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Establishing Clinically Significant Patient-reported Outcomes for Diverticular Disease

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Abstract

Background: Diverticular disease can undermine health-related quality of life (HRQoL). The diverticulitis quality of life (DV-QOL) instrument was designed and validated to measure patient-reported burden of diverticular disease. However, values reflecting meaningful improvement (i.e., minimal clinically important difference [MCID]) and the patient acceptable symptom state (PASS) have yet to be established. We sought to establish the MCID and PASS of the DV-QOL and describe the characteristics of those with DV-QOL above the PASS threshold.

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Declarations

Ethics approval and consent to participate: This study was approved by the University of Washington IRB (STUDY00003708), for the following study sites: University of Washington Medical Center, Harborview Medical Center, Northwest Hospital, Legacy Health, and Valley Medical Center. Approval was also attained for the Ronald Reagan UCLA Medical Center and Skagit Regional Health from the UCLA IRB (#16-000599) and Skagit Regional Health IRB (DEBUT study), respectively. Patient consent was given in writing, online, or in person with a research coordinator.

Declaration of interest: none

Disclosures: The authors report no proprietary or commercial interest in any product mentioned or concept discussed in this article.

Availability of data and material: Data from the DEBUT participating cohorts for this analysis are not publicly available as the DEBUT study is still ongoing. The dataset may be available upon request after 2022 once the main DEBUT study is completed, as described by the National Institutes of Health.

Material and methods: We performed a prospective cohort study of adults with diverticular disease from seven centers in Washington and California (2016–2018). Patients were surveyed at baseline, then quarterly up to 30 months. To determine the MCID and PASS for DV-QOL, we applied various previously established distribution- and anchor-based approaches, and compared the resulting values.

Results: The study included 177 patients (mean age 57 years, 43% female). A PASS threshold of 3.2/10 distinguished between those with and without HRQoL-impacting diverticulitis with acceptable accuracy (area under the curve [AUC] 0.76). A change of 2.2 points in the DV-QOL was the most appropriate MCID: above the distribution-based MCIDs and corresponding to patient perception of importance of change (AUC 0.70). Patients with DV-QOL PASS were more often male, younger, had Medicaid, had more serious episodes of diverticulitis, and had an occupational degree or high school education or less.

Conclusions: Our study is the first to define MCID and PASS for DV-QOL. These thresholds are critical for measuring the impact of diverticular disease and the evaluation of treatment effectiveness.

Keywords

Diverticulitis quality of life; minimal clinically important difference (MCID); patient acceptable symptom state (PASS); symptomatic uncomplicated diverticular disease (SUDD); health-related quality of life (HRQoL); patient-reported outcomes

Introduction

Between two and three million Americans experience an episode of acute diverticulitis each year, resulting in over 370,000 emergency department (ED) visits, 200,000 hospital admissions, and almost \$5.5 billion in total health care expenditures.¹ One in four patients will have recurrent episodes of diverticulitis, and, historically, patients with more than a few episodes (ranging from one to three, based on risk) were recommended to have an elective colectomy.^{2,3} In 2015, the American Society of Colorectal Surgeons (ASCRS) proposed that an “episode count” indication for elective colon resection be replaced by an assessment of the impact of diverticulitis on health-related quality of life (HRQoL).⁴ The evolution in the ASCRS guideline demonstrates a recognition that some patients who have recovered from an acute episode of diverticulitis often have ongoing gastrointestinal (GI) symptoms and psychosocial distress after recovery.⁵ This emphasizes the importance of a reliable metric to understand the impact of diverticulitis on patient-reported symptoms and HRQoL domains over time.

In 2015, Spiegel et al. developed the first diverticulitis-specific HRQoL measure (DV-QOL),⁶ a 17-question survey of patient-reported burden of disease focused on those with uncomplicated diverticular disease. The DV-QOL includes questions about both intestinal and extra-intestinal symptoms, behavior changes related to the disease, and disease-specific cognitions and emotions. Each question of the DV-QOL is worded so that symptoms are attributable specifically to diverticular disease, unlike more generic patient-reported outcome (PRO) measures, such as the Gastrointestinal Quality of Life Index (GIQLI) or the 36-Item

Short Form Health Survey questionnaire (SF-36).⁷ While generic measures are useful for comparing outcomes across different populations and programs, disease-specific tools have been suggested as a way to capture unique concerns for patients with particular conditions and may be helpful for measuring clinically important changes with treatment.⁸ This is especially important for investigators and clinicians who need tools that include features of a particular disease and are responsive to treatments and variations in health status over time.

