Classification of Gastrointestinal Symptom Patterns in Young Adults

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Abstract

Background: The purpose of this study was to identify common GI symptom groups within a large sample of young adults based on Rome IV functional gastrointestinal (GI) disorder (FGID) symptom domains using the Patient-Reported Outcomes Measurement Information System - GI symptom scales (PROMIS-GI). The PROMIS-GI is a freely available, adaptable, symptom measurement system that is applicable to most health assessment situations.

Methods: Participants were 956 adults between the ages of 18 and 25 who completed the PROMIS-GI as part of ongoing research monitoring physical and psychological health of students at a major southeastern university. GI symptom groups were determined using a latent class analysis (LCA) approach. Homogenous groups of participants (latent classes) were then compared on key psychosocial factors including self-reported mood, anxiety, physical health related quality of life (HRQoL), and diet using MANOVA.

Results: Three groups were identified based on GI symptom elevations: Normal (n=649), Mild (n=257), and Moderate (n=50). Self-reported mood and anxiety levels were significantly higher in the mild and moderate GI symptom groups, and physical health HRQoL was significantly lower.

Conclusions: This study demonstrated that approximately a third of young adults surveyed were experiencing at least one GI symptom above normative levels. Both the mild and moderate GI groups demonstrated a similar configuration of symptoms with the highest relative elevations in pain, gas/bloating, and nausea/vomiting. Following the Rome IV diagnostic criteria, the configuration of symptoms for the mild and moderate groups were consistent with IBS mixed or unclassified subtypes. Self-reported anxiety and depression increased, and physical functioning decreased with the severity of GI symptoms. Mild to moderate GI symptoms appear to emerge at much earlier ages and are more frequent than previously documented. Based on this study’s findings, it is recommended that
health service providers evaluate patterns of GI health when young adults present with anxiety and depression, and conversely, they should assess anxiety and depression when they present with GI complaints.

Background

Functional gastrointestinal disorders (FGIDs) are characterized by persistent and recurring gastrointestinal (GI) symptoms that are a result of abnormal functioning of the GI tract and not associated with obvious structural or biochemical abnormalities. FGID includes any combination of the following: motility disturbance, visceral hypersensitivity, altered mucosal and immune function, altered gut microbiota, and altered central nervous system processing [1]. The Rome IV criteria contains 6 primary FGID domains for adults including: 1.) Esophageal Disorders, 2.) Gastroduodenal Disorders, 3.) Bowel Disorders, 4.) Centrally Mediated Disorders of GI Pain, 5.) Gallbladder and Sphincter of Oddi Disorders, and 6.) Anorectal Disorders. Each FGID is classified based on the patient’s report of symptom type and severity. One of the most studied FGID domains is Bowel Disorders. This domain is further separated into 6 subcategories including an IBS subcategory, the most frequently diagnosed GI disorder [2]. The Rome IV criteria describe FGIDs as a “spectrum of chronic GI disorders with combinations of symptoms ... existing on a continuum rather than as discrete disorders [3]. Multiple studies support this dimensional approach to the Rome IV criteria, providing scientific evidence that patients can transition from one disorder to another and may receive multiple diagnoses [2, 3, 5, 6].

A study within a general US adult population (n = 71,812, ages 18–65) used the National Institutes of Health (NIH) Patient-Reported Outcomes Measurement Information System GI scales (PROMIS-GI) to evaluate the prevalence of eight overarching FGID symptom domains: abdominal pain, bloating/gas, bowel incontinence, constipation, diarrhea, swallowing, reflux, and nausea/vomiting [7]. Sixty-one percent of their sample endorsed at
least one symptom within the past 7 days. Of those, 58.4% indicated they experienced two or more symptoms concurrently. A third of their sample population experienced reflux/heartburn, making it the most prevalent symptom. One quarter reported abdominal pain and a fifth of their participants’ experienced bloating, diarrhea, and constipation. This study included emerging adults in their population sample, finding that over 54% (n = 6,954) reported the occurrence of at least 1 FGID symptom within the past week. However, further descriptions of FGID symptoms within emerging adults were not provided.

