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Associations Among Executive Functioning, Family Functioning, Adolescent Responsibility, and Adherence in Pediatric Inflammatory Bowel Disease

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Abstract

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Background: Inflammatory Bowel Disease (IBD) is a common cause of chronic pain for adolescents in the United States. Adherence to the treatment regimen is a significant concern, particularly for adolescents. Barriers to adherence are varied, but include cognitive factors, such as forgetting. Parent involvement is associated with increased adherence in this population, though adolescent involvement is less studied. Family functioning is associated with adherence to medication regimen across pediatric chronic illnesses, including IBD treatment regimen. To better inform clinical care, this study aims to understand the relations among adolescent's responsibility, executive functioning, family functioning, and adherence. **Methods:** The current study used a cross-sectional, observational design with a sample of 48 adolescents with IBD and their caregivers. Adolescents completed measures of family responsibility in IBD care and executive functioning at one time point. Parents completed measures of demographics, family responsibility in IBD care, and family functioning. Additionally, parents and adolescents conjointly completed a measure of medication adherence. The PROCESS macro was used to conduct a mediation analysis to determine if adolescent responsibility served as a mechanism or a mediator in the relation between executive functioning and adherence. The PROCESS macro was also used to test if executive functioning and family functioning acted as moderators in the relation between adolescent responsibility and adherence. **Results:** Adolescents in the study who took daily medications ($N = 23$) reported high adherence rates even after a correction factor was used to account for inflation in self-report ($M = 90.41\%$, $SD = 3.44$). Mediation analyses between executive functioning, adolescent responsibility, and adherence were not significant using either parent-reported child involvement or self-reported child involvement scores. However, executive functioning was a significant predictor of adherence even when adolescent involvement was included in the model, with greater challenges with executive functioning associated with worse adherence (B = -.19, $SE = .07$, $t = -2.63$, $\beta = -.53$, $p = .02$ with parent-report; B = -.18, $SE = .07$, $t = -2.44$, $\beta = -.50$, $p = .03$ with child-report). Moderation analyses between adolescent responsibility, executive functioning, family functioning and adherence were not significant. **Discussion:** There seems to be evidence to support an association between executive functioning and adherence. This association should be further studied in a larger sample for confirmation. Additionally, the low percentage of participants who took daily medications suggests a changing landscape in the IBD treatment regimen, which has implications for future research.

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Associations Among Executive Functioning, Family Functioning, Adolescent Responsibility, and Adherence in Pediatric Inflammatory Bowel Disease

Inflammatory bowel disease (IBD) is a category of chronic, gastrointestinal disease that includes Crohn's disease and Ulcerative Colitis. Specifically, IBD is a chronic inflammation of the gastrointestinal tract that ultimately causes damage to it (CDC, 2014). The symptoms of IBD include diarrhea, abdominal pain, rectal bleeding, weight loss, and fatigue (CDC, 2014). IBD often has an onset in adolescence and has an estimated prevalence rate of approximately 34 and 58 adolescents (under the age of 20) per 100,000 diagnosed with Ulcerative Colitis and Crohn's Disease, respectively (Kappelman et al., 2013). While the incidence rate of IBD is highest among White adolescents, one study found that health-related quality of life scores are lower for Black adolescents with IBD as compared to those who identified as another race (Klages et al., 2021). The overall prevalence rate has increased over time (Kappelman et al., 2013), indicating the importance of promoting better outcomes in this population. Indeed, IBD is one of the most prevalent causes of chronic pain in adolescence (King et al., 2011).

Treatments for IBD vary depending on disease severity and other factors, although common treatments include taking aminosalicylates, oral corticosteroids, immunomodulators, and biologics (CDC, 2014). Some of these medications are taken orally (e.g., oral corticosterioids, aminosalicylates), while others can be taken via injection or infusion (e.g., biologics). Adherence to treatment regimens in general is often lowest in adolescence (DiMatteo, 2004), marking this developmental period as one that is particularly important for intervention. Estimates for adolescents' adherence to IBD treatment regimen range from 51.56% to 96.99%, depending on the treatment regimen and method of reporting (DiMatteo, 2004; Greenley et al., 2015; Hommel et al., 2008;

Reed-Knight et al., 2015). Additionally, studies have suggested that parent-reported and patient-reported adherence rates are generally higher than those found when an objective measure of adherence, such as electronic monitoring, is used (see Wu et al., 2013), indicating that the prevalence of adherence problems is likely even higher than estimated by self-report. Adherence rates also vary as a function of the aspect of the IBD treatment regimen being studied; for example, self-report of adherence is worse for vitamins (32-44%) than for other oral medications (Greenley et al., 2013b). Importantly, studies (e.g., Schurman et al., 2011) have found that the majority of non-adherence is accidental (e.g., forgetting). Adolescents engaging in volitional non-adherence is low (approximately 1/3) and those who engaged in it reported that they did so only about 3 times a year or less (Schurman et al., 2011). Given the higher prevalence of adherence problems in adolescents and the potential long-term impacts of non-adherence to IBD (e.g., increased risk of relapse, greater healthcare utilization, and higher associated costs; Higgins et al., 2009; Kane et al., 2003), factors related to adherence in adolescence are particularly important to study. Understanding the specific barriers that patients and families experience in their daily IBD care is a good place to start.

Barriers to Adherence

Barriers are frequently endorsed by adolescents with IBD; estimates range as high as 96.2% of adolescents reporting experiencing some sort of barrier (Gray et al., 2012). Forgetting is the most prevalent barrier in studies, with as many as 84.8%-87.8% of participants endorsing it (Gray et al., 2011; Ingerski et al., 2010). Another study examined adherence in IBD over time and found that there were two trajectories—near-perfect adherence and mild non-adherence—and found that medication regimen

complexity was the only predictor of which trajectory an adolescent exhibited (Greenley et al., 2015). In addition, one form of treatment for IBD, oral corticosteroids, may be associated with behavioral and cognitive side effects that may also impact the likelihood of adherence to the treatment regimen (Mrakotsky et al., 2013).

However, in a sample of adolescents to young adults with IBD (ages 16-20), different potential barriers were identified, notably disease frustration as opposed to forgetfulness (Greenley et al., 2018). These discrepant findings may suggest a need to study older teens separately (Greenley et al., 2018). Longitudinal research is especially important to understanding barriers to adherence as well, given how particular barriers may shift over time. Moreover, a longitudinal study of barriers to adherence found that the presence of more barriers over the course of the study was associated with poorer adherence on any individual day (Plevinsky et al., 2019). Problem-solving around barriers and shifting strategies in response to them is related to a person's executive functioning skills.

Executive Functioning

Executive functioning (EF) is commonly conceptualized as being composed of higher order cognitive processes that engage lower order cognitive processes, often to complete specific goals (Miyake et al., 2000). According to a model suggested by Gioia et al. (2015), EF is thought of as being responsible for the completion of goals and future-oriented behavior through a set of interrelated processes. Specific elements of EF include the initiation of behavior, planning and organization, selection of appropriate goals, monitoring problem solving strategies and evaluating their efficacy, shifting strategies as indicated by this evaluation, impulse control, and working memory (Gioia et al., 2015).

However, different measurement strategies of EF (i.e., cognitive performance-based tasks and rating scales) have low correlations with each other, suggesting that despite the generally agreed upon components of EF, EF is not a unitary construct (Mahone et al., 2002; Toplak et al., 2013; Wallisch et al., 2018). One explanation for low correlations could be that cognitive performance-based tasks are conducted in a controlled, laboratory setting in which the experimenter provides organization and structure that the participant therefore does not need to provide themselves, like in their daily lives (Toplak et al., 2013). As such, ratings-based assessment instruments of EF have been suggested to be more ecologically valid than performance-based assessment instruments (Mahone et al., 2002; Toplak et al., 2013). These ratings-based assessment instruments are conceptualized as capturing meaningful differences in the abilities of individuals to perform under typical conditions and in the pursuit of individual, rational goals (Toplak et al., 2013). Therefore, ratings-based assessments provide particularly relevant information in the context of the study of adherence.

