Vitamin and Mineral Supplement Adherence in Pediatric Inflammatory Bowel Disease

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Objective Although vitamin and mineral supplementation for nutritional deficiencies is a common component of pediatric inflammatory bowel disease (IBD) management, little is known about supplement adherence in this group. This study described adherence to multivitamin, iron, and calcium supplements among 49 youth aged 11–18 years with IBD. Additionally, the study examined relationships between supplement knowledge and adherence.

Methods Participants completed supplement adherence ratings using a validated interview. Knowledge was assessed using an open-ended question from the same interview; responses were later categorized into 1 of 3 knowledge sophistication categories (low, moderate, or high).

Results Mean adherence rates ranged from 32 to 44% across supplements. Youth who did not know the reason for supplementation (approximately 25% of the sample) displayed substantially poorer adherence than did those with moderate or high levels of knowledge, across all supplements.

Conclusions Findings highlight the importance of evaluating and addressing nonadherence to vitamin and mineral supplements in youth with pediatric IBD.

Key words adherence; adolescence; chronic illness; gastroenterology; inflammatory bowel disease.

Inflammatory bowel disease (IBD) is a chronic relapsing disease of the gastrointestinal tract, which results in significant morbidity, including diarrhea, abdominal pain, anemia, anorexia, and growth delay. Pediatric IBD incidence is estimated at 7 per 100,000 in the United States (Kugathasan et al., 2003). Approximately 30% of all cases are diagnosed before age 20, with a peak onset during adolescence (Sawczenko et al., 2001). Successful management of IBD necessitates adherence to a treatment regimen that often involves multiple medications and nutritional supplements. Although nonadherence to oral maintenance medication is a well-studied and pervasive problem within this population (Hommel, Davis, & Baldassano, 2009; Ingerski, Baldassano, Denson, & Hommel, 2010; Oliva-Hemker, Abadom, Cuffari, & Thompson, 2007), less is known about adherence to vitamin and mineral supplements. This is true despite the fact that there are well-documented micronutrient deficiencies in this population that require supplement use as a mainstay of IBD treatment (Hendricks & Walker, 1988; Thomas, Taylor, & Miller, 1993).

Up to 64% of youth with IBD have been shown to have dietary intake levels below the recommended daily allowance in one or more of the following domains: Zinc, calcium, iron, copper, folic acid, vitamin C, and vitamin D (Hendricks & Walker, 1988; Thomas et al., 1993). Nutritional deficiencies are influenced by several related factors and have significant implications for short- and
long-term growth. Moreover, emerging research suggests that deficiencies in certain nutrients (e.g., vitamin D) may be directly related to disease relapse risk (Samson et al., 2012). Reduced caloric intake and chronic undernutrition, even among asymptomatic patients, are the most common reasons for altered growth (Motil, Altsuler, & Grand, 1985; Motil, Grand, Maletkos, & Young, 1982; Kelts et al., 1979; Kirschner, Klich, Kalman, de Favaro, & Rosenberg, 1981; Kirschner, Vionchet, & Rosenberg, 1985; Seidman et al., 1991). Reasons for growth impairment include cytokine-mediated anorexia, failure to reduce resting energy expenditure (an energy-conservation response in malnourished populations), intentional dietary restriction in response to fear of worsening gastrointestinal symptoms such as stomach pain or diarrhea after eating (Azcue, Rashid, Griffiths, & Pencharz, 1997; Ballinger et al., 2000), the direct impact of pro-inflammatory cytokines, adverse effects of medication, and disease-related sequelae (Mauras, 2001; Walters & Griffiths, 2008). Vitamin and/or mineral deficiencies have been reported as being more pronounced in youth with growth delays, but also have been documented in youth who appear to have normal growth (Hendricks & Walker, 1988; Kirschner et al., 1981).

