

Evaluation of the adherence of patients with chronic inflammatory bowel diseases to a PRO telemonitoring using connected devices: a prospective monocentric study

N. Delhougne¹, L. Monin¹, S. Vieujean¹, C. Van Kemseke¹, C. Reenaers¹, O. Warling¹, E. Louis¹

Gastroenterology Department, CHU Sart Tilman, Liège University, Liège, Belgium.

Abstract

Background and study aims: Monitoring the symptoms of inflammatory bowel diseases (IBD) patients is now frequently made in the form of patient reported outcomes (PRO), rather than historical clinical activity scores. Unlike several chronic diseases, the role of telemonitoring in IBD has not yet been defined, particularly in terms of patient compliance with remote monitoring; the aim of our study was to assess patient compliance with digital monitoring of PRO as part of routine medical follow-up.

Patients and methods: we performed a monocentric prospective study in the Gastroenterology Unit of Liège's University Hospital between May 2023 and February 2024. Adherence was considered optimal if 50% of the recordings planned for the duration of the follow-up were carried out.

Results: 31% of the patients included achieved at least 50% total encoding of their PRO over the 9 months of follow-up. The main cause of failure cited by patients was technical difficulties, well ahead of poor motivation. The overall satisfaction of practitioners and patients was generally good. Male gender was the only factor associated with adherence.

Conclusion: Overall adherence to PRO telemonitoring in IBD was around 40% and was mainly impaired by technical difficulties. Despite this, both patients and healthcare professionals found this type of monitoring relevant. (*Acta gastroenterol. belg.*, 2024, 87, 457-467).

Keywords: Inflammatory bowel disease, patient reported outcomes, remote monitoring.

Introduction

Inflammatory chronic bowel diseases (IBD) include Crohn's disease (CD), ulcerative colitis (UC) and unclassified colitis. The incidence of UC in Europe is still rising, while that of CD tends to stabilize, particularly in the high-incidence countries of Northern Europe (1). The prevalence of IBD in Europe is currently estimated around 1.3 million, which represents 0.2% of the population (1). Historically, IBD management focused on symptoms, but it has now been established that there may be a significant discrepancy between what patients feel and the objective inflammatory activity, particularly in Crohn's disease (2). In the long term, this persistence of inflammation may generate intestinal damages and, ultimately, complications. Current treatments are based on the concept of "treat-to-target", which involves defining a therapeutic target tailored to the patient (age, comorbidities, wishes, ...) and to the disease itself (severity, location, phenotype, ...). Then, gastroenterologists regularly assess the effectiveness of the treatment on the

basis of subjective clinical parameters, but also on the basis of objective biological, iconographic, endoscopic and histological parameters (3). However, this regular monitoring is expensive, time-consuming and potentially unacceptable to patients, which can lead to a loss of compliance (4). Recent data also suggest that patients' expectations and objectives (focused on their symptoms and quality of life) are sometimes very different from those of practitioners, without the latter always taking this into account (5). The revision of the "treat-to-target" concept in 2021 considered additional objectives such as absence of functional disability and normalization of quality of life, alongside the "classic" targets (6).

In this context, there has been a renewed scientific interest in the last years in the feelings of patients, and particularly their symptoms as they perceive them, grouped together under the terminology of "patient reported outcomes" (PRO). These are subdivided into two categories: those assessing the impact of the disease on social and professional life (PRO-1) and disease-related symptoms (PRO-2) (7,8). These are now regularly included in the main objectives of phase 3 pharmaceutical studies, which form the core of registration files for new drugs, due to the growing attention paid to this family of objectives in recent years by the main medicines agencies (FDA and EMA). Moreover, PRO are now used regularly beside or even instead of historical clinical evaluation scores (Mayo score, Harvey-Bradshaw Index, Crohn disease activity index, ...) both in daily practice and in clinical trials. The optimum outcome would therefore be a "holistic" remission including objective control of IBD (biomarkers, imaging, endoscopy, histology) but also an improvement in the patient's subjective symptoms and the repercussions on their daily life (PRO). In line with this development by drug registration agencies, scientific societies are also increasingly advocating the use of these PRO in daily practice. However, systematically collecting these PRO using conventional questionnaires is tedious and time-consuming, both for patients and healthcare

Correspondence to: Nicolas Delhougne, Centre Hospitalier Universitaire de Liège, Gastroenterology Department, Avenue de l'Hôpital 1, 4000 Liège, Belgium. Fax : 04/3237889.
Email: ndelhougne@chuliege.be

Submission date: 23/06/2024

Acceptance date: 05/09/2024

professionals. Other ways of monitoring these PRO have emerged in recent years, with the rise of connected/smart tools (9). As society becomes more and more digital, connected devices are now part of our daily lives, with the proportion of the population using them regularly and easily growing very quickly. Their use therefore makes sense in the eyes of the public, and it seems appropriate to assess whether the trend in thinking is similar in the field of health. Currently, these connected medical tools have proved their scientific value in two families of chronic pathologies: diabetes and cardiovascular disease (10). This type of monitoring would also enable patients to regain control of the management of their chronic disease, by being in control of the regular encoding of their data, and thus giving them an active role in the management of their disease. This could also potentially reassure certain patients who don't feel enough listened during the consultation and give them the ability to communicate their feelings more faithfully and in greater details than they are able to do during the consultation, due to lack of time. This is particularly the case for PRO-1, which are very often neglected by practitioners, as they are difficult to assess concisely and/or of little interest to them. Obviously, this omnipresence of connected devices also has its pack of detractors among the society, who are particularly concerned about respect for privacy and the secrecy of their personal data, especially regarding their health (10).

