reviews (denoted as [Q=] in the Results) was independently assessed by two

reviewers (NA and MG) using AMSTAR-2.[17] Disagreements were resolved by consulting a third reviewer (PN). The tool consists of 16 items, each rated as yes, partially yes, or no. Depending on the score and balance of critical and non-critical flaws in the article, reviews were classified as high quality, moderate quality, low quality, or critically low quality.

The following AMSTAR-2 critical domains were determined a priori: protocol registered before the commencement of the review; adequacy of the literature search; justification for excluding individual studies; risk of bias from individual studies being included in the review; appropriateness of meta-analytical methods; consideration of risk of bias when interpreting the results of the review; and assessment of presence and likely impact of publication bias.[17]

A recommended framework for interpreting weaknesses in critical and non-critical items was applied to determine confidence levels (appendix pp 24–25).[17] Appraisers decided a priori on the most relevant items for assessing the reviews under consideration.

Data synthesis and statistical analysis

For reviews in which data were not limited to IBD, individual study effect sizes, CIs, and sample sizes were extracted, and the pooled effect size was calculated for IBD-specific studies. For other studies, effect sizes were collated as differences from the control arm. Since outcome measures varied across studies, in this umbrella review, we included only the predefined outcome measures that were consistently reported across studies.

The review protocol was registered in PROSPERO, CRD42023417525.

Results

The literature search retrieved 69 studies for title and abstract screening (figure). Three duplicates were removed. Of the remaining 66 studies, 43 were excluded based on title and abstract screening. The full texts of the remaining 23 studies were assessed independently by two authors (NA and MG). A third reviewer (PN) was involved in five cases for which disagreements arose regarding inclusion or exclusion after full-text review. Nine systematic reviews met the inclusion criteria for this umbrella review. The study inclusion process is summarised in the PRISMA flowchart (figure).[18,19] A list of excluded papers and the reasons for their exclusion are provided in the appendix (p 1).

Data were extracted by two independent authors for the nine included systematic reviews (five meta-analyses). A third author verified and merged the extracted data.

We used the JBI critical appraisal checklist to determine the methodological quality of the studies.[7,8] Four reviews were rated as high quality and five as critically low quality. Complete details of the quality assessment are presented in the appendix (p 2).

Table 1 presents the characteristics of the five meta-analyses,[20–24] and table 2 details the four systematic reviews without meta-analyses.[4,25–27] Additional information

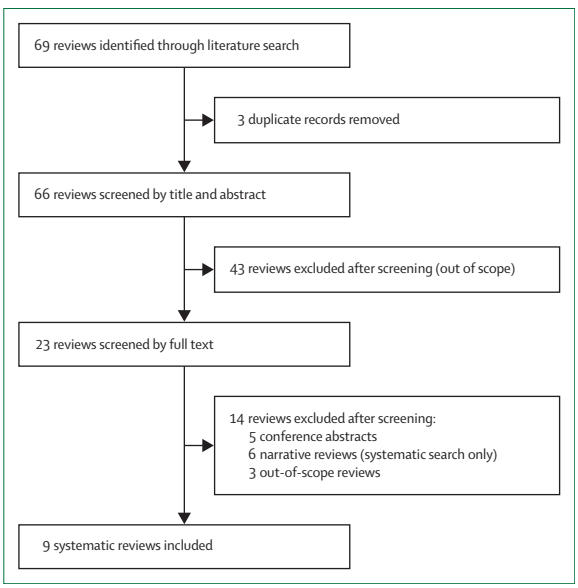

Figure: **PRISMA flow chart summarising the systematic review inclusion process.**

pertaining to the studies is presented with descriptive summaries of the main findings in each review and provided in the appendix (pp 3–7). The AMSTAR-2 quality ratings for the included systematic reviews are denoted as "(Q=)" in the following sections.

Only five systematic reviews[20–24] reported results as meta-analyses using primary effectiveness outcomes such as QoL, clinical response or remission, disease activity, and relapse rates. The effectiveness outcomes are reported as they were presented in the published systematic reviews for IBD-related QoL. For disease activity, we grouped reviews that described disease severity and relapse frequency. Only two reviews[20,24] reported remission rates as an outcome (table 3).

Overall, substantial heterogeneity (I^2) in effect sizes for QoL was observed in studies reporting intervention benefits, reducing confidence in the certainty of the effects. In their review, Gordon and colleagues[21] (Q=high) assessed the quality of evidence by scoring the risk of bias and applying the Grade of Recommendations, Assessment, Development, and Evaluation (GRADE) framework to evaluate effect sizes.[28] The findings suggested, at best, no superiority of the intervention over usual care, with moderate certainty in evidence for the adult population.

Although QoL could not be assessed in the systematic review by Rohde and colleagues[23] (Q=critically low), as the effect size included other conditions such as irritable bowel syndrome (IBS) and coeliac disease, positive differences of 0·25 (95% CI 0·06–0·43) were identified by Hunt and colleagues[29] and 1·33 (0·47–2·18) by Walmsley and colleagues,[30] albeit with wide CIs. In their systematic review with meta-analysis, Kuriakose Kuzhiyanja and colleagues[24] (Q=high) found improved QoL in the e-health intervention arm compared with that in the standard care arm.