It is estimated that between 23 and 88% of youth with IBD experience growth impairment. Estimates vary depending on the time of assessment, definition of growth impairment used, and nature of the population studied (Walters & Griffiths, 2008). Short-term growth impairments are common before and in the years immediately after diagnosis (Kundhal, Critch, Hack, & Griffiths, 2002; Sawczenko & Sandhu, 2003; Wine et al., 2004). Youth diagnosed during early adolescence and males are at particular risk for growth impairment (Rogol, Roemmich, & Clark, 2002). Although catch-up growth occurs once chronic inflammation is controlled (Griffiths, Nguyen, Smith, MacMillan, & Sherman, 1993; Hildebrand, Karlberg, & Kristianson, 1994; Kuhdhal et al., 2002), adult height is often compromised relative to the general population among youth diagnosed before puberty (Almazadeh et al., 2002; Griffiths et al., 1993; Hildebrand et al., 1994; Kuhdhal et al., 2002; Sawczenko & Sandhu, 2003). In addition, nutritional deficiencies and growth impairment adversely impact youth psychosocial adjustment (Griffiths et al., 1999). Given that early adolescence is a critical time when youth are at most risk for growth impairment secondary to nutritional deficiencies (Rogol et al., 2002), understanding supplement adherence takes on special relevance in this age-group.

To the authors’ knowledge, only one study to date has examined adherence to supplements in the context of IBD. In a cross-sectional study examining self-reported adherence to IBD maintenance medications and vitamin, mineral, and herbal supplements, Kitney et al. (2009) reported an average adherence rate of 80% across all medications and supplements combined. Additionally, results suggested that a greater proportion of those classified as nonadherent (defined as an overall adherence rate of 80% or less) were prescribed herbal supplements compared with those classified as adherent (defined as an overall adherence rate of >80%). No differences in the frequency of prescription of vitamin or mineral supplements between the nonadherent and adherent groups were documented, however. Additionally, those in the nonadherent group were significantly older and had been diagnosed for a longer period than those in the adherent group.

Although this study is a first step in understanding supplement adherence in the context of pediatric IBD, several limitations are evident, each of which offers opportunities for future research. First, Kitney et al. (2009) computed overall adherence across the entire regimen, rather than reporting rates separately for each medication or supplement. Thus, the ability to make generalizations about specific supplement adherence rates based on this study is limited. Second, although Kitney et al. (2009) provided some information about correlates of adherence, their efforts focused on demographic or disease-related factors, which are not modifiable barriers to adherence. Moreover, these correlates were examined in relation to overall regimen adherence, and as such, the importance of each factor to adherence to separate supplements is unknown. Attention to rates of adherence to individual supplements could serve to identify specific supplements for which youth are at an increased risk of nonadherence. Furthermore, attention to modifiable factors that may influence adherence to individual vitamin and mineral supplements in the context of pediatric IBD would be helpful insofar as it may serve to identify targets for adherence-promotion interventions.

Consistent with the recent framework proposed by Modi et al. (2012), one modifiable individual self-management behavior that may be associated with adherence is youth knowledge. Although research with other populations has inconsistently documented a relationship between illness knowledge and medication adherence (Alm-Roijer, Stagmo, Uden, & Erhardt, 2004; McQuaid, Kopel, Klein, & Fritz, 2003; Rapoff, 2010), knowledge is generally considered to be a necessary, but not sufficient, condition for adherence (Stockwell & Schulz, 1992). Moreover, previous studies examined general knowledge of illness rather than knowledge of the role of a specific medication, a factor that may help explain inconsistent findings between knowledge and adherence. It may be that specificity of...
knowledge related to the role of the particular medication or supplement in the treatment of IBD would be associated with adherence more strongly than general condition-related knowledge. Knowledge may be particularly important in the case of supplementation, as supplements are likely to have more long-term health benefits but fewer immediate observable benefits or consequences of nonadherence than would occur with nonadherence to IBD maintenance medications. Thus, without knowledge about the value of vitamin and mineral supplements, adherence to supplements might be considered a lower priority and sacrificed in the interest of simplifying a complex treatment regimen.

The documented connection between nutritional supplementation and improved growth (O’Sullivan & O’Morain, 2006) reinforces the potential importance of maximizing adherence to prescribed supplements in promoting health. As such, one aim of the current study was to summarize rates of adherence to three oral vitamin and mineral supplements (i.e., multivitamins, iron, and calcium) that are frequently recommended for youth with pediatric IBD. We expected rates of supplement adherence to be comparable with published rates of adherence to oral prescription medication in this population. Additionally, the study aimed to examine relationships between supplement adherence and youth knowledge of the role of the vitamin or mineral supplements in the treatment of their IBD (a potentially modifiable barrier to adherence). To this end, we hypothesized that those with more sophisticated knowledge of a given supplement would have higher rates of adherence to that supplement than those with less sophisticated knowledge.

