Prospective validation study of the International Classification of Functioning, Disability and Health score in Crohn's disease and ulcerative colitis

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Abstract

Background and aims: Inflammatory bowel diseases (IBD) may result in disability. We aim to validate a novel scoring system for the IBD disability index (IBD-DI), and identify predictors of disability and its correlation with work absenteeism.

Methods: This prospective IBD ambulatory clinic cohort study measured IBD-DI, Crohn's Disease Activity Index (CDAI) for Crohn's disease (CD) or partial Mayo score (pMayo) for ulcerative colitis (UC), IBDQ quality-of-life, and Work Productivity and Activity Impairment. Negative IBD-DI represented greater disability. Validation tests were performed and predictors and extent of work absenteeism were determined.

Results: 166 consecutive subjects were recruited (75 CD, 41 UC, 50 controls). IBD-DI correlated with CDAI (r = −0.77, P < 0.001), pMayo (r = −0.82, P < 0.001) and IBDQ (r = 0.86, P < 0.001). IBD-DI differentiated CD, and UC from controls (medians −7, −4, +10; P < 0.001) with a score of >3.5 identifying controls with 94% sensitivity and 83% specificity (area-under-curve 0.92). Stable patients had unchanged IBD-DI (P = ns) but not in those who relapsed (P < 0.001). Intraclass correlation was 0.89 and Cronbach's alpha of internal consistency was 0.94. Diagnosis age, sex, phenotype, perianal disease, prior surgery, steroid-use and disease duration did not influence the IBD-DI but active use of biological agents significantly reduced disability (P = 0.03). 21.6% of

Abbreviations: CD, Crohn's disease; CDAI, Crohn's disease activity index; IBD-DI, Inflammatory bowel disease disability index; IBDQ, Inflammatory Bowel Disease Questionnaire; ICF, International Classification of Functioning, Disability and Health; pMayo, partial Mayo score; UC, ulcerative colitis.

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1. Introduction

Disability is defined by the World Health Organization International Classification of Impairments, Disabilities and Handicaps (ICIDH) as “any restriction or lack (resulting from any impairment) of ability to perform an activity in the manner or within the range considered normal for a human being”. Disability, therefore, more accurately reflects impairments, activity limitation and participation restriction which correlates with the lost work productivity and increased health resources utilization. Reversal of disability to minimize or eliminate such limitations and restrictions then becomes an important driving force of any intervention as a marker of successful treatment. This in turn allows the cost of newer treatments to be directly incorporated into the regulatory approval process as a trade-off for the reduction in disability. In contrast, “quality of life” is a patient-reportable outcome on their feeling of their limitations and restrictions. Quality of life is heavily subjective based upon inter-individual coping strategies.

Inflammatory bowel diseases (IBD) are chronic incurable gastrointestinal diseases that typically affect the young working-age population. Active disease, progressive course with cumulative intestinal damage, development of complications, the presence of extra-intestinal manifestations and treatment adverse effects may result in disability. Functional assessment is an essential consideration in chronic illnesses; as such the World Health Organization (WHO) is currently revising the International Classification of Diseases to include functional properties for disabling conditions. The WHO developed the International Classification of Functioning, Disability and Health (ICF), a structured and complete framework that classifies body functions, structure, activity and participation. This framework has been endorsed for use as the international standard to describe and assess health and disability. Disability data can be correlated with medical and rehabilitative service requirements. Studies on rehabilitation and rheumatology have previously used the ICF as an outcome measure.

The ICF Comprehensive and Brief Core Sets, with the latter termed the IBD disability index (IBD-DI), have recently been developed for IBD to measure its functional consequences and disease burden. The IBD-DI was developed following an extensive literature search and consensus pertaining to disability in IBD. This questionnaire, however, has not yet been tested clinically or validated to capture the full spectrum of issues in IBD. To date no scoring system has been designed for the IBD-DI, which ideally must reflect the fluctuating nature of both Crohn’s disease (CD) and ulcerative colitis (UC), demonstrate reversibility following successful medical and surgical therapies, and capture the multi-dimensionality of IBD. This score should be objective, has a sufficiently wide range to be useful, correlate with work absenteeism, and correlate with measures of quality of life and disease activity.