	Population type and age	Number of RCTs	Population size	Type of intervention	Duration of intervention	Comparator
Pang et al (2022)[20]	Children and adults with IBD; age range 12–69 years	17; 4 RCTs in paediatric population (age <19 years); 13 studies in adult population (age ≥19 years)	2571	Telemedicine: telephone, internet, mobile phone and web-based applications, SMS text messaging, email, telephone calls, telemonitoring, and tele-education through a web-based system using smartphone and tablet apps, CBT delivered online, and teleconsulting through real-time images	6–96 weeks	Standard care or usual care provided by the medical centre according to IBD treatment guidelines
Gordon et al (2022)[21]	Children and adults with IBD; age range 8–95 years	19	3489	IBD telehealth management: telephone, instant messenger, video, text message, and web-based services	8–12 weeks	Usual care according to IBD treatment guidelines; sham web-based interventions; self-screening; face-to-face monitoring
Huang et al (2014)[22]	Adults with IBD (age >16 years); mean age range 41·7–49·0 years	16	1463	Distance management interventions: telemedicine, web-based intervention, telephone clinics, patient-directed open access clinics, and other methods that incorporate patient self-management strategies for remote management of patients	48 weeks	Standard clinic follow-up as per the institutional protocol at the time of the study
Rohde et al (2021)[23]	Adults and adolescents with chronic gastrointestinal disorders: IBD, IBS, coeliac disease; mean age range 14·9–49·11 years	19; 13 studies related to IBD	2618	GI e-health interventions: educational text messages (telemedicine), online self-management portals and home units, self-management online coaching modules, web-based mobile disease management platforms, email reminders for self-management, digital CBT, and smartphone apps for disease management	Median 52 weeks (6–104)	Standard clinical care as per the institutional protocol at the time of the study
Kuriakose Kuzhiyanja et al (2023)[24]	Children and adults with IBD; age range 8–95 years	14 RCTs; 3 studies in paediatric population (age <18 years); 11 studies in adult population (age >18 years)	3111	E-health interventions including virtual clinics, telephone consultations, remote monitoring, or any web-based health platform for IBD management	6–24 months	Standard care for IBD, based on evidence-based guidelines—including initial assessment, guideline compliant therapies, planned and urgent office visits, and supply of educational leaflets for patients as required

CBT=cognitive behavioural treatment. GI=gastrointestinal. IBD=inflammatory bowel disease. IBS=irritable bowel syndrome. NA=not applicable. RCT=randomised controlled trial.

Table 1: **Baseline characteristics of five systematic reviews that included a meta-analysis**

Secondary outcomes related to medication adherence are also reported as presented in the systematic reviews; clinic visits and hospital attendance were grouped (table 3). An overall reduction in outpatient and hospital visits was observed; however, the heterogeneity for effects is high, with I^2 ranging between 85 and 89 in three of the five reviews. Likewise, medication adherence improved with the intervention in two reviews. However, no difference was found in the third review[20] (Q=high), which reported marked heterogeneity in effect sizes.

Four systematic reviews[4,25–27] included quantitative data but did not pool outcomes to estimate an overall effect. In the systematic review by Knowles and Mikocka-Walus[25] (Q=critically low), the effects of mental health interventions on gastrointestinal disorders were reported. Since the findings were outside the scope of the review, we focused on the results of interventions related to gastroenterology care within controlled study designs.

Three RCTs on IBD (n=397; 212 [intervention] *vs* 185 [standard care]) were identified.[5,31,32] Elkjaer and colleagues[5] reported significant differences between the intervention and standard care groups in compliance (451·20) and patient knowledge (Crohn's and Colitis Knowledge Score 5·16). The median relapse duration was 18 days (95% CI 10–21) in the intervention group versus 77 days (46–108) in the control group. The number of acute and routine outpatient visits was lower in the digital health group than in the control group.

The second study[31] was an RCT of home telemanagement for ulcerative colitis versus best available care for adults (mean age 41 years [SD 14]). No significant differences were observed for disease activity, QoL, or adherence during the 12-month follow-up period (date not shown). The third RCT[32]

	Population type	Included studies	Number of RCTs and population size	Type of intervention	Comparator
Knowles and Mikocka-Walus (2014)[25]	Adolescents and adults with chronic gastrointestinal disorders: IBD, IBS, and coeliac disease	17 (observational and RCTs)	3 on IBD; n=397	Internet-based e-health technology to promote physical and psychological wellbeing	Standard of care for clinical management and monitoring
Helsel et al (2018)[26]	Adult and paediatric patients with chronic gastrointestinal disorders	11	3 related to IBD; n=1133	Mobile health technology interventions, including mobile apps, responsive websites, and other telemedicine methods, that focus on digestive disease symptoms and management	Standard of care for clinical management and monitoring
Gohil et al (2022)[27]	Adults and children with IBD	7 studies; 3 RCTs in population aged >18 years; age not specified in 1 RCT (mean age 43·6 years); 1 RCT in population aged ≥8 years; 1 RCT in population aged 11–18 years; 1 RCT in population aged 10–17 years	7 related to digital health technology; children n=180 children; adults n=1160	Online educational resources or courses, telemedicine, automated reminder text messages, electronic needle container	Standard of care for clinical management and monitoring
Nguyen et al (2021)[4]	Children and adults with IBD	14 studies; 9 RCTs in adults; 1 RCT in population aged 8–16 years; 2 RCTs in population aged 10–17 years; 1 RCT in population aged 10–19 years; 1 RCT in population aged >8 years	14; n=2637	Web-based interventions, mobile apps, and telemedicine with phone consultations offering educational resources or courses	Standard of care for clinical management and monitoring

IBD=inflammatory bowel disease. IBS=irritable bowel syndrome. RCT=randomised controlled trial.

Table 2: **Baseline characteristics of four systematic reviews that did not include a meta-analysis**

involved an older population (mean age in the intervention group 62·8 years [SD 11·5]; mean age in the control group 58·5 years [9·6]) with a 9-month follow-up. No significant differences were reported for primary or secondary outcomes.