Methods

Procedure

All procedures were completed in accord with institutional review board requirements at participating sites. Participating youth were part of a larger longitudinal study of adherence to oral thiopurine medications among youth with IBD. Eligibility criteria for the larger study included: (1) 11–18 years old at time of enrollment, (2) able to read and understand study questionnaires validated in English, (3) accompanied by an English-speaking parent or guardian who was willing to participate, (4) diagnosed with IBD based on medical record confirmation, (5) prescribed an oral thiopurine for IBD treatment for at least 3 months immediately preceding recruitment, and (6) willing to use a Medication Events Monitoring System (MEMSTM) cap electronic monitor for their thiopurine medication. Additionally, to be included in the data analytic sample for the present investigation, youth must have been taking at least one of three oral supplements of focus in this study (i.e., multivitamin, iron, or calcium supplement) on a daily basis. These supplements were chosen because they are among the most commonly used supplements in pediatric IBD, were the three most common supplements prescribed to youth in this sample, and had a sufficient number of youth on each to allow for between-group analyses in examining the impact of knowledge on adherence.

Participants

Sixty-eight youth were approached to participate in the larger study, of which 61 (90%) consented to participate. Of those who consented, eight (13%) failed to complete the study either because of the discontinuation of their oral thiopurine medication regimen as a part of their regular medical care, which disqualified them from continuing in this study (n = 5; 8%), or because of a voluntary withdrawal due to the time commitment of the study (n = 3; 5%). Of the 53 participants who completed the study, 49 (92%) were eligible for inclusion in the current data analytic sample because they were taking at least one of the three supplements of focus.

Participants included 49 youth, ages 11–18 years [M (SD) = 14.63 (2.03)]. The majority were male (n = 29; 59%), Caucasian (n = 45; 92%), and diagnosed with Crohn’s disease (n = 42; 86%). Seventy-six percent (n = 37) of youth had no disease activity at the time of enrollment based on physician global assessment rating, 18% (n = 9) had mild disease activity, and 6% (n = 3) had moderate disease activity. Participants (n = 49) did not differ from those who declined participation, those who did not complete the study, or those ineligible for inclusion in the study (n = 19) in demographics, including youth age (t (66) = 0.50, p = .62) or sex (Φ = 0.09, p = .48).
Measures

Demographics
Parents provided demographic information, including youth age, sex, and race/ethnicity at baseline, using a questionnaire developed for the current study.

Supplement Knowledge
Supplement knowledge was assessed with the Medication Module of the MAM (Zelikovsky & Schast, 2008), a validated semistructured interview of adherence to supplements or medications over the past 7 days. The MAM has been previously used in pediatric IBD samples (Hommel et al., 2009). For each vitamin or supplement, youth were asked the following question: “What kind of vitamin or supplement is this?”—a standard follow-up question included in the MAM interview.

Youth responses were recorded verbatim, and a coding system was developed for this study to categorize youth responses. All participant responses were categorized into one of three knowledge categories by two independent raters. Categorization was done separately for each supplement. Category 1 responses reflected a response of “I don’t know” and were viewed as a low level of knowledge sophistication. Category 2 responses involved providing either the name of the supplement or a nonspecific way in which the supplement was helpful (e.g., “It makes me healthy,” “For my nutrition,” or “It helps my body”) and were viewed as a moderate level of knowledge sophistication. Category 3 responses were those which provided information about a specific way that the supplement helped the child’s health, body, or IBD symptoms (e.g., “It helps my immune system/blood/digestive system”) and were viewed as the most sophisticated group of responses. Inter-rater agreement of response categorization was 98%. Discrepancies were resolved through a discussion among coders until agreement was reached. See Table I for a list of knowledge categories and additional examples of responses from each category. For analyses examining relationships between knowledge and adherence, youth’s most sophisticated knowledge response given during the 6-month study interval was used. This strategy was deemed most appropriate, given that it would be unlikely for knowledge to decrease over time and because approximately 50% of youth remained stable in the category to which their knowledge response was assigned across the 6 months of study participation. Thus, any fluctuation noted in knowledge responses was likely more related to the completeness with which youth responded to the open-ended question on a given day versus actual knowledge change. This strategy ensured we were capturing the highest level of knowledge reported.

