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A Digital Health Intervention to Improve the Clinical Care of Inflammatory Bowel Disease Patients

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Abstract

Background   Inflammatory bowel disease (IBD) is a chronic condition that requires close monitoring. Digital health virtual care platforms can enable self-monitoring and allow providers to remotely surveil patients and efficiently identify those with active disease.

Objectives   The primary aim was to design and implement an IBD remote monitoring program, identify predictors of patient engagement, and determine who found the chat to be a valuable tool.

Methods   We developed the IBD Virtual Care Chat, an electronic health record (EHR)-integrated chat to monitor electronic patient reported outcomes (ePROs), medication changes, and disease activity, and subsequently report concerning findings to providers via the EHR. All patients in the IBD practice over age 18 with a clinical encounter in the preceding 12 months were eligible to be enrolled. The primary aim was to identify predictors of patient engagement and determine who found the chat to be a valuable tool.

Results   Between May 2021 and March 2022, 2,934 patients were enrolled. A total of 1,160 engaged at least once and 687 (23.4%) continually engaged, submitting at least three ePROs. Disease severity (based on Harvey–Bradshaw Index or Simple Clinical Colitis Activity Index) did not impact ePRO submissions. Patients were significantly more likely to be continually engaged if they self-reported the presence of extraintestinal manifestations (7%, 95% confidence interval: 0.01–0.14; $p = 0.04$). Patient satisfaction remained moderately high with a median score of 8 (interquartile range: 5–10) on a scale of 1 (poor) to 10 (good).

Conclusion   Our program demonstrates the potential for EHR-integrated digital health as part of routine IBD care to achieve sustained engagement with high patient satisfaction.

Keywords

► inflammatory bowel disease
► digital health
► remote patient monitoring
► telemedicine

Background and Significance

Inflammatory bowel disease (IBD) is a lifelong condition with an oscillating and sometimes unpredictable clinical course. Its management can involve the use of immune suppressing medications with the potential for significant side effects, including laboratory derangements, opportunistic infections, and malignancy. IBD prevalence increased by 123% in adults and 133% in the children between 2007 and 2016.[1] This has negatively impacted patient access to the frequent monitoring they require to prevent complications from the disease itself and the medications used for treatment.[2]

Digital health virtual care platforms can fill this gap by enabling patient engagement in self-monitoring and allowing providers to remotely surveil stable patients and more efficiently identify those with active disease.[3,4] We have already begun to see the success of remote patient monitoring technologies as well as how the need for them has grown with the coronavirus disease 2019 pandemic.[5,6] For the IBD population, at least a dozen applications on education, symptom monitoring, and quality of life improvement have been created and studied.[3] The HealthPROMISE smartphone application developed at the Icahn School of Medicine in Mount Sinai led to a 22% reduction in hospitalizations after utilization of the application among its 32 patients when compared with the year prior.[7] This application incorporated questions to assess patient symptoms, quality of life, and health care resource utilization. Easily accessible trends and support tools created by the use of these systems additionally help health care providers increase adherence to standards of care. Another mobile application from the Netherlands was implemented in 45 patients to serve as a reminder for blood draws and infusion appointments for IBD patients receiving infliximab or vedolizumab; this resulted in increased compliance and a nearly 50% decrease in need for nursing telephone.[8] On the other hand, a systematic review of 14 randomized controlled trials compared web-based interventions, mobile applications, and different telemedicine platforms with standard of care (clinic based encounters) in IBD.[8] While these studies demonstrate the promise of digital health, these tools are only effective if they are utilized by a large number of patients with consistent engagement and contain the necessary electronic health record (EHR) integrations and triaging capabilities to assist providers.

We developed and implemented an automated, EHR-integrated, virtual care chat tool (IBD Virtual Care Chat) to monitor a population of patients with IBD. It was designed to monitor electronic patient reported outcomes (ePROs), medication changes, and determine disease activity as well as report alarming symptoms to a patient's IBD provider via their standard EHR in-basket. The IBD Virtual Care Chat can adjust the frequency of assessments based on disease activity and medication changes. Here, we report the largest known digital health monitoring study in IBD patients to date and demonstrate that this intervention can be scaled to large patient populations. The primary aim of this study was to design and implement an IBD remote monitoring program,

identify predictors of patient engagement, and determine who found the chat to be a valuable tool.

Methods

This is a prospective cross-sectional study of patient engagement and outcomes with the IBD Virtual Care Chat. Patients were invited to enroll if they were at least 18 years of age, had a clinical encounter within our IBD practice in the preceding 12 months, and had a visit diagnosis of IBD based on International Classification of Diseases, 10th Edition (ICD-10) diagnosis codes. An EHR-based registry is used to identify all IBD patients. Automated data exports from the EHR and secure transmission to the vendor are used to enroll patients. Patients were invited to participate on a rolling basis by either text message or email. Patient enrollment started in May 2021 and is currently continues as of March 2023. Patients enrolled between May and November 2021 were included in this analysis. Engagement data until March 25, 2022 were included.