However, important questions remain regarding how to interpret the DV-QOL scores for clinical application. Mean scores are difficult to interpret, and clinicians often need to know what constitutes a clinically relevant treatment success when using these scores. For example, when evaluating an intervention, is the observed improvement in score clinically relevant? What is the score that separates well from unwell? The concepts of minimal clinically important difference (MCID) and the patient acceptable symptom state (PASS) were created to address these questions. In the literature, MCID is defined as “the smallest change that is important to patients” and PASS is defined as the “score below which patients consider themselves well”.^{9,10} Determining these thresholds is critical for interpreting the scores of groups of patients undergoing treatment and is essential to support treatment guidelines. The goals of this study were to establish the PASS and MCID of the DV-QOL and to explore additional characteristics associated with patients reporting more severe disease on the DV-QOL.

Material and methods

Study design and population

This was a prospective cohort study with patients recruited between April 1, 2016, and November 30, 2018, from the Diverticulitis Evaluation of Patient Burden, Utilization, and Trajectory (DEBUT) study.¹¹ Patients with a history of acute diverticulitis were recruited from different clinic environments (EDs, surgery clinics, and GI clinics) at seven medical centers in California and Washington and at different stages of disease (e.g., recent diagnoses or those with recurring episodes). Adult patients were recruited if they had a computed tomography (CT) scan-confirmed report or a physician-confirmed diagnosis of diverticular disease. Patients who had a prior colon resection, used a medical proxy for decisions about care, or were non-English speaking were excluded. Patients were predominantly recruited remotely via emails and letters. Informed consent was obtained for participation in the study. Of the 591 patients approached for the study, 214 (36%) agreed to participate; of these, 177 (83%) returned a completed baseline survey. We continued to survey these participants every 3 months via a multi-modal approach that included outreach by phone, mail, and email with options to complete the survey on paper or online. At the time of this analysis, the longest follow-up was 30 months.

The baseline survey collected information related to patient demographics (i.e., age, sex, race, ethnicity, marital status, education, insurance, job requiring physical activity, income), smoking status, diverticulitis history (i.e., years of disease, episodes of disease, timing and severity of the last episode), and recruitment site type.

Outcome measure

The DV-QOL is a 17-item questionnaire for diverticular disease designed to assess patients' HRQoL in the past two weeks.⁶ It was developed through focus groups, literature search, and cognitive briefings with patients who had diverticular disease, capturing important experiences of illness using patients' own words. This instrument is diverticulitis-specific, with each question attributing symptoms to the disease of interest as opposed to overall well-being. It combines four domains relevant to the HRQoL of patients with diverticulitis: 1) physical symptoms, 2) concerns, 3) emotions, and 4) behavioral changes (see eTable 1 in the supplementary materials for items in each domain). One important distinction of the DV-QOL from other GI system-specific instruments (e.g., GIQLI or Patient-Reported Outcomes Measurement Information System (PROMIS®) gastrointestinal symptom scales) is the inclusion of questions related to patient concerns,^{7,12} such as whether diverticulitis might flare up or get worse at any time, or whether people might be looking down at them because of their diverticulitis symptoms. The questionnaire takes approximately 4–8 minutes to complete. The total DV-QOL score is reported on a 0–10 scale, with 0 indicating the lowest symptom burden (best HRQoL) and 10 the highest burden (worst HRQoL). The DV-QOL was collected at baseline and quarterly thereafter.

Anchors

An anchor question asked about an individual's HRQoL improvement over time: "Do you feel that your digestive health has improved over the last 3 months?" Patients could answer "Yes," "No," or "Not sure." These answers were dichotomized into 1 = Improved ("Yes") and 0 = Not improved ("No" or "Not sure"). Patients were asked to complete this anchor question at all time-points following the baseline survey.

An additional anchor question collected information regarding satisfaction with current digestive quality of life. At baseline and at each follow-up time-point, patients were asked, "Are you content with your digestive quality of life today?" Patients could answer "Yes," "No," or "Not sure." These answers were further dichotomized into 1 = acceptable ("Yes") and 0 = unacceptable ("No" or "Not sure"). Only a subset of patients (n=120/177, 68%) received this question at baseline.