Supplement Adherence
Supplement adherence was assessed using the Medication Module of the MAM (Zelikovsky & Schast, 2008). Youth reported all vitamins and supplements that they were taking for their IBD, as well as the number of days that they had missed the given vitamin or supplement in the past 1 week in response to a single question. The MAM has been used as a measure of medication adherence in previous studies of youth with IBD ranging in age from 11 to 18 years (Greenley et al., 2012; Hommel et al., 2009). The MAM was administered at the time of study enrollment and at monthly intervals over the duration of the study. A monthly estimate of adherence was calculated as follows: ([number of doses prescribed in a given week – number of doses reported missed in a given week]/number of doses prescribed in a given week] × 100. To enhance stability of the adherence estimate, and given our small sample size, which precluded the use of longitudinal modeling approaches, in the current study, each of the monthly adherence estimates were averaged to form a single adherence estimate for a given vitamin or supplement. Adherence estimates were significantly correlated from month to month, suggesting substantial stability in adherence scores over time (rs = .61, .63, and .48 for mean monthly multivitamin, iron, and calcium adherence correlations, respectively).

Data Analytic Plan
Frequency analyses were conducted to examine the proportion of study participants on one, two, or three

Table I. Frequency of Knowledge Response Categories by Vitamin or Supplement Type

<table>
<thead>
<tr>
<th>Category</th>
<th>Definition</th>
<th>Sample responses</th>
<th>Multivitamin n (%)</th>
<th>Iron n (%)</th>
<th>Calcium n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Youth responded that they did not know what the supplement was for</td>
<td>“I don’t know”</td>
<td>14 (31%)</td>
<td>6 (33%)</td>
<td>6 (23%)</td>
</tr>
<tr>
<td>2</td>
<td>Youth gave the name of supplement or described a nonspecific way the supplement was helpful</td>
<td>“Calcium,” “It makes me healthy”</td>
<td>25 (56%)</td>
<td>3 (18%)</td>
<td>9 (38%)</td>
</tr>
<tr>
<td>3</td>
<td>Youth reported a specific way that the supplement helped their health/body or their IBD symptoms</td>
<td>“Helps my inflammation”</td>
<td>6 (13%)</td>
<td>8 (47%)</td>
<td>9 (38%)</td>
</tr>
</tbody>
</table>
supplements. Then, descriptive statistics, including means, standard deviations, and ranges, were computed to summarize rates of vitamin and mineral supplement adherence. Additionally, to summarize levels of supplement knowledge, the frequency of knowledge response category by supplement type was examined. Finally, three one-way analyses of variance (ANOVA) were conducted to examine differences in adherence as a function of sophistication of knowledge. ANOVAs with significant overall F ratios were probed using a post hoc procedure in which the mean level of adherence of a given knowledge category was compared with the mean adherence of each of the other knowledge categories. Effect size analyses (i.e., the computation of Cohen’s d statistics) were used rather than traditional post hoc procedures (e.g., t tests using Bonferroni corrections to protect against type I error). Computation of effect size estimates was the preferred strategy rather than the use of typical post hoc procedures, given attenuated power to detect a significant effect because of the small sample size and the likelihood that a lack of statistically significant differences between mean comparisons would be due to the small sample size rather than the absence of a real effect. In accord with published recommendations, Cohen’s d was interpreted as: small effect = 0.2, medium effect = 0.5, and large effect = 0.8 (Cohen, 1988).

Results
Rates of Supplementation
The majority of participating youth (92%; n = 43) was taking a multivitamin supplement, whereas fewer were taking calcium (49%; n = 24) or iron (35% n = 17) supplements. Most youth were prescribed two supplements (59%; n = 29); fewer were taking only one supplement (33%; n = 16). Only 8% of the sample (n = 4) was on three supplements. Among the 16 youth taking one supplement, the majority (n = 13; 81%) was prescribed a multivitamin, with fewer prescribed iron (n = 2; 13%) or calcium (n = 2; 13%). The majority of the 29 youth prescribed two supplements was taking a multivitamin, with fewer prescribed iron (n = 10; 35%) or a calcium and an iron (n = 1; 3%) supplement.