The systematic review by Helsel and colleagues[26] (Q=critically low) included gastrointestinal disorders beyond IBD, such as IBS and colorectal cancer. Outcomes included disease activity, treatment compliance, patient satisfaction, and QoL. Three RCTs focused on IBD.[5,6,33] McCombie and colleagues[33] evaluated cognitive behavioural therapy for IBD rather than a gut-focused intervention, making it irrelevant to the scope of the current review.

Two RCTs reported outcomes for disease activity and QoL. Elkjaer and colleagues[5] reported the effect on disease activity with an Simple Clinical Colitis Activity Index score in 333 patients with IBD randomised to web-based management or usual care (control group) and showed an overall improvement (≤5; OR 2·74) compared with that in the controls. de Jong and colleagues[6] reported that only the mean number of hospital admissions was significantly lower in the telemedicine (n=16) group than in the standard care (n=29) group (estimated intervention effect –0·05 [95% CI –0·10 to 0·00]; p=0·046). However, no other significant outcomes were observed. For QoL outcomes, both disease-specific and general QoL improved in the web group compared with those in the control group: disease-specific QoL (OR 1·57; p=0·04), general QoL (p=0·009), vitality (p=0·03), role emotional (p<0·0001), and social functioning (p=0·002).[5] Conversely, in the larger RCT by de Jong and colleagues,[6] QoL did not differ between telemedicine (baseline: 53·34 [SD 10·29]; 12 months: 54·44 [SD 9·05]) and standard care (baseline: 53·42 [SD 9·95]; 12 months: 53·71 [SD 9·87]) groups (estimated intervention effect: 1·22 [95% CI –0·04 to 2·49; p=0·057]). This disparity could be attributed to differences in the mode of intervention delivery, with one study using a mobile phone platform,[6] whereas another implemented a web-based application.[5]

The systematic review by Gohil and colleagues[27] (Q=critically low) was restricted to assessing the effect on one outcome measure,—namely medication adherence, and included seven RCTs, three of which were paediatric studies (n=180). The duration of the intervention (12 months) was only reported in one adult study[6] and one paediatric study[34] (four sessions: 60–90 min for the first session, and 45 min each for the remaining sessions). In contrast, the follow-up duration reported in all the studies ranged between 1 month and 1 year. The nature of interventions is described as behavioural for two paediatric studies[35,36] and cognitive behavioural in the third one.[34] The adult studies were multicomponent interventions[6,37,38] and educational.[39] A detailed narrative on the relationship between different interventions and outcomes is included in the appendix (pp 28–29).

The fourth systematic review by Nguyen and colleagues[4] assessed the use of DHT for remote monitoring and management of IBD across 14 RCTs. The studies were highly heterogenous with mixed findings as summarised in the appendix (pp 6–7). Three of the studies investigated the role of DHT in paediatric and adolescent populations,[40–42] yet none showed any statistically significant difference for QoL, disease activity, relapse rates, or

	Number of RCTs	Number of participants	Effect size and results, SMD (95% CI; p value)	Heterogeneity, I^2	Comment or conclusions
Primary outcomes					
IBD-related QoL					
Pang et al (2022)[20]	10	1632	0·18 (0·01 to 0·34; p=0·03)	47	Telemedicine associated with higher QoL than standard care
Gordon et al (2022)[21]	19	Web-based disease monitoring n=594; usual care n=505	0·08 (−0·04 to 0·20)	Certainty: moderate	Web-based disease monitoring is probably equivalent to usual care
Huang et al (2014)[22]	3	338	Mean difference 16·30 (12·36 to 20·24; p<0·0001)	96	Electronic telemanagement system significantly improved QoL
Rohde et al (2021)[23]	19	2126	Includes other conditions	NA	Unable to dissect effect size from other gastrointestinal conditions
Kuriakose Kuzhiyanja et al (2023)[24]	6	1422	0·2 (0·05 to 0·35; p=0·008)	I^2=36	Higher QoL in the e-health intervention group than that under standard care
Disease activity					
Pang et al (2022)[20]	7	955	0·08 (−0·09 to 0·24; p=0·38)	0	No significant difference between telemedicine and standard care
Gordon et al (2022)[21]	19	Web-based disease monitoring n=254; usual care n=174	0·09 (−0·11 to 0·29)	Certainty: moderate	Web-based disease monitoring is probably equivalent to usual care in reducing disease activity
Huang et al (2014)[22]—number of relapses	4	450	0·33 (0·15 to 0·51; p=0·0007)	75	Electronic web-based distance management did not affect the number of relapses
Kuriakose Kuzhiyanja et al (2023)[24]	5	495	0·09 (−0·09 to 0·28; p=0·32)	0	No difference between e-health intervention and standard care
Remission					
Pang et al (2022)[20]	7	955	RR 0·94 (0·83 to 1·05; p=0·26)	6	No significant difference in intervention group between telemedicine and standard care
Kuriakose Kuzhiyanja et al (2023)[24]	5	603	OR 1·12 (0·78 to 1·61)	0	No difference between e-health intervention and standard care
Secondary outcomes					
Clinic or hospital visits					
Pang et al (2022)[20]—visits per patient	6	1479	−0·71 (−1·07 to −0·36; p<0·001)	85	Significantly lower in the telemedicine group than in the standard care group
Gordon et al (2022)[21]	..	..	..	..	Meta-analysis not possible
Huang et al (2014)[22]—visits per patient)	5	Telemanagement n=156; directed open-access clinic (control) n=386	−0·57 (−0·83 to −0·30; p<0·00001)	89	Electronic telemanagement reduced the number of visits per year patient
Rohde et al (2021)[23]—hospital visits	19	1176	Effect size d=0·78 (0·24 to 1·33)	88·56	Moderate effects on reducing the number of IBD patient visits to the clinic or hospital relative to control
Kuriakose Kuzhiyanja et al (2023)[24]	..	..	..	..	Meta-analysis not possible
Outpatient visits	6	984	RR 0·85 (0·78 to 0·93; p=0·0003)	22	Considerably fewer clinic visits in the e-health intervention group than those under standard care
Emergency visits	5	931	RR 0·70 (0·51 to 0·95; p=0·02)	0	Considerably fewer emergency visits in the e-health intervention group than those under standard care
Hospitalisations	4	767	RR 0·82 (0·52 to 1·29; p=0·38)	0	No difference in IBD-related hospitalisations between the e-health intervention group and the group managed with standard care
Medication adherence					
Pang et al (2022)[20]—compliance score	5	1169	0·11 (−0·09 to 0·30; p=0·27); relative risk 1·29 (0·77 to 2·17; p=0·33)	19; 88	No significant difference between telemedicine and standard of care
Gordon et al (2022)[21]	19	Web-based disease monitoring n=340; usual care n=331	MD 0·24 (0·01 to 0·47)	Certainty: moderate	Web-based disease monitoring probably leads to slightly higher medication adherence than that under usual care
Rohde et al (2021)[23]	19	1072	Effect size Cohen's d 0·17 (0·04 to 0·31)	0	Small effect on increased medication adherence relative to control
IBD knowledge					
Kuriakose Kuzhiyanja et al (2023)[24]	2	890	0·23 (0·10 to 0·36; p=0·0008)	0	Increased IBD knowledge in the e-health intervention group