The primary objective of this study was to design and validate a numerical scoring system for the IBD-DI to measure IBD disability using standard statistical techniques. Secondary endpoints were to describe the extent of disability in IBD, correlate the disease index with work absenteeism, and identify significant exploratory predictors of employment status.

2. Materials and methods

2.1. Subjects

Consecutive ambulatory patients aged 16 to 80 years old with established CD and UC of at least 6 months were prospectively recruited from the IBD clinics of Concord and Bankstown Hospitals, which are tertiary IBD referral centers in Sydney, Australia. Subjects were excluded if they were unable to comprehend the questionnaire, have an active psychiatric disorder, significant symptomatic comorbidity that might influence disability, with stomas or ileoanal pouches were excluded. Age- and sex- group-matched controls without a gastrointestinal disorder or gastrointestinal symptoms in the preceding month were recruited to determine baseline function. They were recruited from the same catchment area as cases, typically hospital visitors and relatives of patients. The Australian unemployment rate at the time of the study was 5%.

2.2. Inflammatory bowel disease disability index (IBD-DI) score

The ICF IBD-DI consists of 19 items divided into 28 parts covering the 5 domains of Overall Health, Body Function, Body Structures, Activity Participation and Environmental Factors. The IBD-DI was specifically designed to exclude the use of any questions that examine patients’ subjective coping and feelings. It explores the severity of disability and limitations in the areas of sleeping, mood, abdominal pain, bowel frequency, regulating defecation, participation in social events and work or school and exacerbating effects of medication, food, family and healthcare professionals. In line with other ICF scores, positive scores were proportional to the lack of difficulties and the alleviating effects of medication, food, family and healthcare professionals. A novel composite scoring system was designed and implemented to test the IBD-DI to represent the presence and
severity of disability in the previous week with lower or more negative scores indicating greater disability (Appendix A). The response of each item on the questionnaire was either dichotomous “yes” versus “no” or ordinal on a 1 to 5 Likert scale (1 being no difficulty and 5 being extreme difficulty). Scores from each question were combined into domain totals and a final composite score representative of the overall degree of disability ranging from −80 (maximum degree of disability) to 22 (no disability) with ‘0’ as the anticipated point of neutrality. Scores of severe, moderate, mild and minimal disability correlated with the ability to work <50%, 50–75%, 76–99% and 100% of work-hours in the previous week.

Pilot testing was performed on 5 IBD patients to determine the questionnaire script, test the protocol and the scoring system. The questionnaire was administered face-to-face by a single trained research assistant (TH) blinded to the clinical encounter and the subject’s IBD history. Subjects completed the questionnaire prior to their physician interview to ensure independent self-reporting. The face-to-face questionnaire administration ensured that there was no missing data. IBD subjects were invited to provide commentary relating to the questionnaire and to repeat the questionnaires 4 weeks later to capture any changes to the IBD-DI.

2.3. Demographics and comparative assessment tools

Clinical information obtained included demography, smoking status, disease duration, IBD phenotype, the presence of extra-intestinal manifestations (EIM), medical treatment, prior hospitalization and surgery. Subjects completed the Work Productivity and Activity Impairment Questionnaire: General Health that measured the impact of health problems on employment status, number of hours worked, work productivity and daily activities in the preceding week. Employment was defined as labor force participation of at least 1 day per week with 35–40 h regarded as full-time work.

Patients also completed the 32-question Inflammatory Bowel Disease Questionnaire (IBDQ) measuring their subjective disease-related quality of life. Disease activities were measured using the Crohn’s Disease Activity Index (CDAI) for CD and partial Mayo Score (pMayo) for UC. The CDAI assessed the parameters of soft/liquid stool frequency, abdominal pain, well-being, EIM, fistulas, abdominal mass, use of anti-diarrheal agent, anemia and weight loss. The pMayo was scored according to diarrhea, per rectal bleeding and physician global scale of disease severity. Higher scores represented greater disease severities.