EF abilities increase throughout childhood and adolescence (Miyake et al., 2000). However, despite the general increase in EF abilities as children age, different developmental trajectories of EF abilities can be identified in children and adolescents (Miyake et al., 2000). Due to these individual differences, EF has been studied as a variable associated with adherence in adolescents with IBD, as well as those with other chronic diseases, such as diabetes (e.g., Berg et al., 2019). In a study of adolescents with diabetes, executive functioning, as measured by the Delis-Kaplan Executive Function System battery (Delis et al., 2001), was significantly associated with glycated hemoglobin (HbA1c) levels (Berg et al., 2019). Specifically, emerging adults with lower

EF scores on these tasks had better HbA1c levels in years when their mothers reported greater knowledge of diabetes information (Berg et al., 2019), suggesting that mothers may be providing supplemental support for emerging adults with lower EF. No significant results were found for the interaction between EF, HbAIc, and diabetes knowledge with fathers (Berg et al., 2019). However, there was a significant interaction found between EF levels, HbA1c levels, and diabetes disclosure (Berg et al. 2019). Specifically, emerging adults with lower EF levels had better HbA1c levels in years when they disclosed diabetes information to their fathers (Berg et al., 2019), implying that some aspect of paternal involvement is beneficial for young adults with EF difficulties. Notably, however, executive functioning was not associated with self-reported adherence in this population despite the associations with HbA1c levels (Berg et al. 2019). Overall, parental involvement may be particularly helpful in promoting better outcomes for emerging adults with diabetes with lower levels of executive functioning (Berg et al., 2019). While these results may not apply to other chronic illness populations, they do suggest that executive functioning may be a factor related to disease management that needs further study.

Indeed, constructs related to executive functioning, such as attention issues, have been studied in relation to adherence to IBD treatment regimen (e.g., Reed-Knight et al., 2013). One study of attention problems, conduct problems, and their correlations to medication adherence, as well as the mediational role of barriers in these associations for adolescents with IBD was conducted by Reed-Knight et al. (2013). Parent-reported attention problems in youth, as measured by the Behavior Assessment System for Children—Second Edition (BASC-2; Reynolds & Kamphaus, 2004), were negatively

correlated with parent-reported adherence (Reed-Knight et al., 2013). Only one aspect (i.e., subscale) of barriers – regimen adaptation/cognitive issues - as measured by the *Parent Medication Barriers Scale* (PMBS; Simons & Blount, 2007) was a significant mediator in the relationship between attention and parent-reported adherence (Reed-Knight et al., 2013). This subscale is related to executive functioning, suggesting that EF may play a role in adherence. This study had strengths in that it examined multiple models to explain relations to parent-reported adherence, although it was limited by both the high overall medication adherence levels in the sample and low frequency of significant attention problems (Reed-Knight et al., 2013).

In another study of adolescents and young adults (AYA) with IBD, parents and AYA had discrepant scores for the regimen adaptation/cognitive barriers subscale of the PMBS, with parents reporting more of these barriers than adolescents (Greenley et al., 2018). The authors suggest that these differences may be due to parents taking responsibility for some of the tasks assessed in these items, including self-monitoring and getting medication refills (Greenley et al., 2018). As such, these barriers may be less salient to adolescents. In some ways, these parents may be playing the role of EF for adolescents by increasing their involvement in IBD management. The interaction between EF and the division of family responsibility of IBD management is therefore an important direction for further research.

Family Responsibility

The division of responsibility of IBD management amongst family members is related to regimen adherence. In general, parent involvement in IBD management is thought to be beneficial to adherence (e.g., Hommel et al., 2011). Nevertheless, there may

be some variance in benefit depending on treatment modality (Reed-Knight et al., 2011). One study by Reed-Knight et al. (2011) found that parental involvement was not associated with adherence to prescription medications. However, parent-reported adherence to over-the-counter medications was positively correlated with maternal involvement in IBD regimen (Reed-Knight et al., 2011), suggesting that maternal involvement may still be beneficial for adherence to IBD treatment regimen generally. In addition, adolescents' own motivation to adhere to their treatment regimen was positively associated with adherence (Reed-Knight et al., 2011), implying that adolescent involvement in IBD treatment regimen is an important area for further study.

In particular, as Hommel et al. (2011) suggest, the period of adolescence may present challenges when diffusion of responsibility occurs and there are not clearly defined roles in disease management, in turn leading to disease mismanagement. In one study of adolescents with IBD, adolescents were primarily in charge of their own IBD treatment management in some families, while parents, and particularly mothers, were primarily involved in others (Ingerski et al., 2010). In this study, approximately one-third of adolescents were even responsible for renewing prescriptions (Ingerski et al., 2010). Other adolescents, however, feel caught in the "limbo" of not feeling completely like an adolescent but also not feeling like an adult (Kamp et al., 2019). Along these lines, in their qualitative study, Reichenberg et al. (2007) found that the overarching theme of adolescents' feelings around navigating family responsibility of disease care was ambivalence about parental involvement. Specifically, adolescents reported wanting close contact with their parents at times, yet at other times wanting parents to be less involved (Reichenberg et al., 2007). While this study is limited by a small sample of only 17

adolescents with IBD (Reichenberg et al., 2007), it suggests that adolescents' wishes about taking responsibility for their treatment regimen are nuanced. Indeed, in another qualitative study, adolescents with IBD having lower feelings of being in that limbo (i.e., not quite an adult and not quite an adolescent) was associated with better adherence (Kamp et al., 2019). These results imply that adolescents having feelings of greater responsibility are related to higher adherence rates.

In contrast, however, other researchers have shown that parental monitoring in youth with IBD was a facilitator of adherence (e.g., Hommel et al., 2011). The positive relation between parental monitoring and adherence may be a result of parents providing reminders to take medications. Through providing these reminders and engaging in other monitoring behaviors, parents may supplement EF skills that adolescents lack. However, in one qualitative study of treatment adherence in IBD, there was no consensus reached through the interviews on at what age parents should become less involved and reduce their monitoring (Hommel et al., 2011). Additionally, although adolescents reported that parental monitoring was beneficial for adherence, they also expressed that this monitoring felt like nagging at times (Hommel et al., 2011). In sum, the mixed findings from these studies illustrate the difficulties in navigating responsibility roles amongst family members within the context of IBD regimen adherence.

Additionally, while adherence and family responsibility have traditionally been studied through the lens of parental involvement, there is less research conducted through the lens of adolescent responsibility. However, one study of adolescents with IBD conducted by Greenley et al. (2012) found a significant, positive correlation between adolescent involvement in remembering to take their IBD medication and adherence.

Indeed, adolescents who were involved in remembering to take their medication were 7.9 times more likely to be classified as adherent as compared to their peers who were not very involved (Greenley et al., 2012). These results suggest that adolescent responsibility in IBD management is an important variable for further study that may have important implications for adherence.

Family Functioning

The navigation of the division of responsibility for IBD treatment regimen may be complicated by the functioning of the family. Family functioning is conceptualized as encompassing different aspects of how family members relate to each other and how the family is structured (Epstein et al., 1983). Family functioning changes over the course of children's development, with adolescence being a temporary period of increased conflict for families (Psihogios et al., 2019). One model for conceptualizing family functioning is the McMaster Model of Family Functioning (MMFF; Epstein et al., 1983). In this model, six dimensions of family functioning are suggested: the ability of families to resolve problems, the ability of the family to communicate with one another, the establishment of understood roles, the ability to experience an appropriate affective response, the level of involvement in the lives of the other members of the family, and the ways in which family members attempt to control each other's behaviors across different settings (Epstein et al., 1983).

For children with chronic health conditions, the functioning of the family may impact the child's experience of the medical condition, including with respect to the child's adherence to their medication regimen (Psihogios et al., 2019). A meta-analysis of family functioning and medication adherence across a range of pediatric chronic illnesses

found a significant, positive association between family functioning and adherence (Psihogios et al., 2019). Specifically, there was a significant, negative association between adherence and family conflict (Psihogios et al., 2019). There was also a significant, positive association between adherence and family cohesion, family flexibility, family communication, and family problem-solving (Psihogios et al., 2019).

