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Inflammatory Bowel Disease Disability Index is a valid and reliable measure of disability in an English-speaking hospital practice and predicts long-term requirement for treatment escalation

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ABSTRACT

Objective The Inflammatory Bowel Disease Disability Index (IBD-DI) was developed according to WHO standards and has been validated in population-based cohorts. However, there are limited data on its relationship to various psychosocial and economic variables or its relevance to hospital clinical practice. The study aims were to determine the validity and reliability of the IBD-DI in an English-speaking hospital out-patient population and to evaluate its association with short and long-term disease activity.

Design/Methods 329 subjects were enrolled in a cross-sectional and longitudinal study assessing the IBD-DI and a range of quality of life, work impairment, depression, anxiety, body image, interpersonal, self-esteem, disease activity, symptom scoring scales in addition to long-term outcome.

Results The IBD-DI had adequate structure, was internally consistent and demonstrated convergent and predictive validity and was reliable in test–retest study. Disability was related to female sex (p=0.002), antidepressant use (p<0.001), steroid use (p<0.001) and disease activity (p<0.001). Higher IBD-DI scores were associated with long-term disease activity and need for treatment escalation in univariate (p<0.001) and multivariate (p=0.002) analyses.

Conclusion The IBD-DI is a valid and reliable measure of disability in English-speaking hospital populations and predicts long-term requirement for treatment escalation.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The Inflammatory Bowel Disease Disability Index (IBD-DI) was recently developed in community IBD populations to provide a patient reported measure of functional status. We performed this research to assess the IBD-DI in an English-speaking hospital *out-patient* population, using objective disease activity criteria and a wide range of psychosocial and economic survey tools for the first time.

WHAT THIS STUDY ADDS

⇒ The IBD-DI is a valid measure of disability in hospital practice and correlates closely with psychological, economic and social function. The IBD-DI also correlates with subsequent long-term outcome.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The IBD-DI is a simple self-administered questionnaire, which takes patients approximately 10 min to complete and may become a valuable patient-reported outcome measure in hospital-based clinical and research practice.

INTRODUCTION

The WHO defines disability as '…restriction or lack of ability to perform an activity in the manner, or within the range, considered normal for a human being'.[1] Disability is a broad measure of functional impairment and can result from diverse

circumstances. For people with inflammatory bowel disease (IBD), disability may include incapacity, fatigue and poor health associated with active disease, treatment side-effects, a lack of educational and economic opportunities, inadequate environmental supports including bathroom or changing facilities, poor healthcare, social or psychological services, limited participation in community, sporting, family, interpersonal and sexual relationships and psychological disorders associated with the subjects disease.[2] Disability survey tools are used as patient-reported outcome measures (PROMs) in many non-gastroenterological inflammatory disease states.[3 4] In contrast, the functional status of people with IBD has frequently been measured using quality of life (QOL) indices.[5] However, current QOL survey tools underplay the importance of many functional aspects such as sleep, body image, work, social, interpersonal and economic function.[6 7] Additionally, existing QOL tools were developed prior to contemporary PROM development guidelines,[8] compromising their validity in clinical trials.[2] A comprehensive measure of disability, constructed within an appropriate framework, would be a valuable clinical and research tool[9] and the importance of various PROMs has been emphasised in recent consensus statements relating to randomised controlled trials.[10]

In 2009, the *International Programme to Develop New Indexes for Crohn's Diseases* commenced a 2-year study to design an objective IBD-specific disability index according to standardised International Classification of Functioning, Disability and Health and WHO criteria,[1 11] thus fulfilling contemporary PROM guidelines.[12] This resulted in a core 18-item Inflammatory Bowel Disease Disability Index (IBD-DI) in mid-2011,[11] and an item reduced and validated 14-question survey tool in 2017.[13] The IBD-DI has since been assessed in a large Canadian population study and in a Portuguese cohort,[14 15] while different scales have been developed in Australian and New Zealand, Chinese and Spanish populations.[16–18] The IBD-DI is thought to have a valid construct but has not been tested across a broad range of psychosocial or economic domains or studied in an English-speaking hospital population. Finally, there are no longitudinal data assessing the impact of disability on subsequent prognosis or requirement for future treatment escalation. We aimed to assess the validity and reliability of the IBD-DI across all its domains in an English-speaking hospital population, to evaluate its association with short and long-term disease activity and assess its relationship with subsequent treatment needs.

MATERIALS AND METHODS

Participants

Three hundred and eighty-seven ambulatory care patients, attending two Irish Hospitals with a radiological and histological diagnosis of Crohn's disease or ulcerative colitis were invited to participate in a longitudinal cohort study. Baseline data were collected between January 2012 and March 2013. In total, of 387 subjects invited, 46 declined to participate, 7 had critical IBD-DI data missing and 5, whose disease could not be confirmed, were excluded, leaving 329 subjects (85%) (online supplemental figure 1), flow diagram). Subjects completed a self-administered questionnaire that included the 14-item IBD-DI evaluating overall health, sleep, energy, depression, anxiety, body image, abdominal pain, defecation, diet, personal and community relationships, work/education, number of liquid motions and arthralgia. Likert scale items were scored from 0 to 4, while the number of bowel motions was categorised into five levels, and the single binary scale item categorised as 0 or 4 as described.[13] Scores were calculated from the formula: summary score × 100/(number questions answered × 4) and gave a range from 0 to 100, with higher scores representing greater disability.[13]

The questionnaire also assessed multiple economic and psychosocial domains. Quality of life was measured using the Short Health Scale,[19] work impairment with the Work Productivity Index,[20] depression with Beck's depression inventory[21] and sexual dissatisfaction using the sexual satisfaction scale.[22] Disease activity was assessed based on symptoms, physical examination, blood tests, faecal calprotectin, endoscopic and histological data where appropriate by a physician who was unaware of study results. Faecal calprotectin was not routinely used to assess disease activity in routine outpatient practice when the study commenced and was, therefore, not used as a discrete study endpoint.