2.4. Power calculation

Using social security system data covering 93% of the German workforce, the disability rate of IBD patients requiring rehabilitation was 9%. Power calculation was based on the ability to detect a difference in overall severe disability of 9% with 80% power and a 1-sided alpha level of 0.05. Recruitment using a 2:1 ratio of cases versus controls required a sample size of 115 IBD cases to 50 controls.

2.5. Statistics and ethical consideration

The IBD-DI total score and domain sub-scores were analyzed using non-parametric tests of Spearman correlation, Mann Whitney U, Wilcoxon signed-rank test for unpaired and paired median comparisons respectively and Kruskal-Wallis test for comparison of 3 or more continuous variables. Discriminative ability refers to how well the IBD-DI differentiated active IBD from controls. Construct validity refers to how well the IBD-DI correlated with the IBDQ (convergent validity) and clinical disease activity indices (divergent validity). Paired IBD-DI of a subject’s index and repeat scores was tested for test–retest reliability in those with stable disease activity. Responsiveness was assessed by comparing pre- and post-treatment in those with clinically relevant changes in disease activity (defined as a CDAI change of >70 points in CD or pMayo score of >2 in UC) and measured by Wilcoxon signed-rank test, effect size and responsiveness coefficient. Reliability assessed the homogeneity of the IBD-DI using intra-class correlation coefficient (ICC), and standardized Cronbach’s alpha for internal consistency. An ICC of >0.8 indicates excellent reliability. Data reduction, dimensionality and variance testing was performed by factor analysis using principal component analysis with an Eigenfield value >1 and the varimax rotation method. Receiver operator characteristics (ROC) was performed and measured by area under curve (AUC) to identify the best statistical cut-off differentiating IBD from controls. Subjects provided commentary on disability and the IBD-DI and the time to its completion was recorded. The questionnaire readability was tested using the Flesch reading scale. Binary logistic regression was performed to determine independent predictive factors of employment status.

Statistical analyses were performed using IBM SPSS version 20.0. A P value of less than 0.05 was deemed statistically significant. Informed consent was obtained for all subjects. The study was approved by the Concord Hospital Ethics Committee and registered with the Australian New Zealand Clinical Trials Registry (ACTRN12613000903785).

3. Results

3.1. Study population

Over a 6 month period, 192 consecutive subjects were prospectively approached for the study. Of these 10 were excluded due to limited comprehension, 13 declined participation and 3 failed to complete the full study protocol. There was no missing data. Of the 166 subjects recruited, 116 were IBD patients (75 CD, 41 UC) and 50 were controls. In the patient group, 35 (21 CD 14 UC) patients consented for a follow up survey. Of these paired cases, 20 had stable disease and 15 had significant clinical changes in their disease activities. The mean ages of IBD subjects and controls were 40.5 and 41.2 respectively and male sex proportion was 52.6% and 56.0% respectively (both P > 0.05). Only 59.5% of IBD subjects (61% CD, 56% UC; P = 0.30) were in current full- or part-time employment or study compared to 100% of controls. Only 1 control (2%, 95% CI: +/- 3.9) had a negative IBD-DI score (Table 1).
The mean age of IBD diagnosis was 31.5 years, and the mean disease duration was 8.9 years. No statistically significant differences between age, proportion of male sex, age of diagnosis, proportion of smokers and disease duration were found between CD and UC subjects. The CD location phenotypes were 22% ileal (Montreal L1), 20% colonic (L2) and 58% ileocolonic (L3) with 36% having perianal disease (p). The CD behavioral phenotypes were 35% non-stricturing, non-penetrating (B1), 27% stricturing (B2) and 38% penetrating (B3). In UC, 12.2% had proctitis (E1), 48.8% left-sided disease (E2) and 39.0% extensive colitis (E3). Prior hospitalization was recorded in 71.6% of subjects with a mean of 1.8 hospitalizations per subject, which was higher in CD (2.2) than in UC (1.1; P < 0.01).