Patient acceptable symptom state (PASS)

The PASS has been widely used in the literature to facilitate the interpretation of PROs (e.g., pain, function, treatment burden) in both chronic and acute conditions.^{13–15} It describes "an intermediate state between activity of the disease and complete remission, defined as the score below which patients consider themselves well".¹⁴ An anchor to self-identified satisfaction was used to determine the DV-QOL threshold for the PASS that best differentiated patients who were currently content with their digestive HRQoL (acceptable) versus those who were not (unacceptable). The cutoff values for PASS were estimated using baseline data by applying two commonly used approaches. The primary approach is a receiver operating characteristic (ROC) analysis (Table 1).¹⁶ The acceptable threshold for PASS is the value that provides the best balance between sensitivity and specificity, representing the lowest overall misclassification. The area under the curve (AUC)

was also computed for each DV-QOL threshold, representing the probability of correctly differentiating between an acceptable and an unacceptable state. An AUC of 0.7 to 0.8 is considered acceptable, and an AUC of 0.8 or above excellent.¹⁷ In the second approach, PASS was defined as the 75th percentile of the cumulative distribution for DV-QOL among those who considered the symptom state satisfactory.^{14,18} The 75th percentile analysis was performed to support the findings of the ROC approach.

Minimal clinically important difference (MCID)

To calculate the MCID, we used data from the quarter with the highest DV-QOL score (Q_{\max}) that was not the final quarter of the study participation. Only patients who had completed two consecutive quarters of the DV-QOL questionnaire and had a DV-QOL score at Q_{\max} the PASS were included. Given the heterogeneity of disease severity of our cohort, this inclusion criterion was selected to capture meaningful improvement among those with HRQoL-limiting diverticular disease. Three anchor-based approaches (average change, change difference, and ROC-derived) and three distribution-based approaches (0.5 standard deviation [SD], effect size, and minimum detectable change) were used to determine the MCIDs;^{19,20} these are outlined in Table 1. The anchor-based MCIDs were derived using the anchor question about HRQoL improvement. It is important to note that distribution-based approaches do not directly address the question of clinical importance but instead are measures of statistical distribution of outcome scores. They are specific to the sample and can be used to determine the minimum detectable effect that is expected due to random measurement error alone. We therefore expect distribution-based MCIDs to be the lower bound for a minimum, and experts recommend that they should be used to confirm the findings of anchor-based methods.²¹ The final MCID value was chosen based on the fulfillment of two criteria: it must be at least greater than the distribution-based MCIDs, and it must correspond to the patient perception of importance of change (anchor-based). This aligns with a published recommendation that anchor-based estimates be assigned the most weight.²¹

Statistical analysis

We described the patient characteristics and disease history among patients with baseline DV-QOL below and above the PASS value in order to examine how the two groups differed in these factors using bivariate analysis. We also examined whether HRQoL-limiting disease, as defined by DV-QOL above PASS, could distinguish patients with worse general health, more work impairment, and worse psychosocial measure from other patients at baseline, again with a bivariate analysis. For general health, we used responses from the PROMIS global health instrument which assesses an individual's generic mental health (four items) and physical health (four items) domains.^{22,23} The total raw scores were translated into standardized T-scores with a mean of 50 and a SD of 10. A higher score indicates better health. To measure impairments in both paid and unpaid work due to health problem, we used responses from the Work Productivity and Activity Impairment questionnaire.²⁴ We also used responses from a self-reported chronic sickness question, "Do you feel sick all of the time?", which has been used in other studies as a psychosocial validity measure.^{25,26} We expected most individuals with DV-QOL below PASS (satisfactory disease state) to have responses that are positive in all of these measures. Chi-squared and the Student's t-test were

used for comparisons of categorical and continuous variables, respectively. Statistical tests were considered significant if the final p-value was $<.05$. Data analysis was performed using Stata version 14 (Stata-Corp). This study was approved by the University of Washington Institutional Review Board (IRB) (STUDY00003708), the UCLA IRB (#16-000599), and Skagit Regional Health IRB (DEBUT study).

Results

Among 177 patients who filled out a baseline survey (43% female, mean age 57 years [SD 13]), 81 (46%) were recruited in EDs, 76 (43%) from surgical clinics, and 20 (11%) from GI clinics. Table 2 shows patient characteristics at baseline. In this patient sample, 79% were white, 51% had private insurance, and 50% were currently employed. Time since diverticulitis diagnosis varied greatly, with a median of 1.7 years (first to third quartile [Q1-Q3] 0.2–7.5). The median baseline DV-QOL total score was 3.9 (Q1-Q3, 2.2–5.6) out of 10 (Table 3). The domain related to concerns had the worst (highest) score (median 5.0; Q1-Q3 2.5–7.5). There were 31 (18%) patients who reported feeling chronically sick; median PROMIS physical and mental health summary scores were 45 and 48, respectively, both within one SD of the standardized mean score of 50. Median percentage of work and activity impairment due to health was 20% (Q1-Q3 1–30%) and 30% (Q1-Q3 0–70%), respectively.