Generally, emerging adults (age 18–25) are viewed as a physically healthy cohort [8] and consequently often overlooked in current GI health research. More recent epidemiological studies suggest that FGIDs are increasing in emerging adults [9, 10, 11]. As many as 65% of emerging adults are experiencing symptoms [12] and approximately one third are seeking medical care [13]. Of all the FGID syndromes, the most commonly studied in emerging adults is IBS. According to the ACHA-National College Health Assessment II national survey for the Fall 2017 semester, 3.2% of the undergraduate students surveyed (n = 5,789) had been diagnosed by a healthcare professional of having IBS [14]. Another study evaluated the frequency of self-reported IBS symptoms in college students demonstrating that 34% of the sample (n = 508, mean age: 22+/−2.8yrs) experienced clinical levels [13]. This previous research demonstrated a high incidence of IBS in the emerging adult population but is limited in that it does not capture a broader range of general GI distress or other clinical symptomatology. Emerging adulthood marks the shift from being dependent on a care provider to taking independent responsibility for seeking medical care [15]. Research indicate this population have decreased adherence to medication and attend fewer physician appointments [10, 16]. Furthermore, this period establishes fundamental health and self-
care behaviors that carry forward into adulthood [17, 18]. Adverse health behaviors have been observed in the amount of sleep, cigarette use, drinking, exercise, and eating habits of emerging adults [16, 18, 20].

The current understanding of FGIDs is supported by a biopsychosocial model [1], which places equal value in researching the patient’s reported experience of illness with the physical indicators of disease [19]. Additionally, researchers have identified a bi-directional communication pathway between the central nervous system and the GI tract, termed the gut-brain axis [1, 21]. The gut-brain axis suggests that changes in either the central nervous system or gut can disrupt the balance of the other. Therefore, psychosocial factors impacting the gut-brain axis could enhance the risk of developing GI symptoms, symptom severity, and affecting treatment outcomes [1, 21]. At present, the psychosocial factors involved in FGIDs include but are not limited to environmental, cultural, and psychosocial factors, including the composition of an individual’s gut microbiome, diet, and nutrition [21]. The biopsychosocial factors involved with FGIDs are illustrated in Fig. 1.

An environment with chronic and high levels of life stress has proven to be one of the strongest factors for developing FGIDs [19]. Emerging adults are especially susceptible to chronic stress as they transition into adulthood [23]. Stress provoking environments for emerging adults include attending college and adjusting to new social settings [24]. Consequently, the inability to properly cope with chronic stress frequently results in depression and maladaptive eating behaviors in emerging adults [18]. According to the latest Rome IV overview, psychosocial factors associated with the gut-brain axis that interact with the development and severity of FGIDs include mood disorders (depression and suicide ideation), anxiety disorders, somatization, and cognitive-affective processes [21].
Anxiety disorders are closely associated with the onset and duration of FGIDs. Studies have found that general anxiety disorders (GAD) are directly associated with the biological stress response processes, and as a result, can alter pain tolerance and motility [21]. In a sample of 604 college students (age = 20.93 ± 1.47 years), 36.9% endorsed IBS symptoms, according to Rome III criteria, with 13.9% presenting with both IBS and GAD [25]. Additionally, it’s been argued that anxiety disorders have a greater impact on the risk, comorbidity, and outcome of IBS than depression [26]. The prevalence of depression was found in 30% of medical-seeking patients presenting with FGIDs [27] with 15–38% of clinical patients with IBS presenting with suicidal ideation [28], while anxiety disorders were revealed in 30%-50% of clinical patients with FGIDs [21]. Only a few studies have evaluated GI symptoms and depression in an emerging adult population. One study with emerging adults found that 13.6% (n = 773) of their sample reported moderate to major depression [30]. The comorbidity of depression and anxiety can be associated with poor health outcomes and inferior quality of life [31, 32]. Experiencing chronic GI symptoms can also result in consequences for overall health-related quality of life (HRQoL), i.e. “...one’s general well-being, daily function status, and sense of control over the symptoms” (p. 1273) [1]. Studies have shown that HRQoL was significantly lower in individuals with IBS than healthy individuals [33]. However, studies concerned with health outcomes in emerging adults are very limited.