There were 62.9% never smokers, 24.8% ex-smokers and 12.2% current smokers. Active or recent EIM was reported in 60% of IBD subjects (65% CD and 49% UC). Long-term steroid use was recorded in 29% (27% CD and 32% UC) of cases, previous long-term steroids in 33% and never on long-term steroids in 38%. At the time of study, only CD patients can claim reimbursement for anti-tumor necrosis factor (TNF)-alpha through the government. As such 44.6% of CD and 14.6% of UC subjects have previously or are currently users of biological agents. Current use of biological agents was 20.9% (infliximab, adalimumab and drugs under trial such as vedolizumab and ustekinumab) whereas 13.0% and 66.1% were ex- and non-users of biological agents respectively.

3.2. IBD disability score distribution and discriminant ability

The total IBD-DI ranged from −80 to 22 in a skewed distribution (Fig. 1). The IBD-DI discriminated controls (median 10) from CD (median −7) and UC (median −4, P < 0.001) but for CD and UC they were not dissimilar (P = 0.266), and both forms of IBD demonstrated significantly greater disability against controls for all domain sub-scores (P = 0.002).

### Table 1

Demographic factors of subjects with Crohn's disease (CD), ulcerative colitis (UC), total inflammatory bowel diseases (IBD) and normal controls.

<table>
<thead>
<tr>
<th></th>
<th>Patients</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CD</td>
<td>UC</td>
</tr>
<tr>
<td>n</td>
<td>75</td>
<td>41</td>
</tr>
<tr>
<td>Age (mean years)</td>
<td>39.1</td>
<td>43.1</td>
</tr>
<tr>
<td>Duration of disease (mean years)</td>
<td>8.7</td>
<td>9.3</td>
</tr>
<tr>
<td>Males, n (%)</td>
<td>40 (53.3)</td>
<td>21 (51.2)</td>
</tr>
<tr>
<td>Current smokers, n (%)</td>
<td>9 (12.1)</td>
<td>5 (12.2)</td>
</tr>
<tr>
<td>Current employment (%)</td>
<td>46 (61.3)</td>
<td>23 (56.1)</td>
</tr>
<tr>
<td>Long term steroids (%)</td>
<td>20 (27.0)</td>
<td>13 (31.7)</td>
</tr>
<tr>
<td>Current or prior biological agent (%)</td>
<td>33 (44.6)</td>
<td>6 (14.6)</td>
</tr>
<tr>
<td>Previous surgery (%)</td>
<td>42 (56.0)</td>
<td>3 (7.3)</td>
</tr>
<tr>
<td>Previous hospitalization (%)</td>
<td>60 (80.0)</td>
<td>23 (56.1)</td>
</tr>
<tr>
<td>Hospitalization episodes (mean)</td>
<td>2.2</td>
<td>1.1**</td>
</tr>
<tr>
<td>Disease activity (mean, median)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>CDAI</td>
<td>191, 136</td>
<td>—</td>
</tr>
<tr>
<td>pMayo</td>
<td>3.6, 2</td>
<td>—</td>
</tr>
</tbody>
</table>

a Long term steroids defined as use of corticosteroids for at least 6 months.

b Severity was defined according to percentage of actual hours worked as follows: minimal 100%, mild 76–99%, moderate 50–75%, and severe <50%.