Another potential problem is the tendency of this type of regular monitoring to keep patients 'immersed' in their disease, by constantly reminding them of what they are suffering from through data encoding and notifications. It is therefore very important to assess the extent to which patients would accept this type of monitoring, and above all, to be assiduous about it. At present, the ideal and efficient technical ways of integrating this monitoring in IBD is still being debated, as is the type of PRO to be collected (11). The evaluation of IBD patients' adherence to such monitoring has already been assessed in several studies (12-14), but this evaluation remains currently limited. It is therefore important to reproduce these assessments in different populations in order to better calibrate the future use of these tools. The main objective of our study was therefore to assess patient adherence to the monitoring process using two connected devices (a smartwatch and a mobile application), and then to evaluate the satisfaction of both doctors and patients.

Patients and Methods

Study design and patients' inclusion

This is a prospective, observational, single-center cohort study, which took place in the gastroenterology department of Liège University Hospital over a period of 9 months. Patients were enrolled in spring 2023 and the study ended on the 26th of February 2024. Consecutive patients were offered the participation in the study during a routine consultation. Each patient was informed of the

goals and process of the study, and informed consent was given and signed prior to inclusion. The protocol was submitted to the hospital's ethics committee and validated before the start of the project (number B7072023000036), as well as to the hospital's data protection committee.

To be eligible, patients had to be over 18 years of age, have an established diagnosis of IBD and be able to use the digital tools used in the study with ease. Otherwise, or if the patients did not have a smartphone, the patients were excluded from the study.

Outcomes and judgement criteria

The main aim of this study was to assess patients' compliance with PRO telemonitoring via a connected watch and/or mobile application. Adherence was quantified by calculating the percentage of data encoded by the patient. Adherence was arbitrarily considered optimal if 50% of the recordings planned for the duration of the follow-up were carried out.

One of the secondary outcomes was to evaluate the satisfaction of the health practitioner and the possible impact of the data – collected by the patient and summarized for the doctor – on the orientation of care, and more generally on the overall added value that this monitoring would bring. During the follow-up, the practitioner carried out at least one standard consultation with all the elements available to her/him in routine clinical practice (history, clinical examination, para-clinical investigations) and, at the end of the consultation, examined the summary of the data collected by the patient, possibly resulting in a change of decision. A questionnaire was therefore created for practitioners to find out their perception of this monitoring, its relevance to them and whether it could be 'implemented' into a clinical routine (particularly in terms of time spent analyzing the data collected). The questionnaire was filled in by the practitioners at the end of the routine consultation with the patient, after having had access to the summary data from the PRO. Another secondary objective was to assess patient satisfaction with this kind of monitoring. Two questionnaires were therefore completed by patients during the follow-up.

The last secondary outcome was to assess whether certain factors were associated with better adherence to the monitoring programme.

The factors that have been studied include the clinical and demographic characteristics of patients and their IBD to determine whether some patient "profiles" could be associated with the rate of adherence to monitoring. The usual biomarkers (CRP and calprotectin) were also studied if they were available in the six months prior to inclusion. For fecal calprotectin, a value greater than 250 µg/g was defined as pathological (15).

Study procedures and timelines

The patients included in the study were given a Fitbit® connected watch for 9 months. The data collected were

the encoded PRO. Initially, certain vital parameters such as the number of daily steps, heart rate and quality of sleep were also to be recorded, but this was abandoned following synchronization difficulties between the watch and the storage server, with the result that the data collected was too incomplete to be analyzed. The patient retained access to these data, for information purposes only.

The PRO could be collected either by encoding on the watch or via the mobile application connected to it. The different PRO collected, and their respective scales/frequency of encoding are detailed in Table 1. The choice of PRO and their frequency of collection were decided by the two main investigators (ND and EL) and the IBD nurse (LM). We focused on the most commonly used PRO in clinical practice, i.e. those assessing the main digestive symptoms of IBD (rectal bleeding, abdominal pain, number of liquid stools, urgency). The other PROs assessing extra-intestinal manifestations or functional impact of the disease were on purpose collected less frequently to avoid an excessive workload for the patient. During an initial interview after inclusion, our IBD nurse gave the patient her/his smartwatch and helped her/him to synchronize it with the mobile application. This interview

also allowed the nurse to explain what each PRO meant, how to encode them and answer any questions.

All the data were regularly transferred to a secure virtual storage server. These raw data were accessible only to the gastroenterology team, on a secure platform (BeWell), which served as a digital dashboard for each patient. The data were available in raw form, but also in graphical form to assess the kinetic of each item collected. Using statistical data-processing tools, this information was summarized in the form of an average data for a given period (usually the period between two successive consultations) in order to synthesize the PRO as a single absolute value or an average score out of 10.

This abstract, accessible to the doctor, brought together all the data analyzed in the form of an average of their values over the predefined period. For example, the average abdominal pain (on a scale from 0 to 10) of a patient with CD was collected to find out the ‘average’ pain over the last few months.

The frequency of data collection was tailored to each patient’s situation. Several PRO were not relevant for some of the patients (assessment of joint stiffness in a patient with no rheumatological symptoms, for example).

Table 1. — **Illustration of the different PRO assessed by the patients with their scale and theoretical encoding frequency**

PRO-1

Type	Scale	Frequency
Asthenia	0: none 10: maximal	1 time / week
Limitation of daily activities	0: none 10: maximal	1 time / week
Productivity	0: the best 10: the worst	1 time / week
Sleep quality	0: the best 10: the worst	1 time / week
Ability to cope	0: very good 10: very bad	1 time / week
Psychic well-being	0: very good 10: very bad	1 time / week
Psychological stress	0: none 10: maximal	1 time / week
Global impact on health	0: no impact 10: maximal impact	1 time / week

PRO-2

Type	Scale	Frequency
Abdominal pain	0: none 10: maximal pain	Daily
Number of liquid stools	Absolute value	Daily
Rectal bleeding	Yes or no	Daily
Bowel urgency (UC)	0: none 10: the worst	Daily
Arthralgia	0: none 10: maximal pain	1 time / week
Morning stiffness (if arthralgia)	0: none 10: maximal	1 time / week

UC: ulcerative colitis. PRO: patient reported outcomes.