Intervention

The IBD Virtual Care Chat is a patient monitoring tool developed in collaboration with the Center for Colitis and Crohn's Disease and the Center for Digital Health Innovation (CDHI), using a platform from a third-party vendor, Conversa. In the existing implementation, patients receive an introductory text message or email, depending on their preferred method of contact, which then launches them into a personalized, secure, web-based chat interface, which is linked to the EHR. In the chat, patients see a brief introductory video and are asked details about their disease type, medications, and symptoms using validated and widely accepted Patient Reported Outcomes Measures (►**Fig. 1**). Based on their reported outcomes, patients are classified by disease severity. Patients with active disease initially receive weekly chat reminders. Patients who are stable as determined by ePROs receive monthly chat reminders. Patients received reminders at their scheduled interval regardless of engagement status.

Chat Design

The IBD virtual care chat consists of six modules: Introduction, Housekeeping, Symptom Monitoring, Medications, Laboratory Reminders, and Goodbye. During the Introduction module, patients are given a general chat overview and asked to input their health care provider, IBD type, surgical history, and medications as well as choose reminder intervals. Patients can self-report their IBD type as Crohn's disease, ulcerative colitis, or IBD undetermined. Patients are then asked a series of symptom-based questions to complete an ePRO. The content in the Introduction module is saved and is not repeated with subsequent ePRO submissions. The Housekeeping module allows patients to update contact information and medications.

In the Symptom Monitoring module, patients enter their ePROs. Based on their symptom responses, a Harvey–Bradshaw Index (HBI)[9] is calculated for patients diagnosed with
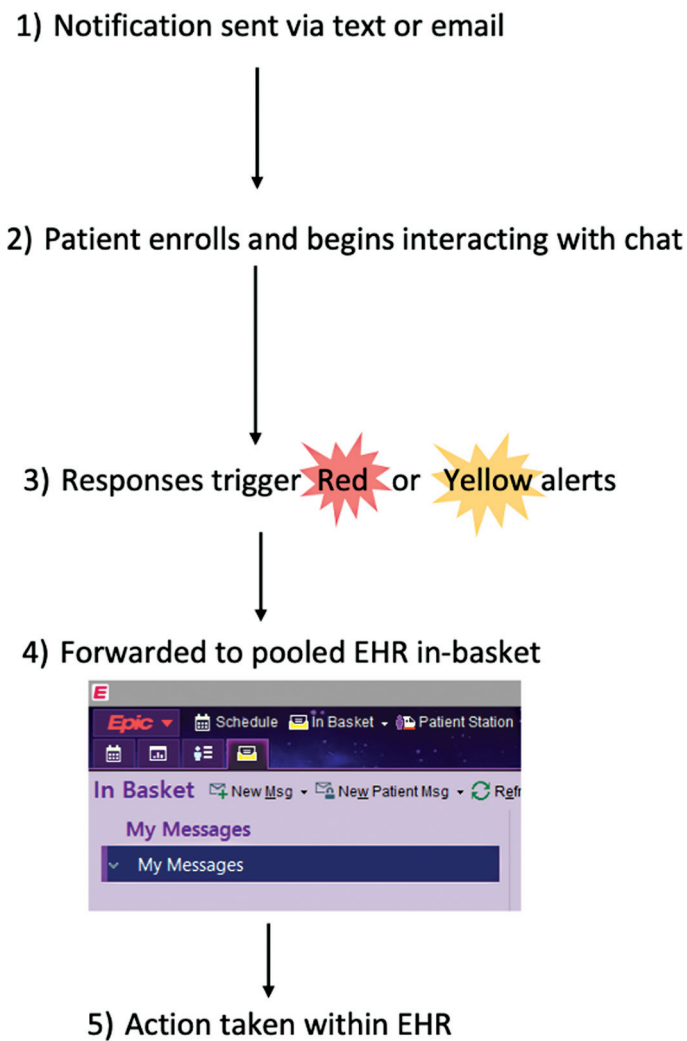
Fig. 1 IBD virtual care chat flowsheet. EHR, electronic health record; IBD, inflammatory bowel disease.

Crohn's disease and a Simple Clinical Colitis Activity Index (SCCAI)[10] is calculated for patients with ulcerative colitis or IBD undetermined. These scores are validated and commonly used to measure disease activity in the IBD literature. Disease activity is determined by these scores. An HBI score < 5 or SCCAI score < 2 is consistent with disease remission. An HBI score of 5 to 7 and SCCAI score of 3 to 5 are consistent with mild disease. An HBI score of 8 to 16, inclusive, and SCCAI score of 6 to 9, inclusive, are consistent with moderate disease activity and trigger a yellow alert or a red alert if the score is greater than the prior ePRO submission. An HBI score > 16 and SCCAI score > 9 is consistent with severe disease and triggers a red alert. Patients with a J-pouch or stoma have been excluded from calculation of HBI or SCCAI as these scoring systems cannot be applied to this subset of patients.

All participants are asked about the presence of extra-intestinal manifestations and the presence of additional complications including fistulas, abscesses, and fissures. They can view images on extraintestinal manifestations for accurate identification. In the Medications module, patients are asked to self-report their current dosage and any side effects of any current medications taken by patients. The Laboratory Reminders module provides reminders to schedule laboratory testing for monitoring based on inputs into the Medications module. Lastly, the Goodbye module allows patients to provide feedback, assesses satisfaction scores, and includes general reminders.