** P < 0.01.
3.3. Construct validity

The total IBD-DI significantly and positively correlated with the IBDQ (r = 0.865, P < 0.001) and separately for CD (r = 0.849, P < 0.001) and UC (r = 0.871, P < 0.001). The IBD-DI inversely correlated with the CDAI for CD (r = −0.771, P < 0.001) and pMayo for UC (r = −0.818, P < 0.001). All IBD-DI domain sub-scores significantly correlated with CD and UC disease indices (all P ≤ 0.028) except for ‘environmental factors’ with CDAI (r = −0.169, P = 0.147) and with IBDQ-CD (r = 0.205, P = 0.078). Table 2 discloses the correlation coefficients of the IBD-DI total score and sub-scores against the CDAI, pMayo and IBDQ. Fig. 2 demonstrates the correlation between IBDQ and IBD-DI for CD and UC.

3.4. Responsiveness, internal consistency and reliability

On ROC, an IBD-DI of 9.5 had 93.3% sensitivity and 95.0% specificity in detecting a clinical meaningful change of disease activity (change in CDAI >70 or pMayo >2) with AUC of 0.97 (95%CI: 0.92–1.00). Observed change (11.0) and effect sizes were large (0.76), and responsiveness coefficient was high (2.24), all demonstrating excellent responsiveness. Paired comparisons of patients that relapsed or entered remission on follow-up was performed pooling CD and UC cases (n = 15 pairs).17 The IBD-DI demonstrated significant sensitivity to change comparing higher disease activity (median –13) against lower disease activity (median 4, difference 17, P < 0.001). All 5 domain sub-scores demonstrated significant changes (all P ≤ 0.017; Table 3). In contrast, subjects with unchanged disease activities at follow up (n = 20 pairs) demonstrated test–retest reliability with stable IBD-DI (median –5 versus –1, difference 4, P = 0.152). All 5 domain sub-scores similarly demonstrated no significant changes (all P > 0.05). The intraclass correlation was 0.893 and Cronbach’s alpha was 0.943 all indicating excellent test reliability and internal consistency.

3.5. Work productivity

Overall, IBD patients worked a mean of 33.2 h in the week prior to IBD-DI testing. There was no significant difference between CD and UC in terms of unemployment status (39% versus 44%; P = 0.58), percentage hours worked (81% versus 83%; P = 0.56) or total hours worked (20.3 versus 20.3 h; P = 0.69). The IBD-DI was significantly poorer in those missing work compared to those that did not (median –16 versus –3, P < 0.001). The IBD-DI negatively correlated with work hours missed due to health issues (r = −0.517, P < 0.001, Table 2). Percentage hours worked in the previous week for minimal, mild, moderate and severe disabilities were 100%, 84%, 62%, and 0% (P < 0.001) respectively and equivalent to median IBD-DI of –36.5, –14, –5, and –3 respectively (P < 0.001).

3.6. Factorial analysis and receiver operator characteristics

Dimension reduction using factor analysis demonstrated that 8 components accounted for 69% of the overall variability. Several questionnaire items were found to have very low variances. They related to school attendance and environmental impact from family members and physicians. Receiver operator characteristics demonstrated that a cut off score of 3.5 to differentiate IBD from controls with a sensitivity of 94%, a specificity of 83% and an area under

![Figure 2](image-url) Correlation of the inflammatory bowel disease disability index with the Inflammatory Bowel Disease Questionnaire for Crohn’s disease (gray circle) and ulcerative colitis (black triangle).