Research with adolescents with IBD specifically has suggested that family conflict, particularly over adherence and often between mothers and their children, is an issue (Hommel et al., 2011). In chronic disease populations, parents commonly report feelings of stress; however, parents of adolescents with IBD reported low levels of parenting stress generally (Guilfoyle et al., 2010). These lower stress levels may be attributed to the fact that families of youth with IBD typically are White and characterized by higher socioeconomic status (Guilfoyle et al., 2010). Nevertheless, family functioning does still seem to be related to IBD adherence in both qualitative and quantitative studies. Good parent-child relationships appear to be beneficial to adherence (Hommel et al., 2011). However, some research has suggested that the impact of family functioning on adherence may differ depending on the medication regimen. Reed-Knight et al. (2011) found that parent-child conflict was not associated with adherence to prescription medication but was negatively correlated with adherence to over-the-counter medications (Reed-Knight et al., 2011).

COPES Model

One novel model has been proposed to conceptualize the potential relations between executive functioning, adherence, adolescent responsibility, and chronic pain (as is associated with IBD). This model is called the “Cyclical model Of Pain, Executive

function, emotion regulation, and Self-management" (COPES; Caes et al., 2021). The COPES model suggests that low executive functioning and emotional regulation in teenagers negatively impact adherence, which increases pain and functional disability, which in turn impacts executive functioning and emotion regulation. Emotional regulation refers to the adaptive regulation of emotional responses and is thought to be influenced by EF skills (Caes et al., 2021). Functional disability refers to activity limitations that result from chronic illnesses and particularly pain (Hoff et al., 2006).

The theorized relationship between executive functioning and the ability of adolescents to take responsibility for their own care that has yet to be fully supported by empirical testing. However, the ability of adolescents to manage their own care is important in preventing increased pain severity and functional disability (Caes et al., 2021). There is evidence to suggest that EF levels are correlated with adolescents' ability to cope with pain, as lower EF (measured by the parent-report Behavior Rating Inventory of Executive Functioning; Gioia et al., 2000) scores were associated with worse health-related quality of life for adolescents with sickle cell disease (Ludwig et al., 2018). Furthermore, in adults, increased pain severity and functional disability are significantly related to lower executive functioning (as measured by a variety of performance-based tasks) and emotional regulation (Moriarty et al., 2011). Research with children with chronic pain also shows that executive functioning may be a particular challenge in this population, as teens with chronic pain had impairments on tests of working memory as compared to pain-free teens (Miller et al., 2016). Moreover, approximately 50% of adolescents with chronic pain at a pain clinic scoring abnormally low on either a performance-based (e.g., Wide Range Assessment of Memory and Learning (WRAML);

Adams & Sheslow, 2003) or a self-report measure of executive functioning (e.g., BRIEF; Gioia et al., 2000; Weiss et al., 2018). This model provides a framework from which the proposed study operated.

Summary of Relevant Literature & Rationale for Current Study

The current literature on adherence in IBD suggests that adherence is a critical issue to address in adolescence (DiMatteo, 2004, Higgins et al., 2009; Kane et al., 2003). Parental involvement has been indicated as beneficial to promoting adherence in youth with IBD (e.g., Hommel et al., 2011). This help may be due in part to the parents playing the role of the adolescent's executive functioning, through monitoring medication, providing reminders to adolescents, and taking on organizational components (Greenley et al., 2018). There is also evidence to suggest that adolescent involvement in remembering to take medications is beneficial for adherence (Greenley et al., 2012). Additionally, family functioning is associated with medication adherence across a range of pediatric chronic health conditions, including IBD (Psihogios et al., 2019). Through the framework provided by the COPES model (Caes et al., 2021), there is a potential relation between adolescent responsibility and medication adherence that is also associated with executive functioning and family functioning. Overall, the current literature has largely focused on parental involvement in IBD management and the associations of this involvement with adherence (e.g., Reed-Knight et al., 2013). However, there is a lack of study of adolescent responsibility and its association with adherence, despite the significant association found by Greenley et al. (2011). Additionally, the relation between executive functioning and adherence is theorized and supported by some research using related constructs, such as attention problems (e.g.,

Reed-Knight et al., 2013). However, more explicit study of the relation between EF and adherence is called for.

Statement of the Problem

Because there continue to be issues with adherence in pediatric IBD and the associations between executive functioning, family functioning, and adherence have yet to be fully elucidated in this population, these associations remain an important area for further study. The theorized relations between executive functioning, adolescent responsibility, family functioning, and adherence align directly with the COPES model (Caes et al., 2021) in that a reduced capacity for executive functioning is expected to be associated with a reduced capacity to engage in treatment regimen, although this study expands upon the model by including adolescent responsibility and family functioning as potentially associated variables. Results from this study could inform interventions as well as specific recommendations for parent involvement to help promote adherence for youth with IBD. Our study's specific aims were as follows:

Aim 1. The first aim was to examine adolescent responsibility as a potential *mediator* in the relationship between executive functioning and adherence to an IBD treatment regimen. It was hypothesized that adolescent responsibility will be a mediator in the relationship, with higher executive functioning associated with higher adolescent responsibility and in turn higher adherence to treatment regimen.

Aim 2. The second aim was to investigate executive functioning and family functioning as potential *moderators* in the relationship between adolescent responsibility and adherence to an IBD treatment regimen. It was hypothesized that the association between adolescent responsibility and adherence will be greater for those with higher

levels of executive functioning and family functioning as compared to those with lower levels of executive functioning.

Method

Design

This study was observational and used a cross-sectional design.

Participants

The study included 48 adolescents (and their primary caregiver) recruited from pediatric gastrointestinal clinics at three medical centers in the United States (West Virginia University Health Sciences Center, Nationwide Children's Hospital, and Children's Hospital of Philadelphia). To participate, adolescents needed to: (a) be diagnosed with either Crohn's Disease or Ulcerative Colitis, (b) be between 11 and 17 years of age, (c) have a caregiver who consents to participate in the study and consents for their adolescent to take part, and (d) be fluent in English. Adolescents were excluded from the study if the clinic staff identify them as having a significant cognitive impairment.

Procedures

Medical providers at the pediatric gastrointestinal clinics screened patients for eligibility criteria through chart review. Potentially eligible patients and their families were either (a) approached by their medical provider during their care appointment to ask if they were interested in hearing more about a research study opportunity or (b) emailed a flyer about the study by their medical care team.

If families were approached at their care appointments, those who expressed interest met with research staff to discuss study information and obtain consent and assent. When possible, families completed measures on an iPad during the clinic

appointment. If not possible, families were emailed a secure, REDCap® link to complete the surveys at home.

If families were emailed a flyer about the study, they were asked to complete an electronic form on REDCap® consenting to be contacted by the study team and providing contact information. A member of the study team called the families to discuss study information and obtain consent and assent. Families were emailed a secure, REDCap® link for both the parent and child to use to complete the surveys at home.

Research staff were available in-person or over the phone to answer questions and help to ensure that surveys were completed independently if in-person. Remote participants were reminded to complete the surveys independently by research staff. Participants were given a $20 gift card for their participation.

Measures

Demographics Form

Caregivers filled out a family information form that provided patient and family demographic information, including age, sex, gender, race, and ethnicity. This form also included questions about disease information, such as age of diagnosis, treatment regimen, and caregiver involvement in the adolescent's treatment regimen.

Medical Adherence Measure

The *Medical Adherence Measure* (MAM) is a semi-structured interview that assesses for treatment regimen adherence in chronic illness groups (Zelikovsky & Schast, 2008). With the permission of the measure's primary author, the MAM was adapted in this study to be given in a self-report survey format and its focus was narrowed to include only the section on medication. In its original form, it includes additional sections on diet

and appointment attendance. Consistent with its original development (Zelikovsky & Schast, 2008), caregivers and adolescents completed the measure conjointly. To calculate adherence for each of the medications taken by the participant, the number of doses taken per week is divided by the prescribed number of doses and then multiplied by 100% (Zelikovsky & Schast, 2008), and capped at 100%. Adherence for each medication was averaged across all medications prescribed to a participant to create a single mean adherence score per participant for analyses.