Alerts and Program Monitoring

Red or yellow alerts are generated based on patient responses and are sent to the care team's EHR in-basket (►Fig. 1). In addition to elevated HBI and SCCAI scores, if patients indicate possible side effects from their medication, an increase in steroid dose, new extraintestinal manifestations, or rate their general well-being as "poor," "very poor," or "terrible," *red* alerts are forwarded to a pooled EHR in-basket for triage by the care team. Red alerts allowed patients and nurse coordinators to communicate within the EHR messaging system and coordinate next steps (►Supplementary Fig. S1, available in online version).

The CDHI product development team meets with the vendor twice per week and with the clinical team every other week for program monitoring and iterative

codification of alerting threshold requirements. Both red and yellow alerts were forwarded to the EHR from May 2021 through October 2021. Only red alerts are being forwarded since then as both clinician feedback and a review of actions from the EHR showed that yellow alerts did not require action from the clinical teams and led to alert fatigue.

Data from the vendor are automatically integrated into clinical data warehouse, and dashboards were created using Tableau (Seattle, Washington, United States). These Dashboards are regularly reviewed with both product and clinical teams and contain metrics on patient demographics, enrollment and engagement trends, and patient satisfaction. Patient engagement data were measured by tracking patient responses and actions taken within the IBD Virtual Care Chat.

Data Collection

Patient demographic data were extracted from the EHR including age, biological sex, address of residence, race/ethnicity, primary language, insurance payor, and marital status. Rural or urban zip code status was determined by corresponding data from the U.S. Department of Agriculture Rural Urban Commuting Area Codes.[11] As a proxy for socioeconomic status, the address of residence was geocoded to the U.S. census block groups and matched to the respective Area Deprivation Index (ADI) national percentiles.[12] HBI and SCCAI scores as well as patient satisfaction were extracted from the IBD chat. The number of *red* and *yellow* alerts was obtained from the live Tableau database.

Outcomes

The primary outcome was patient engagement with the IBD Virtual Care Chat. This was measured by tracking ePRO completion status. ePRO completion status was determined by whether or not they answered a question on the symptom questionnaire. Patient engagement was defined as completing at least one ePRO, and continued engagement was defined as submitting at least three ePROs within the first year of enrollment. Predictors of engagement were stratified by patient demographics and disease characteristics.

Statistical Analysis

Differences in patient cohorts conditioned on engagement status were compared using the Fisher's exact test for categorical features and two-sample *t*-test for continuous features. Multivariable logistic and linear regression models were developed to identify patient and disease-related predictors of initial and continued patient engagement. R 3.5.1 was used for analysis and a *p*-value < 0.05 was considered significant.

Results

Patient Demographics and Engagement

Between May 2021 and March 2022, 3,163 patients were offered enrollment in the IBD Virtual Care Chat. A total of 230 patients (7.3%) opted out and were excluded from analysis. Of the 2,933 (92.7%) patients that accepted the invitation to enroll, the median age was 41 years old (interquartile range

[IQR]: 32–55), 69% identified as non-Hispanic White, 53.1% were female, 98.5% had a primary language of English, 53.6% were married/partnered, 69.3% had commercial insurance, and 95.6% were from an area identified as urban (►**Supplementary Table S1**, available in online version).

Of the 2,933 patients that enrolled, there was a total of 18,158 unique chat sessions from 1,210 patients. Of these 1,210 patients, 1,159 (39.5%) completed at least one ePRO module (classified as initially engaged) and 687 (23.4%) completed at least three ePROs over time (classified as continually engaged). The engaged and unengaged cohorts were composed of similar urban/rural zip code makeup and insurance payor type (►**Table 1**). Engaged patients were more likely to be older (40.9 vs. 40.2 years; *p* < 0.01), be female (57.5 vs. 49.9%; *p* < 0.01), have a primary language of English (99.5 vs. 98.0; *p* < 0.01), be married or partnered (56.8 vs. 52.5%; *p* = 0.03), and have a higher ADI national percentile (4 vs. 3, *p* < 0.01).

In a multivariable logistic model to identify demographic factors associated with initial engagement we found that patients of female sex were more likely to be engaged (odds ratio [OR]: 1.31, 95% confidence interval [CI]: 1.09–1.57; *p* < 0.01; ►**Table 2**). Patients identifying as single/separated/other marital status were less likely to be initially engaged (OR: 0.80, 95% CI: 0.66–0.98; *p* = 0.03) as were patients with a non-English primary language (OR: 0.13, 95% CI: 0.02–0.46; *p* < 0.01). There was no significant association between initial engagement status and rural/urban status, socioeconomic status, insurance, or age.

A linear regression model was developed to identify the degree of engagement in continually engaged patients (►**Table 3**). Disease severity did not significantly impact the count of ePRO submission. Continually engaged patients who self-reported the presence of extraintestinal manifestations were associated with 0.07 (95% CI: 0.01–0.14; *p* = 0.04) more ePROs compared with patients who did not self-report extraintestinal manifestations. The absolute number of ePRO submissions was the highest in October and November 2021, which is the time at which we had bulk enrollment of all remaining patients. The number of ePRO submissions has steadily declined since then (►**Fig. 2**).