Follow-up

Follow-up data were obtained from a prospectively maintained clinical patient records system as previously described.[23] Physicians and IBD nurse specialists updated the computerised records system throughout hospital admissions, at clinic visits and during telephone and email consultations. Databases linked automatically to the hospital's patient administration system and were cross-referenced with clinical laboratory and surgical pathology databanks. Further data were accessed from hard copy charts, as necessary. Treatment escalation was defined as a need for additional medical (steroid, thiopurine or biologic) or surgical therapy in response to active disease, in accordance with national and international guidelines and without knowledge of prior study data.[24–26] Treatment changes related to drug intolerance or in response to therapeutic drug monitoring without inflammatory activity, surgery without intestinal resection (strictureplasties, endoscopic dilations or stent insertions for fibrotic disease, abscess drainages, fistula procedures or examinations under anaesthesia) and prescription renewals following periods of non-compliance were not included as escalation endpoints.[24] Follow-up data were collected by researchers blinded to baseline

information. Clinical follow-up ended in June 2020 with an accumulated 2166 patient years of follow-up (median 7.5 years (mean 6.6 years); range 0–8.6).

Statistical analysis

We used Strengthening the Reporting of Observational Studies in Epidemiology guidelines to conduct analyses and assess study quality, and the study protocol was published on the Open Science Framework in 2020 (https://osf.io/x8bw4). Response prevalence (the frequency with which a score of 1 or more was obtained for each question) was determined and principal component analysis was employed to assess structure and content validity. Internal consistency was determined using Cronbach's alpha (α) coefficient. IBD-DI scores were compared with quality of life, health-related work activity impairment, depression and sexual satisfaction to evaluate convergent validity. Predictive validity was examined by comparing IBD-DI scores with physician-reported disease (13,14 shafer). Forty-four patients, who were in remission and whose treatment remained unchanged, completed the IBD-DI 1 week apart (range 6–32 days) to determine test–retest reliability. Summary data are presented as medians and IQRs. The Mann-Whitney U test and Kruskal-Wallis test were used to assess differences between groups. Correlations were analysed using Spearman's rank correlation coefficient (r_s) and intraclass correlation coefficients. Linear regression analyses were performed to correct for confounding variables and their association with IBD-DI scores.

Kaplan-Meyer analysis with log-rank testing was used to assess and compare cumulative event probabilities. Subjects were categorised into those with 'no (or low) disability' (IBD-DI score 0–19), 'mild disability'[20–35] and 'moderate/severe disability' (>35) as recommended by Gower-Rousseau *et al*.[13] Cox's proportional hazards model, with backward regression, was used to determine variables significantly and independently associated with treatment escalation. IBD-DI scores, and other quantitative data, were entered into multivariate analyses as continuous variables. The longitudinal endpoint was cumulative risk of first clinical recurrence requiring treatment escalation over the short term and over the long term.[24 27] Short term was defined as follow-up in the first study year, anticipating that baseline active disease would largely be treated over this time period.[28] Long-term follow-up was defined as follow-up after the first year of study.[29] The Statistical Package for the Social Sciences (SPSS V.27.0; SPSS, Chicago, Illinois) was used for all analyses.

RESULTS

IBD-DI: baseline characteristics, distribution and response prevalence

Baseline data of the 329 participants (mean age 39 years, range 18–82) are shown in table 1, with subgroup data for Crohn's disease and ulcerative colitis subjects shown in online supplemental tables 1 and 2. Figure 1A,B shows that there was a wide IBD-DI score distribution across both Crohn's disease and ulcerative colitis subjects. Figure 1C shows the response prevalence to individual IBD-DI questions. Between 12% and 68% scored 0 on each of the 14 questions. As an example, 52% of subjects answered, 'very good' to question 1 concerning general health, whereas 36%, 7%, 3% and 2% answered 'good', 'moderate', 'bad' or 'very bad', respectively.

IBD-DI: factor analysis, internal consistency, validity and reliability

Following scree plot examination of eigenvalues (figure 1D), a single factor solution emerged with an eigenvalue of 5.8, explaining 41% of total variance and with 13 of the 14 question items correlating (≥0.4) with the principal component (online supplemental table 3). Question 14, relating to arthritis/arthralgia did not load highly onto the model. Internal consistency of the questions was demonstrated with a Cronbach's α of 0.86. Figure 2 shows the association between disability, disease activity and psychosocial variables. Disability was higher in subjects with active disease (median, 36; IQR, 23–48) than in those in remission (median, 20; IQR, 11–32; $p<0.0001$) ($r_s=0.34$; $p<0.0001$), supporting predictive validity. Disability was also associated with quality of life ($r_s=0.69$), percentage work impairment ($r_s=0.60$), depression ($r_s=0.79$) and sexual satisfaction ($r_s=0.46$), establishing convergent validity (all $p<0.001$). Disability was also weakly associated with serum C reactive protein ($r_s=0.17$; $p=0.007$) and inversely associated with serum albumin ($r_s=-0.18$; $p=0.004$) (data not shown). IBD-DI scores were marginally higher in anaemic patients (median 30 (IQR 16–41)) than those without anaemia (median 23 (IQR 13–38) ($p=0.043$)) (data not shown). Online supplemental figure 2 shows IBD-DI scores measured a median of 1 week apart in 44 subjects with inactive disease. Test–retest reliability was demonstrated with an r_s of 0.85 ($p<0.001$) and an intraclass correlation coefficient of 0.90 (95% CIs, 0.81 to 0.94; $p<0.001$).