The medical data of the patients included in the study were collected in consultation and via their computerized medical files by the investigation team. The PRO were collected via the digital dashboard to which the watch and the mobile app were connected. Patients had to be assessed 1 time during the follow-up period by their referring gastroenterologist during a standard consultation. The data were then entered anonymously into an Excel database for statistical processing.

Statistical analysis

The primary endpoint was adherence to the remote monitoring system, quantified by the percentage of PRO harvested compared with theoretically expected.

The results are presented in the form of means and standard deviations (SD), quartiles (median, Q1, Q3) and extremes (minimum, maximum) for the quantitative variables and in the form of frequency tables for the qualitative variables.

Optimal adherence was defined arbitrarily by a total adherence of more than 50%. The chances of success were studied as a function of patient characteristics using logistic regression. Odds ratios (OR), confidence intervals and p-values are reported. In some cases, the Firth correction was applied and some variables were log-transformed to normalize their distribution.

The results are considered significant at the 5% uncertainty level ($p < 0.05$). Calculations were performed using SAS version 9.4.

Results

Baseline characteristics of the patients

47 patients were screened for inclusion. After being informed of the terms and aims of the study, 9 patients refused or were unable to take part. 38 patients were finally included in the protocol and received a smartwatch, as well as access to the mobile application and help with starting up the various devices (Figure 1). The patients baseline characteristics are shown in Table 2.

Adherence to remote monitoring

The average PRO encoding over the whole study was 39.29%. Half of the patients had an average encoding value of between 21% and 51% (Figure 2). Patient compliance was arbitrarily considered optimal if at least 50% of the encodings initially planned had been completed.

In total, 12 out of 38 patients (31.5%) exceeded the 50% average encoding rate (Figure 3).

Relevance of monitoring in medical care

Six gastroenterologists and a therapeutic education nurse from Liège University Hospital took part in the study and clinical follow-up. The questionnaire was completed by doctors for 31 of the 32 patients who fulfilled their "patient" questionnaire.

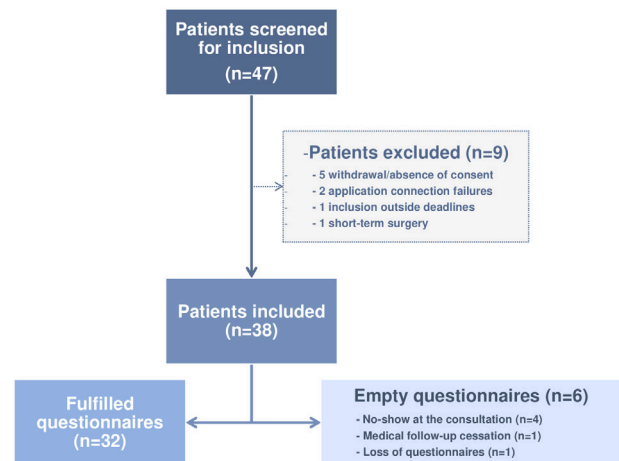


Figure 1. — Study flowchart.

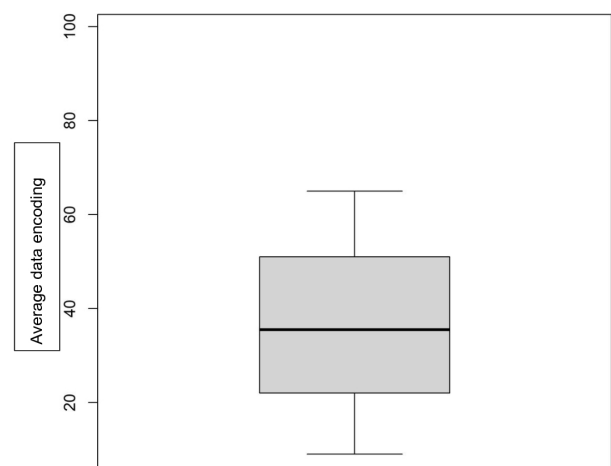


Figure 2. — Study of average adherence (percentage of data encoded). Average total adherence was 39.29% (± 24.44). Half of the patients had a mean adherence value between 21 and 51%. The lowest average encoding was 4%, while the highest was 99%.

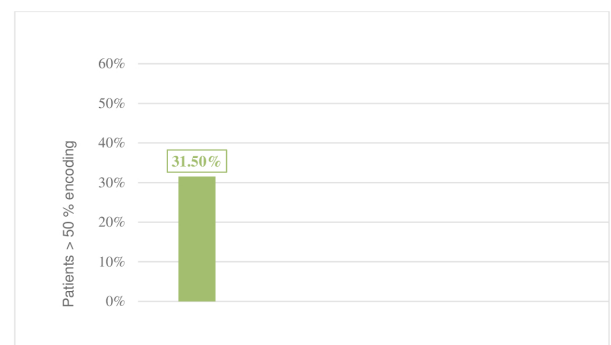


Figure 3. — Percentage of patients achieving at least 50% encoding of their PRO during the whole follow-up.

Regarding the time spent by the practitioner analyzing the summarized data, the doctors found it at least acceptable or fairly acceptable in 45% of cases and completely acceptable in 51% of cases. In 90% of medical follow-up, the doctors felt that the data enabled them to

Table 2. — Basic characteristics of the patients included (values are represented as percentages or averages). Values in brackets separated by a dash represent minimum and maximum values.