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Construct validity of inflammatory bowel disease disability index total and domain sub-scores in comparison to Crohn's Disease Activity Index (CDAI), partial Mayo Score, Inflammatory Bowel Disease Questionnaire (IBDQ) and number of work hours missed. r = Spearman correlation coefficient.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CDAI</td>
</tr>
<tr>
<td></td>
<td>r</td>
</tr>
<tr>
<td>IBD-DI sub-scores</td>
<td></td>
</tr>
<tr>
<td>Total IBD-DI</td>
<td>–0.771</td>
</tr>
<tr>
<td>Overall health</td>
<td>–0.671</td>
</tr>
<tr>
<td>Body functions</td>
<td>–0.722</td>
</tr>
<tr>
<td>Body structures</td>
<td>–0.470</td>
</tr>
<tr>
<td>Activity participation</td>
<td>–0.739</td>
</tr>
<tr>
<td>Environmental factors</td>
<td>–0.146</td>
</tr>
</tbody>
</table>
compared to ex-users (median IBD-DI = 0.028). Biological agents significantly improved IBD-DI (P = 0.016) as did younger age of IBD diagnosis (r = 0.253, CD versus UC were not independent significant predictors of biological agents, EIM, age, previous surgery, and diagnosis of IBD. Younger subjects had significantly poorer IBD-DI (r = 0.244, −4 versus −13, P = 0.03). A trend towards improving IBD-DI between current biological agent users and non-users was found (median IBD-DI = 4 versus −7, P = 0.052). Only the IBD-DI was an independent predictor of employment status (OR: 0.94, 95% CI: 0.89–0.99, P = 0.042; Table 4f). The IBDQ, use of biological agents, EIM, age, previous surgery, and diagnosis of CD versus UC were not independent significant predictors of employment status on multivariate analysis.

### 3.7. Qualitative analysis

The questionnaire’s completion time was between 10 and 15 min with a Flesch reading score of 67 equivalent to a grade 9 level of English. Respondents considered the questionnaire to capture many issues surrounding their disability but many commented the redundancy of some items such as that referring to schooling. No patients felt the IBD-DI to be intrusive or disagreed with the need to identify and measure disability.

### 4. Discussion

Functional limitations and restriction in participation correlate with the economic impact of IBD. Work absenteeism and requirement for financial support add to the mounting cost of these diseases. Measuring disability is relevant to patients, support organizations, lobby groups, social security agencies, health insurance companies and government health departments. High unemployment rates of 35% to 39% have been identified in IBD subjects from the USA, Netherlands and Sweden and are similar to the rate in our cohort of 40%. Reversal of disability, therefore, becomes an essential patient-centered goal for medical and surgical treatments. As such, there needs to be a valid tool that measures disability. The IBD-DI was developed from the universally accepted WHO International Classification for Functioning, Disability and Health. Using similar methods, core data sets have been developed for other chronic diseases such as systemic sclerosis, and cross sectional cohort studies have assessed disability such as in osteoarthritis. This is the first validation study using the ICF methodology on IBD and is the first study correlating a disability score with work productivity in IBD. Importantly, the IBD-DI was valid in measuring disability for both CD and UC.

Recruitment from specialized IBD clinics provided the full spectrum of disability necessary to validate the IBD-DI. Recruitment of controls also determined baseline levels of functioning to which IBD patients can aspire. Patients in remission had IBD-DI similar to controls indicating the reversibility of disability. The IBD-DI correlated to both CD and UC clinical disease activities (negatively), work hours missed and with quality of life (positively) (all P < 0.001). The IBD-DI correlated closely with IBDQ, but only the IBD-DI was an independent predictor of employment status on multivariate logistic regression. It demonstrated test–retest reliability and excellent responsiveness to change. Prior surgery, hospitalization and IBD phenotypes did not predict disability levels, signifying the importance of current disease activity in influencing disability. A previous study had also revealed that surgery, IBD location or behavioral phenotypes did not influence quality of life. Arthralgia, the commonest EIM in our cohort, significantly increased disability. This was also seen in a previous study that found arthralgia to be associated with unemployment (OR: 2.27; 95% CI: 1.27–7.14). Younger age, but not sex, was associated with greater disability, which was similar to a previous study on quality of life. Current-smoking exacerbated the IBD-DI in CD and had the opposite effect in UC. This provided internal validation that IBD-DI can detect the inverse smoking-related effects on CD