IBD-DI and risk of short-term and long-term treatment escalation

Figure 3A,B shows cumulative treatment escalation risk in the first year associated with disease activity and disability. Immediate and early treatment changes were fundamentally linked to the initial physician's disease activity assessment (figure 3A). A Cox proportional hazards model with backward elimination of baseline variables (online supplemental table 4) showed that baseline disease activity, with a small independent contribution from disease duration and baseline IBD-DI, was the predominant factor associated with treatment escalation during the first year. In contrast, long-term risk of uncontrolled activity requiring escalation was unrelated to baseline disease activity (figure 3C) ($p=0.160$) but was closely associated with baseline

Table 1 Baseline characteristics of 329 subjects with univariate and multivariate analysis of demographic and clinical factors associated with disability

	Univariate analysis		Multivariate analysis	
Variable	**IBD-DI (IQR)**	**P value**	**B (95% CI)**	**P value**
(Constant)			20.79 (8.74 to 32.85)	0.001
Age≤35 years (n=168)	23 (14–38)	0.264*	−0.14 (−0.31 to 0.03)†	0.111
Age>35 years (n=161)	23 (12–34)			
Male (n=171)	20 (11–34)	<0.001*	–	–
Female (n=158)	29 (16–39)		5.17 (1.87 to 8.47)	0.002
Ulcerative colitis (n=137)	21 (11–32)	0.014*	–	–
Crohn's disease (n=192)	27 (13–39)		1.27 (−2.35 to 4.89)	0.491
Disease duration≤5 years (n=155)	25 (11–36)	0.627*	−0.07 (−0.19 to 0.32)†	0.610
Disease duration>5 years (n=174)	23 (14–38)			
Student (n=41)	25 (12–43)	<0.001‡	–	–
Employed/homemaker (n=203)	21 (13–32)		−2.10 (−7.66 to 3.45)	0.457
Unemployed (n=60)	36 (23–48)		3.36 (−3.32 to 10.04)	0.323
Retired (n=25)	23 (10–28)		−4.65 (−14.58 to 5.28)	0.357
Education to 16 years (n=69)§	29 (17–40)	0.080‡	–	–
Education to 18 years (n=91)	23 (11–38)		−4.03 (−8.87 to 0.81)	0.102
Third level (university) education (n=164)	22 (13–36)		−2.72 (−7.46 to 2.03)	0.261
No current cigarette smoking (n=270)†	23 (12–36)	0.015*	–	–
Current cigarette smoking (n=57)	30 (16–44)		2.70 (−1.74 to 7.13)	0.233
No resectional surgery (n=233)	23 (13–34)	0.019‡	–	–
Previous bowel resection (n=72)	29 (16–43)		2.80 (−1.63 to 7.22)	0.214
Permanent stoma surgery (n=24)	26 (9–48)		−0.80 (−7.65 to 6–05)	0.818
No current steroid (n=264)	23 (11–34)	<0.001*	–	–
Current steroid (n=65)	30 (21–43)		7.90 (3.68 to 12.11)	<0.001
No current immune modulator (n=196)	25 (11–38)	0.703*	–	–
Current immune modulator (n=133)	23 (14–36)		−0.11 (−3.59 to 3.37)	0.951
No current biologic (n=230)	23 (14–36)	0.335*	–	–
Current biologic (n=99)	25 (11–39)		1.80 (−1.86 to 5.45)	0.335
Inactive disease (n=241)	20 (11–32)	<0.001*	–	
Active disease (n=88)	37 (23–48)		10.73 (6.98 to 14.47)	<0.001

Dummy variables for the multivariate analysis included male sex, ulcerative colitis, retired subjects, Education to 16 years, no antidepressant use, no cigarette smoking, no resectional surgery, no steroid medications, immune modulators or biologic agents and disease remission. Univariate data are presented as medians and IQR and multivariate data as B and 95% CI.
*Mann-Whitney U test.
†Entered into multivariate model as a continuous variable.
‡Kruskal-Wallis test.
§Data not available for all cases.
IBD-DI, Inflammatory Bowel Disease Disability Index.

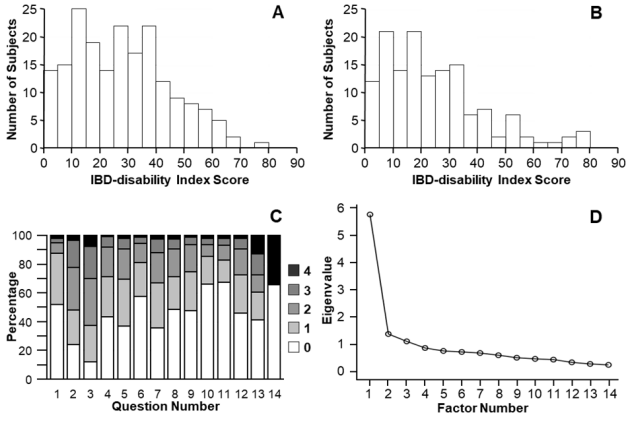

Figure 1 Frequency of IBD-DI scores in (A) Crohn's disease and (B) ulcerative colitis subjects. (C) Percentage of 329 subjects answering each of 14 IBD-DI questions 1–5. (D) Scree plot of eigenvalues from principal component analysis. IBD-DI, Inflammatory Bowel Disease Disability Index.