Age	41,6 years (21-65)
Gender: Female Male	57,8 % (22/38) / 42,1 % (16/38)
Duration of IBD	11,65 years (1-47)
Duration of IBD $\geq$ 5 years	60 % (23/38)
Smoking Never Active smoker Former smoker	68,4 % (26/38) 5,2 % (2/38) 26,3 % (10/38)
Crohn's disease	65,7 % (25/38)
Location Ileal (L1) Colonic (L2) Ileocolonic (L3)	56 % (14/25), 4 % (1/25), 40 % (10/25) of which 8 % (2/25) = L3 + L4
Phenotype Inflammatory (B1) Stricturing (B2) Penetrating (B3)	52 % (13/25) 32 % (8/25) 16 % (4/25)
Ano-perineal lesions	24 % (6/25)
Ulcerative colitis	34,2 % (13/38)
Extensive colitis (E3) Left-sided colitis (E2) Proctitis (E1)	15,3 % (2/13) 69,2 % (9/13) 15,3 % (2/13)
$\geq$ 1 course of corticosteroids	89 % (34/38)
Immunosuppressive drugs (past or current)	57,8 % (22/38)
Number of treatments used Current drug 5-ASA Thiopurines Anti-TNF Vedolizumab Ustekinumab JAK inhibitors Ozanimod	4,11 (1-9) 15,7 % (6/38) 2,6 % (1/38) 42,1 % (16/38) 8 Adalimumab + 8 Infliximab 13,1 % (5/38) 18,4 % (7/38) 5,2 % (2/38) 1 Tofacitinib + 1 Upadacitinib 2,6 % (1/38)
Extra-intestinal manifestations Rheumatologic Ophtalmologic Dermatologic	21 % (8/38) 10,5 % (4/38) 5,2 % (2/38) 5,2 % (2/38)
Past surgery for IBD	28,9 % (11/38) 10 Crohn + 1 RCH
C-Reactive Protein (n=37) > 5 mg/l < 5 mg/l	4,35 mg/l (0-22) 24,3 % (9/37) 75,6 % (28/37)
Fecal calprotectin (n=32) < 250 mg/kg > 250 mg/kg	222,8 mg/kg (0-1600) 78,1 % (25/32) 21,8 % (7/32)

better integrate items usually ignored or set aside, such as the PRO1.

On the other hand, in the majority of cases (55%), the doctors did not change their management after obtaining these data. Despite this, more than 9 times out of 10, they considered that this system added value to their care and/or their relationship with the patient and were almost always (93%) in favor of continuing this type of monitoring in their medical department.

Patients' satisfaction

32 of the 38 patients (84%) included in the study completed satisfaction questionnaires. One focused more on the application, the other on the connected watch. Only 20% of patients said they were not satisfied or not at all satisfied with monitoring by the connected devices. The same small proportion had a negative or very negative opinion of devices' ergonomics and ease of use. The

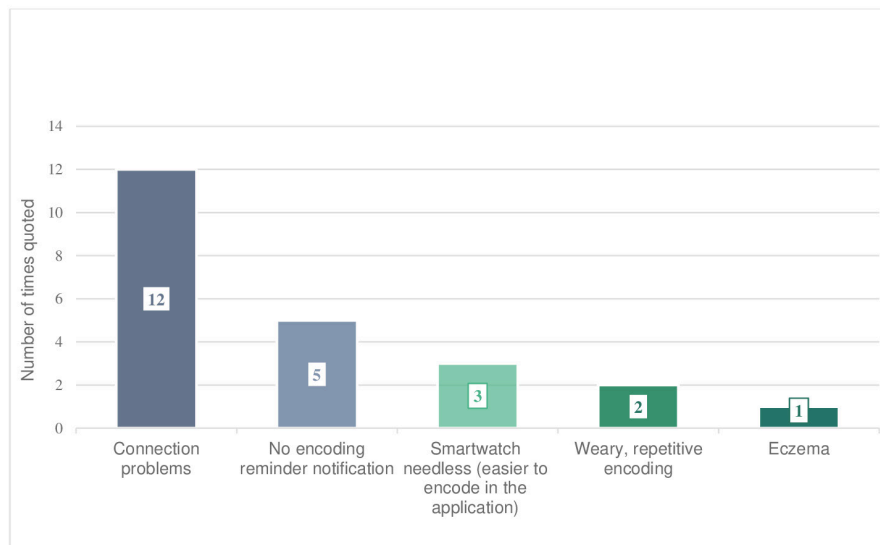


Figure 4. — Explanations given by patients for lack of encoding.

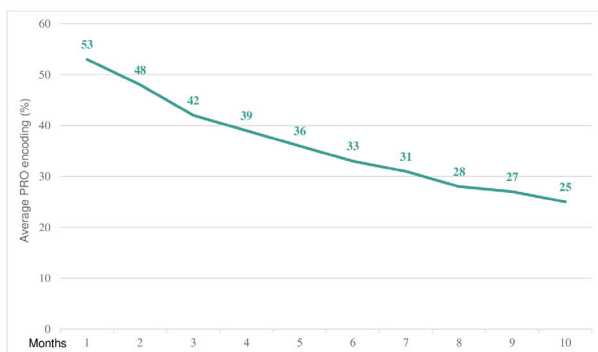


Figure 5. — Course in average patient adherence during the follow-up period. Adherence is represented by the percentage of PRO encoded.

problems most frequently described by patients were untimely disconnections with difficulty in reconnecting (particularly when they were changing their mobile phone during the study), the absence of systematic notification to serve as a reminder to enter data and the difficulties/impossibilities of synchronization between the smartwatch and the mobile application. Several patients also explained that they set the watch aside and only used the mobile application, which they found more convenient to enter their data. One patient also reported that she had stopped using her connected watch because of the appearance of a slight eczema under the strap. Problems of weariness were rarely mentioned (Figure 4). There was a gradual erosion of adherence, which was much greater in the first few months of follow-up, when more than half the PRO were encoded on average, than at the end, when only 25% were encoded (Figure 5).

