Development and Reliability of a Correction Factor for Family-Reported Medication Adherence: Pediatric Inflammatory Bowel Disease as an Exemplar

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The methods of this study are based on methods first described in the following study: Hommel, K. A., Hente, E. A., Odell, S., Herzer, M., Ingerski, L. M., Guilfoyle, S. M., & Denson, L. A. (2012). Evaluation of a group-based behavioral intervention to promote adherence in adolescents with inflammatory bowel disease. *European Journal of Gastroenterology and Hepatology, 24*(1), 64–69. doi:10.1097/MEG.1090b1013e32834d32809f32831.

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Objectives To examine the issue of accurate adherence assessment and illustrate methodologies for correcting parent-reported medication adherence. **Methods** 40 children with inflammatory bowel disease provided medication adherence data using electronic monitoring. Parents provided subjective reports of medication adherence. Receiver operating characteristic analyses were used to examine the detection of non-adherence at several adherence cut-points. 2 methods for empirically deriving a correction factor for subjectively reported adherence were applied. **Results** Although parent-report and EM adherence were significantly correlated, parent-reported adherence was significantly higher than EM adherence. A 90% cut-point provided the highest sensitivity and specificity. Both correction factors reliably adjusted parent-reported adherence based on EM adherence. **Conclusions** Application of an empirically derived correction factor for parent-reported adherence using methodologies, such as those illustrated in the current study, could yield more accurate adherence assessment. Obtaining more accurate adherence assessments based on parent-report will have implications for self-management interventions, clinician prescribing behavior, and medication safety.

Key words compliance; measurement; medication-taking; nonadherence; self-management.

Poor adherence to prescribed medical regimens can lead to a number of negative consequences, including suboptimal symptom management, increased disease severity, risk of relapse, and greater health care utilization (Higgins, Rubin, Kaulback, Schoenfeld, & Kane, 2009; Hommel, Denson, & Baldassano, 2011; Kane, Huo, Aikens, & Hanauer, 2003; Rapoff, 2010; Sokol, McGuigan, Verbrugge, & Epstein, 2005). Of central importance to understanding medication adherence and its effects is accurate assessment of adherence to the medical regimen in the context of clinical care.

There are a number of available adherence assessments, each with advantages and disadvantages, such as feasibility for use in clinical practice (Hommel, Mackner, Denson, & Crandall, 2008b). For example, although

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bioassays are clinically feasible and provide objective data on medication levels, they are subject to bias due to white coat compliance (i.e., patients more conscientiously taking medication prior to medical appointments) and do not provide information on patterns of non-adherence (i.e., when medication was taken or not taken), which is essential for informing intervention. Electronic monitoring (EM), which some consider a gold standard assessment method (Cramer, 1995), provides more specific, real-time information on when doses were removed from pill bottles; however, EM is costly to implement and may rely on patients to bring pill bottles to clinic appointments so that adherence data can be downloaded. In clinical practice, patient- and/or parent-report of medication adherence is likely the most feasible method of adherence assessment. For instance, a recent survey of gastroenterology clinicians found that of those respondents who reported screening for medication adherence, 81% relied on patient-report (i.e., clinical interview; Trindade, Morisky, Ehrlich, Tinsley, & Ullman, 2011). Within the context of pediatric practice, parent-report (versus patient-report) of adherence is often used because of the high level of parent involvement in implementing prescribed regimens (e.g., medication administration). Subjectively reported adherence (e.g., parent-report), however, provides higher estimates of medication adherence as demonstrated across multiple patient populations, relative to other methods of assessing adherence such as EM (Hommel et al., 2008b; Rapoff, 2010). Subjectively reported adherence can lead to overestimates of medication adherence due to factors such as recall bias and social desirability.

The current manuscript examines the issue of accurate adherence assessment and illustrates methodologies for correcting parent-reported adherence. These methodologies could be applied across chronic illness populations; however, we chose to use pediatric patients with inflammatory bowel disease (Otley et al., 2006) as an exemplar because this population demonstrates substantial variance (16–88%) in nonadherence to prescribed medication regimens (Hommel, Davis, & Baldassano, 2009; Mackner & Crandall, 2005; Oliva-Hemker, Abadom, Cuffari, & Thompson, 2007; Ooi, Bohane, Lee, Naidoo, & Day, 2007). Overestimation of adherence is also likely an issue among children with IBD and their families. For example, in a sample of adolescents with IBD, on average, patients overestimated their EM adherence by 7.8%, and there was wide variability in individuals' overestimation of adherence (e.g., 2.3–23.2%; Greenley et al., 2012). Subjective reports of adherence could, however, be used with greater confidence if a correction factor based on objective adherence assessment was applied to adjust for inflated subjectively reported adherence estimates. Such a correction factor would be a cost-effective, easily implemented, and a more accurate method of assessing adherence in pediatric IBD based on caregiver-report. Better identification of patients and families who have adherence problems could enable clinicians to deliver targeted interventions to promote adherence and improve child health outcomes.