IBD-DI scores (figure 3D) (p<0.0001). The probability of treatment escalation after 5 years of long-term follow-up was 44% for subjects with 'no (or low) disability', 70% for those with 'mild disability' and 74% for those with 'moderate/severe disability' (p<0.0001). Younger age was the only other variable independently associated with long-term disease recurrence and treatment (online supplemental table 4).

DISCUSSION

In this longitudinal cohort study, the 14-item IBD-DI was found to be a valid and reliable disability measure in a hospital population. The results expand on previous research and include a more comprehensive range of psychosocial and economic variables in an English-speaking hospital out-patient population for the first time. The results suggest that the IBD-DI is a suitable measure of functional impairment and disease burden in hospital practice.

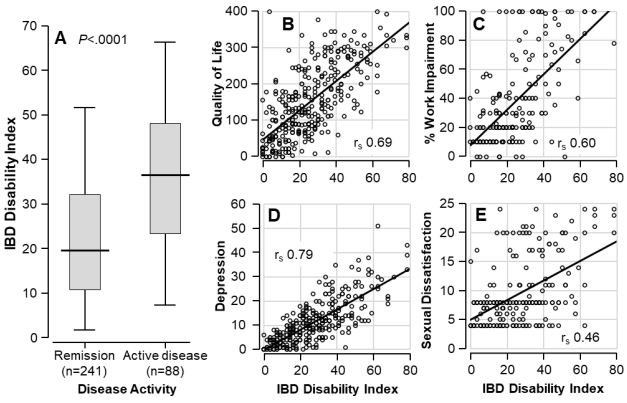

Figure 2 Relationship between disability, disease activity and psychosocial variables in 329 IBD subjects. (A) Box and whisker plot of physicians' baseline disease activity assessment and disability. (B) Spearman correlations between disability and quality of life, (C) percent overall health-related work impairment, (D) depression and (E) sexual dissatisfaction. IBD-DI, Inflammatory Bowel Disease Disability Index.

IBD Investigators have highlighted the need for an objective measure of disability.[13 14] A single widely accepted survey tool could serve as an appropriate secondary endpoint in clinical trials, facilitate disability comparisons across various public health and social support systems and allow researchers to assess the impact of a broad range of interventions on global disease burden. Several research groups item reduced and validated Peyrin-Biroulet *et al*'s original 18 question IBD-DI,[11] resulting in different final survey tools.[16–18] Item reduction generates the most appropriate questionnaire for the cohort under study, but each data set results in a unique disability index, preventing meaningful comparison. We thought it important to use Gower-Rousseau *et al*'s 14 question index without change to encourage consensus on developing a standardised scale, as commentators have previously emphasised.[9]

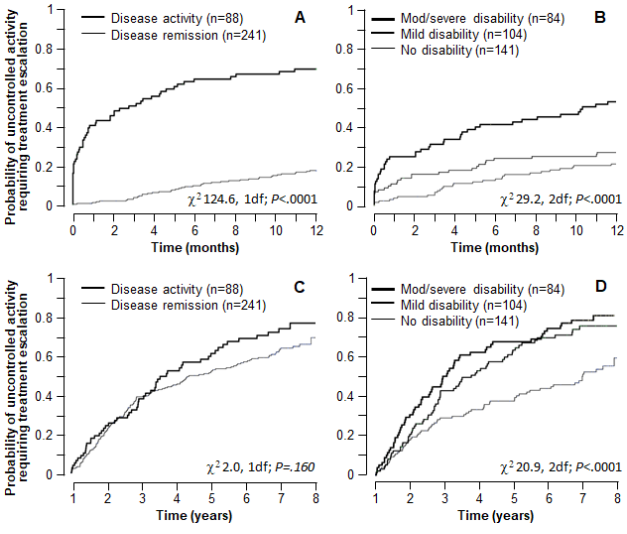

Figure 3 Cumulative risk of short-term disease activity requiring treatment escalation (in the first follow-up year) associated with (A) baseline disease activity and (B) baseline disability (IBD-DI). Cumulative risk of long-term disease activity requiring treatment escalation (after 1 year) associated with (C) baseline disease activity and (D) baseline IBD-DI. IBD-DI, Inflammatory Bowel Disease Disability Index.

The IBD-DI fulfils the requirements for a valid disability index in hospital practice. It forms an objective assessment of disease burden and provides a clear message for clinical gastroenterologists, researchers and sociologists to interpret. It was simple to use with a standardised format and unambiguous questions, and our study subjects, with a range of educational abilities, found little difficulty with the questionnaire, with less than 2% failing to complete it satisfactorily. In addition to its format, the IBD-DI fulfils accepted structural, validation and reliability criteria and was relevant to both Crohn's disease and ulcerative colitis subjects. From a statistical viewpoint, disability was associated with disease activity. However, figure 2 confirms that there was a sizeable overlap in scores between those with inactive and active disease, as previously observed by Gower-Rousseau *et al*.[13] Half of the present subjects in remission had elevated IBD-DI scores, with normal results reported by over 20% with active disease and the overall association between baseline disease activity and disability was weak (r_s=0.34), with larger correlations found between IBD-DI scores and economic and psychosocial variables.