Problem Statement: Defining Patterns of FGID Symptoms in Emerging Adults

The purpose of this study was to identify common GI symptom groups within emerging adults based on Rome IV functional gastrointestinal (GI) disorder (FGID) symptom domains. A secondary goal was to identify psychosocial comorbidities within these groups.
To accomplish this task, the National Institutes of Health (NIH) Patient-Reported Outcomes Measurement Information System GI symptom scales (PROMIS-GI) was administered [34] which is freely available at www.healthmeasures.net. The PROMIS-GI has been validated to measure the multiple FGID symptom domains as specified in the Rome IV Criteria. The use of the PROMIS-GI scales afforded this study with a means to measure a broad range of GI functioning and symptom levels within a general emerging adult population group. To date, there is no comprehensive study exploring general GI functioning in the emerging adult population using the PROMIS-GI symptom scales. To identify common GI symptom patterns, a latent class analysis approach was employed. Latent class analysis (LCA) is a statistical method that allows the researcher to use a set of observed variables to identify hidden but meaningful patterns resulting in homogenous groups of participants (latent classes) [35]. Ideally these groups would represent symptom profiles corresponding to different FGID diagnostic categories.

Method

Participants

Undergraduates enrolled in introductory psychology courses at a large university in the southeastern United States were recruited to participate in ongoing research monitoring physical and psychological health for course credit. Introductory psychology is a required course in the general education curriculum for most majors at this university. Therefore, the undergraduate population and all majors were well represented. Eligibility criteria excluded vulnerable populations, required participants to be between the age of 18 and 25 years, and able to complete an online questionnaire in the English language. This study was approved by the UCF Institutional Review Board (IRB).

Measures
Demographic assessment. Demographic information collected in this study can be grouped by 1.) standard items (age, gender, race/ethnicity, marital status); 2.) socioeconomic 3.) current housing; and 4.) physiological profile (BMI, allergies, taking antibiotics, probiotics, or multivitamins). See Table 1 for a description of study participants on these variables.

The NIH PROMIS-GI symptom scales. The PROMIS-GI has been validated in studies as an effective PRO measure to be used in both clinical and general populations [34]. The PROMIS-GI scales evaluate eight GI symptom domains, of which this study focused on six: abdominal pain (6 items), gas/bloating (12 items), diarrhea (5 items), constipation (9 items), gastroesophageal reflux (GER) (13 items), and nausea/vomiting (4 items). Individuals’ scores are provided as a T-score metric with 50 representing the U.S. general population mean with a standard deviation (SD) of 10 [34]. This means the higher the T-score, the greater the severity of the symptom. T-scores were calculated by the scoring service available via the PROMIS website. T-scores were then converted into GI symptom severity levels using the suggested ranges of mild (T-scores between 55 and 60), moderate (T-scores between 60 and 70), and severe (T-scores above 80) as demonstrated in Fig. 2.

Patient Health Questionnaire (PHQ-9). To evaluate self-reported symptoms of depression, the Patient Health Questionnaire (PHQ-9) was administered. This instrument consists of 9 items, scored 0 (not at all) to 3 (nearly every day), with a total summary score of 27. Validated cut-off points include scores above 10 considered mild symptoms, and scores of 15 or greater indicating moderate to severe symptoms [36]. The PHQ-9 has been validated with other widely used instruments [36].

Generalized Anxiety Disorder 7-Item Scale (GAD-7). To evaluate self-reported symptoms of anxiety, the Generalized Anxiety Disorder Screener (GAD-7) was administered. This quantifies levels of general anxiety experienced within the past two weeks using a set of 7
questions [37]. The GAD-7 scored each question from 0 (not at all) to 3 (nearly every day) with a total score of 21. Summary scores of 5, 10, and 15 are frequently used as threshold values for mild, moderate and severe anxiety [37]. The GAD-7 was constructed using existing GAD criteria from the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV [37]. It has been validated in multiple studies [38].

36-Item Short Form Health Survey Physical Health Functioning Scale (SF-36PF). The SF-36PF was administered to measure the physical health status of participants. The SF-36PF is derived from four subscales: physical functioning, pain, role limitations based on physical health, and general health perception [39]. The mental health summary score was not used because of a high correlation with the PHQ-9 and GAD-7.

Mediterranean Diet Adherence Screener (MEDAS). The Mediterranean Diet is a frequently recommended dietary pattern by nutritional research and the USDA in their Scientific Report of the 2015 Dietary Guidelines Advisory Committee, Part D. Chapter 2 [40]. This study employed the validated 14-Item (MEDAS) to assess the quality of the participants’ diet. The 14-Item MEDAS is the English version of the original Spanish version [41]. It is scored (0–14) based on 14 questions [42]. This questionnaire has been validated in Spain and the United Kingdom [41, 42].