Using the original, semi-structured interview format, Zelikovsky (2007, as cited in Hommel et al., 2008) found adequate convergent validity evidence for scores on the MAM (r = -.40, p < .05). Additionally, the test-retest reliability of the scores was found to be good (r = .89, p < .05; Zelikovsky, 2007, as cited in Hommel et al., 2008). The MAM has previously been adapted into self-report and parent-report questionnaires of medication adherence behaviors by Klages et al. (2021). In the study by Klages et al., internal consistency reliability of the scores was found to be good (α = .84 for youth self-report; α = .86 for caregiver report).

Behavior Rating Inventory of Executive Function 2--Self Report

The *Behavior Rating Inventory of Executive Function 2 Self Report* (BRIEF2 SR; Gioia et al., 2015) is a 55-item measure of executive functioning intended for adolescents aged 11-18. Respondents are asked to rate how often statements apply to them, such as "I don't plan ahead for future activities.". Response options include N (Never), S (Sometimes), and O (Often). Higher scores indicate greater challenges with executive functioning. The BRIEF2 SR generates seven subscale scores (Inhibit, Self-Monitor, Shift, Emotional Control, Task Completion, Working Memory, Plan/Organize), three

index scores (Behavior Regulation Index, Emotion Regulation Index, and Cognitive Regulation Index), and a composite summary score (Global Executive Composite). The Global Executive Composite score was used in the current study's analyses. For the BRIEF2 SR Global Executive Composite score, Cronbach's alpha was .94 in a clinical sample and .97 in a standardization sample (Gioia et al., 2015). The correlation coefficient for test-retest using the self-report form was .85 (Gioia et al., 2015). The internal consistency of this scale was good in the current study, with a Cronbach's alpha of .97.

Evidence has been reported for the content validity, internal structure, and concurrent validity of the instrument and its scores (Gioia et al., 2015). Scores on the BRIEF2 SR are significantly and positively correlated with scores on the *Child Behavior Checklist Youth Self-Report* (CBCL-YSR; Achenbach, 1991) Internalizing Problems Composite ($r = .32$, $p < .01$), Externalizing Problems Composite ($r = .43$, $p < .01$), and the Total Problems Composite ($r = .32$, $p < .01$; Gioia et al., 2015). Additionally, scores on the BRIEF2 SR are significantly correlated with scores on the *Behavior Assessment Scale for Children* (2nd Edition) *Self-Report of Personality* (BASC-2-SRP; Gioia et al., 2015; Reynolds & Kamphaus, 2004). For example, Global Executive Composite scores on the BRIEF2 SR are significantly, positively correlated with scores on the BASC-2-SRP Attention Problems subscale ($r = .71$, $p < .01$), the Hyperactivity subscale ($r = .65$, $p < .01$), and the Inattention/Hyperactivity Composite ($r = .77$, $p < .01$). Global Executive Composite scores on the BRIEF2 SR are also significantly, negatively correlated with scores on the BASC-2-SRP Self-Reliance subscale ($r = -.28$, $p < .01$).

Correlations between scores on the BRIEF2 Parent Form and the Conners 3rd Edition-Parent Short Form [Conners 3-P(S); Conners, 2008] have also been examined (Gioia et al., 2015). Scores on the BRIEF2 Global Executive Composite are significantly, positively correlated with scores on the Conners 3-P(S) Inattention scale ($r = .55$, $p < .01$), Hyperactivity/Impulsivity scale ($r = .49$, $p < .01$), Learning Problems scale ($r = .22$, $p < .05$), Executive Function scale ($r = .56$, $p < .01$), Aggression scale ($r = .39$, $p < .01$), and Peer Relations scale ($r = .43$, $p < .01$).

Family Assessment Device, General Subscale

The *Family Assessment Device* (FAD) is a self-report measure intended for family members aged 12 and older that assesses relations between family members and the general functioning of the family (Epstein et al., 1983). The FAD is a 60-item measure that includes seven subscales (General Functioning, Problem Solving, Communication, Roles, Affective Responsiveness, Affective Involvement, and Behavior Control). Respondents rate their agreement to various statements about their family, such as "In times of crisis we can turn to each other for support." Response options include "Strongly Agree," "Agree," "Disagree," and "Strongly Disagree." In the current study, only the FAD General Functioning Scale was completed by parents.

The internal consistency of the General Functioning Scale is adequate, with a Cronbach's alpha of .86 (Byles et al., 1988). For evidence of the construct validity of the scores, correlations between scores on the General Functioning Scale and scores on questionnaires assessing different family variables (i.e., parent incarceration, alcohol abuse, parent mental health, domestic partner violence, parental separation, and marital disharmony; Byles et al., 1988) were evaluated. For the dichotomous variables, *t*-tests

were used to examine group differences on mean scores of the General Functioning Scale for families who had experienced certain stressors (e.g., domestic violence, parent incarceration; Byles et al., 1988). The authors found significant group differences on the General Functioning Scale between families who had experienced the stressor and families who had not ($p < .01$ for all; Byles et al., 1988). For the relation between General Functioning Scale scores and the continuous variable of marital disharmony, a Pearson's correlation showed that scores are significantly, positively correlated ($r = .57$, $p = .0001$; Byles et al., 1988). The internal consistency of the scale was good in this sample, with a Cronbach's alpha of .92.

IBD Family Responsibility Questionnaire

The *IBD Family Responsibility Questionnaire* (IBD-FRQ) is a self-report measure of caregiver and adolescent responsibility in IBD management (Greenley et al., 2010). The 26-item measure is completed separately each by the adolescent and their caregiver. Respondents rate how involved the child, male caregiver, female caregiver, and other caregiver (as appropriate) are involved in aspects of IBD management provided in statement form. For example, in the parent version, respondents are asked to rate how involved the child and each caregiver are in "Making sure your child is getting enough calories each day" (Greenley et al., 2013a). Response options range from 0 ("Not Involved at All") to 3 ("Involved Almost all of the Time"). There is also an option for "Not Part of IBD Care.". The IBD-FRQ generates a total involvement score and four subscale scores for the child and each of the caregivers. These subscale scores are for the general health area, social area, condition management area, and nutrition area. The total

involvement score of the child using both parent-report and self-report versions was used in the analyses.

Each of the domain scores demonstrated adequate internal consistency, having a Cronbach's alpha of >.80 (Greenley et al., 2010). Youth report of youth involvement alpha is 0.94, while maternal and paternal report of youth involvement resulted in an alpha of 0.93 and 0.96, respectively. In the current sample, Cronbach's alpha was .97 for parental-report of child involvement and .96 for self-report of child involvement, demonstrating good internal consistency.

As evidence of validity, child-reported scores for child involvement were significantly correlated with both caregiver-reported youth involvement scores (r = .72, p < .001 with maternal report; r = .66, p < .001 for paternal report; Greenley et al., 2010). Correlations between total involvement scores on the IBD-FRQ and scores on the *Decision Making Questionnaire* (DMQ; Prinz et al., 1979) provided evidence of convergent validity. Maternal- and paternal-reported self-involvement scores were significantly correlated with maternal and paternal DMQ scores, respectively (r = -.43, p <.001; r = -.39, p = .05, respectively), although youth-reported youth involvement scores were not significantly correlated with youth-reported DMQ scores (r = .15, p =.26; Greenley et al., 2010).

Results

All statistical analyses were conducted using the IBM Statistics Package for the Social Sciences (SPSS 27).

Preliminary Analyses

Power Analyses

An *a priori* power analysis, using G*Power 3.1.9.6 (Faul et al., 2007) was conducted to determine sufficient sample size for the proposed analyses. Prior research has found a large association between adolescent involvement in medication regimen and nonadherence using a logistic regression ($\beta = -2.07$, Odds Ratio = 0.13, 95% CI = .02 - .71; Greenley et al., 2012). These results support using an effect size of 0.2 as a conservative estimate. Based on a power analysis for a linear multiple regression model with 5 total predictors, 2 tested predictors, a power level of .80, an alpha level of .05, and an effect size of 0.2, 52 participants were needed to be adequately powered. As such, the current study ($N = 48$) is likely underpowered, especially given that only 23 participants completed a self-report measure of adherence.