Correction factors for self-reported medication adherence have previously been developed for children with epilepsy (Modi, Guilfoyle, Morita, & Glauser, 2011), adults with HIV (Liu et al., 2001), and low-income pregnant women (Jasti, Siega-Riz, Cogswell, & Hartzema, 2006). However, each population has a unique treatment regimen (e.g., dosing schedule, number of medications, medication side effects), which may differentially impact adherence. Further, adherence in pediatric populations is qualitatively different from adherence in adults because caregivers and family members are highly involved in administering the prescribed treatment regimen for children. As a result, correction factors for subjectively reported adherence may differ across illness populations and age groups.

For pediatric patients with IBD, no studies have examined the relationship between medication adherence assessed via parent-report versus a more objective method such as EM or developed a correction factor for parent-reported adherence. Only one study has compared EM and subjectively reported adherence among children with IBD, but used adolescent-report of adherence. That study also compared the two methods of adherence assessment using sensitivity and specificity analyses at one adherence cut-point (i.e., indicating what percent of medication doses taken constitutes ''adherent'' versus ''non-adherent''; Greenley et al., 2012). Although continuous data (e.g., adherence on a 0–100% scale) leads to a more detailed understanding of patient adherence, the dichotomous labels ''adherent'' and ''non-adherent'' are often used in clinical practice to guide treatment decisions. Because sensitivity and specificity may vary across different adherence cut-points, an important next step is to identify cut-points that yield the highest specificity and sensitivity. Building on the one prior study comparing EM and subjectively reported adherence in the pediatric IBD population (Greenley et al., 2012), the first aim of the current study was to examine the specificity and sensitivity of parent-reported versus EM adherence using different cut-points for adherence. Exploratory analyses were also conducted to examine the relationship between parent-reported and EM adherence below and above the cut-point which had the highest specificity and sensitivity. Also, to obtain more accurate assessments of adherence when parent-report may be an overestimation, the second aim of the current study

was to develop a correction factor for parent-reported adherence that could be feasibly used in clinical practice. Consistent with prior findings (Greenley et al., 2012; Modi et al., 2011; Shi et al., 2010), we hypothesized that subjectively reported adherence would be higher than EM adherence and positively correlated, and that higher adherence cut-points would yield better sensitivity and specificity when comparing these adherence assessment methods.

Methods

Participants

Data for the current study came from a larger randomized controlled trial of an adherence promotion intervention for adolescents with IBD (Hommel et al., 2012). The prior publication from this larger study described outcomes associated with the adherence promotion intervention. In contrast, the current investigation focuses on adherence assessment through development of a correction factor for parent-reported adherence from the larger study.

Patients were eligible for the study if they were between the ages of 11 and 17 years, were diagnosed with inflammatory bowel disease (i.e., Crohn's disease, ulcerative colitis, or indeterminate colitis), were prescribed an immunomodulator (i.e., 6-MP/azathioprine) and/or mesalamine (i.e., 5-ASA), and were fluent in English. Patients were excluded if they had a pervasive developmental disorder or comorbid chronic illness other than Primary Sclerosing Cholangitis (due to its comorbidity with IBD). Eligible patients ($n = 179$) were identified by medical chart review and were sent a recruitment letter, including an opt-out phone number for families declining further contact about the study. Four families opted out of participation. Eighty-four patients and their families were contacted about the larger study at their gastroenterology clinic appointment or by telephone. Approximately half ($n = 43$) of the families declined participation ($n = 21$ time limitations, $n = 6$ live too far away from hospital, $n = 6$ not interested, $n = 6$ no adherence concerns, $n = 3$ patient did not want to talk about IBD, $n = 1$ patient going away to college). One participant was excluded from the analyses due to not using the electronic monitor of adherence, which yielded a final sample size of 40 patients and caregivers.