Alerting

A total of 3,523 of patient chat sessions generated alerts. There were 649 *red* alerts in total (18.4% of total alerts) from 292 unique patients. A total of 81 patients had a single red alert. The median proportion of *red* alerts per month was 13% (IQR: 9–21%) and 87% for *yellow* alerts (IQR: 79–91%). Engaged patients had a median of 0 *red* alerts (IQR: 0–1) and 3 *yellow* alerts (IQR: 0–10).

Harvey–Bradshaw Index and Simple Clinical Colitis Activity Index Scores

A total of 249 patients with Crohn's disease had multiple ePRO submissions resulting in multiple HBI scores. A total of 262 patients with ulcerative colitis had multiple ePRO submissions resulting in multiple SCCAI scores. At the time of their first ePRO submission, 15.4% (*n* = 44) of patients with

Table 1 Patient demographics by initial engagement status

	Nonengaged	Engaged	*p*-Value
Total patients	1,774	1,159	
Age (median, IQR)	40.2 (31.8–54.3)	40.9 (32.9–55.6)	<0.01
Birth sex			
Male	888 (50.1%)	485 (41.9%)	<0.01
Female	884 (49.9%)	673 (57.5%)	
Module completions (median, IQR)	–	3 (2–10)	
ePRO submissions (median, IQR)	–	4 (2–7)	
Race/ethnicity			
Non-Hispanic White	1,197 (67.5%)	827 (71.2%)	0.13
Non-Hispanic Black or African American	68 (3.8%)	33 (2.8%)	
Hispanic or Latino	136 (7.7%)	100 (9.1%)	
Asian American, Native Hawaiian, or other Pacific Islander	212 (12.0%)	115 (9.8%)	
Other/unknown	160 (9.1%)	83 (7.1%)	
Primary language			
English	1,737 (98.0%)	1,152 (99.5%)	<0.01
Non-English	36 (2.0%)	6 (0.5%)	
Marital status			
Married/partnered	916 (52.5%)	655 (56.8%)	0.03
Single/separated/other	857 (48.5%)	503 (44.2%)	
Insurance status			
Commercial	1,184 (69.6%)	791 (71.1%)	0.31
Medicare	245 (14.4%)	167 (15.0%)	
Medicaid	194 (11.4%)	103 (9.8%)	
Other	78 (4.6%)	46 (4.1%)	
Community code classification			
Urban	1,696 (95.9%)	1,108 (95.7%)	0.93
Rural	76 (4.1%)	48 (4.3%)	
ADI national percentile (median, IQR)	3 (2–10.8)	4 (2–11)	<0.01

Abbreviations: ADI, Area Deprivation Index; ePRO, electronic patient reported outcomes; IQR, interquartile range.

Crohn's disease had an HBI >2 and 58.5% (*n* = 179) with IBD undetermined or ulcerative colitis had a SCCAI > 2, both indicating active disease. A total of 13.0% (*n* = 37) of patients with Crohn's disease and 33.7% (*n* = 103) of patients with ulcerative colitis had mild disease. A total of 2.5% (*n* = 7) of patients with Crohn's and 20.6% (*n* = 63) with ulcerative colitis or IBD undetermined had moderate disease. No patients with Crohn's disease had an HBI >16, which would indicate severe disease. A total of 4.2% (*n* = 13) with ulcerative colitis had a SCCAI > 10, indicating severe disease.

For the same patients, at the time of most recent ePRO submission, 11.9% (*n* = 34) of patients with Crohn's disease and 50.3% (*n* = 154) with IBD undetermined or ulcerative colitis had active disease, both decreased from initial ePRO submission. The number of patients with active disease decreased by 8.2% (25 patients) in the ulcerative colitis and IBD-undetermined cohorts and by 3.5% (10 patients) in the Crohn's disease cohort at the time of study completion.

Overall, the scores remained similar, the median change in HBI among the continually engaged was 0 (IQR: −1, 1), and the median change in SCCAI among the continually engaged was also 0 (IQR: −1, 1; ►Fig. 3A, B).

Patient Satisfaction
Patients were asked about their satisfaction with the intervention at the end of the chat on a scale of 0 to 10 with 10 representing a high level of satisfaction. There was a 71% response rate (2,370 total submissions), and the median score was 8 (IQR: 5–10; ►Fig. 4).

Discussion

The introduction of digital health care and remote monitoring has transformed the way in which medicine is practiced, allowing for more efficient population level care delivery and increased geographic reach.[13,14] This is an especially

Table 2 Multivariable logistic regression model of predictors of initial engagement ($n = 1,159$)

	OR	95% CI	*p*-Value
Age (each year)	1.00	0.99, 1.01	0.51
Female sex (comparator: male)	1.31	1.09, 1.57	<0.01
Race/ethnicity (comparator: non-Hispanic White)			
Non-Hispanic Black or African American	0.69	0.40, 1.15	0.16
Hispanic or Latino	1.10	0.77, 1.57	0.59
Asian American, Native Hawaiian, or other Pacific Islander	0.93	0.68, 1.25	0.62
Other/unknown	0.78	0.55, 1.11	0.18
Primary language non-English (comparator: primary language English)	0.13	0.02, 0.46	<0.01
Marital status: single/separated/other (comparator: married/separated)	0.80	0.66, 0.98	0.03
Insurance category (comparator: commercial insurance)			
Medicare	1.12	0.80, 1.56	0.51
Medicaid	0.80	0.58, 1.10	0.17
Other	0.85	0.55, 1.31	0.48
Rural community code classification (comparator: urban community code classification)	0.77	0.45, 1.28	0.32
ADI national percentile	1.01	1.00, 1.01	0.11

Abbreviations: ADI, Area Deprivation Index; CI, confidence interval; OR, odds ratio.

necessary tool when caring for a patient population that requires active surveillance such as those with IBD.