Data Cleaning and Assumption Checks

All data were cleaned and analyzed for assumptions for regression in SPSS. Responses on all measures were cleaned according to instructions for each measure. Additionally, because the IBD-FRQ did not have instructions for scoring with missing data, scores for the IBD-FRQ were removed from analyses if participants were missing responses on more than 10% of the items. Mean imputation was used for participants with less than 10% of responses missing on the FAD and the IBD-FRQ. According to the scoring instructions of the BRIEF, scores were not used in analyses if participants were missing responses for 10 or more questions. For participants with fewer than 10 items with missing responses, the value "1" (corresponding to "Never") was imputed per the scoring instructions.

Data were analyzed for missingness and determined to be MCAR. Data for primary variables and potential covariates (disease severity, length of time since

diagnosis, child age) were checked for skewness and kurtosis and were found to be within normal limits apart from the adherence data, which was negatively skewed (-3.46) and leptokurtic (12.40). A logarithmic transformation using the LOG10 function after reflecting the data (given the negative skew) decreased skewness (2.62) and kurtosis (5.84). However, significant and non-significant findings did not change and therefore results using the non-transformed data are reported to enhance the ease of interpretation. Scatterplots were examined to see if the data met the assumption of linearity. However, due to limited variability in adherence data, it was difficult to determine linearity from a visual inspection. Given these results, it was also hard to determine whether the assumption of homoscedasticity was met from a visual inspection of the scatter plots. There appeared to be some variability in spread across graphs and this limitation should be considered when interpreting results. Analyses of Cook's D and leverage values suggested that there were no data points that exerted undue influence on the regression line. Multicollinearity was examined using variance-inflation factor (VIF) values. All VIF values were less than 2, indicating no significant issues with multicollinearity. Normality of the residuals was examined using normal p-p plots and histograms. While the data varied slightly from a normal distribution, all data points were included due to the limited sample size.

Medication Adherence Correction Factor

Self-reported adherence in the sample was high, with most participants with adherence data ($N = 23$) reporting 100% adherence ($N = 20$) and the lowest reported adherence rate being 85.71% ($M = 98.91$, $SD = 3.31$). In reviewing the literature, two correction factors were found for self-reported adherence to IBD medications based on

comparisons with electronic monitoring data (Wu et al., 2013). The first correction factor is a regression equation [corrected adherence = -12.46 + (1.04 * (parent-reported adherence)], while the second is a simple equation (corrected adherence = .924 * parent-reported adherence). Both correction factors were found to produce similar adherence rates (Wu et al., 2013). The authors conducted *t*-tests to examine the difference between the corrected adherence rates with each correction factor equation and data collected from electronic monitoring (Wu et al., 2013). The *t*-tests revealed no significant differences, suggesting that each correction factor did indeed correct the adherence rates to rates similar to those found using electronic monitoring (Wu et al., 2013). In the current sample, both correction factor equations were used. A paired-samples *t*-test of the differences between the two correction factors found that they were significantly different from one another [$t(22) = -12.33$, $p < .001$]. As such, analyses were run using each correction factor.

Descriptive Statistics

In total, 48 adolescents (52.1% male, 47.9% female, $M_{age} = 14.69$) and their caregivers participated in this study. Participants were recruited from three sites: West Virginia University Health Sciences (N = 23, 47.92%), Nationwide Children's Hospital (N = 6, 12.50%), and Children's Hospital of Philadelphia (N = 19, 39.58%). The sample was racially homogenous, with 97.92% of participants identifying as White and 2.08% identifying as Native Hawaiian/Other Pacific Islander. In terms of ethnicity, 95.8% of the sample identified as not Hispanic or Latino, while 2.08% identified as Hispanic or Latino and 2.08% did not report ethnicity. The average age of diagnosis with IBD was 10.23 (*SD* = 4.23) and the average disease severity was 1.63 (*SD* = .761) which is in between mild

and moderate severity. The average annual income in the sample skewed high (*M* = $104,140.54, *SD* = $60,178.69), even after the removal of an outlier that reported an annual income of $1,000,000. See Table 1 for additional demographic and medical information.

A total of 23 participants reported taking any daily medications, with 25 participants reporting not taking any daily medications. For those not taking daily medications, IBD symptoms were managed through in-hospital infusion treatments, dietary regimens alone, or injections (N = 15, 31.25%). Independent samples *t*-tests were conducted to determine if there were significant differences in any of the independent variables (child involvement in IBD care, executive functioning, family functioning) by whether the child was prescribed a daily medication or not. All *t*-test results were non-significant. For participants who took daily medications, 86.95% (*N* = 20) reported perfect adherence (i.e., 100%) to the medication regimen. The mean rate of adherence once a correction factor was used was 90.41% (*SD* = 3.44).

A total of 45 participants completed the BRIEF2 SR. Scores on the BRIEF2 SR were transformed into *T* scores based on normative data from age and gender matched samples. The mean *T* score of adolescents in the study was 52.57 (*SD* = 11.65), which is in the normative range. A total of 43 participating parents and 42 participating adolescents completed the IBD-FRQ and yielded an average total parent-reported child involvement score of 2.03 (*SD* = .76) and a self-reported child involvement score of 2.08 (*SD* = .77). The range of response options on the IBD-FRQ is 0 to 3, with 2 corresponding to “Somewhat involved.” All 48 parents completed the FAD general subscale with an average score of 1.52 (*SD* = .47). Possible scores range from 1 to 4 and

higher scores indicate worse family functioning. A mean score of 1.52 is typical for a non-stressed family (Epstein et al., 1983).

Correlations

Table 2 displays correlation coefficients between the primary variables in the study. Neither parent-reported nor child-reported child involvement in IBD management as measured by the IBD-FRQ was significantly correlated with adherence. Family functioning as measured by the FAD was also not significantly correlated with adherence. However, adolescents' self-reported executive functioning as measured by the BRIEF2 SR was significantly, negatively correlated with adherence (r = -.49, p = .02). Higher scores on the BRIEF2 SR indicate greater issues with executive functioning.

Covariates

Before completing the primary data analyses, Pearson's correlation coefficients with adherence and potential covariates were calculated for continuous variables, while *t*-tests for categorical variables were performed. Specifically, child age, length of time since diagnosis with IBD, number of medications prescribed, child sex, and disease severity were examined. No significant correlations or *t*-test results were found with adherence and therefore no covariates were included in the primary analyses. However, child age was significantly correlated with child-reported involvement in IBD regimen as measured by the IBD-FRQ (r = .33, p = .03), indicating that older children took on more responsibility for their IBD care.

Reporter (Parent-Child Agreement)

The IBD-FRQ child total involvement score was calculated for both parent and child-report versions of the measure. A Pearson correlation revealed that parent and

child-report of child involvement were significantly correlated with each other (r = .48, p = .001). These results suggest that parents and children generally agreed on the overall level of the child's involvement in IBD management.

Primary Data Analyses

All primary analyses including adolescent responsibility were run with parent-reported adolescent responsibility and child-reported adolescent responsibility separately. Given that there were no potential covariates that were significantly correlated with adherence, no covariates were included in the primary analyses. Additionally, all analyses were run using parent-reported adherence, parent-reported adherence corrected using the first correction factor equation in Wu et al. (2013), and parent-reported adherence corrected using the second correction factor equation in Wu et al. (2013). While effect sizes differed slightly depending on which adherence statistic was included, statistical significance did not change regardless of the adherence statistic. Because there is evidence to use a correction-factor for self-reported adherence and the first correction factor equation was developed based on the primary analyses as compared to the second which was developed using exploratory analyses (Wu et al., 2013), the adherence statistic used in the analyses will be the corrected adherence percentage using the first correction factor equation [corrected adherence =-12.46 + (1.04 * (parent-reported adherence)].