In addition to validation, the present research is the first to assess disability and disease activity in a longitudinal manner. Predictably, short-term treatment escalation was almost exclusively linked to the index physicians' disease activity assessment, with only minor additional contributions from IBD-DI scores and disease duration. In contrast, long-term disease activity correlated closely with baseline IBD-DI scores and was unrelated to either initial disease activity or other clinical features, except younger age, but there are no previous studies with which to compare the present results. As noted above, IBD-DI scores correlated with depression, and several studies have assessed the effect of psychological disability on subsequent disease activity and treatment escalation, so that some comparisons can be attempted. Studies indicate that depression is associated with an increased cumulative risk of long-term IBD activity, with initial risks beginning to appear after 1 or 2 years.[24 27] The present data likewise showed that IBD-DI scores were poorly related to subsequent activity over the first year, but that long-term recurrence risk was greater in those with elevated baseline scores, especially over the subsequent 2 years (figure 3D). Previous researchers have highlighted the role of brain–gut interactions in this psychological disability/disease activity sequence,[24 30] and this is supported by animal studies establishing a link between prolonged psychological stress, chronic neuroendocrine alterations and gut mucosal inflammation.[31 32] Alternatively, Keefer *et al*[33] and others[34] have

suggested that psychological disability may promote poor coping and self-care strategies with negative effects on daily activities including medication adherence, ultimately impacting mucosal inflammation and activity. The present data, showing that disability and depression correlate closely, support a role for psychological assessment and interventions that reduce stress and depression[35] and improve treatment adherence.[36] It also suggests a complex link between disability and subsequent activity, likely involving biological and socioeconomic as well as psychological and coping attributes, as suggested by Keefer *et al*[33]

The study had strengths. It incorporated an array of established psychological, social and economic survey tools for the first time, and was large, with a well-defined cohort and a participation rate exceeding 85%. The validation process used standardised procedures, and the research was performed independently of the original IBD-DI development team to enhance integrity. A further strength is that disease activity was determined by a stringent physician's evaluation rather than a patient-reported symptom scale, since a comparison between a patient-reported symptom scale and a disability index, both containing subjective self-reported symptom scores, would have provided a heavily biased assessment. Finally, 40% of participants were taking an immune modulator at baseline, 30% a biologic agent and 13% an antidepressant, while 29% had a previous bowel resection, and the patient population is likely generalisable to IBD cohorts that most hospital gastroenterologists see in clinical practice.

There are several areas relating to the IBD-DI that need further exploration. First, as noted above, 20% of subjects with baseline active disease had normal IBD-DI scores. Research has tended to highlight subjects with extensive disability, but studies focusing on those with especially low disability levels might identify important personality traits or environmental factors that protect some individuals from psychosocial disability and allow them to cope particularly well with active IBD. In addition, IBD-DI scores are known to vary across different populations[14 37] but the cultural, medical, economic and social aspects that shape disability are likely complex and should be clarified to identify modifiable factors. Second, although 'normalised QOL' and 'absence of disability' may be used interchangeably to describe a desirable clinical state,[5] QOL and disability are distinct paradigms, and it will be valuable to incorporate both well-being concepts into clinical trials, along with activity, psychosocial and economic indexes, to compare their fitness as primary disease burden measures. Third, the present results show that IBD-DI scores are linked to a range of individual disabilities and a globally accepted index might be used in comparative effectiveness research studies that test the impact of psychological and socioeconomic as well as therapeutic interventions on disease burden across diverse populations. Finally, a single research group developed and originally validated the IBD-DI in France,[11 13] while Canadian and other research groups have built on these foundations.[14–16 37] However, there is no international framework to progress or finalise a working disability index. Crohn's and Colitis Organisations, along with expert bodies,[5] influence quality and practice standards and could perhaps help achieve consensus on a widely recognised survey tool. The present study suggests that an operational version would not be too dissimilar to the IBD-DI scale developed by Gower-Rousseau *et al*,[13] which appears to be valid and reliable in a hospital outpatient population and capable of predicting long-term disease activity and need for treatment escalation.

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Contributors Study design: EMD, DS, HEM. Patient recruitment and data acquisition: DS, EMD, JM, RS, JS, GC, GD. Data analysis and interpretation: DS, LMcH, HEM, LK. Manuscript drafting: DS, HEM. Manuscript revision and redrafting: all authors. HEM was the author responsible for the overall content as the guarantor and accepts full responsibility for the work.

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Competing interests DS is a UCD Newman Fellow sponsored by Boston Scientific. GD has served as a speaker, a consultant and an advisory board member for Abbvie, MSD, Pfizer, Amgen, Janssen, Shire, Takeda and Tillotts, and has received research funding from Abbvie, MSD and Pfizer. HM has served as a speaker for Dr Falk Pharma, MSD, Ferring, Boston Scientific, Tillotts and Janssen, serves as a consultant for Boston Scientific and has received funding from Pfizer, Dr Falk and Abbvie.

Patient consent for publication Not applicable.

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Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. The de-identified raw data relating to this study are available as an Excel spreadsheet upon reasonable request from Professor Hugh Mulcahy by emailing hugh.mulcahy@ucd.ie.