Procedure

The online survey totaled 198 questions. The survey took approximately 30 minutes to complete. Nine validity check questions were also included in the questionnaire to ensure data integrity. 291 subjects were eliminated because of inconsistent or random responding. The survey was generated using Qualtrics software (Qualtrics, Provo, UT).

Statistical Analysis

Severity ratings from the PROMIS-GI symptoms scales were analyzed in LatGold v5.1
(Statistical Innovations Inc.), a latent class analysis software package. LCA methods have the same goal as traditional cluster analysis, in that both attempt to create the largest between-cluster and smallest within-cluster differences. However, unlike standard cluster methods, LCA uses a probabilistic model-based approach rather than distance measures of dissimilarity [43]. The ideal model was based on appropriate model fit, the number of individuals per class, the certainty of being assigned to one class (membership probability), and significant difference between classes [44]. Class differences based on psychosocial factors were then explored using multivariate analysis of variance (MANOVA) analysis. Groups that differed significantly were compared at a pair level using the Tukey’s Honestly Significant Difference (Tukey’s HSD) test. A p value of < 0.05 was considered statistically significant. Both MANOVA and Tukey’s HSD tests were conducted in SPSS (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp.).

Results

The final study sample totaled 956 emerging adults between the age range of 18 and 25 (M = 18.97, SD = 1.47) with 58.3% identifying as female, and 57.3% identified as Caucasian. To evaluate the presence of GI symptoms within the emerging adult sample group, the T-scores derived from the PROMIS-GI symptoms scales were assigned a rating of 1 through 4, as illustrated in Fig. 2, marking symptom severity. Symptom prevalence was assessed using the severity scores. Using these ratings, frequencies were calculated using SPSS. As presented in Table 2, 36.4% of the emerging adult sample group presented with at least one GI symptom within the past 7 days. Next, latent class analysis (LCA) was conducted using the assigned symptom severity scores of 1–4 for each PROMIS-GI scale. A baseline model was created using a 1-Class (latent) cluster model [45]. Classes were subsequently added and compared to the baseline 1-Class model. Model sizes with up to 7
classes were calculated as there were no previous studies that suggested the number of classes for conducting a latent class analysis using the PROMIS-GI scales.

Table 3 provides an overview of the various information criteria considered in determining the best model fit. The information criteria consisted of the likelihood ratio chi-squared statistic (L2) and Bayesian Information Criterion (BIC) with lower values indicating improved model prediction of the data (p. 69) [46]. The L2 statistic calculates the similarity between model-based estimated frequencies and observed frequencies with smaller values indicating better model fit. The BIC accounts for model complexity and endorses model parsimony of the latent classes, and when using sample sizes larger than 500, proves to be a superior indicator to model fit compared to all other information criteria (p. 563) [47]. A more formal assessment of the model holding true for the population is determined by the p-value with p < 0.05 indicating a poor model fit. Due to some of the GI symptom severity levels containing small group sizes, a bootstrapping method was used to better assess the global fit of the model [47]. Additionally, entropy R-squared was evaluated for quality of membership classification with values closest to 1 indicating improved probability of an individual belonging to just one class [35]. Individual class sizes below 3% were considered too small for this study. Accordingly, the 4-Class model (and higher) were thus eliminated.

The 2-Class model had the lowest BIC; however, conducting a conditional bootstrap analysis revealed that the 3-Class model showed a statistically significant improvement over the 2-Class model (p < 0.05) for overall model fit, thus the 3-Class model was selected.

**Describing the Latent Classes (Groups)**

Differences between classes are graphically illustrated in Fig. 3 based on the T-Score means for each class. The differences between these classes are statistically significant
(p < .001) for each symptom domain. It was concluded that the 3-Class model adequately identified three unique latent classes that were informative to the study and could be defined based on their GI symptom patterns. The three classes or groups were described as Normal (649 individuals, 67.89%), Mild (257 individuals, 26.88%), and Moderate (50 individuals, 5.2%). Visual inspection of the profile of scale scores in Fig. 3 indicates that symptom severity marked the main difference between these groups. The mild group fell into what is likely a pre-clinical range with 3 symptom scores .5 SD above the normative population mean, while the moderate group was probably in the clinical range with 4 symptom scores 1 SD above the population mean. Both the mild and moderate GI groups demonstrated the highest relative symptom elevations in pain, gas/bloating, and nausea/vomiting. Both groups evidenced higher levels of nausea/vomiting than would be expected with typical IBS diagnoses. Taken together, the symptom patterns for the mild and moderate groups were consistent with IBS mixed or unclassified subtypes following the Rome IV diagnostic criteria.