Measures

Caregivers were asked to complete a demographic questionnaire assessing child, caregiver, and family characteristics (e.g., child age, gender, and ethnicity, time since IBD diagnosis, family income, caregiver relationship to child, caregiver marital status).

Subjective report of adherence was assessed using a questionnaire developed for the larger study, which assesses parent-report of adherence to medication and diet recommendations, barriers to adherence, organization of medications, and treatment responsibility. Parent-report of medication adherence was assessed in the following way:

> ''Children and adolescents often have difficulty taking medications. They may forget, have activities that conflict with the treatment, or just decide not to take a dose of medication. There may be other reasons too. All of these reasons are completely understandable. Please tell us the number of medication doses your child/adolescent has missed in the past 2 weeks and which medication was missed: ____''

Medication adherence was calculated based on the number of doses missed in the last 2 weeks reported by caregivers: Medication adherence percentage = 100− [(number of doses missed ÷ number of doses prescribed) × 100].

EM adherence was assessed using the MEMS™ TrackCap. A microchip embedded in the TrackCap records the date and time of each bottle opening. Microchip data was downloaded onto a computer for analysis. The TrackCap computer program calculated the average percent adherence over the 2-week monitoring period based on the number of bottle openings and the prescribed dosing regimen. For the current analyses, EM adherence data from the same 2-week period assessed on the parent-report questionnaire was used (i.e., 6 weeks into the study). Families were provided TrackCaps for their primary IBD medications. While the majority of families were given one TrackCap for their primary and only IBD medication, seven families were provided with two TrackCaps each (i.e., child took two primary IBD medications). Of these seven families, four discontinued one medication, so EM data for the medication that continued to be taken was used. For the remaining three families, the current study used EM data from the TrackCaps for medication requiring twice daily dosing.

Procedure

All participating youth and their caregivers provided informed assent/consent. Caregivers and youth completed the demographic questionnaire at a baseline study visit. They were provided with instructions on use of the MEMS™ TrackCap, and were asked to bring their TrackCap to the next scheduled study visit. At that visit, families completed the questionnaire assessing subjective

report of adherence. All study procedures were approved by the hospital's institutional review board.

Data Analyses

Medication adherence assessed by EM versus parent-report was compared using Wilcoxon-signed rank tests due to the negative skew in the adherence estimates. The association between EM adherence levels and parent-reported adherence was examined using Spearman's correlation coefficient (rho). Non-parametric methods of analysis were used due to the negative skew of the adherence data. Receiver operating characteristic (ROC) analyses were used to examine the detection of non-adherence across the two methods of assessment at five adherence cut-points (i.e., 50, 60, 70, 80, and 90%), with EM as the reference assessment method. Cut-points (i.e., 50, 80, and 90%) were selected based on the existing literature (Modi et al., 2011) and to ensure a full exploration of potential cut-points for this population (i.e., 60–70%). The area under the curve (AUC) indicates how well a measure (i.e., parent-reported adherence) correctly classifies an individual (e.g., as adherent versus non-adherent). An AUC of 0.5 indicates an equal probability of correct and incorrect classification, with increasing values of the AUC (i.e., approaching 1.0) indicating better than chance classification. In addition, calculations of sensitivity (i.e., proportion of participants who were adherent according to EM and were correctly identified as adherent using parent-report) and specificity (i.e., proportion of participants who were non-adherent according to EM and were correctly identified as non-adherent using parent-report) were obtained for each adherence cut-point. Positive predictive values (PPV) and negative predictive values (NPV) for each cut-point were also calculated, which indicate the proportion of individuals correctly classified as adherent or non-adherent by parent-report using EM adherence as the comparison standard. Given the results obtained with the a priori cut-points (i.e., 50, 60, 70, 80, and 90%), we also conducted an exploratory analysis to examine one additional cut-point (i.e., 85%).