<table>
<thead>
<tr>
<th>Domain</th>
<th>First IBD-DI</th>
<th>Second IBD-DI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total IBD-DI</td>
<td>−13.0</td>
<td>4.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Overall health</td>
<td>−2.0</td>
<td>−1.0</td>
<td>0.013</td>
</tr>
<tr>
<td>Body functions</td>
<td>−13.0</td>
<td>−3.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Body structures</td>
<td>0.0</td>
<td>2.0</td>
<td>0.011</td>
</tr>
<tr>
<td>Activity participation</td>
<td>−8.0</td>
<td>−2.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Environmental factors</td>
<td>4.0</td>
<td>8.0</td>
<td>0.017</td>
</tr>
<tr>
<td>Total IBD-DI</td>
<td>−5.0</td>
<td>−1.0</td>
<td>0.152</td>
</tr>
<tr>
<td>Overall health</td>
<td>−1.0</td>
<td>−1.0</td>
<td>0.782</td>
</tr>
<tr>
<td>Body functions</td>
<td>−5.5</td>
<td>−4.0</td>
<td>0.252</td>
</tr>
<tr>
<td>Body structures</td>
<td>0.0</td>
<td>0.0</td>
<td>0.726</td>
</tr>
<tr>
<td>Activity participation</td>
<td>−1.5</td>
<td>−2.0</td>
<td>0.655</td>
</tr>
<tr>
<td>Environmental factors</td>
<td>6.0</td>
<td>6.0</td>
<td>0.253</td>
</tr>
</tbody>
</table>

* Pooled IBD cases with CDAI change of >70 points or pMayo change of >2 points.
versus UC. Biological agents were the only drugs that improved IBD-DI. Current users of biological agents had less disability compared to primary or secondary non-responders (median IBD-DI difference = 9; P = 0.03) and non-users (median IBD-DI difference = 3; P = 0.052). Younger IBD patients, those with arthralgia and smokers with CD require the greatest attention towards their risk of disability. Use of biological agents may be justified based on their ability to reduce disability. These factors require further attention using a larger-scale population-based study on disability.

Overall, our cohort had an unemployment rate of 40%, similar to the ACCENT 1 cohort of refractory CD patients’ rate of 39%, the Dutch rate of 35% and the Swedish rate of 39%. In this study, only the IBD-DI significantly predicted employment status. Even minimal disability with IBD-DI scores of 0 to −9 was sensitive enough to detect work absenteeism of a mean of 1.3 h in the previous week. Over 1 in 5 of our patients had moderate to severe disability corresponding high proportions of unemployment seen in IBD and consistent with data from the USA.

Other studies have evaluated disability only according to disability compensations. This measure by itself does not sufficiently capture disability information. A previous study showed that pension data was only associated with the IBDQ domain of emotional function and not the other domains. The IBD-DI, however, correlated significantly against all 4 IBDQ domains. Receiving the pension is heavily influenced by personal attitudes towards collecting benefits, secondary gain, personal savings, means testing, social security benefits, health policies and local job availability. The IBD-DI, therefore, is a more robust scoring system in quantifying the full spectrum of disability. Our study also differs to the recently published IBD Disability Score (IBD-DS) that was designed in consultation with the authors of the ICF, but was different to the ICF IBD-DI. The IBD-DS differentiated active from inactive CD, but did not demonstrate statistical difference between active and inactive UC. The IBD-DI, however, was significantly validated against both CD and UC. To date our study was the only one to explore the influence of IBD phenotypes, medical and surgical treatments, EIM, and smoking on disability and the cumulative effects of disability on workforce participation. It also involved an international key opinion leader on the ICF (FK), the core concept from which the IBD-DI was derived. Validation tests were also performed independently to the authors of the ICF IBD-DI to ensure objectivity and absence of conflict of interest.

The IBD-DI was easy to complete but language simplification may further increase capacity. For the purpose of pilot validation and to obtain feedback it was administered to subjects face-to-face. Self-administration would require further validation. Three items lacked sufficient variance to be of use and require modification. They pertain to ‘schooling or studying activities’ and whether there was ‘worsening of the problems caused by family or health professionals’.