**Group Differences on Psychosocial Factors**

Based on previous literature, this study hypothesized that the groups would differ on psychosocial factors with a decrease in psychosocial functioning as levels of GI symptoms increase (Mild and Moderate classes). Demographic analyses revealed differences between the three groups in the proportion of men and women ($\chi^2(2) = 75.431, p < .001$) with females more frequent in both the Mild and Moderate groups (Normal = 48.8%, Mild = 77.1%, Moderate = 84%). While no specific hypotheses were developed based on sex differences, it was necessary to include sex as an independent variable to account for this difference in proportions. A two-way MANOVA was run with two independent variables: Group and sex, and four dependent variables: depression (PHQ-9) score, anxiety (GAD-7)
score, physical health HRQoL summary score (SF-36 PF), and Mediterranean diet (MEDAS) score. The combined dependent variables were used to assess psychosocial functioning. There was a statistically significant main effect for group on the combined dependent variables, $F(8, 1896) = 23.322, p < .001$, Pillai’s $V = .179$, partial $\eta^2 = .090$. Follow-up univariate two-way ANOVAs were run, showing a statistically significant main effect of group on PHQ-9, $F(2, 950) = 47.924, p < .001$, partial $\eta^2 = .092$, GAD-7, $F(2, 950) = 54.438, p < .001$, partial $\eta^2 = .103$, SF-36PF, $F(2, 950) = 61.194, p < .001$, partial $\eta^2 = .114$, but not for the MEDAS. A post hoc Tukey pairwise comparison was conducted to evaluate the differences in mean psychosocial scores between group and these are presented in Table 4. To summarize, the mild group demonstrated significantly higher scores on the PHQ-9 and GAD-7 than the normal group. The mild group also showed significantly lower scores on the SF-36PF than the normal group. The moderate group in turn, demonstrated significantly higher scores on the PHQ-9 and GAD-7 than the mild group and they showed significantly lower scores on the SF-36PF than the mild group. Additionally, there was a statistically significant main effect of sex on the combined dependent variables, $F(4, 947) = 5.95, p < .001$, Pillai’s $V = .025$, partial $\eta^2 = .025$. Follow up univariate two-way ANOVAs showed a statistically significant main effect of sex for the SF-36PF, $F(1, 950) = 6.707, p = .010$, partial $\eta^2 = .007$, and MEDAS, $F(1, 950) = 16.794, p < .001$, partial $\eta^2 = .017$, but not for the PHQ-9, or the GAD-7. Taken together, all women demonstrated lower SF-36PF and higher MEDAS scores. The interaction effect between group and sex on the combined dependent variables was statistically significant, $F(8, 1896) = 2.638, p = .007$, Pillai’s $V = .022$, partial $\eta^2 = .011$. Follow up univariate two-way ANOVAs were run for each dependent variable. Analysis showed a statistically significant interaction effect between group and sex for the SF-36PF scores, $F(2, 950) = 8.301, p$
< .001, partial $\eta^2 = .017$, but not for the PHQ-9, GAD-7, or MEDAS. The main interaction effect between GI groups and sex was considered trivial due to the small effect size (partial $\eta^2 = .011$) and was not interpreted further.

**Discussion**

Recent studies have demonstrated that GI symptoms are common in the general population; however, there is limited information on patterns of GI symptoms in emerging adults, those between the ages of 18 and 25. This study reports on GI symptoms in a sample of 956 emerging adults to determine if meaningful patterns corresponding to the Rome IV diagnostic criteria would emerge. Self-reported GI symptoms were assessed using the freely available PROMIS-GI scales. Latent class analyses revealed that 32% of the emerging adults surveyed here experienced one or more GI symptom above normative ranges, and 5.5% of the sample reached levels of GI symptom severity associated with clinical diagnoses. Three latent GI classes or groups were identified, Normal ($n = 649, 67.89\%$), Mild ($n = 257, 26.88\%$), and Moderate ($n = 49, 5.2\%$). Additionally, groups differed in the proportion of men and women. The Mild and Moderate GI Symptom groups had more females.