(Table 3 continues on next page)

	Number of RCTs	Number of participants	Effect size and results, SMD (95% CI; p value)	Heterogeneity, I^2	Comment or conclusions
(Continued from previous page)					
Self efficacy					
Kuriakose Kuzhiyanja et al (2023)[24]	2	893	−0·09 (−0·22 to −0·05; p=0·21)	0	No difference between e-health intervention and standard care
IBD-related surgery					
Kuriakose Kuzhiyanja et al (2023)[24]	2	714	RR 0·87 (0·44 to 1·72; p=0·68)	0	No difference between e-health intervention and standard care
Endoscopic procedures					
Kuriakose Kuzhiyanja et al (2023)[24]	3	565	RR 1·00 (0·77 to 1·31; p=0·98)	0	No difference between e-health intervention and standard care
Corticosteroid use					
Kuriakose Kuzhiyanja et al (2023)[24]	2	366	RR 0·97 (0·47 to 1·98; p=0·93)	0	No difference between e-health intervention and standard care

I^2=heterogeneity (values of 0–40%: might not be important; 30–60%: might represent moderate heterogeneity; 50–90%: might represent substantial heterogeneity; and 75–100%: considerable heterogeneity). IBD=inflammatory bowel disease. MD=mean difference. NA=not applicable. OR=odds ratio. QoL=quality of life. RCT=randomised controlled trial. RR=relative risk. SMD=standardised mean difference.

Table 3: **Summary of findings**

treatment adherence. Two of the three paediatric studies reported lower costs for DHT compared with usual care as face-to-face encounters.[41,42]

The summary of findings table (table 3) suggests that digital technology interventions do not significantly influence disease activity or clinical remission but might reduce outpatient and hospital visits and improve medication adherence and QoL.

Most of the systematic reviews without meta-analyses listed in the panel and appendix (pp 5–7) included non-RCTs, which explains why a meta-analysis could not be performed. Although such studies offer valuable insights into the nature of the intervention, they are too biased to draw any conclusions about the effect of the intervention. Therefore, we focused on RCTs within the systematic reviews to gauge the effects.

Key observations include that the systematic review by Knowles and Mikocka-Walus[25] (Q=critically low) included three RCTs but did not reveal consistent benefits, with more negative than positive findings reported. Helsel and colleagues[26] (Q=critically low) included two RCTs showing benefits for disease activity and fewer hospital visits but conflicting QoL outcomes; one RCT showed improvement in disease-specific and general QoL,[5] whereas the other reported no differences.[6] The effect of interventions on medication adherence appeared more promising in paediatric populations than in adult populations but was not sustained beyond 20 weeks. Two of three RCTs in the systematic review by Gohil and colleagues[27] (Q=critically low) reported benefits for medication adherence. In contrast, Nguyen and colleagues[4] (Q=critically low) summarised the findings of all RCTs and suggested a possible decrease in the overall health-care utilisation, mainly hospital visits and health-care costs, but no effect on IBD-related disease activity, QoL, or treatment adherence. The review by Nguyen and colleagues[4] offers valuable insights into the limitations of interpreting findings from many studies, wherein the risk of bias tool was applied to each study included:[43] of 14 studies, only three trials met all five criteria for low risk of bias;[37,44,45] most trials carried concerns and a high risk of bias affecting the conclusions that can be confidently drawn for most outcomes.[5,6,37,44,45] The certainty of evidence for each outcome was assessed using the GRADE framework.[28] In the overall GRADE assessment, the effect of interventions was either of low or very low certainty. None of the reviews reported on the potential harms of DHT, and this outcome was not mentioned in any of the included studies.