Aim 1. The mediation hypothesis was tested using the PROCESS macro created by Andrew F. Hayes (2017). In the model, X=executive functioning, M=adolescent involvement, and Y=adherence. See Figures 1 and 2 for further details. While the model including executive functioning and adolescent involvement with adherence as an outcome variable was significant [$F(2, 17) = 3.86$, $R^2 = 0.31$, $f^2 = 0.45$, $p = 0.04$], it does

not represent a significant mediation model as the relation between executive functioning and parent-reported adolescent involvement is not significant. However, after testing the association between executive functioning and adherence with adolescent involvement in the model, executive functioning remained a significant predictor of adherence (B = -.19, *SE* = .07, *t* = -2.63, β = -.53, *p* = .02). The mediation model using child-reported adolescent responsibility was not significant overall, nor was the effect of executive functioning on child-reported adolescent responsibility. Executive functioning remained a significant predictor of adherence even when adolescent involvement was included in the model (B = -.18, *SE* = .07, *t* = -2.44, β = -.50, *p* = .03). See Table 3 for detailed results.

Aim 2. The moderation hypothesis was tested using the PROCESS macro created by Andrew F. Hayes (2017). In the model, the association between adolescent responsibility and adherence is expected to be moderated by executive functioning and family functioning (X=adolescent responsibility, M=executive functioning, W=family functioning, Y=adherence). The moderation model and each of the interactions did not reach statistical significance using either parent or child-reported adolescent responsibility (see Table 4).

Discussion

Given prior research suggesting challenges with adherence to medication regimen for children with IBD (e.g., Ingerski et al., 2010), the current study aimed to fill a gap by examining understudied factors associated with these challenges. Specifically, the study sought to understand the associations between executive functioning, adolescent responsibility, family functioning, and adherence using a moderation model and a mediation model. While neither of the models yielded significant results overall, the

effect sizes were moderately sized, but the *B* values had large confidence intervals. These results suggest that if the study were to have a larger sample, it is possible that significant results would be found. Regardless, the current study provides a few avenues for contribution to the literature as it stands.

In contrast to prior research, adherence rates for those in the sample taking daily medications were quite high, with an average adherence rate of 98.91%. Though prior research has found a wide range of adherence rates – i.e., 51.56% to 96.99% (DiMatteo, 2004; Greenley et al., 2015; Hommel et al., 2008; Reed-Knight et al., 2013) – lower rates of adherence tend to be obtained with more objective measures such as pill counts (e.g., 51.56 % adherence in a study by Hommel et al., 2008) or electronic monitoring equipment (e.g., 82.59% adherence in a study by Greenley et al., 2015), while self-report measures tend to yield higher adherence rates (e.g., 92.83% parent-reported adherence in a study by Reed-Knight et al., 2013), like our findings.

Even after the use of a correction factor to account for inflated parent- and self-report of adherence (Wu et al., 2013), the adherence levels in the sample averaged 90.40% (*SD* = 3.44%). These adherence percentages are both above normal clinical cut-offs for consideration of nonadherence which is typically defined at the 80% level (e.g., Greenley et al., 2012). These findings suggest that youth with IBD, at least in this sample, are finding ways to better manage their medication regimen than those in prior research. This interpretation would suggest a positive change in the management of IBD. However, it is also possible that youth in this sample reported higher adherence rates because they were only asked to recall their doses missed in the past week, which could be less representative of their adherence over a longer period, such as a month. Additionally, our

study suggests another changing aspect of IBD care and research, given that over 50% of our sample did not manage their IBD through a daily medication. Instead, the majority of these patients managed their IBD through infusion treatments, while some through dietary modifications. Factors that are associated with adherence to infusions may be conceptually different than factors associated with adherence to daily medications.

The current study also did not replicate the results of prior research by Greenley et al. (2012) that showed an association between adolescent involvement and adherence. In our sample, there was no significant association between either parent-reported child involvement or child self-report of involvement in the treatment regimen and adherence to medication, although both were positive correlations which is the expected direction of association (r = .02, p = .92 with child-report; r = .18, p = .44 with parent-report). Given the paucity of research through the lens of adolescent responsibility, it is unclear of the true extent of this association. A study conducted over a decade ago (Greenley et al. 2012) obtained greater variability in adherence, with approximately one-third of the sample taking less than 80% of prescribed doses. Consequently, it remains possible that with greater variability in adherence rates in our sample, a similar association may have been found. The current study also did not support prior research that has suggested that worse family functioning is associated with adherence challenges in a variety of chronic illness conditions, including IBD (e.g., Psihogios et al., 2019). However, the family functioning in this sample was overall indicative of healthy family functioning; thus, limited variability may account for the lack of significant results. Additionally, a negative correlation was found between family functioning and adherence (r = -.22, p = .32) and it

is possible that a significant association might be found if the study were not underpowered.

Prior research has not directly examined the role of executive functioning in adherence for youth with IBD. Although there is mixed evidence to suggest that executive functioning is associated with adherence in diabetes (e.g., Berg et al., 2019), and some work with constructs related to executive functioning such as attention have been shown to be correlated with adherence in IBD (Reed-Knight et al., 2013), this study fills an important gap in the literature in directly examining executive functioning and adherence in IBD. Furthermore, the results of the study suggest that executive functioning is indeed correlated with adherence rates in children with IBD. Specifically, executive functioning challenges were negatively correlated with adherence percentages. In other words, children with greater challenges with executive functioning (including worse working memory, organizational, emotional control, and self-monitoring capacities) had lower adherence rates than those children who had fewer challenges with executive function. Moreover, this significant result was found with the use of an ecologically valid assessment measure (the BRIEF2 SR), increasing the applicability to real-life settings. Items on the measure that ask about challenges in remembering routines and initiating tasks even when reminded seem directly relevant to the construct of adherence, as children are often asked to maintain a medication routine and respond to reminders from parents to take medications.

Limitations

The current study is impacted by multiple limitations. First, the analyses are generally underpowered which severely limits our ability to find significant effects where

they may truly exist. Every effort was made to collect a sample large enough to be properly powered, as participants were recruited from three children's hospitals over the course of 16 months. Nevertheless, the final sample consisted only of 48 parent-child pairs, which is slightly less than the 52 participants required to be powered based upon an a-priori power analysis. However, the study's power was significantly limited by the low proportion of individuals with available adherence data ($N = 23$), as fewer than half of participants were taking daily medications and therefore able to fill out the study's adherence measure. As such, the mediation and moderation analyses were underpowered.

The small number of participants who reported taking daily medications is indicative of what is likely a larger limitation of adherence research in IBD at this time. Patients are increasingly being prescribed infusion and injection treatment regimens for IBD. Currently, a validated measure to assess adherence to these different forms of treatment regimens that IBD patients complete is not available. Indeed, it would be challenging to capture adherence even through traditional objective measures of adherence, as there is not an electronic device that can be attached to injections to track administrations. Capturing adherence to injections via self-report also would require an adherence measure that asks about adherence over a long window of time, as many patients are prescribed to take injections once every few weeks. While it is possible to gather infusion appointment attendance as a measure of adherence, there are still challenges in deciding what would be classified as non-adherence (e.g., would it be considered non-adherence for a patient to reschedule an infusion treatment for one day or even one week later than originally scheduled). Additionally, it is highly likely that the barriers to adherence for these very different treatment approaches would vary.

Furthermore, a significant limitation of the current study is the lack of adherence challenges in the sample of participants who did take daily medications. While these high rates of adherence are clinically beneficial, they create ceiling effects that make it hard to detect if the independent variables are truly associated with adherence. It is possible that these high adherence rates are due to the limitation of the use of parent- and self-reported adherence to medications. The use of self-report measures can lead to participants giving socially desirable answers and it is possible that the participants in this study reported higher adherence rates than are accurate because of a social desirability response bias. Moreover, our self-report measure (MAM) is one that requires the child and parent to complete it together. Perhaps assessing self-report separately would have been better if some children felt pressured to report higher adherence with parental awareness. Objective measures, like electronic monitoring data, are more accurate at measuring adherence; however, these are resource-intensive (e.g., logistical challenges in terms of providing and retrieving the necessary devices to participants) and costly. The use of a correction factor should help to mitigate some of the inflation normally seen through self-report measures of adherence, as was found in the study that developed the correction factor (Wu et al., 2013). It is also important to note that our study used a convenience sample of adolescents recruited from a GI clinic. As such, our participants are likely to be more adherent thane adolescents who missed clinic appointments or do not come to clinic at all. Additionally, some prior research has found lower adherence rates even using uncorrected, self-reports of adherence in a sample of teenagers recruited from a GI clinic (e.g., Greenley et al., 2015), suggesting that the adherence rates of participants in our

study may have indeed been higher in our sample than in previous samples of children with IBD.