Supplement Adherence Rates
Mean adherence ranged from 32 to 44% for multivitamin, iron, and calcium regimens. Table II presents adherence rates by supplement type. Significant variability in adherence rates among youth with IBD was documented, as evidenced by the large ranges for each supplement.

Supplement Knowledge
Between one-quarter and one-third of youth did not provide a description of why they were prescribed the given supplement, responding with “I don’t know” (Table I). This response was categorized into the low knowledge group (Category 1). Among youth taking a multivitamin, the most common response (56%) was to provide the name of the supplement or a general detail about how it helps them (e.g., “It makes me healthy”), responses within the moderate knowledge group (Category 2). For youth on calcium supplements, 38% of responses were in the moderate knowledge group, whereas an equal number of youth on calcium (38%) also provided a more sophisticated reason for the need for supplementation, citing a specific way it helped their health or their IBD (high knowledge group; Category 3). Nearly one-half of youth on iron (47%) reported a specific way that the iron helped their health or IBD (e.g., “It helps with my blood count”), responses indicative of the high knowledge group.

Relationship Between Knowledge and Adherence
Three one-way ANOVAs were conducted to look at differences in adherence as a function of knowledge category. Separate ANOVAs were conducted for each supplement. Results are presented in Figure 1. A significant effect of knowledge on multivitamin adherence was documented (F(2, 42) = 21.29, p < .001). Follow-up analyses indicated large effect size differences between the following groups: (1) low [M (SD) = 7.00 (14.93)] versus moderate [M (SD) = 44.71 (26.38)] knowledge groups, d = 1.64; (2) low versus high [M (SD) = 70.91 (14.79)] knowledge groups, d = 4.29; and (3) moderate versus high knowledge groups, d = 1.06. All findings were consistent with the hypothesis that more sophisticated knowledge would be associated with higher adherence.

A significant effect of knowledge on iron adherence was also documented (F (2, 14) = 5.48, p = .017). Follow-up effect size analyses to examine differences between group means suggested meaningful differences between the following groups: (1) low [M (SD) = 15.36 (22.93)] versus moderate [M (SD) = 45.71 (32.95)] knowledge groups, d = 1.16; (2) low versus high [M (SD) = 65.24 (29.53)] knowledge groups, d = 1.85; and

1Based on reviewer suggestion, we examined whether age and baseline disease activity should be considered as covariates in analyses of relationships between knowledge and supplement adherence. Results failed to support significant correlations between age and adherence (r = -0.21). Similarly, correlations among baseline disease activity and supplement adherence were small in magnitude and not statistically significant (r = -0.02 to -0.24). Thus, neither age nor disease activity was included as covariates in analyses.
(3) moderate versus high knowledge groups, $d = 0.64$. All effect sizes were medium or large, and all findings were consistent with the prediction that those with more sophisticated knowledge had higher levels of adherence.

Finally, a significant effect of knowledge on adherence was documented for calcium ($F(2, 21) = 3.88, p = .037$). Follow-up analyses indicated large effect size differences between the following means: (1) low [$M (SD) = 7.14 (17.50)$] versus moderate [$M (SD) = 4.68 (30.00)$] knowledge groups, $d = 1.26$; and (2) low versus high [$M (SD) = 40.02 (23.16)$] knowledge groups, $d = 1.55$. Both findings were consistent with prediction. Finally, there was no meaningful difference in mean calcium adherence between those in the moderate versus high knowledge groups, as evidenced by a small effect size ($d = 0.01$).