With nearly 3,000 patients enrolled and over 600 continually engaged, this is the largest known evaluation to date of a digital health tool in IBD to date. A total of 39.5% of enrolled patients engaged at least once, and 21.6% were continually engaged. Our study evaluated predictors of engagement to better understand the type of population that perceives a greater need for this platform and finds it to be a valuable tool. Patients that were male, single, and/or had a primary language other than English were less likely to engage. Our analysis builds on prior studies by showing that associations in engagement among an IBD cohort are consistent with those found in the literature regarding digital health usage among the general population.[15–17] These findings also correlate with demographic features associated with patient adherence seen in the literature with standard of care interventions.[18,19]

Continued engagement was increased in those with extraintestinal manifestations of disease. Extraintestinal manifestations such as joint pain, skin rashes, or eye symptoms do not necessarily follow the disease course of gastrointestinal luminal symptoms. However, extraintestinal manifestations can sometimes be more apparent and result in more obvious discomfort. From these data we can extrapolate that those patients experiencing greater discomfort from their IBD may be more likely to desire communication with their provider and therefore supplement their care delivery with digital modalities. Moreover, contrary to what we may have expected, older patients opted to utilize and continue to interact with a technology-based interven-

tion. We have created educational videos for specific outreach toward older IBD patients to encourage usage of the chat.

Disease severity was not a major determinant of continued engagement. While the absolute number of ePRO submissions was greater in those with moderate and severe disease, the percentage submitted out of total reminders sent was not variable among different categories of disease activity. We hypothesize that patients with severe disease activity preferred direct communication with their providers (through mediums other than the virtual care chat) such as the EHR patient portal, video visits, and phone calls, and they were more likely to have clinic appointments and procedures scheduled, obviating the need for the chat. There is previous literature reporting that sicker IBD patients have higher anxiety and health care utilization, which would be in line with our findings that high-acuity IBD patients might be seeking or prefer in-person care over virtual remote monitoring. On the other hand, it is conceivable that patients with more severe disease had reduced access to medical care or were less engaged with the medical system, which may have led to their severe disease activity in the first place. Based on the above data, we feel that the IBD Virtual Care Chat is best suited to monitor the status of clinically stable patients. Pending future study into safety and efficacy, this asynchronous monitoring may decrease the frequency of in-person clinical visits needed for stable patients, which may free synchronous clinic time and resources for sicker patients.

In addition to disease severity, history of IBD-related surgery was not a determinant of engagement. The scoring system of HBI and SCCAI does not cater to those with prior

Table 3 Multivariable linear regression model to identify predictors of degree of continued engagement ($n = 687$)

	Estimate	95% CI	*p*-Value
Age (each year)	0.00	0.00, 0.01	<0.01
Female sex (comparator: male sex)	−0.01	−0.08, 0.06	0.71
Race/ethnicity (comparator: non-Hispanic White)			
Non-Hispanic Black or African American	−0.14	−0.35, 0.07	0.19
Hispanic or Latino	−0.09	−0.21, 0.03	0.14
Asian, Native Hawaiian, or Other Pacific Islander	−0.03	−0.14, 0.08	0.58
Other/unknown	0.01	−0.12, 0.14	0.91
Primary language non-English (comparator: primary language English)	0.12	−0.42, 0.66	0.67
Rural community code classification (comparator: urban community code classification)	−0.10	−0.33, 0.13	0.40
ADI national percentile	0.00	−0.00, 0.00	0.75
Marital status: single/separated/other (comparator: married/separated)	0.06	−0.02, 0.13	0.15
Insurance category (comparator: commercial insurance)			
Medicare	-0.07	−0.18, 0.15	0.27
Medicaid	−0.02	−0.14, 0.10	0.74
Other	−0.02	−0.15, 0.11	0.81
Disease type (comparator: Crohn's disease)			
Ulcerative colitis	0.05	−0.03, 0.13	0.21
IBD undetermined	0.08	−0.12, 0.28	0.43
Disease severity (comparator: remission)			
Mild	0.01	−0.07, 0.11	0.70
Moderate	0.01	−0.09, 0.11	0.83
Severe	0.06	−0.15, 0.27	0.58
History of ostomy or J-pouch	−0.07	−0.13, 0.02	0.29
Change in IBD-related medications (comparator: no medication changes)			
Biologics	−0.05	−0.13, 0.02	0.16
Immunomodulators	−0.03	−0.16, 0.11	0.68
Steroids	0.09	−0.03, 021	0.13
Mesalamine	−0.01	−0.12, 0.09	0.80
Active perianal disease: fistula, fissure, and/or abscess	0.01	−0.10, 0.11	0.89
Presence of extraintestinal manifestations	0.07	0.01, 0.14	0.04

Abbreviations: ADI, Area Deprivation Index; CI, confidence interval; IBD, inflammatory bowel disease.

surgery, and the chat was therefore likely less effective in identifying active disease in this population subset. A Pouchitis Disease Activity Index for those with a J-pouch will be added in the future to better account for these patients.[20]

There was a decline in ePRO submissions over time (►**Fig. 2**). When solicited for feedback individually, patients commented that the chat felt repetitive and that since the chat did not have direct provider interaction, they wished for more opportunities to connect with their care team. The patient experience and engagement could be improved upon by decreasing the frequency of chat reminders for those who are more stable. A feature will be incorporated into the chat every other month with an option to indicate "no changes" from the prior submission so as to avoid answering the same questions again. Furthermore, we have started incorporating educational videos recorded by IBD providers so patients have greater incentive to complete ePROs.