The current study is also limited in that the participants are overwhelmingly White (95.83%). The lack of racial diversity limits the generalizability of any significant findings. The lack of racial diversity is not only important in terms of overall representation but also because of documented racial health disparities that exist in IBD care, such as the lower health-related quality of life scores for Black youth with IBD (Klages et al., 2021). As reported by Barnes et al. (2021), there is evidence to suggest that Black youth with IBD have worse adherence rates as compared to White youth with IBD. These differences are a result of a multitude of systemic barriers, including access to care and insurance status (Barnes et al., 2021). It is therefore possible that our study did not include a portion of patients with IBD who may still be experiencing challenges with adherence.

Strengths

As described, the results of the study should be interpreted with caution. However, the study has a strength in that it used multi-site recruitment. While the multiple locations participants were recruited from did not result in racial or ethnic diversity, the geographic diversity is beneficial in that our sample is not all from a rural area. Methodologically, the study has a methodological strength by requiring all participants to answer all questions; rather than skipping items, they were given the option of "I do not wish to answer" for each question. This design ensured that participants were alerted if they missed questions automatically and the only missing data resulted from questions families did not want to answer. Furthermore, the parent and

youth reported child-involvement in IBD care scores were significantly correlated, a finding that is not always seen in pediatric psychology research.

Implications and Future Directions

The results of this study suggest an association between executive functioning and adherence that is worthy of further study. The use of a larger sample and a different method of capturing adherence may result in a stronger association between these variables. Longitudinal research could be conducted to assess changes in adherence as executive functioning changes to try to illustrate a causal relationship. Presently, there is a paucity of longitudinal research examining executive functioning and adherence in children with a chronic illness. One study of children with chronic kidney disease found that executive functioning did not predict adherence over a period of 24 months (Eaton et al., 2020), although few youth included in the study reported challenges with executive functioning which may have limited the study's ability to find an effect. While future research is certainly needed to confirm the association between executive functioning and adherence, if these associations are found, it would be important for clinicians to screen for executive functioning capacities to determine who might be at risk for worse adherence to medication regimens. Clinicians could then work to provide extra support for children with worse executive functioning, such as greater structured parental involvement in adherence or formal reminder systems for taking medications.

An additional implication of this study is that the landscape of the treatment regimen in IBD is changing and requires adaptations for future research. Specifically, adherence measures should be designed to capture infusion and injection data. As mentioned previously, self-report measures of adherence to these two kinds of medication

regimens would require asking participants about a wide timeframe as these treatments are infrequent. It would be possible to measure infusion adherence through medical chart review, although as discussed above challenges remain in terms of decisions about classifying adherence or nonadherence to recommended scheduling. Additionally, it will be necessary for researchers to think about conceptual differences in the treatment regimens that may be important to account for in study design. For example, parents are likely inherently more involved in IBD treatment regimen when the regimen is infusions, as they bring their children to their infusion appointments, whereas adolescents are likely more involved in the act of remembering to take a daily prescription. Furthermore, coming to clinic one time per month for an infusion requires less continual effort than a daily medication and therefore may be less challenging for those who struggle with working memory. Yet, attendance at clinic appointments may require families to overcome different barriers, such as travel and financial constraints.

Conclusions

In summary, this study examined the associations between executive functioning, family functioning, adolescent responsibility, and adherence. A model of the association between executive functioning and adherence as mediated by adolescent responsibility was not significant, nor was a model examining the relations between adolescent responsibility and adherence, as moderated by executive functioning and family functioning. However, there was a significant effect found for the association between executive functioning and adherence. Despite these overall non-significant results, the study provides important information about the changing adherence and treatment landscape in IBD. Namely, the results of the study suggest that youth with IBD may not

be having challenges in following their IBD treatment regimens. Additionally, it was revealed that a high proportion of teens are receiving infusion treatments for their IBD, necessitating a redesign of the ways adherence is calculated. Moreover, a significant association was found between executive functioning and adherence, suggesting an area for further study. This study therefore provides valuable information for those considering researching adherence in IBD.

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Table 1.
Demographics

Variable	n (%)	*M*(SD)	Skew	Kurtosis	Minimum	Maximum
Age	48	14.69 (1.93)	-0.56	-0.87	11	17
Sex						
Male	25 (52.1)					
Female	23 (47.9)					
Gender						
Cisgender	51 (100)					
Race						
White	47 (97.9)					
Native Hawaiian or other Pacific Islander	1 (2.1)					
Ethnicity						
Hispanic or Latino	1 (2.1)					
Not Hispanic or Latino	46 (95.8)					
Prefer not to answer	1 (2.1)					
Age of Diagnosis	47	10.23 (4.23)	-0.35	-1.12	3	17
Disease Severity						
Mild	25 (52.1)					
Moderate	17 (35.4)					
Severe	5 (10.4)					
Prefer not to answer	1 (2.1)					
Medication Type						
Immunosuppressants	22 (34.9)					
Anti-infective	7 (11.1)					
Vitamins	8 (12.7)					
Injections	15 (23.81)					
Prefer not to answer	11 (17.5)					
Annual Income	37	$104,140.54 (60,178.69)	0.723	-0.349	$1,000.00	$275,000.00

Table 2.

Correlation Table of Potential Covariates and Primary Variables of Interest

	Variable	*n*	*M*(SD)	Range	1	2	3	4	5	6	7	8	9
1.	Age	48	14.69 (1.93)	11-17	-								
2.	Disease Severity	48	1.62 (0.76)	1-4	.09	-							
3.	Number of Medications Taken	46	.96 (1.33)	0-5	.14	.06	-						
4.	Years since diagnosis	47	4.47 (3.72)	0-12	-.02	.07	-.01	-					
5.	Adherence (corrected)	23	90.41% (3.44%)	76.68%-91.54%	.12	.34	.09	.05	-				
6.	BRIEF2 SR Global Executive Composite T-Score	45	52.67 (11.65)	36-88	.16	-.16	.13	.06	-.49*	-			
7.	FAD General Functioning	48	3.48 (0.47)	2.42-4.00	.01	-.26	-.32	.28	-.22	.13	-		
8.	Parental-report IBD-FRQ Child Involvement	43	2.03 (0.76)	.19-3.00	.28	-.07	-.21	-.12	.18	.09	-.05	-	
9.	Self-report IBD-FRQ Child Involvement	42	2.08 (0.77)	0.0-2.88	.33*	.02	-.09	-.13	.02	.23	-.18	.48**	-

*p< .05, **p<.01

Table 3.
Mediation Models of Executive Functioning, Adolescent Involvement, and Medication Adherence