**Discussion**

Adherence to multivitamin, iron, and calcium supplements was poor in the present investigation, with mean levels well below 50%. As youth in the current study were aged 11–18 years, the unique challenges associated with their developmental phase likely contributed to suboptimal adherence levels. Indeed, there is a well-documented trend for lower levels of adherence during adolescence compared with other developmental periods among youth with chronic conditions (Rapoff, 2010). However, the estimates of supplement adherence obtained in this study appear to be even lower than what might be expected based on published rates of adherence to prescribed oral medications in pediatric IBD. Specifically, previous studies that have used similarly aged participants and have assessed adherence using the same semistructured interview used in this study (i.e., the MAM) have documented oral prescription medication rates between 93 and 98% (Greenley et al., 2012; Hommel et al., 2009), rates more than twice as high as the supplement adherence rates in the current investigation. Thus, it appears that adherence to nutritional supplements may be a particular domain of challenge with respect to self-management among youth with IBD. Although speculative, our clinical experiences suggest one possible contributory factor may be the greater time and emphasis health care providers place on educating patients and families about the prescription medications relative to nutritional supplements during routine medical appointments. In addition, in the context of other ongoing studies within our group, families often report prioritizing oral medication adherence over supplement adherence based on the perception that the former is “more important” than the latter. Such cognitions may contribute to devoting less effort to taking nutritional supplements and ultimately lower levels of adherence. However, future research to empirically examine these hypotheses is necessary.

Whereas average supplement adherence was poor in the current sample, substantial variability in adherence rates did exist, and sophistication of knowledge exerted a

<table>
<thead>
<tr>
<th>Time point</th>
<th>Multivitamin adherence ($N = 45$)</th>
<th>Iron adherence ($N = 17$)</th>
<th>Calcium adherence ($N = 24$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>$39.70 (44.49)$ 0–100</td>
<td>$45.71 (48.95)$ 0–100</td>
<td>$32.14 (41.94)$ 0–100</td>
</tr>
<tr>
<td>Month 1</td>
<td>$45.49 (46.84)$ 0–100</td>
<td>$60.95 (43.96)$ 0–100</td>
<td>$40.37 (47.70)$ 0–100</td>
</tr>
<tr>
<td>Month 2</td>
<td>$41.39 (47.02)$ 0–100</td>
<td>$47.62 (45.71)$ 0–100</td>
<td>$41.93 (46.11)$ 0–100</td>
</tr>
<tr>
<td>Month 3</td>
<td>$33.33 (45.45)$ 0–100</td>
<td>$29.22 (41.95)$ 0–100</td>
<td>$30.61 (44.78)$ 0–100</td>
</tr>
<tr>
<td>Month 4</td>
<td>$32.92 (41.42)$ 0–100</td>
<td>$34.29 (44.79)$ 0–100</td>
<td>$19.48 (37.81)$ 0–100</td>
</tr>
<tr>
<td>Month 5</td>
<td>$41.76 (47.31)$ 0–100</td>
<td>$36.73 (46.11)$ 0–100</td>
<td>$26.09 (41.24)$ 0–100</td>
</tr>
<tr>
<td>Month 6</td>
<td>$47.69 (47.14)$ 0–100</td>
<td>$27.38 (42.84)$ 0–100</td>
<td>$28.57 (41.31)$ 0–100</td>
</tr>
<tr>
<td>Overall</td>
<td>$36.47 (30.77)$ 0–93.88</td>
<td>$44.19 (34.86)$ 0–100</td>
<td>$31.67 (27.85)$ 0–91.84</td>
</tr>
</tbody>
</table>

**Figure 1.** Mean rates of adherence to vitamin and mineral supplements for the total sample and by subgroup of participants based on supplement knowledge category. Standard deviations are represented in the figure by the error bars attached to each column.
significant effect on supplement adherence. Specifically, youth who reported not knowing why they were taking a given supplement had mean adherence rates between 7 and 15%, depending on the supplement assessed. In contrast, youth who were able to report knowledge of a specific way in which the supplement contributed to more optimal health or disease functioning had much higher adherence rates—mean rates between 40 and 70%. Differences between these groups demonstrated medium to large effect sizes in all cases, lending support for the real-world significance of these findings.

Interestingly, knowledge has not been supported consistently as a correlate of adherence in previous research (Alm-Roijer, et al., 2004; McQuaid et al., 2003; Rapoff, 2010). One possible explanation for the discrepancy between the present findings and those of past research may relate to the specificity with which knowledge has been previously assessed. Many past studies have examined general illness-related knowledge as an adherence correlate. In contrast, this investigation focused on a specific aspect of knowledge that was directly tied to the adherence outcome of interest. Thus, it may be that general knowledge of one’s illness symptoms, disease trajectory, or medical regimen may not be highly influential to adherence. Instead, the extent to which one can articulate a specific benefit or reason for taking a medication or supplement may be more strongly related to adherence. Consistent with models of health behavior change, including the health beliefs model, positive outcome expectancy related to taking the supplement may promote higher adherence. Thus, our assessment of knowledge had a high degree of specificity and may have been a proxy for beliefs about supplement efficacy.