Discussion

In this umbrella review, we evaluated the effect of digital technologies on IBD care and patient outcomes. While digital technology contributes to reduced IBD-related hospital visits, data from multiple RCTs and systematic reviews show no superiority in achieving or maintaining IBD remission. Methodological limitations in existing RCTs and systematic reviews present an opportunity for future research to re-examine the questions with stronger evidence.

The main limitations of the systematic reviews analysed in our umbrella review include heterogeneity in clinical domains and patient populations; variability in intervention types, frequency, and duration; and inconsistencies in measurement metrics, which hindered meta-analyses and quantitative assessments of the effect of digital technology in this context. A high risk of reporting bias due to the absence of blinding across all studies, reliance on patient-reported outcomes subject to recall bias, small sample sizes affected by attrition, and short follow-up durations that could underestimate the long-term effectiveness of digital technology were also noted. Additionally, most studies did not account for social and demographic factors, including ethnicity, language, digital access, and literacy, which could influence the use of digital technology.

We, therefore, recommend that future RCTs assess standardised interventions by defining types, frequency, and duration; incorporate long-term follow-up (ideally at

Panel: **Summary of findings for systematic reviews that did not include a meta-analysis**

Knowles and Mikocka-Walus (2014)[25]
- Assessed an internet-based e-health technology to promote physical and psychological wellbeing.
- Suggested e-health is a promising tool for disease management.
- Three RCTs measured different outcomes and reported conflicting findings.

Helsel et al (2018)[26]
- Assessed telemedicine and mobile health technology in managing disease activity, symptom monitoring, compliance to treatment protocols, and communication between patients and providers.
- The results from IBD studies suggest high medication adherence and good patient satisfaction. However, results on disease activity and QoL are conflicting.
- Conclusions cannot be drawn due to different outcome measures and timepoints used to compare outcomes before and after intervention *vs* standard care.

Gohil et al (2022)[27]
- Assessed interventions to enhance medication adherence and their effectiveness in enhancing care.
- Digital technologies led to improvement in medication adherence.
- Conclusions cannot be drawn due to the poor quality of the studies included and the absence of statistical data (only one study met all five MMAT criteria).

Nguyen et al (2021)[4]
- Assessed digital health technologies for clinical management and monitoring and reporting the effect on IBD activity, treatment adherence, QoL, health-care utilisation, and cost-effectiveness.
- The review found mixed results from highly heterogeneous studies.
- Although the review summarises the possibility of digital interventions to improve outcomes, the majority of studies did not show clear benefits.
- All the included studies used a web-based or mobile phone-based tool to monitor adherence or remission rates.
- The effect on disease activity was examined in ten of 14 studies (comprising 1301 of 2637 patients) in this review and no statistical difference was observed between the control and intervention groups for improving disease activity.
- QoL interventions and cost-effectiveness measures were approximately 30–40% effective.
- Medication adherence was improved in four of seven studies.
- Overall, digital interventions showed inconsistent utility across all measured areas. Medication adherence showed the most success but was assessed in the fewest studies.

IBD=inflammatory bowel disease. MMAT=mix methods appraisal tool. QoL=quality of life. RCT=randomised controlled trial.

least 2 years) to evaluate sustained effectiveness; ensure adequate sample sizes to mitigate attrition rates; and implement randomisation strategies that can minimise social and demographic factors, including access to digital technologies. Moreover, establishing a defined set of relevant outcomes would enhance consistency across future RCTs, including measures such as disease activity, clinical steroid-free remission, unplanned hospital or clinic attendances due to IBD relapse, IBD-related QoL, medication adherence, and patient satisfaction.

On the basis of the preliminary evidence available, future research should focus on assessing non-inferiority rather than the superiority of digital technology compared with that of standard care. Despite intrinsic study limitations, findings from RCTs to date support the role of digital technology as an adjunct to standard care. While emerging technologies are increasingly integrated into real-world IBD management, current evidence primarily describes their role in complementing and, in some cases, improving standard clinical care. However, existing trials have not provided evidence of a direct benefit of digital technology in achieving or maintaining clinical remission. Nevertheless, improving study designs is essential to improve validation and generate high-quality evidence in this field.

In this regard, a James Lind Alliance Priority Setting Partnership on DHT for children and young people with IBD, conducted in the UK between 2021 and 2023, helped to identify 18 priority areas for future research, including access to health information, disease education, emotional support, notification of results, communication with health-care professionals, transition of care, disease monitoring, and real-world research.[46]

Until new trials address the priorities, digital technology and telemedicine should be regarded as important adjuncts to standard clinical practice. Future research will help to identify the patient populations that might derive the greatest benefit from digital technology and telemedicine, facilitating tailored health-care strategies.

Collectively, this umbrella review provides up-to-date, evidence-based recommendations on the use of digital

technology in IBD care while also acknowledging the strengths and limitations of the analysis. Strengths include the application of a rigorous and reliable methodology, including clear definitions of digital technology, well-defined inclusion and exclusion criteria for literature selection, systematic data extraction, quantitative study assessment, and quality appraisal of the included systematic reviews. Limitations include the exclusion of studies not published in English and those published before 2012. The intrinsic limitations of the included RCTs and systematic reviews influence the strength of the available evidence and the key conclusions of this work, particularly regarding the lack of observed superiority of digital technologies in inducing and maintaining IBD remission. However, the limitations do not compromise the methodological rigour of this umbrella review or its ability to synthesise existing evidence objectively and provide meaningful recommendations for future research.