There are limitations of our study analysis and the chat development itself. First, design and implementation of the chat experience was based on in-depth analysis of patient
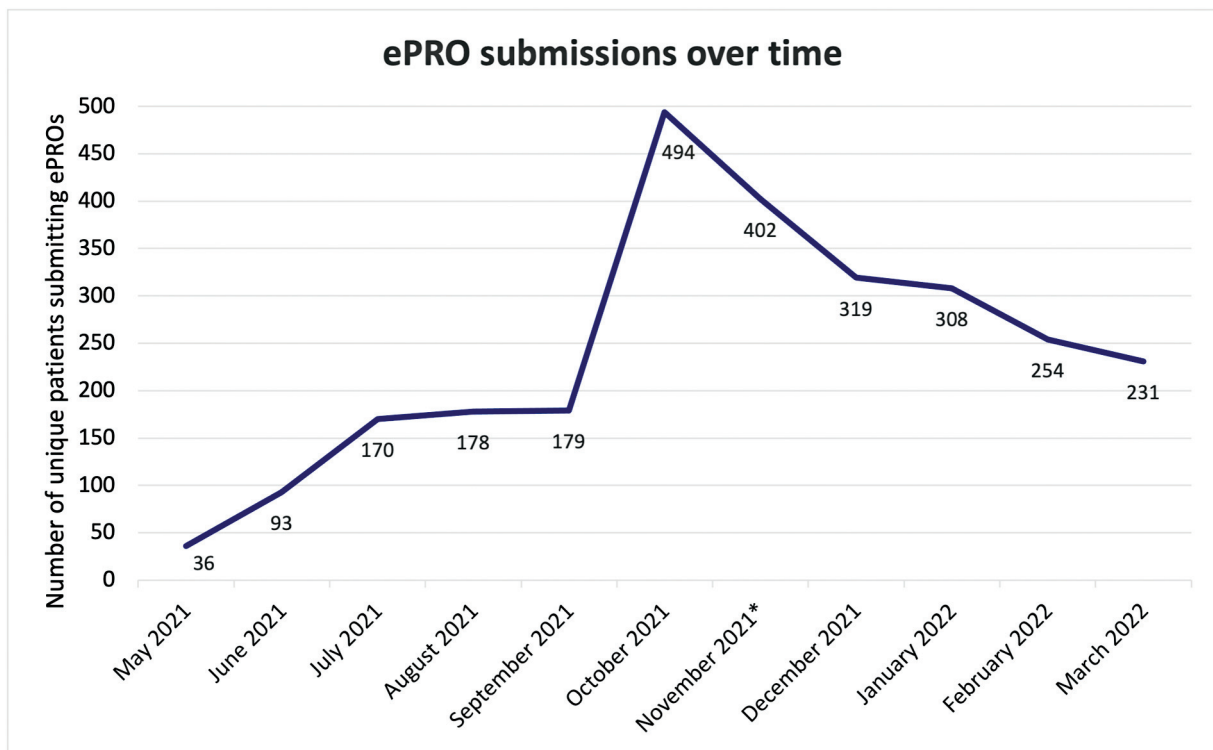
ePRO submissions over time

Fig. 2 Monthly unique patient submission on ePROs. ePRO, Electronic patient-reported outcome.

feedback from a pilot program of a small number of patients, resulting in a chat experience that may not be reflective of patient needs in a diverse population. Second, clinical predictors of engagement were gathered from ePROs. There are likely unmeasured sociodemographic or clinical predictors of engagement such as stable internet connectivity, household digital literacy, and comorbidities that may act as confounders in our analysis. Additionally, the low number of non-English-speaking patients affect the reliability and external validity of our regression results, as our results may be specific to our specific patient population. We plan to conduct qualitative research specifically focusing on the needs of our non-English-speaking population. Lastly, many patients did not initially engage and accept the chat invitation because they were unsure of what it was. We have started a campaign to raise awareness and increase trust about the IBD Chat via University of California San Francisco-hosted IBD Town Halls and during individual provider interactions. Future efforts to improve the IBD chat experience for patients and providers are to be iteratively developed. These includes different language translations to improve engagement and onboarding for non-English speakers, expedited chat experience for continually stable patients, and continued content development for patient in the form of provider-created videos. Videos to be developed include educational videos on pregnancy, hospitalizations, colorectal surgery, IBD medications, health maintenance, and indications for dysplasia surveillance, among others. Additional modifications will likely be required to ensure equity of access and

care. Further analysis is needed on change in clinical outcomes for patients. The duration of analysis and data included does not allow us to fully understand how these alerts impacted clinical outcomes such as hospitalization, need for steroid use, and incidence of IBD flares. We further plan to evaluate the actions taken by providers after receiving an alert, as well as the impact on provider in-basket burden.