In terms of motivation for encoding data, only 5 of the 32 patients found it difficult to keep on encoding data (15%). 40% of patients described it as quite easy and 28% as fairly easy. No one described the task as very difficult.

75% of patients described this type of monitoring as an added value in their care. The results were very mixed regarding the feeling that this connected monitoring had improved doctor-patient communication (31% disagreed, 31% moderately agreed and 38% strongly agreed). 47% thought that this monitoring had enabled them to discuss subjects that are usually neglected during consultations. 82% of patients said they were interested in continuing such monitoring in the future.

Factors associated with adherence

Factors associated with optimal adherence defined as >50% filling are shown in Table 3. In univariate analysis, only male gender was significantly associated with adherence above 50% (OR (95% CI) = 4.50 (1.04-19.23), $p=0.044$). No factor was significantly associated with low average adherence (Table 4). There was only a trend for fecal calprotectin (OR=0.57, $p=0.089$). Low calprotectin tends to increase the risk of poor adhesion. It seems that patients in deeper remission would be less compliant than active patients.

Discussion

Our study shows that patients' adherence to PRO remote monitoring using a connected device is around 40% on average which is consistent with previous studies (12). 1/3 of patients exceeded 50% encoding over the entire study. Adherence levels were much higher in the first phase of the trial, with a gradual decline in values over the 9 months of follow-up. The technical problems inherent in the digital tools were very frequently cited by patients as the main reason for their loss of compliance, much more frequently than their (lack of) willpower. The only factor significantly associated with better adherence was male gender.

Table 3. — Univariate logistic regression model analyzing factors associated with average adherence of more than 50%

Variable	N	OR	Lower limit OR	Upper limit OR	P-value
Age (years)	38	1.014	0.961	1.069	0.61
Gender Female vs Male	38	0.222	0.052	0.958	0.044
Smoking (former vs non-smoker)	38	1.800	0.392	8.271	0.65
(active vs non-smoker)	.	2.599	0.143	47.317	.
Ulcerative colitis vs Crohn's disease	38	2.714	0.653	11.289	0.17
IBD duration (years)	38	1.022	0.958	1.091	0.50
IBD duration (years) >5 vs ≤ 5	38	1.027	0.257	4.107	0.97
CD Montreal A > 40 vs 17-40 years	25	0.203	0.007	5.554	0.34
CD Montreal L colonic vs ileal	25	15.084	0.131	>999.999	0.56
Ileocolonic vs ileal	.	1.923	0.238	15.552	.
L3+L4 vs. Ileal	.	5.000	0.223	111.861	.
CD Montreal B Stricturing vs Inflammatory	25	0.812	0.117	5.628	0.71
Penetrating vs. Inflammatory	.	0.235	0.007	7.521	.
CD Montreal Perineal lesions Yes vs No	25	5.333	0.707	40.216	0.10
UC Left-sided vs proctitis	13	0.818	0.038	17.577	0.99
Extensive colitis vs proctitis	.	1.000	0.020	50.397	.
EIM Rheumatologic Yes vs No	35	1.667	0.202	13.735	0.82
Dermatologic Yes vs No	.	0.333	0.007	14.894	.
Ophthalmologic Yes vs No	.	0.333	0.007	14.894	.
Corticosteroids Yes vs No	38	1.435	0.134	15.415	0.77
IS Purines vs No	38	0.917	0.208	4.048	0.90
MTX + Purines vs No	.	1.467	0.184	11.719	.
Number of treatments used	38	.	0.825	1.547	0.45
CRP (mg/L) (Log)	37	0.919	0.437	1.933	0.82
CRP > 5 vs < 5 mg/l	37	1.056	0.214	5.212	0.95
Calprotectin (µg/g) (Log)	32	1.112	0.648	1.908	0.70
Calprotectin > 250 vs < 250 µg/g	32	1.122	0.182	6.903	0.90
Current drug Adalimumab vs 5-ASA	38	1.410	0.117	16.995	0.96
Infliximab vs 5-ASA	.	1.410	0.117	16.995	.
Vedolizumab vs 5-ASA	.	2.619	0.187	36.657	.
Ustekinumab vs 5-ASA	.	1.667	0.134	20.740	.
Tofacitinib vs 5-ASA	.	11.474	0.079	>999.999	.
Upadacitinib vs 5-ASA	.	11.474	0.079	>999.999	.
Ozanimod vs 5-ASA	.	11.474	0.079	>999.999	.
Purines vs 5-ASA	.	1.224	0.009	168.861	.
Surgery Yes vs No	38	0.750	0.159	3.532	0.72

EIM: extra-intestinal manifestations; UC: Ulcerative colitis; CD: Crohn's disease ; IS : immunosuppressive drugs ; CRP : C-reactive protein.

In terms of IBD characteristics, the cohort of patients constituted is fairly similar to the epidemiological data classically reported. However, it is worth noting the under-representation of 5-aminosalicylates treatments compared with the usual cohorts - it is considered that around 50% of UC are treated with this therapeutic class (16) - which was expected given the UC population from a tertiary university center (selection bias of a population probably more refractory to the first line therapies)

and given the preponderance of Crohn's disease in our cohort, where the therapeutic role of amino salicylates is not demonstrated (17).

In terms of patient adherence to data encoding, the arbitrarily set target of 50% total encoding was achieved by 31% of patients. This level was probably too ambitious, insofar as they were asked to enter certain data on a daily basis for almost 9 months, with some of the data changing over the course of a single day (mainly stool frequency).