Prior literature deriving correction factors for self-reported adherence have used two methods of calculation (Jasti et al., 2006; Liu et al., 2001; Modi et al., 2011). The first method entails a regression-based approach where the independent variable or predictor is parent-reported adherence and the dependent variable or outcome is EM adherence. The regression results include an intercept term (i.e., EM adherence when parent-reported adherence = 0) and a slope term (i.e., change in EM adherence for every 1% change in parent-reported adherence), which together form an equation that can be used to predict EM adherence from parent-reported adherence. In other words, the regression equation provides a correction for parent-reported adherence based on EM adherence. To maximize statistical power, our primary correction factor analysis uses this regression-based approach. However, to examine our data in the most comprehensive manner, we also conducted exploratory analyses using a second method for deriving a correction factor used in prior literature. The second method consists of calculating a correction factor on half of the sample. Specifically, for the first half of the sample, each participant's EM adherence is divided by parent-reported adherence. The average of these results is the correction factor. This correction factor is then applied to the parent-reported adherence levels for the second half of the sample by multiplying each parent-reported adherence level by the correction factor. Finally, to statistically examine the difference scores between the corrected parent-reported and EM adherence levels for the second half of the sample, a one-sample *t*-test with a test value of 0 is conducted. A non-significant t-test result indicates that the difference between the corrected parent-reported adherence and EM adherence is not significantly different from 0, and thus that the correction factor obtained from the first half of the sample was valid for and reliably applied to the second half of the sample.

Results

See Table I for the sample demographic characteristics and descriptive adherence data.

Comparison of Adherence by Method of Assessment

Adherence level indicated by parent-report (median = 98.8%) was significantly higher than EM adherence (median = 91.7%; Wilcoxon-signed ranks test $Z = -3.76$, $p < .001$). Parent-report and EM adherence were positively correlated (Spearman's rho = .64, $p < .001$, $n = 40$).

Sensitivity, Specificity, and ROC Analyses

See Table II for sensitivity and specificity calculations for all planned and exploratory adherence cut-points. The 90% cut-point provided the highest sensitivity and specificity (ROC analysis AUC = .69, $p < .05$), 80% (AUC = .67, $p = .08$), 70% (AUC = .50, $p = 1.0$), 60% (AUC = .50, $p = 1.0$) and 50% cut-points (AUC = .50, $p = 1.0$).

The exploratory cut-point analysis (i.e., 85%; AUC = .66, $p = .10$) further supported the finding that the 90% cut-point provided the highest sensitivity and

Table I. *Descriptive Data for Participant Demographics and Medication Adherence Levels*

Demographic and Adherence Variables	Mean ± *SD* unless otherwise noted
Patient	
Age (years)	15.4 ± 1.5
Sex (% male)	50
Ethnicity (% White, not Hispanic)	90
Patient IBD diagnosis (%)	
Crohn's disease	75
Ulcerative colitis	17.5
Indeterminate colitis	7.5
Caregiver	
Relationship to child (% mother)	90
Marital status (% married)	87.5
Education level (% with college degree or higher)	65
Annual household income (median)	$100,001–$125,000
Adherence (%)	
Parent-report	93.8 ± 8.9
Electronic monitoring	84.8 ± 18.1

specificity. Exploratory analyses (i.e., *t*-tests) were conducted to examine the difference between parent-reported and EM adherence for people above and below the 90% cut-point. The results indicated that the difference between parent-reported and EM adherence was significantly greater for patients below the 90% cut-point (mean difference = 17%, *SD* = 19%) as opposed to patients above the 90% cut-point for adherence (mean difference = 1%, *SD* = 5%; $t = 3.8$, $p = .001$).

Correction Factor

The first method of analysis yielded a regression equation for correcting parent-reported adherence: Corrected adherence (%) = −12.46 + [1.04 × (parent-reported adherence %)]. After this regression equation was applied to parent-reported adherence levels, a one-sample *t*-test comparing the difference between EM adherence and the regression-based corrected adherence levels to a test value of 0 was non-significant ($t = -.09$, $p > .05$), indicating that the regression-based adjustment reliably corrected parent-reported adherence based on the objective, EM adherence.

Table II. *Sensitivity and Specificity at Adherence Cut-Points*

	EM adherence[a]							
Parent-reported adherence	Adherent	Non-adherent	Total *n*	Sensitivity %	Specificity %	PPV %	NPV %	Accuracy %
50% cut-point								
Adherent	39	1	40	100.0	–	97.5	0.0	97.5
Non-adherent	0	0	0					
Total	39	1	40					
60% cut-point								
Adherent	37	3	40	100.0	–	92.5	0.0	92.5
Non-adherent	0	0	0					
Total	37	3	40					
70% cut-point								
Adherent	34	6	40	100.0	–	85.0	0.0	85.0
Non-adherent	0	0	0					
Total	34	6	40					
80% cut-point								
Adherent	26	8	34	96.3	38.5	76.5	83.3	77.5
Non-adherent	1	5	6					
Total	27	13	40					
85% cut-point								
Adherent	25	9	34	96.2	35.7	73.5	83.3	75.0
Non-adherent	1	5	6					
Total	26	14	40					
90% cut-point								
Adherent	20	11	31	95.2	42.1	64.5	88.9	70.0
Non-adherent	1	8	9					
Total	21	19	40					

Note. PPV = positive predictive value; NPV = negative predictive value; – = could not be calculated due to category frequencies.
[a]Electronic monitoring (EM) adherence used as the reference standard.