Conclusion

Our program demonstrates the potential for an EHR-integrated digital health chatbot to efficiently engage and monitor a complex patient population with IBD. Iteratively tailoring the alert triggers and triage recommendations can reduce the burden on providers and patients alike. The IBD chat represents an opportunity to streamline outpatient care for stable patients, while simultaneously increasing clinic capacity for new and sick patients.

Clinical Relevance Statement

IBD is a chronic condition that requires close monitoring. Digital health platforms can enable patient self-monitoring but are not always successful. In this study, we successfully developed an EHR-integrated virtual chat for IBD patients. We found that disease severity was not a factor in patient engagement. EHR-integrated digital health can be utilized as part of routine IBD care to achieve sustained engagement with high patient satisfaction.
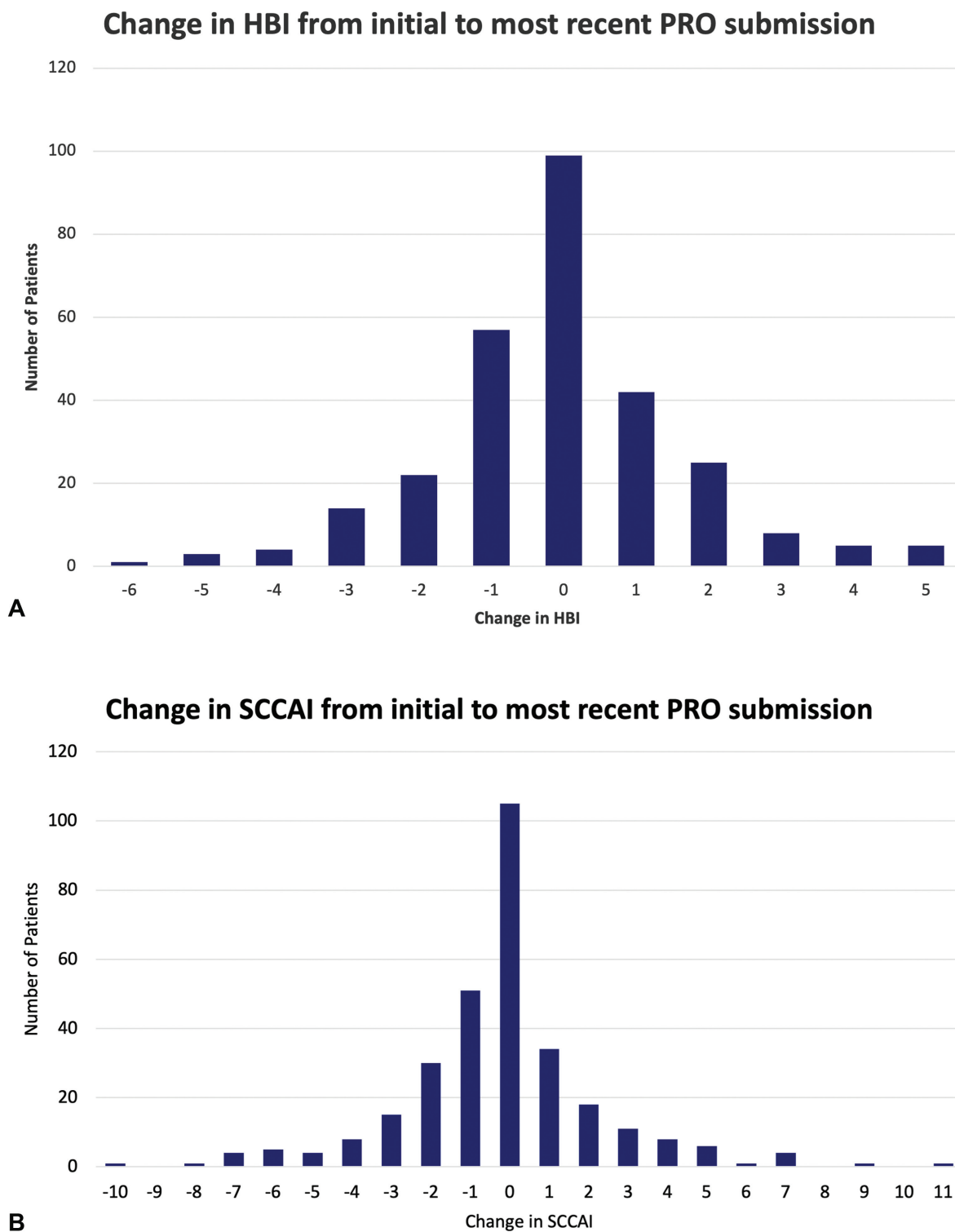
Change in HBI from initial to most recent PRO submission