Table 4. — Univariate logistic regression model analyzing factors associated with total adherence of less than 21% (first quartile). No parameter was significantly associated with low adherence. There was only a trend for low calprotectin (OR=0.57, p=0.089) that was associated with a risk of low adherence

Variable	N	OR	Lower limit OR	Upper limit OR	P-value
Age (years)	38	1.010	0.953	1.071	0.73
Gender Female vs Male	38	1.625	0.339	7.788	0.54
Smoking (former vs non-smoker)	38	1.824	0.355	9.381	0.57
(active vs non-smoker)	.	3.911	0.208	73.346	.
Ulcerative colitis vs Crohn's disease	38	0.468	0.082	2.667	0.39
IBD duration (years)	38	1.042	0.972	1.117	0.25
IBD duration (years) >5 vs ≤ 5	38	1.625	0.339	7.788	0.54
CD Montreal A > 40 vs 17-40 years	25	0.744	0.080	6.953	0.80
CD Montreal L colonic vs ileal	25	0.990	0.008	121.349	0.60
Ileocolonic vs ileal	.	3.286	0.512	21.079	.
L3+L4 vs. Ileal	.	0.657	0.013	33.107	.
CD Montreal B Stricturing vs Inflammatory	25	1.154	0.157	8.461	0.64
Penetrating vs. Inflammatory	.	3.000	0.293	30.761	.
CD Montreal Perineal lesions Yes vs No	25	0.433	0.041	4.566	0.49
UC Left-sided vs proctitis	13	0.882	0.014	55.664	0.58
Extensive colitis vs proctitis	.	4.999	0.048	516.655	.
EIM Rheumatologic Yes vs No	35	1.753	0.169	18.197	0.38
Dermatologic Yes vs No	.	4.092	0.219	76.623	.
Ophthalmologic Yes vs No	.	20.450	0.441	949.315	.
Corticosteroids Yes vs No	38	0.923	0.084	10.154	0.95
IS Purines vs No	38	0.643	0.119	3.463	0.59
MTX + Purines vs No	.	2.000	0.241	16.612	.
Number of treatments used	38	1.033	0.733	1.455	0.85
CRP (mg/L) (Log)	27	0.862	0.375	1.977	0.73
CRP > 5 vs < 5 mg/l	37	0.375	0.040	3.551	0.39
Calprotectin (µg/g) (Log)	27	0.566	0.293	1.091	0.089
Calprotectin > 250 vs < 250 µg/g	32	0.475	0.060	3.780	0.48
Current drug Adalimumab vs 5-ASA	38	1.146	0.128	10.268	0.99
Infliximab vs 5-ASA	.	0.360	0.030	4.383	.
Vedolizumab vs 5-ASA	.	1.286	0.112	14.743	.
Ustekinumab vs 5-ASA	.	0.415	0.033	5.206	.
Tofacitinib vs 5-ASA	.	0.564	0.004	75.183	.
Upadacitinib vs 5-ASA	.	0.564	0.004	75.183	.
Ozanimod vs 5-ASA	.	0.564	0.004	75.183	.
Purines vs 5-ASA	.	0.564	0.004	75.183	.
Surgery Yes vs No	38	1.313	0.263	6.549	0.74

Regarding the fairly linear decrease in adherence over time, we could of course put forward the logical idea that patients were becoming bored with their regular encoding, but the results of the patient questionnaires described above run counter to this hypothesis. It should be made clear that all the patients started coding at the same time and that there was no staggered inclusion. This drop in encoding cannot therefore be explained by a different population or general context during second half of the study. In terms of motivation, the vast majority of patients who completed the satisfaction questionnaires

(at the end of the study) reported that their motivation remained unchanged, even after 9 months. In their opinion, the lack of encoding was primarily due to the technical problems mentioned above. Apart from these constraints, the lack of encoding is explained more by forgetfulness on their part (smartwatch not worn, no reminder notifications, remission of the disease, etc.) than by a real drop in motivation. Finally, only a minority mentioned a drop in motivation (15% considered data encoding to be burdensome), often justified by the fact that the data was entered too frequently or repetitively

(in particular the PRO requested daily). Only one patient gave a medical reason for stopping encoding (local eczema against the watchband).

The results were more mixed concerning the possible benefits of this type of monitoring in doctor-patient communication (1/3 refuted this hypothesis, 1/3 modestly supported it and a final third frankly supported it). On the other hand, most of them (nearly 75%) thought that this could nevertheless represent an added value in their medical care, even if the subjects usually neglected in consultations (in particular PRO1) were not discussed more, according to half of them. These data confirm those of previous studies which report a high level of satisfaction of patients to a symptoms remote monitoring, for example with the HealthPROMISE platform created by the Mount Sinai hospital, or in a survey by the same New York's health center, which reported a rate of 89% of patients in favor of the introduction of a digital monitoring tool, similar to ours (over 80%) (18,19).

In technical terms, the majority of patients (80%) said they were (very) satisfied with this type of monitoring, and the same proportion did not experience any technical difficulties with encoding. However, many also reported frequent problems with synchronization between the application and the watch, or problems with (re)connections. Several patients who still wanted to continue encoding had to stop all monitoring altogether because they were unable to reconnect to the application (particularly after changing their mobile phone). Many of them also described the watch as useless, as data encoding was very simple and sufficient via the mobile application. In their view, the only potential benefit of the watch would be to be able to encode stool frequency – a value that is difficult to assess accurately after 24 hours, especially during IBD flares – as the day progresses, in order to improve accuracy. These data are in line with studies of the first mobile telemonitoring applications specifically for IBD created around ten years ago (e.g. GI Buddy or GI Monitor), which also suffered from frequent connection or interface problems hampering their regular use and leading to their abandonment after a few years (18).