In summary, while our umbrella review offers evidence to support the use of DHT to reduce IBD-related hospital visits, it does not show significant or consistent benefits of using DHT for disease activity, QoL, and medication adherence. Additionally, the evidence in children is insufficient to draw definitive conclusions. The quality of the included systematic reviews (AMSTAR-2)[17] was high (no critical or minor flaws) for four systematic reviews[20–22,24] and critically low (more than one critical flaw) for the fifth review that included a meta-analysis.[23] However, the main limitation is the inability to recognise the complexity of DHT as an intervention, with few studies in the systematic reviews offering sufficient detail to allow a better understanding of how the effects of interventions are mediated across different settings and contexts, key components, and underlying mechanisms.

Further research in this field might be best served via three approaches. First, the MRC–NIHR framework should be applied for complex interventions in health care for future studies on digital technology. The framework guides researchers to design and conduct research under five core elements—context, programme theory, stakeholder engagement, key uncertainties, intervention refinement, and economic consideration. By applying the framework, researchers are encouraged to address a broader range of questions that extend beyond whether an intervention works to consider the broader impacts, value relative to resources, mechanisms of change, and real-world decision-making support. Such an approach will help to generate new insights into the processes and mechanisms by which digital technology might improve health care and select more relevant outcomes.[47] Second, further RCTs on the role of digital technology in managing children with IBD (and any further studies on adults) should include an appropriate follow-up duration and more detailed descriptions of the digital technology interventions, alongside capturing outcomes that might be more relevant and tailored to digital interventions than to standard care. Third, the recognition of digital technology should be changed from an intervention into a tool designed to capture outcomes from other interventions. As a tool to capture outcomes, digital technology offers researchers access to long-term outcomes of IBD progression that are difficult to capture in traditional RCTs, as highlighted in the STRIDE[48] and SPIRIT[49] consensus frameworks. Digital technology as a tool relies on patient participation and so it is imperative to educate them on how to use digital technology to monitor disease progression with different therapies.

Several digital technologies are in use in clinical practice, and clinicians should recognise that few digital technologies are supported by robust evidence showing improved IBD-related outcomes. Despite the limited evidence, the use of digital technologies will likely increase, particularly with the integration of artificial intelligence. Although no reported adverse effects associated with digital technology use in IBD care have been identified, potential risks related to accessibility, data privacy, and clinical decision making warrant further investigation. The role of digital technologies for IBD will ultimately depend on the balance between known and studied benefits and unknown risks.

Clinicians should recognise the dual role of digital technologies: their complexity as an intervention and simplicity as a tool for data collection. As a tool, digital technology captures data through patient engagement and participation and supports the study of therapeutic outcomes, particularly as treatment targets continue to evolve and become more stringent.

Search strategy and selection criteria

Relevant publications from January, 2012, to December, 2022 were identified through searches across the following databases: PubMed and MEDLINE via Ovid, Embase via Ovid, The Cochrane Library and PROSPERO, CINAHL via Ovid and EBSCO, PsycINFO via Ovid, Epistemonikos, Health Evidence, and DoPHER. The timeframe starting in 2012 was selected to align with the period of increasing adoption of digital technologies. The Allied and Complementary Medicine database was excluded, as IBD is not a subject area covered by the database. Moreover, relevant clinical IBD-related guidelines published from January, 2012 to January, 2024 were reviewed to identify additional clinically important studies. The guidelines included were those from the British Society of Paediatric Gastroenterology, Hepatology and Nutrition the British Society of Gastroenterology, the European Society of Pediatric Gastroenterology, Hepatology and Nutrition, and the European Crohn's and Colitis Organisation. A search strategy incorporating keywords, Medical Subject Headings terms, and text words was developed and applied in combination (details in appendix pp 10–21). A repeat search conducted in September, 2023, identified an additional systematic review. A subsequent re-run on Sept 25, 2024, which incorporated CINAHL via EBSCO (appendix pp 18–21), did not yield any additional studies. The search was restricted to English-language articles. Systematic reviews and meta-analyses were included.

Contributors

MG, PN, and NA identified the topic of the umbrella review, performed data extraction and analysis, and wrote the manuscript and shared it with all co-authors for critical appraisal and consensus on its final version before submission. PN coordinated the literature search. CW, JA, JK, MP, and UK contributed to data extraction and revised the manuscript, providing critical appraisal before submission of its final version. 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

JA is a scientific advisory board member for Orchard Therapeutics and is funded by a National Institute for Health and Care Research (NIHR) advanced fellowship. MG is a non-paid member of the Crohn's in Childhood Research Association Advisor Board; member and previous chair of the Research Committee of the British Society of Paediatric Gastroenterology, Hepatology and Nutrition (BSPGHAN); member and previous chair of the Special Interest Group for Basic Science and Translational Research of ESPGHAN (European Society of Paediatric Gastroenterology, Hepatology and Nutrition); collaborator of a research project led by Cambridge University Hospitals and awarded a Helmsley's Trust Grant in 2022; and collaborator of a study titled "Prime-P" at the Quadram Institute of Bioscience, which was awarded a Seedcorn Grant in 2023. MP is a non-paid board member of the non-profit and foundation MyCoach, a foundation that owns the content of myIBDcoach. NA received funding from the British Society of Gastroenterology (BSG), BSPGHAN, and CYMEDTECH; payment or honoraria from Janssen, AbbVie, and Takeda; and support from Eli Lilly to attend a conference. NA is also a member and previous chair of the BSG Adolescent and Young Persons Committee and a previous chair of the European Crohn's and Colitis Organisation (ECCO) Epi-Committee. PN is the co-lead of the transition theme at the NIHR HealthTech Research centre in Paediatrics and Child Health. UK has received funding from AbbVie, Jannsen, Bristol Myers Squibb, Eli Lilly, Medtronic, and Takeda, as well as consulting fees and payment or honoraria from AbbVie, Jannsen, BMS, Eli Lilly, Medtronic, Takeda, Celltrion, Roche, and Pfizer. UK has participated in a Data Safety Monitoring Board or Advisory Board for AbbVie, Jannsen, Eli Lilly, Medtronic, Takeda, Roche, and Pfizer. UK is also a member of the ECCO committee. All other authors declare no competing interests.