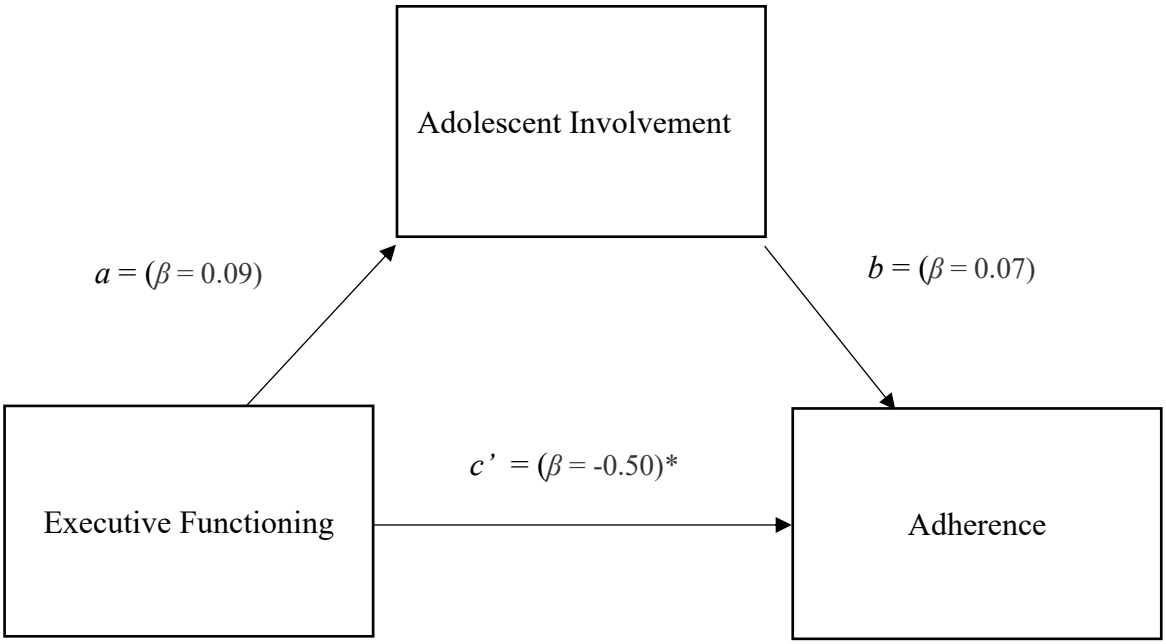
Variable	*B*(SE)	CI (95%)	*p* value	*β*	Model Indices	
Mediation model 1: Medication adherence from executive functioning (BRIEF 2 SR T-Score) and adolescent involvement (IBD-FRQ child-report)						
Step 1—Outcome: IBD-FRQ						
Constant	1.98 (0.75)	0.42 – 3.55	0.02*		*F(df)*	0.14 (1, 19)
BRIEF2 SR Global Executive Composite T-Score	0.01 (0.01)	-0.02 – .04	0.72	0.09	R^2	0.01
					f^2	0.01
					p	0.72
Step 2—Outcome: Adherence						
Constant	98.59 (4.44)	89.26 – 107.91	0.00**		*F(df)*	2.98 (2, 18)
BRIEF2 SR Global Executive Composite T-Score	-0.18 (0.07)	-0.33 – -0.02	0.03*	-0.50	R^2	0.25
					f^2	0.33
					p	0.08
IBD-FRQ Child Involvement	0.37 (1.16)	-2.08 – 2.82	0.75	0.07		
Mediation model 2: Medication adherence from executive functioning (BRIEF 2 SR T-Score) and adolescent involvement (IBD-FRQ parent-report)						
Step 1—Outcome: IBD-FRQ						
Constant	2.10 (.99)	0.03 – 4.16	0.05*		*F(df)*	0.00 (1, 18)
BRIEF2 SR Global Executive Composite T-Score	0.00 (.02)	-0.04 – 0.04	1.00	0.00	R^2	0.00
					f^2	0.00
					p	1.0
Step 2—Outcome: Adherence						
Constant	98.27 (4.23)	89.33 – 107.20	0.00**		*F(df)*	3.86 (2, 17)
BRIEF2 SR Global Executive Composite T-Score	--0.19 (0.07)	-0.34 – -0.04	0.02*	-0.53	R^2	0.31
					f^2	0.45
					p	0.04*
IBD-FRQ Child Involvement	0.82 (0.91)	-1.09 – 2.74	0.38	0.18		

*p< .05, **p<.01

Table 4.
Moderation Models of Adolescent Involvement, Executive Functioning, Family Functioning, and Medication Adherence

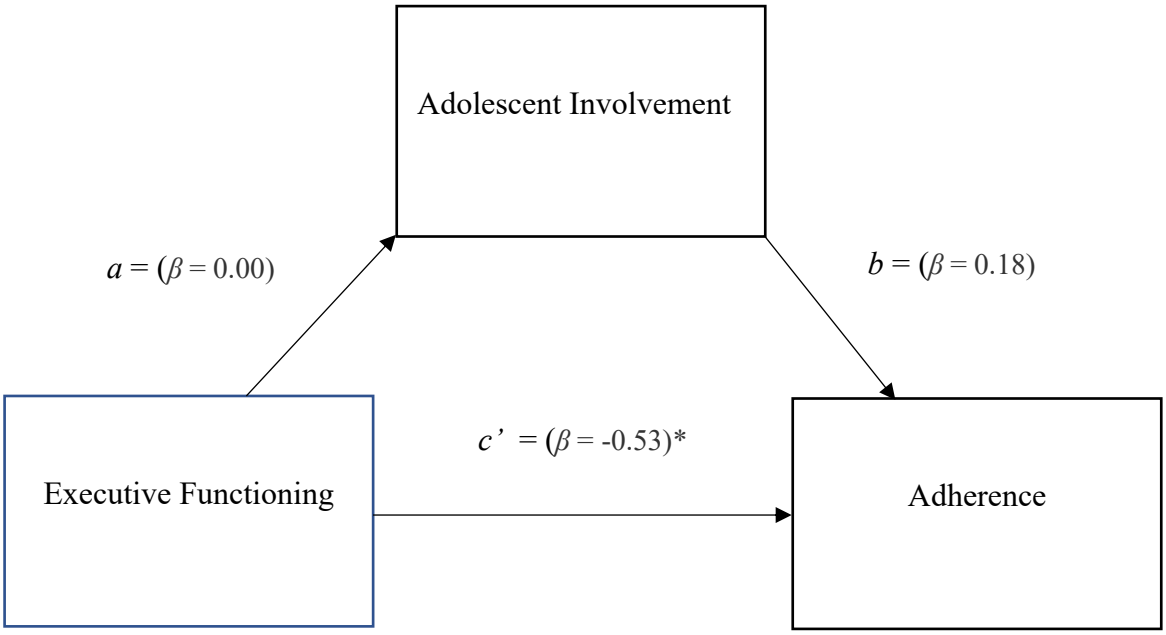
Variable	*B*(SE)	CI (95%)	*p* value	*β*	Model Indices	
Moderation model 1: Medication adherence from adolescent involvement (IBD-FRQ child-report), executive functioning ((BRIEF 2 SR T-Score), and family functioning (FAD General Scale)						
IBD-FRQ Child-Report	1.77 (10.14)	-19.84 – 23.38	0.86	0.00	*F(df)*	1.39 (5,15)
BRIEF2 SR Global Executive Composite T-Score	-0.19 (0.35)	-0.93 – 0.56	0.60	-0.58	R^2	0.32
FAD General Functioning	1.31 (5.49)	-6.85 – 4.06	0.81	-0.22	f^2	0.47
IBD-FRQ Child-Report X BRIEF2 SR Global Executive Composite T-Score	0.01 (0.16)	-0.33 – 0.34	0.97	0.02	*p*	0.28
IBD-FRQ Child-Report X FAD General Functioning	-1.39 (2.56)	-6.85 – 4.06	0.59	-0.15		
Moderation model 2: Medication adherence from adolescent involvement (IBD-FRQ parent-report), executive functioning ((BRIEF 2 SR T-Score), and family functioning (FAD General Scale)						
IBD-FRQ Parent-Report	1.83 (7.29)	-13.81 – 17.48	0.81	0.03	*F(df)*	1.96 (5, 14)
BRIEF2 SR Global Executive Composite T-Score	-0.20 (0.20)	-0.64 – 0.23	0.60	-0.71	R^2	0.41
FAD General Functioning	-0.95 (4.30)	-10.18 – 8.28	0.83	-0.40	f^2	0.70
IBD-FRQ Parent-Report X BRIEF2 SR Global Executive Composite T-Score	0.00 (0.10)	-0.22 – 0.21	0.97	-0.01	*p*	0.15
IBD-FRQ Parent-Report X FAD General Functioning	-0.96 (2.36)	-6.03 – 4.11	0.69	-0.10		

Figure 1. *Mediation Model of Executive Functioning, Adolescent Involvement (Child-Report), and Medication Adherence*



*p< .05, **p<.01

Figure 2. *Mediation Model of Executive Functioning, Adolescent Involvement (Parent-Report), and Medication Adherence*



*p< .05, **p<.01