Validation of the IBD-DI against a rehabilitation assessment tool, such as the Functional Independence Measure designed to demonstrate stroke recovery, is incongruous given their focus on very basic activities of daily living, language and cognitive function. IBD-DI, therefore, occupies a unique position in the measurement of IBD outcomes. This validation study utilized a referral cohort of cases and further studies to specifically investigate the association of demographics, phenotypes, and treatment effects on disability will require unselected large patient cohorts.

### 5. Conclusions

Inflammatory bowel diseases can result in tremendous disability, activity limitation and restriction in participation. Patient reportable outcomes and reversal of disability should be the target of treatment and in clinical drug trials. As such, a novel scoring system was designed for the International Classification of Functioning IBD-Disability Index and it was validated as an instrument highly suitable for measuring IBD-related disability for both CD and UC.

| Table 4 Predictors of employment status on multivariate logistic regression. |
|-------------------------------------|--------------------|-----------------|-----------------|
| IBD disability index                | 0.94               | 0.89–0.99       | 0.042           |
| Inflammatory Bowel Disease Questionnaire | 0.98             | 0.96–1.00       | 0.055           |
| Extra-intestinal manifestations     | 2.26               | 0.92–5.57       | 0.077           |
| Biological agent                    |                    |                 |                 |
| Nil                                 | 1                  |                 |                 |
| Previous                            | 1.69               | 0.49–5.79       | 0.406           |
| Current                             | 1.69               | 0.61–4.70       | 0.311           |
Active disease, younger age, smokers with CD and arthralgia were significant predictors of disability. The IBD-DI correlated with IBDQ and inversely with clinical disease activities. As such, the IBD-DI is suitable for health economics research, regulatory approval processes, or for clinical drug trial endpoint to ensure new treatments generate improvement in patient outcomes.

**Conflict of interest**

Rupert WL Leong declares no conflict of interest and has approved the final draft.

Tony Huang declares no conflict of interest and has approved the final draft.

Yanna Ko declares no conflict of interest and has approved the final draft.

Ari Jeon declares no conflict of interest and has approved the final draft.

Jeff Chang declares no conflict of interest and has approved the final draft.

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Guarantor of the article: Rupert Leong.

**Specific author contributions**

TH, YK, AJ, JC, FK, VK have no conflicts to disclose.

RWL: study concept; study design, study supervision.


RWL, TH, JC, FK, VK: manuscript drafting, critical revision.

RWL, TH, VK: statistical analysis, analysis and interpretation of data.

**Appendix A**

The inflammatory bowel disease disability index scoring key

**Question 1**

- Very good = 0 score
- Good = −1 score
- Moderate = −2 score
- Bad = −3 score
- Very Bad = −4 score

**Questions 2–13**

- None = 0 score
- Mild = −1 score
- Moderate = −2 score
- Severe = −3 score
- Extreme = −4 score

**B525: number of liquid/very soft stools in last week**

- 0 = +1 score
- 1–4 = −1 score
- 5–8 = −2 score
- 9–12 = −3 score
- >12 = −4 score

**BMI**

- <15 = −2 score
- 15.1–19.9 = −1 score
- 20–24.9 = 0 score
- 25–29.9 = −1 score
- >30 = −2 score

**B515: do you feel that you've lost weight in the last week?**

- Yes = −1 score
- No = +1 score

**S540: blood in stool?**

- None = +1 score
- Little = −1 score
- A lot = −2 score

**S770: is arthritis or arthalgia present?**

- Yes = −1 score
- No = +1 score

**Questions 14–18**

**Positive/alleviating effects**

- NA = +4 score
- No positive effect = 0 score
- Mild positive effect = +1 score
- Moderate positive effect = +2 score
- Severe positive effect = +3 score
- Extreme positive effect = +4 score

**Negative/worsening effects**

- NA = 0 score
- No negative effect = 0 score
- Mild negative effect = −1 score
- Moderate negative effect = −2 score
- Severe negative effect = −3 score
- Extreme negative effect = −4 score

**Questions 18–19**

- No = −1 score
- Yes = +1 score
References