Acknowledgments

We are grateful to the Illingworth Library Team, Sheffield Children's NHS Foundation Trust, Sheffield, UK, for their support with the literature search. There was no specific funding for this umbrella review.

References

1 Yin AL, Hachuel D, Pollak JP, Scherl EJ, Estrin D. Digital health apps in the clinical care of inflammatory bowel disease: scoping review. *J Med Internet Res* 2019; **21:** e14630.

2 National Institute for Health and Care Excellence. Evidence standards framework for digital health technologies. Aug 9, 2022. www.nice.org.uk/corporate/ecd7 (accessed Dec 13, 2023).

3 Burisch J, Zhao M, Odes S, et al. The cost of inflammatory bowel disease in high-income settings: a Lancet Gastroenterology & Hepatology Commission. *Lancet Gastroenterol Hepatol* 2023; **8:** 458–92.

4 Nguyen NH, Martinez I, Atreja A, et al. Digital health technologies for remote monitoring and management of inflammatory bowel disease: a systematic review. *Am J Gastroenterol* 2022; **117:** 78–97.

5 Elkjaer M, Shuhaibar M, Burisch J, et al. E-health empowers patients with ulcerative colitis: a randomised controlled trial of the web-guided 'Constant-care' approach. *Gut* 2010; **59:** 1652–61.

6 de Jong MJ, van der Meulen-de Jong AE, Romberg-Camps MJ, et al. Telemedicine for management of inflammatory bowel disease (myIBDcoach): a pragmatic, multicentre, randomised controlled trial. *Lancet* 2017; **390:** 959–68.

7 Aromataris E, Fernandez R, Godfrey CM, et al. Summarizing systematic reviews: methodological development, conduct and reporting of an umbrella review approach. *Int J Evid Based Healthc* 2015; **13:** 132–40.

8 Aromataris E, Fernandez RS, Godfrey C, et al. Methodology for JBI umbrella reviews. Nov 16, 2014. https://ro.uow.edu.au/smhpapers/3344 (accessed April 17, 2023).

9 Belbasis L, Bellou V, Ioannidis JPA. Conducting umbrella reviews. *BMJ Med* 2022; **1:** e000071.

10 Choi GJ, Kang H. Introduction to umbrella reviews as a useful evidence-based practice. *J Lipid Atheroscler* 2023; **12:** 3–11.

11 Fusar-Poli P, Radua J. Ten simple rules for conducting umbrella reviews. *Evid Based Ment Health* 2018; **21:** 95–100.

12 Bastian H, Glasziou P, Chalmers I. Seventy-five trials and eleven systematic reviews a day: how will we ever keep up? *PLoS Med* 2010; **7:** e1000326.

13 Grant MJ, Booth A. A typology of reviews: an analysis of 14 review types and associated methodologies. *Health Info Libr J* 2009; **26:** 91–108.

14 Hartling L, Chisholm A, Thomson D, Dryden DM. A descriptive analysis of overviews of reviews published between 2000 and 2011. *PLoS One* 2012; **7:** e49667.

15 Khangura S, Konnyu K, Cushman R, Grimshaw J, Moher D. Evidence summaries: the evolution of a rapid review approach. *Syst Rev* 2012; **1:** 10.

16 Smith V, Devane D, Begley CM, Clarke M. Methodology in conducting a systematic review of systematic reviews of healthcare interventions. *BMC Med Res Methodol* 2011; **11:** 15.

17 Shea BJ, Reeves BC, Wells G, et al. AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both. *BMJ* 2017; **358:** j40.

18 Moher D, Liberati A, Tetzlaff J, Altman DG, , PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med* 2009; **6:** e1000097.

19 Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021; **372:** n71.

20 Pang L, Liu H, Liu Z, et al. Role of telemedicine in inflammatory bowel disease: systematic review and meta-analysis of randomized controlled trials. *J Med Internet Res* 2022; **24:** e28978.

21 Gordon M, Sinopoulou V, Lakunina S, et al. Remote care through telehealth for people with inflammatory bowel disease. *Cochrane Database Syst Rev* 2023; **5:** CD014821.

22 Huang VW, Reich KM, Fedorak RN. Distance management of inflammatory bowel disease: systematic review and meta-analysis. *World J Gastroenterol* 2014; **20:** 829–42.

23 Rohde JA, Barker JO, Noar SM. Impact of eHealth technologies on patient outcomes: a meta-analysis of chronic gastrointestinal illness interventions. *Transl Behav Med* 2021; **11:** 1–10.

24 Kuriakose Kuzhiyanjal AJ, Nigam GB, Antoniou GA, et al. Management of inflammatory bowel disease using e-health technologies: a systematic review and meta-analysis. *J Crohns Colitis* 2023; **17:** 1596–613.

25 Knowles SR, Mikocka-Walus A. Utilization and efficacy of internet-based eHealth technology in gastroenterology: a systematic review. *Scand J Gastroenterol* 2014; **49:** 387–408.

26 Helsel BC, Williams JE, Lawson K, Liang J, Markowitz J. Telemedicine and mobile health technology are effective in the management of digestive diseases: a systematic review. *Dig Dis Sci* 2018; **63:** 1392–408.