Establishing the PASS

The anchor question regarding self-reported satisfaction with digestive HRQoL at baseline was answered by 120 patients. Baseline characteristics of these patients were similar to those in the complete cohort (eTable 2). Of the 114/120 (95%) who also completed a DV-QOL questionnaire, 36 (32%) reported they were content with their digestive HRQoL. DV-QOL was significantly higher ($p<0.001$) among those who reported discontent (mean 4.89; SD 1.82) compared with those who were content (mean 2.55; SD 1.98), with a standardized mean difference of 1.23. Using the ROC method, the DV-QOL PASS cutoff value of 3.2 out of 10 represented the threshold that provided the best balance between sensitivity and specificity (AUC of the ROC curve 0.76, sensitivity 80.8%, specificity 72.2%) (eFigure 1 in supplementary material). The 75th percentile method estimated a similar PASS threshold of 3.5, supporting the value derived using the ROC-method.

Establishing the MCID

In the study population, 132 patients had at least two consecutive quarters of data. Of those, 87 (66%) had a DV-QOL score at Q_{\max} 3.2, the PASS threshold. Patient characteristics of these patients were similar to those in the complete cohort (Table 2). Mean DV-QOL scores were 5.56 (SD 1.4) and 2.80 (SD 1.9) for Q_{\max} and the quarter after Q_{\max} , respectively. There were 43 (49.4%) patients who answered “Yes” to the improvement anchor question the quarter after Q_{\max} , and their mean DV-QOL change score was significantly higher than those who answered “No” or “Not Sure” to the improvement question (mean change score 3.80 [SD 2.1] versus 1.73 [SD 1.8]; $p<0.001$). Each MCID calculation method yielded a different threshold. The average change method yielded the largest threshold (3.80). The change difference method and ROC curve methodology yielded thresholds of 2.07 and

2.20, respectively. The distribution-based methods yielded the smallest thresholds (0.72 with the 0.5 SD approach, 0.29 with the effect size approach, and 0.89 with the minimum detectable change approach). Applying our choice criteria, the ROC curve-derived value of 2.20 appeared to be the most appropriate MCID because it was above the distribution-based MCIDs and close to the change difference. At the cutoff of 2.20, the AUC was 0.7 (sensitivity 74.4%; specificity 65.9%; eFigure 2 in supplementary material).

Variables associated with clinical significance

Table 4 shows the patient characteristics and diverticulitis history by HRQoL-limiting disease (defined by DV-QOL scores above the PASS threshold). Bivariate analysis showed that patients who had HRQoL-limiting diverticulitis were younger, more often male, had an occupational degree or high school education or less, more often had Medicaid as their primary insurance, and had more episodes of diverticulitis that required an ED visit or overnight hospital stays. HRQoL-limiting diverticulitis was significantly associated with worse PROMIS global health scores in both the physical health and mental health domains, a feeling of being “always sick,” and higher work and activity impairment (Table 5). Specifically, patients whose DV-QOL reflected a satisfactory disease state (i.e., below PASS) had median physical and mental health scores similar to those of the US general population and minimal work and activity impairment (medians 0.2% and 0%, respectively); only 3% reported feeling sick all the time.

Discussion

Our study is the first to define the MCID and PASS for the DV-QOL. Using prospectively collected data from a heterogeneous cohort of patients with diverticular disease, we found a score of 3.2 out of 10 distinguished between those with and without HRQoL-impacting diverticulitis, suggesting this score as a PASS threshold. We found a change of 2.2 points in the DV-QOL to be the most appropriate MCID because it was above the distribution-based MCIDs and corresponded to the patient perception of importance of change. These thresholds are critical for assessing burden of disease and measuring the impact of interventions.

We found that patients with HRQoL-limiting disease (i.e., DV-QOL PASS) at baseline tended to be younger and male, in line with previous studies that found younger age and male sex to be risk factors for recurrence.^{27,28} However, other studies showed no differences in HRQoL between the two sexes and between younger and older patients.^{29,30} Future studies aiming to use DV-QOL as an outcome should consider how these factors might affect HRQoL trajectories or treatment impact, especially given the rapid rise in diverticulitis incidence among younger patients.³¹ We also found that those with worse DV-QOL more frequently had Medicaid as primary insurance and had an occupational degree or high school education or less. One possible explanation is that these subgroups have reduced access to resources (e.g., nutrition, health care, income) and are more often exposed to less favorable environmental factors (e.g., neighborhood safety, working conditions). Stress and psychosocial factors are known to influence the manifestation of symptoms in other GI disorders, including irritable bowel syndrome, and may also play

a similar role in diverticular disease.³² In addition, diet and lifestyle are risk factors for diverticulitis that correlate with socioeconomic status.³³ Results from the comparisons of patient characteristics and disease history between those with HRQoL-limiting disease and those without, at baseline, were meant to be descriptive and support future hypothesis-generating research regarding the cause of HRQoL-limiting disease. Future studies could assess the relationship of one variable with another, test causative hypotheses, and examine the association between these characteristics and the temporal trends of the DV-QOL.