From a medical point of view, the analysis of the summarized data in consultation was an acceptable or completely acceptable constraint for 96% of them. However, it should be pointed out that this data was collected beforehand by our therapeutic education nurse and put together on a summary sheet, which considerably reduced the time spent by the doctor analyzing the data, which had already been summarized. It's easy to imagine that this kind of summary work would be inconceivable without the help of a third person, as it would be too time-consuming. Furthermore, the medical profession was virtually unanimous on the value of this monitoring as a means of addressing issues that are usually neglected during consultations (90% of doctors), whereas more than 53% of patients said the opposite. Concerning possible changes in management, data analysis during

consultations most often had no impact (53%), which is not surprising and supports the hypothesis that these telemonitoring tools bring added value (as 93% of doctors believe) to the doctor-patient relationship, without improving purely medical management. Nevertheless, the average score built for each PRO by the study could have helped physicians to better characterize IBD's clinical activity in consultation and maybe accelerate some explorations (fecal calprotectin, MRI, endoscopy...) to check this out.

Analysis – even brief – of these PRO1 (fatigue, sexual problems, emotional management, etc.) could potentially help patients to manage these “functional” or “non-medical” complaints, which can frequently be disabling in their private and/or professional lives, even if the inflammatory activity of IBD is controlled. We did not ask the participating doctors to specify which PRO1 had given them the most useful information for medical management. It was probably by analyzing them as a whole that the doctors found them interesting. This data collection of PRO1 could be used for screening during consultations to encourage appropriate treatment, as it is tending to happen in some IBD specialist departments (fatigue coaching, yoga/cooking classes, sexology or psychiatry consultations, etc.).

Enthusiasm for continuing this type of monitoring in the future was shared by both doctors (93% in favor) and patients (82%), which is in line with previous studies on the subject (18-20). One weakness of these questionnaires is obviously the lack of response from some patients, who are perhaps more critical of this type of monitoring. Nevertheless, they represent a minority of this cohort (18% of the patients included) and there is no reason to suspect that they would have been more critical in their assessment, insofar as they did not attend their “routine” medical consultation, and not appointments specifically dedicated to the current study. We cannot therefore assume their level of adherence to this type of monitoring/assessment, insofar as all their conventional medical monitoring was stopped.

Our study has several weaknesses. Firstly, it was conducted on a relatively small sample of patients, which limited its statistical power (particularly for determining the factors associated with adherence). Selection biases are also possible given the monocentric nature of our cohort, which was not randomized and came from a university center, with its own specific features.

One of the strengths of this study is its innovative nature. Until now, studies looking at telemonitoring using a connected watch were either spread over a few weeks only, to assess feasibility alone (21), or were telemonitoring studies aimed primarily at creating the most suitable digital tool for IBD patients, most of them without looking at patient adherence and possible reasons for failure. Our study was conducted prospectively over 9 months, with 7 different investigators and a larger sample size than previous feasibility studies and is one of the first to look specifically at patient

adherence. It was fully integrated into routine medical monitoring, and the data obtained from it can therefore be legitimately described as real-life data. In addition, the characteristics of the patients and their IBD were broadly similar to the usual data in the literature and can therefore probably be transposed. Another strength of the study is the use of the various questionnaires, which enabled us to understand the main causes of the loss of adherence and to identify ways of remedying it, in particular by simplifying the digital tools to improve their reliability and probably by reducing the frequency of data encoding. Other prospective studies with larger samples, ideally from several centers, should confirm the hypotheses put forward and enable us to identify more precisely the sub-groups of patients who could benefit most from such a tool. A cost-effectiveness analysis of this type of monitoring is also needed to confirm its value and sustainability in order to expect financial support from the healthcare system. For example, the automatic detection by the mobile application of PRO exceeding a predefined threshold could trigger an alert to the medical or paramedical team, so that the patient could be quickly reassessed in consultation or asked to undergo a test (for example a calprotectin at home). This early response to alerts could prove the added value of this type of monitoring in medical care, avoiding delays in diagnosing a relapse or complication.

In conclusion, this study sheds light on the practicalities and potential benefits of self-monitoring of IBD patients' symptoms. Both patients and practitioners seem to find it of interest, and most are in favor of implementing this type of tool, although it could largely be improved given the many technical difficulties encountered by patients. The value of a connected watch in this type of monitoring seems very limited, since it is not ergonomic enough for data encoding and makes the technical set-up more complex. In future, we suggest using a simple mobile application for easy and more reliable data encoding. Motivation does not appear to be the main limiting factor. Systematic use of reminder notifications could be relevant to optimize adherence as well as a technical help line. Further prospective studies, including larger multicenter cohorts, should be designed to confirm these results and improve the selection of patients who could benefit from this type of monitoring and its methods, before considering proving the medical added value and/or economic benefit of this type of tool.

Financial disclosures

Technical and financial supports were provided by the pharmaceutical company Pfizer $\hat{O}$, which supplied the smartwatches as well as the storage server. However, Pfizer never had access to any encoded data.

Conflict of interest statement

The authors declare no conflict of interest.