27 Gohil S, Majd Z, Sheneman JC, Abughosh SM. Interventions to improve medication adherence in inflammatory bowel disease: a systematic review. *Patient Educ Couns* 2022; **105:** 1731–42.

28 Guyatt GH, Oxman AD, Vist GE, et al. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. *BMJ* 2008; **336:** 924–26.

29 Hunt MG, Rodriguez L, Marcelle E. A cognitive behavioral therapy workbook delivered online with minimal therapist feedback improves quality of life for inflammatory bowel disease patients. *Intern Med Rev* 2017; **3:** 1–16.

30 Walmsley RS, McCombie A, Barclay M, et al. A noninferiority randomised clinical trial of the use of the smartphone-based health applications IBDsmart and IBDoc® in the care of inflammatory bowel disease patients. *Inflamm Bowel Dis* 2020; **26:** 1098–109.

31 Cross RK, Cheevers N, Rustgi A, Langenberg P, Finkelstein J. Randomized, controlled trial of home telemanagement in patients with ulcerative colitis (UC HAT). *Inflamm Bowel Dis* 2012; **18:** 1018–25.

32 Krier M, Kaltenbach T, McQuaid K, Soetikno R. Potential use of telemedicine to provide outpatient care for inflammatory bowel disease. *Am J Gastroenterol* 2011; **106:** 2063–67.

33 McCombie A, Gearry R, Andrews J, Mulder R, Mikocka-Walus A. Does computerized cognitive behavioral therapy help people with inflammatory bowel disease? A randomized controlled trial. *Inflamm Bowel Dis* 2016; **22:** 171–81.

34 Greenley RN, Kunz JH, Walter J, Hommel KA. Practical strategies for enhancing adherence to treatment regimen in inflammatory bowel disease. *Inflamm Bowel Dis* 2013; **19:** 1534–45.

35 Carlsen K, Jakobsen C, Houen G, et al. Self-managed eHealth disease monitoring in children and adolescents with inflammatory bowel disease: a randomized controlled trial. *Inflamm Bowel Dis* 2017; **23:** 357–65.

36 Miloh T, Shub M, Montes R, et al. Text messaging effect on adherence in children with inflammatory bowel disease. *J Pediatr Gastroenterol Nutr* 2017; **64:** 939–42.

37 Del Hoyo J, Nos P, Faubel R, et al. A web-based telemanagement system for improving disease activity and quality of life in patients with complex inflammatory bowel disease: pilot randomized controlled trial. *J Med Internet Res* 2018; **20:** e11602.

38 Linn AJ, van Dijk L, van Weert JCM, et al. Creating a synergy effect: a cluster randomized controlled trial testing the effect of a tailored multimedia intervention on patient outcomes. *Patient Educ Couns* 2018; **101:** 1419–26.

39 Nikolaus S, Schreiber S, Siegmund B, et al. Patient education in a 14-month randomised trial fails to improve adherence in ulcerative colitis: influence of demographic and clinical parameters on non-adherence. *J Crohns Colitis* 2017; **11:** 1052–62.

40 Carlsen K, Houen G, Jakobsen C, et al. Individualized infliximab treatment guided by patient-managed eHealth in children and adolescents with inflammatory bowel disease. *Inflamm Bowel Dis* 2017; **23:** 1473–82.

41 Heida A, Dijkstra A, Muller Kobold A, et al. Efficacy of home telemonitoring versus conventional follow-up: a randomized controlled trial among teenagers with inflammatory bowel disease. *J Crohns Colitis* 2018; **12:** 432–41.

42 Akobeng AK, O'Leary N, Vail A, et al. Telephone consultation as a substitute for routine out-patient face-to-face consultation for children with inflammatory bowel disease: randomised controlled trial and economic evaluation. *eBioMedicine* 2015; **2:** 1251–56.

43 Becker LA, Oxman AD. Chapter 22. Overviews of reviews. In: Higgins JPT, Green S, eds. Cochrane handbook for systematic reviews of interventions Version 5.1.0. The Cochrane Collaboration, 2011.

44 Cross RK, Langenberg P, Regueiro M, et al. A randomized controlled trial of TELEmedicine for patients with inflammatory bowel disease (TELE-IBD). *Am J Gastroenterol* 2019; **114:** 472–82.

45 Schliep M, Chudy-Onwugaje K, Abutaleb A, et al. TELEmedicine for patients with inflammatory bowel disease (TELE-IBD) does not improve depressive symptoms or general quality of life compared with standard care at tertiary referral centers. *Crohns Colitis* 2020; **2:** otaa002.

46 Narula P, Gasparetto M, Wong C, et al. Top 10 research priorities for digital technology for adolescents and young persons with inflammatory bowel disease: results of a James Lind Alliance Priority Setting Partnership. *J Pediatr Gastroenterol Nutr* 2023; **78:** 670–76.

47 Skivington K, Matthews L, Simpson SA, et al. A new framework for developing and evaluating complex interventions: update of Medical Research Council guidance. *BMJ* 2021; **374:** n2061.

48 Peyrin-Biroulet L, Sandborn W, Sands BE, et al. Selecting therapeutic targets in inflammatory bowel disease (STRIDE): determining therapeutic goals for treat-to-target. *Am J Gastroenterol* 2015; **110:** 1324–38.

49 Le Berre C, Peyrin-Biroulet L. Selecting end points for disease-modification trials in inflammatory bowel disease: the SPIRIT Consensus from the IOIBD. *Gastroenterology* 2021; **160:** 1452–60.e21.