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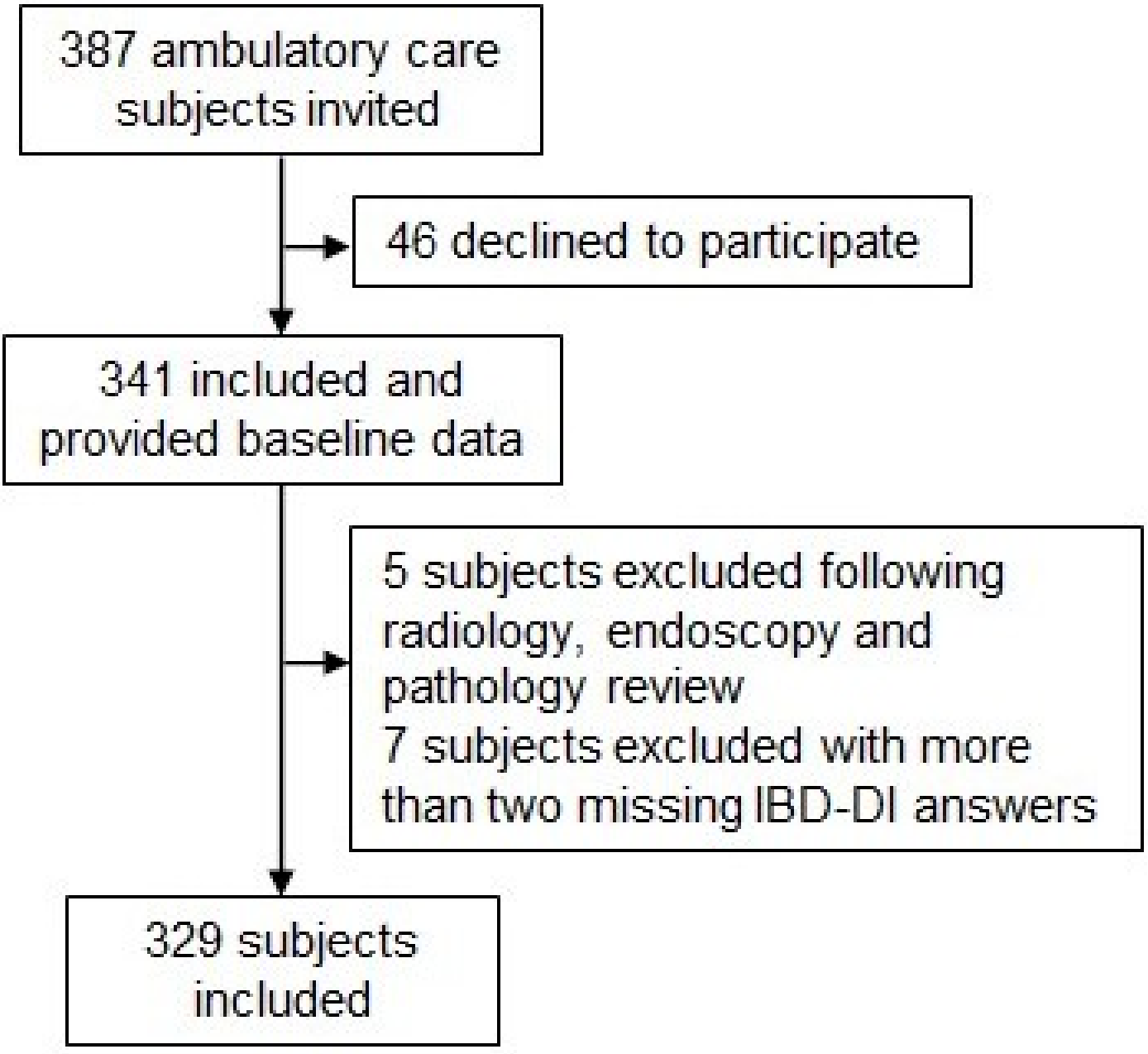

387 ambulatory care subjects invited
46 declined to participate
341 included and provided baseline data
5 subjects excluded following radiology, endoscopy and pathology review
7 subjects excluded with more than two missing IBD-DI answers
329 subjects included

Supplementary Table 1. Baseline characteristics of 192 Crohn's disease subjects with univariate and multivariate analysis of demographic and clinical factors associated with disability.

	Univariate analysis		Multivariate analysis	
Variable	**IBD-DI (IQR)**	**P value**	**B (95% CI)**	**P value**
(Constant)			20.48 (3.62 to 37.36)	.018
Age ≤35 years (n=110)	26 (14-39)	.961[a]	0.01 (-0.26 to 0.27)[b]	.968
Age >35 years (n=82)	27 (13-39)			
Male (n=98)	21 (12-38)	**.007[a]**	-	-
Female (n=94)	31 (17-40)		4.97 (0.22 to 9.73)	**.040**
Body mass index <25 (n=85)[c]	25 (13-39)		-	-
Body mass index 25-29 (n=76)	27 (15-39)	.952 [d]	0.18 (-0.35 to 0.70)[b]	.503
Body mass index ≥30 (n=28)	27 (13-40)			
Disease duration ≤ 5 years (n=85)	27 (11-38)	.394[a]	-0.06 (-0.44 to 0.32)[b]	.749
Disease duration > 5 years (n=107)	25 (14-43)			
Small bowel disease (n=49)[e]	29 (13-43)		-	-
Colonic disease (n=53)	23 (13-38)	.546[d]	0.22 (-6.52 to 6.95)	.949
Small bowel and colonic disease (n=89)	27 (16-39)		0.33 (-5.33 to 5.99)	.907
No perianal disease (n=160)	27 (13-39)	.925[a]	-	-
Perianal disease (n=32)	28 (13-41)		-0.49 (-7.03 to 6.04)	.882
Student (n=32)	29 (13-43		-	-
Employed/Homemaker (n=103)	25 (13-38)	**.007[d]**	-4.09 (-11.11 to 2.94)	.252
Unemployed (n=44)	36 (18-48)		-1.58 (-9.98 to 6.83)	.712
Retired (n=13)	14 (6-27)		-19.62 (-33.63 to -5.60)	**.006**
Education to 16 years (n=43)[c]	32 (21-46)		-	-
Education to 18 years (n=52)	27 (14-41)	.067[d]	-3.68 (-10.38 to 3.02)	.280
Third level (University) education (n=94)	23 (13-38)		-4.97 (-11.47 to 1.53)	.133
No current anti-depressant (n=276)[b]	25 (13-38)	**.007[a]**	-	-
Current anti-depressant (n=44)	39 (19-53)		10.27 (3.45 to 17.09)	**.003**
No current cigarette smoking (n=270)[b]	25 (13-38)	.065[a]	-	-
Current cigarette smoking (n=57)	32 (18-43)		1.15 (-4.65 to 6.96)	.695
No resectional surgery (n=111)	23 (13-36)		-	-
Previous bowel resection (n=63)	30 (17-43)	**.035[d]**	4.88 (-0.55 to 10.30)	.078
Permanent stoma surgery (n=18)	37 (10-54)		2.50 (-6.48 to 11.48)	.583
No current steroid (n=160)	25 (13-38)	**.008[a]**	-	-
Current steroid (n=32)	36 (22-46)		8.35 (1.96 to 14.73)	**.011**
No current immune modulator (n=124)	29 (13-42)	.286[a]	-	-
Current immune modulator (n=68)	23 (14-37)		-1.85 (-6.60 to 2.89)	.442
No current biologic (n=230)	26 (14-38)	.550[a]	-	-
Current biologic (n=99)	27 (11-46)		3.03 (-1.98 to 8.05)	.234
Inactive disease (n=241)	23 (13-36)	**<.001[a]**	-	
Active disease (n=88)	36 (24-46)		7.62 (2.38 to 12.86)	**.005**