The second, exploratory method of analysis, which involved calculating a correction factor based on the first half of the sample, yielded a correction factor of .924 ($SD = .14$) [i.e., corrected adherence (%) = .924 × (parent-reported adherence %)]. After applying this correction factor to the second half of the sample, a one-sample *t*-test comparing the difference between the corrected parent-reported adherence levels and EM adherence levels to a test value of 0 was non-significant ($t = -.92$, $p > .05$), indicating that the correction factor reliably adjusted the parent-reported adherence levels based on the objective, EM adherence.

The mean difference between the corrected adherence values (i.e., Method 2 corrected value − Method 1 corrected value) obtained by the two correction methods was 1.59% ($SD = 1.03\%$).

Discussion

The current study is the first to use and compare two different methods of developing empirically derived correction factors for parent-reported medication adherence. Further, the current study is the first to illustrate the development of such correction factors for children with IBD. Given that the problem of self or parent-reported adherence overestimation is common across pediatric populations, this correction factor methodology could be more broadly applied to other illness groups. In relation to clinical practice, the correction factor approach is a first step toward allowing providers to continue to use self- or parent-report of adherence, which often is most feasible to implement, while providing a more accurate adherence assessment that could be used to identify families who could benefit from adherence promotion interventions.

Consistent with prior literature comparing adherence assessed by subjective versus objective methods in IBD and other chronic illness populations, the current results demonstrated that, while parent-reported and EM adherence are correlated, parent-reported adherence is significantly higher than EM adherence (Greenley et al., 2012; Hommel et al., 2009; Shi et al., 2010). In addition, the results suggested that, consistent with prior results for children with chronic conditions (Modi et al., 2011), an EM-based 90% adherence cut-point defining ''adherent'' versus ''non-adherent'' for pediatric IBD patients has the highest sensitivity and specificity when comparing EM and parent-reported adherence. Using the 90% cut-point, patients who were ''non-adherent'' had significantly larger discrepancies between parent-reported and EM adherence than those who were ''adherent.'' This finding indicates that parent-reported adherence is more likely to be inflated for patients who have lower levels of objectively measured adherence. Thus, application of a correction factor to adjust for inflated parent-reported adherence is particularly important for these patients with lower adherence levels (i.e., <90% using EM assessment).

The current study yielded preliminary findings on two potential methods for correcting parent-reported adherence levels to maximize their accuracy. Applied in a clinical setting, these two methods would be used in the following way: If a parent reported that their child missed 5 out of 14 doses in the last week, this would indicate a parent-reported adherence level of 64% ([14 − 5]/14 = .64). The first method would entail multiplying parent-reported adherence by 1.04 and subtracting 12.46 to yield a corrected adherence level of 54.1%. The second method would entail multiplying parent-reported adherence levels by .924 (64 × .924) to yield a corrected adherence level of 59%. Although neither of these correction factor methods is better than the other mathematically, the second method (i.e., multiplying parent-reported adherence by .924) is more feasible for use in clinical practice, given that it requires a single calculation. Also, while this would need to be examined in other pediatric populations, the corrected adherence values obtained by the two methods are highly similar.

The current study had several strengths. First, this study used multiple methods of assessing adherence (i.e., parent-report and EM) and compared adherence estimates across these methods. Second, the use of EM is a strength because it is argued to be a more accurate and objective assessment of adherence, which can describe patterns of adherence over time (Hommel et al., 2008b; La Greca & Bearman, 2003; Rapoff, 2010). Third, this study included participants with a demographic background similar to other patients with IBD in previously published studies (Mackner & Crandall, 2007). And finally, this study is the first within a pediatric IBD sample to develop correction factors for parent-reported adherence that could be used in clinical practice to increase accuracy of adherence estimates.