We also found that, on average, individuals with DV-QOL below PASS (satisfactory disease state) had generic HRQoL similar to those of the general US population, minimal work and activity impairment, and rarely reported “feeling sick all the time”. This suggests that the DV-QOL PASS threshold in our study was able to reasonably differentiate between individuals who were “well” in these other PRO measures from those who were not, supporting the inference that the DV-QOL threshold of 3.2 is a reasonable PASS value at baseline.

This study has important limitations. MCID and PASS thresholds were generated using data with limited sample size from English-speaking patients from California and Washington state (79% white and 51% with private insurance), which limits the generalizability of our results. Our study protocol was set up such that we began acquiring patient data only after patients consented to participate. The lack of demographic information on patients excluded limited our ability to examine potential sampling bias. Moreover, as a pragmatic observation study, our cohort reflects the heterogeneity of the population with diverticular disease, and our study cohort consisted of patients with both severe and mild disease recruited from EDs and clinicians’ offices, with different disease histories and treatment patterns (e.g., 42 (24%) were diagnosed within 2 months of baseline and 23 (13%) had elective surgery). The physician-confirmed diagnosis of diverticular disease also relied on usual care, which may have included a CT scan, barium study, and/or colonoscopy. Our current analyses estimated MCID and PASS thresholds for this heterogeneous group of patients. MCID and PASS within specific subgroups may be different, and this is critical to explore in future work. Furthermore, we only included those with HRQoL-limiting disease in the MCID analysis. High initial DV-QOL values could have exaggerated the actual change in DV-QOL score due to regression to the mean, resulting in higher MCID values. In addition, 15 out of the 87 patients received surgery between the two time points used in the estimation of the MCIDs. Although we do not think that an intervention alone would affect the MCID for DV-QOL, it is possible that the MCID estimates differ across the disease continuum. To minimize the heterogeneity, we only included those with HRQoL-limiting disease in our analysis, but there was still a range of possible severity. Future studies should examine whether those with more severe disease (e.g. surgical candidates) have different MCIDs than those with less severe disease and calibrate the MCID measures accordingly. Our HRQoL improvement anchor question also did not provide a choice for “getting worse.” The inability to isolate patients whose HRQoL worsened may also have contributed to a larger MCID value.

There are inherent limitations to the MCID and PASS calculation methodologies, including the lack of confidence intervals and the lack of a universally accepted methodology to determine these thresholds. Our choice of the ROC-based MCID and PASS is not

without limitations. The ROC curve approach is subjective and determined by assessing the impact of the value on sensitivity and specificity, based on anchor questions. While balancing sensitivity and specificity is a widely used and conventional approach for MCID and PASS determination, some clinicians may favor thresholds that can identify patients with meaningful change or HRQoL-limiting disease with greater confidence (higher specificity) versus ruling out non-meaningful change or non-HRQoL-limiting disease (higher sensitivity). Nevertheless, the ROC-derived thresholds in our study had good sensitivity and specificity (range 68–82), and the MCID derived from the ROC method corresponds to the change difference between those who reported improvement and those who did not. In order to create dichotomous variables for the ROC analysis, we collapsed the “no” and “not sure” categories of the anchor questions. However, sensitivity analyses (data not shown) with the “no” category removed showed an identical MCID estimate and slightly larger PASS (3.6 vs. 3.2), suggesting minimal bias due to the collapsing of categories. Additionally, there is no gold standard “anchor question” to calculate the MCID and PASS thresholds. It may be the case that different MCID and PASS thresholds would have been calculated had different anchor questions been applied or if different choices of answers were provided.

MCID and PASS thresholds are critical for interpreting PRO scores for groups of patients undergoing treatment. They are particularly useful in clinical research and trial settings where the goal is to determine clinically meaningful differences in effectiveness between treatment or care strategies. Results from such research can support treatment guidelines and facilitate clinician-patient conversations about treatment goals, expectations, and outcomes. PROs are increasingly being considered in the clinical space to enhance the quality of care provided. This is particularly important for conditions such as diverticular disease where PROs serve as primary end-point for treatment goals. Longitudinal PROs are especially useful for understanding how scores change over time and for identifying patients with declining HRQoL where more aggressive disease management may be warranted. PASS and MCID thresholds can potentially provide guidance on the clinical importance of the changes in scores. However, it is important to note that these thresholds are context-specific entities. They are specific to disease type as well as population characteristics, and should not be used as a universal fixed attribute. It has been suggested that MCID derived using anchor-based methods, while useful for assessment of group changes, may misclassify patients as responders if used on an individual level because estimates of individual change have larger standard errors.³⁴ Readers should exercise caution when applying these MCIDs to individuals within a clinical practice context. There are also logistical challenges. Often, PROs are not recorded in electronic health records and longitudinal history is not readily accessible at the point of care, making it challenging to identify patients with meaningful changes in their PRO measures. Gaps remain on how to apply these measures in the clinical space for shared decision-making warranting future research.³⁷