Dummy variables for the multivariate analysis included male sex, Small bowel Crohn's, no perianal disease, retired subjects, Education to 16 years, no current antidepressant use, no cigarette smoking, no resectional surgery, no exposure to steroid medications, immune modulators or biologic agents, and disease remission. Univariate data are presented as medians and interquartile ranges (IQR) and multivariate data as B and 95% confidence intervals (CI).

[a]Mann-Whitney U test.

[b]Entered into multivariate model as a continuous variable.

[c]Data not available for all cases.

[d]Kruskal-Wallace test.

[e]A single Crohn's disease subject had only perianal disease.

Supplementary Table 2. Baseline characteristics of 137 ulcerative colitis subjects with univariate and multivariate analysis of demographic and clinical factors associated with disability.

	Univariate analysis		Multivariate analysis	
Variable	**IBD-DI (IQR)**	**P value**	**B (95% CI)**	**P value**
(Constant)			18.21 (-0.38 to 36.80)	.055
Age ≤35 years (n=58)	21 (14-34)	.303[a]	-0.27 (-0.50 to -0.05)[b]	**.019**
Age >35 years (n=79)	21 (9-32)			
Male (n=73)	20 (9-29)	**.037[a]**	-	-
Female (n=64)	24 (14-35)		4.37 (-0.39 to 9.14)	.071
Body mass index <25 (n=52)[c]	20 (10-33)		-	-
Body mass index 25-29 (n=48)	22 (9-32)	.983[d]	0.09 (-0.34 to 0.51)[b]	.684
Body mass index ≥30 (n=33)	23 (11-32)			
Disease duration ≤ 5 years (n=70)	21 (10-32)	.703[a]	0.06 (-0.29 to 0.42)[b]	.729
Disease duration > 5 years (n=67)	21 (11-32)			
Ulcerative proctitis (n=13)	23 (4-30)		-	-
Ulcerative colitis left colon (n=67)	23 (11-32)	.465[d]	1.33 (-6.89 to 9.55)	.749
Ulcerative colitis total colon (n=57)	18 (10-29)		-1.53 (-10.03 to 6.97)	.723
Student (n=9)	20 (8-42)		-	-
Employed/Homemaker (n=100)	18 (9-30)	**.021[d]**	1.48 (-9.41 to 12.37)	.789
Unemployed (n=16)	32 (25-48)		13.10 (0.59 to 26.62)	**.040**
Retired (n=12)	24 (16-33)		12.99 (-2.84 to 28.82)	.107
Education to 16 years (n=26)[c]	27 (7-34)		-	-
Education to 18 years (n=39)	18 (7-31)	.453[d]	-1.07 (-8.59 to 6.45)	.779
Third level (University) education (n=70)	20 (14-33)		2.10 (-5.43 to 9.63)	.582
No current anti-depressant use (n=121)[c]	20 (10-30)	**.045[a]**	-	-
Current anti-depressant use (n=13)	30 (21-47)		7.31 (-0.94 to 15.56)	.082
No cigarette smoking (n=121)[c]	20 (9-32)	.406[a]	-	-
Cigarette smoking (n=15)	23 (13-52)		4.69 (-2.82 to 12.20)	.218
No resectional surgery (n=122)	22 (11-32)		-	-
Previous bowel resection (n=9)	20 (9-46)	.573[d]	0.82 (-9.77 to 11.41)	.878
Permanent stoma surgery (n=6)	13 (5-29)		-7.31 (-19.05 to 4.44)	.220
No current steroid (n=104)	18 (9-30)	**.001[a]**	-	-
Current steroid (n=33)	29 (19-39)		6.61 (0.88 to 12.33)	**.024**
No current immune modulator (n=95)	23 (9-32)	.688[a]	-	-
Current immune modulator (n=42)	20 (14-33)		1.90 (-3.37 to 7.17)	.476
No current biologic (n=108)	21 (13-32)	.862[a]	-	-
Current biologic (n=29)	23 (9-36)		0.01 (-6.03 to 6.06)	.997
Inactive disease (n=101)	18 (8-27)	**<.001[a]**	-	
Active disease (n=36)	37 (21-51)		15.48 (9.92 to 21.05)	**<.001**

Dummy variables for the multivariate analysis included male sex, ulcerative proctitis, retired subjects, Education to 16 years, no current antidepressant use, no cigarette smoking, no resectional surgery, no exposure to steroid medications, immune modulators or biologic agents, and disease remission. Univariate data are presented as medians and interquartile ranges (IQR) and multivariate data as B and 95% confidence intervals (CI).

[a]Mann-Whitney U test.