GI symptom severity marked the main difference between the three groups and both the mild and moderate GI groups demonstrated a similar configuration of symptoms with elevations in pain, gas/bloating, and nausea/vomiting relative to the other symptom domains. Visual inspection of Fig. 3 while considering the Rome IV diagnostic criteria suggests that the configuration of symptoms for the mild and moderate groups were consistent with IBS mixed or unclassified subtypes following the Rome IV diagnostic criteria. The symptom overlap across the mild and moderate groups supports the proposition that GI disorders exist on a continuum and that emerging adults can transition
from one domain to another in their experience of symptoms (p. 4) [3].

The two previous studies on GI symptoms in emerging adults found even higher rates of GI symptoms in college students. In one, 51.2% of Canadian-based university students endorsed at least one GI symptom [48] and in another 65% of Korean-based nursing students reported more than one GI symptom [12]. The high incidence of GI symptoms in this age range is surprising. However, both studies used high achieving college or professional students under high stress [23]. Collectively these findings may reflect a relationship between GI functioning and stress among the other factors discussed.

Previous cluster analytic/LCA studies have combined GI symptom data and other non-GI data such as stress, fatigue, sleep, depression, etc. in their statistical approach to establish diagnostic classes or groups [49, 50]. This has led to groups that are difficult to classify based on Rome IV criteria because physical and psychosocial symptoms confounded, and causal modeling becomes circular. In the current study, the GI symptom groups were formed first and then individuals were compared on widely used clinical screening measures for depression, anxiety, and HRQoL. The Moderate GI symptom group met the PHQ-9 threshold score of 10 or higher for moderate or severe depression, and the Moderate GI symptom group met the GAD-7 threshold for moderate anxiety levels. This is consistent with other studies that have found that GI symptoms are frequently associated with anxiety and depression [26-30, 33]. For example, previous studies showed 13.9% of their sample presented with both IBS and anxiety [25] and another found 30% of their patients presented with FGIDs and depression [27].

The GI symptoms and associated psychosocial measures found in this study are consistent with the existence of a gut-brain axis communication pathway. The bi-directional communication between the gut and brain is integral in maintaining homeostasis and an imbalance in either can have adverse consequences [51]. Following this theory,
psychosocial functioning can excite or suppress the GI system, or GI functioning can excite or suppress psychosocial functioning [29]. This study observed that the level of GI symptom severity was strongly associated with greater impairment in mood, anxiety and HRQoL.

Although diet did present as a differentiating factor between the three subgroups, its effect was very small. The composition of the microbiota is fundamentally established during 0–2 years of age [51] and therefore the influence of diet on gut functioning may be more subtle at this stage of life. The effect of diet on gut functioning (and the microbiota) may need to be manipulated in a more intentional and targeted way to reveal more significant relationships.

Limitations. The emerging adult population used here was from a university sample, thus generalizing results to the entire population of emerging adults remains to be determined. However, the sample was from a general psychology class, required by all students, regardless of their major. The participants were not presenting for medical treatment and did not receive a medical exam or diagnosis from a physician. This study was a cross-sectional study and thus causation could not be determined. Two PROMIS-GI scales were excluded from the survey measures; one focused on disrupted swallowing and the other on bowel incontinence. Furthermore, several studies suggest that GI symptom severity increases during menstruation [52], however, this came to our attention after the study began and we did not account for possible interactions between menses and belly pain.

Future directions. Including all PROMIS-GI measures in future research would provide a broader scope of GI functioning. Furthermore, additional insight will be gained by comparing the GI symptom groups on other demographic and psychosocial measures. Future studies should consider measuring GI and psychosocial variables over repeated intervals with a time-series design. That way possible cause and effect relationships may
be determined. Future research evaluating GI symptoms in emerging adults should include healthcare seeking measures to determine the likelihood that this population has sought treatment for their GI or psychosocial symptoms. Additionally, stool diaries, and assessment about menses related pain should be considered in future research. Based on this study’s findings, it is recommended that health service providers evaluate patterns of GI health when young adults present with anxiety and depression, and conversely, they should assess anxiety and depression when they present with GI complaints.