Given the salience of supplement knowledge as a predictor of adherence, our finding that less than half of participating youth gave a knowledge response that identified a specific way in which the supplement helped their health or their IBD is worrisome. Currently, a number of published timelines for transitioning condition-management responsibilities from parent to adolescent cite the importance of youth being able to name their medications and supplements by early to mid-adolescence (e.g., Hait, Arnold, & Fishman, 2006). However, the current results suggest that being able to name the medication has limited value for promoting adherence. Instead, a greater focus during medical follow-ups on cultivating a meaningful understanding of the role of the given supplement in promoting the child’s growth, general health, and IBD-related functioning may be of more value during this developmental period than simply assessing the extent to which the child can name his or her supplements.

Study Limitations and Future Directions

The current findings are tempered by the presence of several limitations. Attention to these limitations provides possible avenues for future research. The present study relied on self-reported estimates of adherence, which are subject to social desirability effects and unintentional recall biases, and as such, may overestimate adherence (Greenley et al., 2012; Quittner, Modi, Lemanek, Levers-Landis, & Rapoff, 2008). Thus, future research using multiple measures of supplement adherence, including a more objective indicator of supplement adherence such as electronic monitoring or pill count, may be of benefit and would likely document rates of supplement adherence even lower than those reported in the present study. The use of multiple measures of adherence would also allow for more careful evaluation of the psychometric properties of self-report adherence measures relative to other methods of adherence assessment. In addition, our assessment of knowledge was brief and we relied on youth’s open-ended responses. Such an approach may have underestimated the knowledge levels of some youth who were not extremely talkative. Additionally, using the most sophisticated knowledge response given over the study interval as a correlate of adherence does not allow for an examination of change in knowledge over time and impact on adherence. However, in the current study, approximately 50% of youth remained stable in their knowledge responses over time. Future research may benefit from a more detailed longitudinal assessment of supplement-related knowledge, which could be beneficial in teasing apart the extent to which knowledge of the reason for supplementation versus positive beliefs about supplement efficacy is the driving factor in promoting adherence. This study focused solely on a sample of youth aged 11–18 years who were prescribed an oral thiopurine for IBD treatment. Although this age range was chosen because research suggests adolescence is typically a period of poorer adherence relative to other times in development (Rapoff, 2010), it nonetheless limits the generalizability of the current findings to younger age-groups. Similarly, requiring that participants be prescribed an oral thiopurine led to the exclusion of youth who were on other forms of treatment (e.g., infusion or injection-based maintenance therapies), thereby limiting generalizability to these groups. Our sample was relatively small and fewer youth were prescribed iron or calcium supplements than multivitamins. However, the fact that similar patterns of the relationship between knowledge and adherence emerged across all three types of supplements lends credibility to our findings. Finally, our analyses focused solely on one possible correlate of adherence (i.e., knowledge).
and did not allow for establishing the temporal precedence of knowledge as a predictor of later adherence. Future research that examines the relative influence of knowledge compared with other documented correlates of medication adherence over time may be of benefit. Of particular benefit may be future research to examine relationships between patterns of family allocation of condition management responsibilities and adherence, as this has been documented as an important correlate of adherence in previous research (Anderson, Ho, Brackett, Finkelstein, & Laffel, 1997).

**Clinical Implications**

The present study offers useful information for providers working with youth with IBD. First, assessment of supplement adherence is important and should occur as a routine part of clinical practice, given our data suggesting that many youth do not take supplements as prescribed. Second, greater attention to ensuring adequate understanding of the specific benefits of supplementation may be a practical strategy that health care professionals could use to enhance supplement adherence. Given that youth with IBD often experience nutritional deficiencies (Hendricks & Walker, 1988, Kirschner et al., 1981), and as those deficiencies may contribute to poor growth and negative disease outcomes (O’Sullivan & O’Morain, 2006; Samson et al., 2012), attention to improving supplement adherence has the potential to have a broad impact on health in this population.

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