Conclusions

People with diverticular disease experience a range of symptoms that may affect social and emotional health. As clinical guidelines for elective colectomy in patients with diverticular disease focus on more personalized treatment related to disease burden and

HRQoL limitation,⁴ instruments like the DV-QOL can play a critical role in comparative effectiveness research. Ultimately, clinical shared decision-making discussions for patients with diverticular disease may be enhanced by incorporating data that includes disease-specific PRO measures. Defining meaningful change and HRQoL-limiting state in a PRO score can help inform how well a treatment is working versus when new treatment approaches are needed. This study expands upon existing work by establishing the MCID and PASS for the disease-specific DV-QOL, measures that are critical for the interpretation of PROs in individuals with diverticular disease.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations

ASCRS	American Society of Colorectal Surgeons
AUC	area under the curve
CT	computed tomography
DEBUT	Diverticulitis Evaluation of Patient Burden, Utilization, and Trajectory
DV-QOL	diverticulitis quality of life instrument
ED	emergency department
GI	gastrointestinal
GIQLI	Gastrointestinal Quality of Life Index
HRQoL	health-related quality of life
IRB	institutional review board
MCID	minimal clinically important difference
MDC	minimum detectable change

PASS	patient acceptable symptom state
PRO	patient-reported outcome
PROMIS	Patient-Reported Outcomes Measurement Information System
Q_{max}	quarter with the highest DV-QOL score
ROC	receiver operating characteristic
SD	standard deviation
SEM	standard error of measurement
SF-36	36-Item Short Form Health Survey

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Table 1:

Approaches used for determining the PASS and MCID thresholds of DV-QOL

	Approach	Description
PASS ^a		
Anchor-based	1. ROC ^b curve-derived	ROC curves were computed for each DV-QOL cutoff value. The corresponding ROC curve for each cutoff value represented the relation between the proportion of patients who were correctly classified in the acceptable group (sensitivity) versus the proportion of patients who were incorrectly classified in the acceptable group (specificity). The acceptable threshold is the value that provides the best balance between sensitivity and specificity, representing the lowest overall misclassification.
Distribution-based	2. 75th percentile	PASS was defined as the 75 th percentile of the cumulative distribution for the DV-QOL among those who considered their symptom state acceptable.
MCID ^c		
Anchor-based	1. Average change	The mean DV-QOL change score ^d of the patients who improved
	2. Change difference	The difference in the mean change scores between the patients who improved and did not improve
	3. ROC curve-derived	The change score with even sensitivity and specificity based on the ROC curves, which was used to distinguish between patients who improved and those who did not. (See above for more detail.)
Distribution-based	4. Half a standard deviation (SD)	SD reflects the variation in scores. Studies have shown that the value of 0.5 SD often corresponded to the MCID derived using anchor-based methods for changes in HRQOL for chronic diseases. ^{17,19,20} Authors attributed their finding to the fact that research in psychology has shown that the limit of human mental discriminative capacity is approximately 1 part in 7, which is close to 0.5 SD. The MCID was half the SD of the DV-QOL scores at Q _{max} . ^e
	5. Effect Size	Effect size, the change in scores divided by the SD of the baseline scores, is the standard measure of change. A change in scores corresponding to a small effect size (0.2) is considered the MCID. ^{35,36} MCID was calculated by multiplying SD of the DV-QOL scores at Q _{max} by 0.2.
	6. Minimum Detectable Change	The standard error of measurement (SEM) is calculated as $SD \cdot \sqrt{1-r}$, where $r = 0.95$, the internal consistency reliability estimate of the DV-QOL. ⁶ Minimum detectable change is then calculated as $1.96 \cdot \sqrt{2} \cdot SEM$. ¹⁷

^aPASS, patient acceptable symptom state^bROC, receiver operating characteristic^cMCID, minimal clinically important difference^dThe score in the quarter with the highest DV-QOL score (Q_{max}) minus the score in the subsequent quarter. A positive change score indicates improvement and a negative change represents deterioration in QoL.^eQ_{max}, Quarter with the highest DV-QOL score