References

1. ZHAO M, GONCZI L, LAKATOS P, BURISCH J. The Burden of Inflammatory Bowel Disease in Europe in 2020. *J Crohn's Colitis*, 2021, 25 (9):1573-1587.
2. GRACIE D, WILLIAMS C, SOOD R, MUMTAZ S, BHOLAH M, HAMLIN P, et al. Poor correlation between clinical disease activity and mucosal inflammation, and the role of psychological comorbidity, in inflammatory bowel disease. *Am J Gastroenterol.*, 2016, 111(4):541-51.
3. PEYRIN-BIROULET L, SANDBORN W, SANDS B, REINISCH W, BEMELMAN W, BRYANT R, et al. Selecting Therapeutic Targets in Inflammatory Bowel Disease (STRIDE): Determining Therapeutic Goals for Treat-to-Target. *Am J Gastroenterol.*, 2015, 110:1324-38.
4. BUISSON A, GONZALEZ F, POULLENOT F, NANCEY S, SOLLELLIS E, FUMERY M, et al. Comparative Acceptability and Perceived Clinical Utility of Monitoring Tools: A Nationwide Survey of Patients with Inflammatory Bowel Disease. *Inflamm Bowel Dis.*, 2017, 23:1425-1433.
5. ROCHELLE T, FIDLER H. The importance of illness perceptions, quality of life and psychological status in patients with ulcerative colitis and Crohn's disease. *J Health Psychol.*, 2013, 18:972-83.
6. TURNER D, RICCIUTO A, LEWIS A, D'AMICO F, DHALIWAL J, GRIFFITHS A, et al. STRIDE-II: An Update on the Selecting Therapeutic Targets in Inflammatory Bowel Disease (STRIDE) Initiative of the International Organization for the Study of IBD (IOIBD): Determining Therapeutic Goals for Treat-to-Target strategies in IBD. *Gastroenterology*, 2021, 160:1570-1583.
7. WILLIET N, SANDBORN W, PEYRIN-BIROULET L. Patient-reported outcomes as primary end points in clinical trials of inflammatory bowel disease. *Clin Gastro Hepatol.*, 2014, 12:1246-56.
8. PEYRIN-BIROULET L. 2020. Les PRO (Patients Reported Outcomes) dans les MICI : définition et utilisation au quotidien. Association Nationale Française de Formation Médicale Continue en Hépatogastro-Entérologie, Viewed 2nd of October 2022. <https://www.fmcgastro.org/texte-postu/postu-2020-paris/les-pro-patients-reported-outcomes-dans-les-mici-definition-et-utilisation-au-quotidien>
9. SOSSENHEIMER P, YVELLEZ O, ANDERSEN M, PEARL T, EL JURDI K, RUBIN D, et al. P579 Wearable devices can predict disease activity in inflammatory bowel disease patients. *J Crohn's Colitis*, 2019, 13: S404.
10. GINSBURG G, PICARD R, FRIEND S. Key Issues as Wearable Digital Health Technologies Enter Clinical Care. *N Engl J Med.*, 2024, 390:1118-1127.
11. PLEVRISS N, LEES CW. Disease Monitoring in Inflammatory Bowel Disease: Evolving Principles and Possibilities. *Gastroenterology*, 2022, 162:1456-1475.
12. COENEN S, NIJNS E, WEYTS E, GEENS P, VAN DEN BOSCH B, VERMEIRE S, et al. Development and feasibility of a telemonitoring tool with full integration in the electronic medical record: a proof of concept study for patients with inflammatory bowel disease in remission on biological therapy. *Scand J Gastroenterol.*, 2020, 55:287-293.
13. ATREJA A, KHAN S, ROGERS JD, OTOTO E, PATEL NP, ULLMAN T, COLOMBEL JF, et al. HealthPROMISE Consortium Group. Impact of the Mobile HealthPROMISE Platform on the Quality of Care and Quality of Life in Patients With Inflammatory Bowel Disease: Study Protocol of a Pragmatic Randomized Controlled Trial. *JMIR Res Protoc.*, 2015, 18:e23.
14. SEBASTIAN S, ROBERTS J, WALLER J, JUDGE D, BROWN C, DAVIES R, et al. Remote Monitoring of Patient-Reported Outcomes in Ulcerative Colitis: A Prospective Real-World Pilot Study. *Pharmacoecoon Open.*, 2019, 3 :359-365.
15. REENAERS C, BOSSUYT P, HINDRYCKX P, VANPOUCKE H, CREMER A, BAERT F. Expert opinion for use of fecal calprotectin in diagnosis and monitoring of inflammatory bowel disease in daily clinical practice. *United European Gastroenterol J.*, 2018, 6:1117-1125.
16. RAINE T, BONOVAS S, BURISCH J, KUCHARZIK T, ADAMINA M, ANNESE V, et al. ECCO Guidelines on Therapeutics in Ulcerative Colitis: Medical Treatment. *J Crohn's Colitis*, 2022, 16:2-17.
17. TORRES J, BONOVAS S, DOHERTY G, KUCHARZIK T, GISBERT J, RAINE T, et al. ECCO Guidelines on Therapeutics in Crohn's Disease: Medical Treatment. *J Crohn's Colitis*, 2020, 14:4-22.
18. CHANG S, HAMILTON M, LEES C, ATREJA A. Mobile Health in IBD: Enhancing Care, One Phone at a Time. *Inflamm Bowel Dis.*, 2020, 26:163-166.
19. HIRTEN R, STANLEY S, DANIELETTA M, BORMAN Z, GRINSPAN A, RAO P, et al. Wearable Devices Are Well Accepted by Patients in the Study

- and Management of Inflammatory Bowel Disease: A Survey Study. *Dig Dis Sci.*, 2021, 66:1836-44.
20. DEL HOYO J, MILLAN M, GARRIDO-MARIN A, AGUAS M. Are we ready for telemonitoring inflammatory bowel disease? A review of advances, enablers, and barriers. *World J Gastroenterol.*, 2023, 29:1139-1156.
21. YVELLEZ O, ANDERSEN M, GOLAN M, RODRIQUEZ D, ZMETER N, EL JURDI K, et al. P051 IBD patient Compliance with mobile and wearable technologies as tools to assess quality of life, sleep quality and pain. *Inflammatory Bowel Diseases*, 2018, 24:18–19.