A few important study limitations should be noted, including the fact that adherence was monitored over a limited span of time (i.e., 2 weeks). It is possible that longer monitoring periods are needed to fully assess the changing nature of adherence over time. It will therefore be important to replicate the current findings by assessing adherence for a longer period of time and examining longitudinal patterns of adherence. Although most studies of youth with IBD have included similar or smaller sample sizes, future studies examining youth across multiple sites

and including non-English speaking and lower income families will increase the generalizability of findings. Finally, the adherence levels obtained in the current study are higher than some reported in the literature (Hommel et al., 2009). Adherence has been assessed in a variety of ways among youth with IBD and prior estimates vary from 50–92% (Greenley et al., 2012; Hommel et al., 2009). While participant reactivity to monitoring leading to higher-than-normal levels of adherence is a potential, reactivity was most likely not a strong contributor to the EM adherence levels in the current study due to the fact that EM adherence data was taken from a 2-week period that was 6 weeks post-study enrollment. As discussed in a previous report, the higher adherence rates obtained in the current sample may be due to participants opening their MEMS bottles when taking all medications rather than only the medication being monitored (Hommel et al., 2012). Consequently, our example correction factors may provide conservative corrected values.

The empirically derived correction factors in this study should be confirmed by future research and the concept of the correction factor extended to other pediatric populations. If confirmed and further tested, correction factors have several potential clinical implications. Correction factors could be used in routine clinical practice to adjust subjectively reported adherence levels, which may guide medical treatment (e.g., decisions to change dosages) and interventions to address poor adherence. For instance, providers could use corrected adherence levels to determine whether a patient and his/her family may need intervention targeting medication adherence and providers might tailor interventions to different levels of non-adherence. Alternatively, a low-corrected adherence level could be further examined with longitudinal adherence monitoring to better understand a particular child's or family's patterns of non-adherence prior to beginning clinical intervention. We recommend that correction factors for self- or parent-reported adherence be used in combination with other adherence assessment methods (e.g., blood assays).

The correction factor methods illustrated by the current study provide corrected adherence levels, which could be used as a more accurate approximation of a patient's medication adherence. These corrected adherence levels should not, however, be considered to be exact or ''true score'' adherence levels for individual patients. Instead, the corrected adherence levels could be used to guide decisions about further assessment and intervention, as described above. This issue is particularly relevant at the extremes of adherence. At the upper limit of adherence (i.e., parent reports 100% adherence), the correction factors used in the current study will inevitably lead to adherence levels below 100%. While this may appear to penalize families who, indeed, are 100% adherent, clinically, these families' corrected adherence levels would not suggest that they are in need of further adherence assessment or intervention. On the other extreme, a family reporting very low adherence could have a very low corrected adherence level, including one that is numerically negative. In our view, these very low levels of adherence (including negative adherence values, which are not meaningful alone) would indicate that the patient and family likely would benefit from adherence promotion interventions.

Our results also have implications for future research on adherence. Further work is needed to establish and test similar correction factors for adolescent and young adult self-reported adherence. This work could also assess the degree of responsibility different family members have for medication adherence, given that adolescence is a time during which allocation of treatment responsibilities may change (Pai et al., 2010). Integrating multiple reporters and methods of assessing adherence is critical (Quittner, Modi, Lemanek, Ievers-Landis, & Rapoff, 2008). Thus, while continuing to examine the use of correction factors for subjectively reported adherence will be important, future research could also explore the integration of corrected subjectively reported adherence with other adherence assessment methods, such as drug assays and direct observation of adherence. For example, it will be important to investigate the extent to which corrected levels of subjectively reported adherence are consistent with adherence levels obtained by other assessment methods. In addition, future studies could investigate adherence to other IBD medications to compare adherence to those medications with adherence to the primary IBD medications which were examined in the current study. Future work could also examine the link between varying levels of non-adherence (both corrected and uncorrected) and health outcomes (e.g., disease severity or symptoms) in order to identify the particular adherence cutoffs that could be used to define ''non-adherence.'' In addition, there is a growing literature demonstrating that numerous factors contribute to the medication adherence of children. For example, for children with IBD and their families, family functioning, barriers to adherence, and patient coping, emotional functioning, and quality of life have been shown to be related to adherence (Gray, Denson, Baldassano, & Hommel, 2012; Hommel, Davis, & Baldassano, 2008a; Mackner & Crandall, 2005). Incorporating assessment of these contributors to medication adherence will create a more complete picture of the factors influencing adherence and could, potentially, be used to adjust for the upwards bias typical of subjectively-reported adherence. Increasing the accuracy of

adherence assessments will facilitate better-informed clinical decision making, including the implementation of interventions to promote adherence.

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