[b]Entered into multivariate model as a continuous variable.

[c]Data not available for all cases.

[d]Kruskal-Wallace test.

Supplementary Table 3. Factor loadings of principle component analyses.

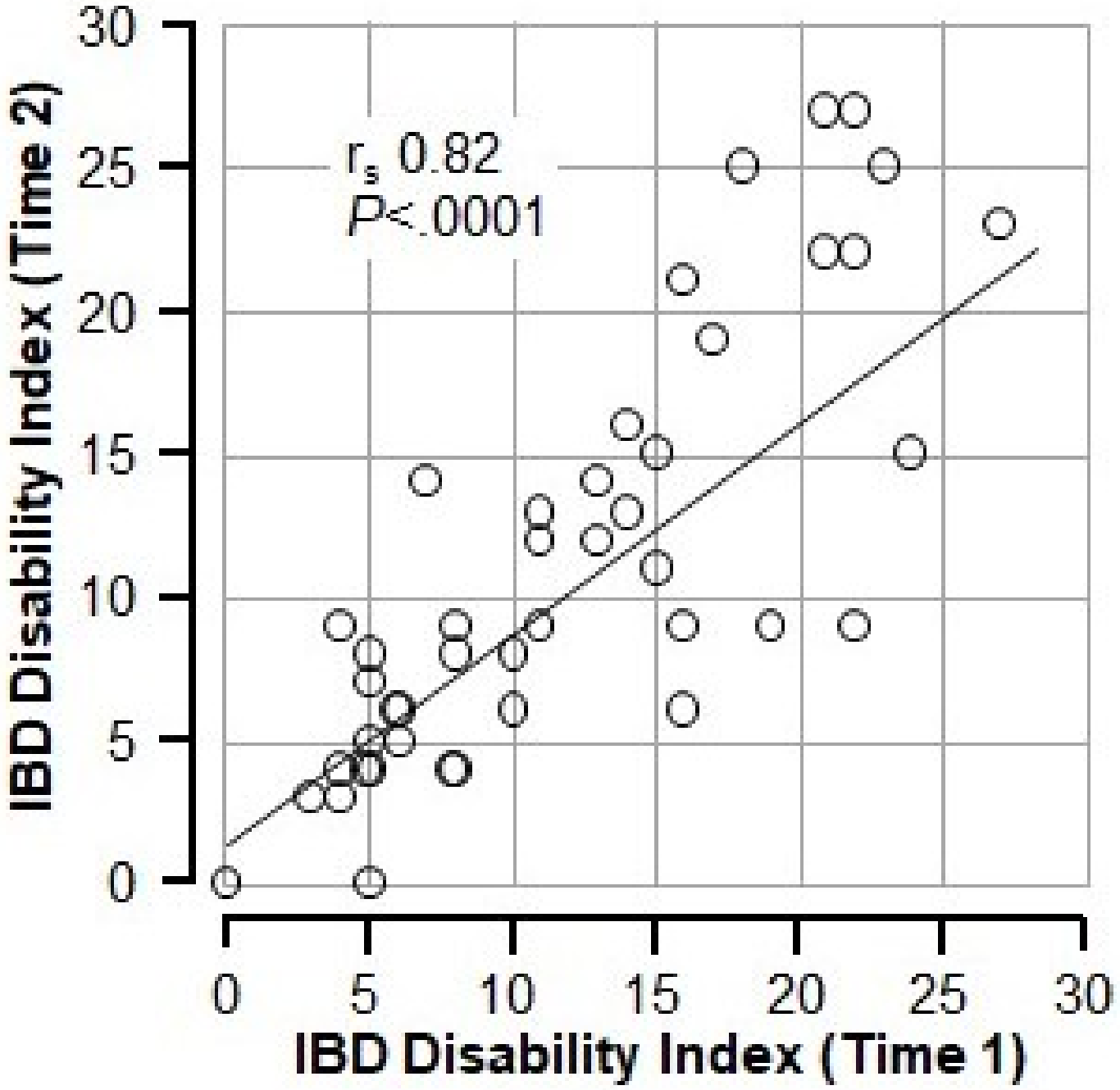
	One-factor model[a]
Question	Factor loading
1 General Health	0.636
2 Sleep	0.670
3 Energy	0.736
4 Depression	0.745
5 Anxiety	0.661
6 Body Image	0.571
7 Abdominal pain	0.669
8 Bowel function	0.588
9 Health and diet	0.710
10 Personal relationships	0.652
11 Community participation	0.716
12 Work/study activities	0.785
13 Liquid stools	0.400
14 Arthralgia/arthritis	0.244

Supplementary Table 4. Final Cox backward regression models identifying baseline factors significantly and independently related to short-term and long-term disease activity.

Short-term disease activity with treatment escalation				
	Coefficient β	Standard error	Relative Risk (95% confidence intervals)	P value
Disease remission baseline	-	-	1	-
Active disease baseline	1.883	0.220	6.575 (4.274-10.116)	<.0001
Disease duration[a]	-0.053	0.017	0.948 (0.917-0.981)	.002
IBD-DI at baseline[a]	0.017	0.006	1.017 (1.005-1.029)	.004

Long-term disease activity with treatment escalation				
	Coefficient β	Standard error	Relative Risk (95% confidence intervals)	P value
IBD-DI at baseline[a]	0.016	0.004	1.016 (1.008-1.024)	<.001
Participant age[a]	-0.015	0.006	0.985 (0.974-0.996)	.007

[a]Entered into multivariate model as a continuous variable.


IBD Disability Index (Time 2)
IBD Disability Index (Time 1)
r_s 0.82
P<.0001
0
5
10
15
20
25
30