A

Change in SCCAI from initial to most recent PRO submission

B

Fig. 3 (A, B) Change in Harvey–Bradshaw Index and Simple Clinical Colitis Activity Index from initial to most recent IBD chat use. HBI, Harvey–Bradshaw Index; IBD, inflammatory bowel disease; PRO, patient-reported outcome; SCCAI, Simple Clinical Colitis Activity Index.
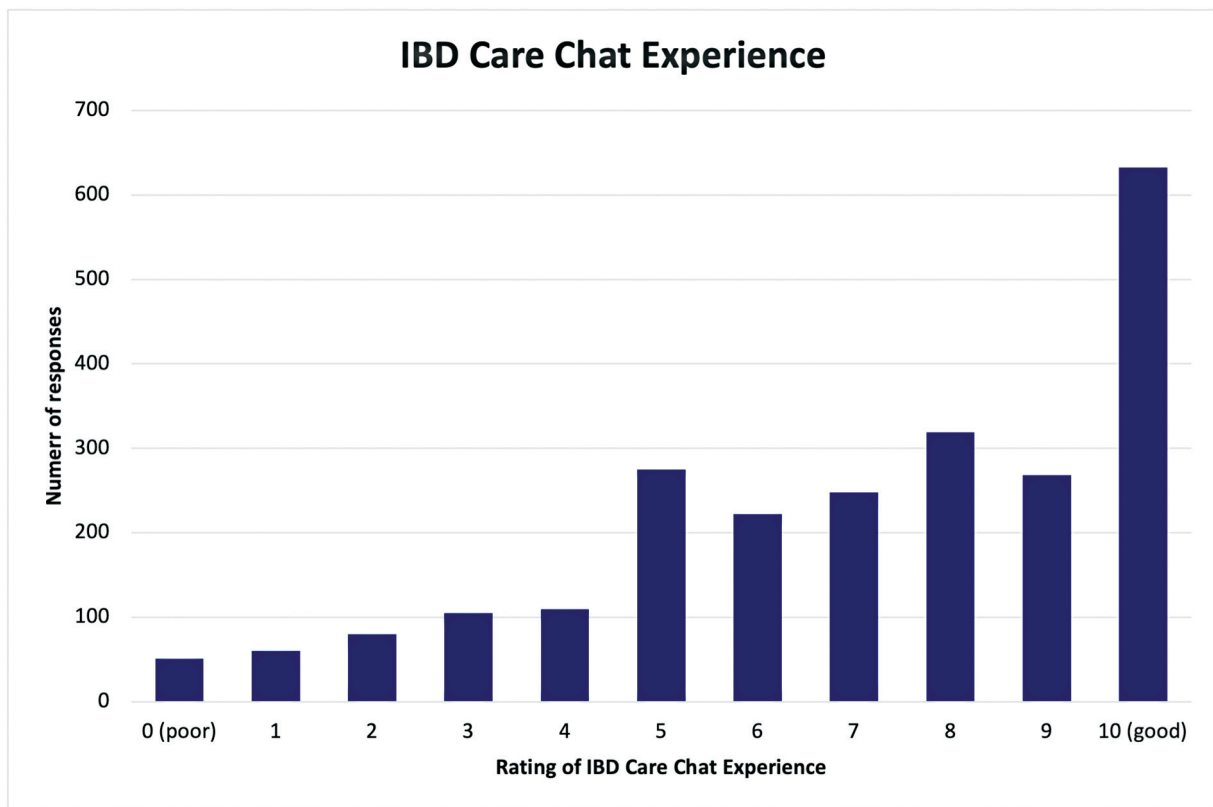
Fig. 4 IBD care chat experience ratings. IBD, Inflammatory bowel disease.

Multiple-Choice Questions

1. What factors were used to invite patients to enroll in the IBD Virtual Care Chat?
   a. <18 years of age
   b. Clinical encounter within our IBD practice in the 12 months before
   c. Visit diagnosis of IBD based on ICD-10 diagnosis codes of disease remission
   d. Video visit in last month

   Correct Answer: The correct answer is option b. Patients had to be >18 and had to have ICD-10m Crohn's or UC diagnoses (disease state independent). Video visit was unused.

2. What factors were not included in multivariate engagement analysis?
   a. Age
   b. Rural/urban zip code
   c. Reminder status
   d. Insurance status

   Correct Answer: The correct answer is option c. Patient reminder status was not an included variable in analysis.

Protection of Human and Animal Subjects
This study was approved by the institutional review board.

Authors' Contributions
R.C.: Conceptualization, data curation, formal analysis, investigation, writing—original draft, writing—review and editing; A.W.L.: project administration, data curation, formal analysis, investigation, writing—original draft, writing—review and editing; Y.I.: data curation, resources; O.B.: funding acquisition, conceptualization, methodology, project administration; A.M.: conceptualization, investigation, visualization; E.M.: funding acquisition, project administration; L.P.: data curation, formal analysis, review and editing; A.Y.O.: funding acquisition, resources, conceptualization, methodology, investigation, formal analysis, writing—review and editing, supervision; U.M.: conceptualization, methodology, investigation, writing—review and editing, supervision.

Conflict of Interest
A.Y.O. was a consultant for VSee, LLC and obtained research support from Pfizer, Microsoft Research, Hatchleaf. ai; U.M. was a consultant for Abbvie, Janssen, BMS, Takeda, Pfizer, Lilly, Gilead, Arena, Prometheus Biosciences, Protagonist, Boehringer Ingelheim. The other authors report no conflict of interest.

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