Table 2:

Patient baseline characteristics

Characteristics		<u>All patients</u>	<u>Included in MCID analysis^a</u>
		N / Total (%)	N / Total (%)
<i>N</i>		177	87
<i>Demographics</i>			
Age at baseline, mean (SD) ^b		56.8 (13.2)	57.3 (11.7)
Female		74 / 174 (42.5%)	27 / 84 (32%)
Race: non-White		17 / 177 (9.3%)	15 / 87 (17.9%)
Married/living with partner		109 / 174 (62.6%)	54 / 85 (63.5%)
Education	High school or less	17 / 177 (9.6%)	7 / 87 (8.0%)
	Occupational ^c	60 / 177 (33.9%)	34 / 87 (39.1%)
	Bachelor's degree	54 / 177 (30.5%)	28 / 87 (32.2%)
	Graduate degree	46 / 177 (26.0%)	18 / 87 (20.7%)
Insurance	Private	88 / 173 (50.9%)	42 / 85 (49.4%)
	Medicare	47 / 173 (27.2%)	22 / 85 (25.9%)
	Medicaid	20 / 173 (11.6%)	13 / 85 (15.3%)
	Other	18 / 173 (10.4%)	8 / 85 (9.4%)
Income	<\$25,000	36 / 171 (21.1%)	20 / 85 (23.5%)
	\$25,000-\$49,999	20 / 171 (11.7%)	8 / 85 (9.4%)
	\$50,000-\$99,999	39 / 171 (22.8%)	20 / 85 (23.5%)
	\$100,000	53 / 171 (31.0%)	27 / 85 (31.8%)
	Prefer not to answer	23 / 171 (13.5%)	10 / 85 (11.8%)
Smoked within the last 30 days		23 / 173 (13.3%)	13 / 87 (14.9%)
Currently employed		86 / 172 (50.0%)	39 / 85 (45.9%)
<i>Diverticulitis history, median (Q1, Q3)^d</i>			
Years since first diagnosis		1.7 (0.2, 7.5) (n=167)	2.7 (0.4, 8.7) (n=85)
Episodes that required antibiotics		1.0 (0.0, 2.0) (n=169)	1.0 (0.0, 3.0) (n=84)
Episodes that required ED ^e visits		1.0 (0.0, 2.0) (n=169)	1.0 (0.0, 2.0) (n=84)
Episodes that required overnight hospital stay		0.0 (0.0, 1.0) (n=169)	1.0 (0.0, 1.0) (n=84)
Days since last episode		31 (13, 70) (n=162)	29 (10, 52) (n=82)
Recruitment site type	ED	81 / 177 (45.8%)	35 / 87 (40.2%)
	Gastrointestinal clinics	20 / 177 (11.3%)	7 / 87 (8.0%)
	Surgical clinics	76 / 177 (42.9%)	45 / 87 (51.7%)

^aOnly patients with at least two consecutive quarters of DV-QOL and who had DV-QOL the PASS threshold of 3.2 at Q_{max} (the quarter with the highest DV-QOL)

^bSD, Standard deviation

^coccupational includes technical or vocational program, or associate degree

^dQ1 and Q3, 25th and 75th percentile

^eED, emergency department

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Table 3:

Patient-reported outcomes and anchor questions at baseline

Characteristics	Median (Q1,Q3 ^a)
<i>Patient-reported outcomes:</i>	
DV-QOL ^b scores	
Symptoms, n=175	3.6 (2.0, 5.2)
Concerns, n=174	5.0 (2.5, 7.5)
Emotions, n=175	3.8 (1.9, 5.6)
Behavior, n=172	4.0 (1.5, 6.0)
Total, n=171	3.9 (2.2, 5.6)
PROMIS ^c scores	
Physical health, n=174	44.9 (39.8, 50.8)
Mental health, n=175	48.3 (43.5, 56.0)
Self-reported chronic sickness, ^d N (%)	31 / 173 (17.9%)
Percent overall work impairment due to health, n=68	20.0 (1.0, 30.0)
Percent activity impairment due to health, n=166	30.0 (0.0, 70.0)
<i>Anchor questions:</i>	
Are you content with your digestive quality of life today? ^e N (%) answered yes	36 / 114 (31.6%)
Do you feel that your digestive health has improved over the last 3 months? ^f N (%) answered yes	43 / 87 (49.4%)

^aQ1 and Q3, 25th and 75th percentile^bDV-QOL, the diverticulitis quality of life instrument^cPROMIS, Patient-Reported Outcomes Measurement Information System^dSelf-reported chronic sickness was measured by the question: Do you feel sick all of the time?^eAt baseline, among those with total DV-QOL scores^fEvaluated in the quarter after Q_{max} (quarter with the highest DV-QOL score) among those with DV-QOL the PASS threshold of 3.2 at Q_{max}

Table 4:

Patient baseline characteristics by DV-QOL below/above PASS threshold (DV-QOL=3.2). Above PASS threshold represents HRQoL-limiting disease state.

Characteristics		DV-QOL ^a <3.2	DV-QOL ≥ 3.2	p-value ^b
		N(%)	N(%)	
N		69	102	
Age at baseline, mean (SD)^c		59.2 (12.2)	54.9 (13.3)	0.040
Female		38/69 (55%)	34/99 (34%)	0.008
Race: non-White		10/69 (14%)	20/102 (20%)	0.33
Married/living with partner		42/69 (61%)	63/99 (64%)	0.72
Education	High school or less	5/69 (7.2%)	11/102 (10.8%)	0.018
	Occupational ^d	15/69 (21.7%)	41/102 (40.2%)	
	Bachelor's degree	23/69 (33.3%)	30/102 (29.4%)	
	Graduate degree	26/69 (37.7%)	20/102 (19.6%)	
Insurance	Private	34/68 (50%)	51/99 (52%)	0.010
	Medicare	25/68 (37%)	20/99 (20%)	
	Medicaid	2/68 (3%)	17/99 (17%)	
	Other	7/68 (10%)	11/99 (11%)	
Income	<\$25,000	10/65 (15.4%)	23/101 (22.8%)	0.38
	\$25,000-\$49,999	6/65 (9.2%)	14/101 (13.9%)	
	\$50,000-\$99,999	18/65 (27.7%)	20/101 (19.8%)	
	\$100,000	24/65 (36.9%)	29/101 (28.7%)	
	Prefer not to answer	7/65 (10.8%)	15/101 (14.9%)	
Smoked within the last 30 days		7/66 (10.6%)	15/101 (14.9%)	0.43
Currently employed		34/66 (51.5%)	51/100 (51.0%)	0.95
Diverticulitis history, median (Q1, Q3)^e:				
Years since first diagnosis		1.7 (0.3, 8.3)	1.8 (0.1, 7.0)	0.50
Episodes that required antibiotics		1.0 (0.0, 3.0)	1.0 (0.0, 2.0)	0.71
Episodes that required ED^f visits		0.0 (0.0, 1.0)	1.0 (0.0, 2.0)	<0.001
Episodes that required overnight hospital stay		0.0 (0.0, 1.0)	1.0 (0.0, 1.0)	0.034
Days since last episode		54 (24, 148)	19 (5, 49)	<0.001

^aDV-QOL, the diverticulitis quality of life instrument

^bp-value from bivariate analyses using chi-squared and the Student t-test for categorical and continuous variables, respectively.

^cSD, Standard deviation

^doccupational includes technical or vocational program, or associate degree

^eQ1 and Q3, 25th and 75th percentile

^fED, emergency department

Table 5:

Patient-reported outcomes by DV-QOL below/above PASS threshold (DV-QOL=3.2). Above PASS threshold represents HRQoL-limiting disease state.

Characteristics		DV-QOL ^a <3.2	DV-QOL 3.2	p-value ^b
		Median (Q1, Q3) ^c	Median (Q1, Q3)	
N		69	102	
PROMIS ^d scores	Physical health	50.8 (44.9, 54.1)	39.8 (37.4, 47.7)	<0.001
	Mental health	53.3 (48.3, 56.0)	45.8 (41.1, 50.8)	<0.001
Self-reported chronic sickness, ^e n (%)		2/66 (3.0%)	29/101 (28.7%)	<0.001
Percent overall work impairment due to health ^f		0.2 (0.0, 27.8)	23.6 (10.0, 39.7)	0.002
Percent activity impairment due to health ^g		0.0 (0.0, 10.0)	70.0 (30.0, 80.0)	<0.001

^aDV-QOL, the diverticulitis quality of life instrument

^bp-value from bivariate analyses using chi-squared and the Student t-test for categorical and continuous variables, respectively.

^cQ1 and Q3, 25th and 75th percentile

^dPROMIS, Patient-Reported Outcomes Measurement Information System

^eSelf-reported chronic sickness was measured by the question: Do you feel sick all of the time?

^fAmong those employed and who responded to the questions related to work impairment (n = 22 in the DV-QOL <3.2 group and n = 45 in the DV-QOL 3.2 group)

^gAmong those who responded to the questions related to activity impairment (n = 64 in the DV-QOL <3.2 group and n = 97 in the DV-QOL 3.2 group)