Abbreviations

ACHA: American College Health Association; ANOVA: Analysis of Variance; BIC: Bayesian Information Criterion; BMI: Body Mass Index; df: degrees of freedom; FGID: Functional Gastrointestinal Disorder; GAD-7: Generalized Anxiety Disorder 7-item (GAD-7) scale; GI: Gastrointestinal; HRQoL: Health Related Quality of Life; IBS: Irritable Bowel Syndrome; LCA: Latent Class Analysis; $L^2$: Likelihood-Ratio; MANOVA: Multivariate Analysis of Variance; MEDAS: Mediterranean Diet Adherence Screener; NIH: National Institutes of Health; p: p-value; PHQ-9: Patient Health Questionnaire 9; PROMIS-GI: Patient-Reported Outcomes Measurement Information System-GI symptom scales; SF-36PF: 36-Item Short Form Health Survey Physical Health Functioning Scale; Tukey’s HSD: Tukey’s Honestly Significant Difference test; UCF: University of Central Florida; USDA: United States Department of Agriculture

Declarations

**Ethics approval and consent to participate:** The protocol (anonymous survey) received a waiver for the need for written informed consent, which was approved by the UCF institutional review board (IRB).

**Consent for publication:** Not Applicable
Availability of data and materials: The dataset used in the current study is available at the ResearchGate repository for Jeffrey E. Cassisi in the file: GI Demographic and Cluster Analysis Data.Sav. DOI: 10.13140/RG.2.2.16826.75209 https://www.researchgate.net/publication/338951233_Demographic_and_Cluster_Analysis_Data

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Authors’ Contributions: HV, EJR, and JEC contributed to the conception and the design of the study. Author HV also performed data acquisition, analysis, and wrote the first draft of the manuscript. All authors substantially contributed to the interpretation of data and contributed to and approved the final revision of the manuscript. All authors have agreed to be both personally accountable for their contributions and to ensure that questions related to the accuracy or integrity of any part of the work are appropriately investigated, resolved, and such resolution is documented in the literature.

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**Tables**
Table 1 Descriptive Characteristics of Participants

| Variable                      | n   | %    |
|-------------------------------|-----|------|
| Age                           |     |      |
| 18                            | 515 | 53.9%|
| 19                            | 222 | 23.2%|
| 20                            | 94  | 9.8% |
| 21                            | 52  | 5.4% |
| 22                            | 33  | 3.5% |
| 23                            | 19  | 2.0% |
| 24                            | 10  | 1.0% |
| 25                            | 11  | 1.2% |
| Sex                           |     |      |
| Male                          | 399 | 41.7%|
| Female                        | 557 | 58.3%|
| Race/ethnicity                |     |      |
| Non-Hispanic white            | 548 | 57.3%|
| Non-Hispanic black            | 114 | 11.9%|
| Puerto Rican                  | 51  | 5.3% |
| Mexican-American              | 14  | 1.5% |
| Other Hispanic                | 108 | 11.3%|
| Asians                        | 92  | 9.6% |
| American Indian               | 10  | 1.0% |
| Other                         | 19  | 2.0% |
| Identified with 2+ ethnicities| 81  | 8.5% |
Living Arrangements

On campus 474 49.6%
Off campus 482 50.4%

Total Household Income

| Income Range          | Frequency | Percentage |
|-----------------------|-----------|------------|
| 0-50,000              | 362       | 37.9%      |
| 50,001-100,000        | 295       | 30.9%      |
| 100,001-150,000       | 166       | 17.4%      |
| ≥ 150,001             | 133       | 13.9%      |

Health

| Condition                        | Frequency | Percentage |
|----------------------------------|-----------|------------|
| Allergies                        | 300       | 31.4%      |
| Currently taking antibiotics     | 48        | 5.0%       |
| Taking antibiotics past 2 months | 197       | 20.6%      |
| Taking probiotics                | 89        | 9.3%       |
| Taking multivitamins             | 356       | 37.2%      |
| Currently a smoker               | 130       | 13.6%      |

Body Mass Index (BMI)

| BMI Category                      | Frequency | Percentage |
|-----------------------------------|-----------|------------|
| Underweight ≤ 18.5                | 47        | 7.9%       |
| Normal weight = 18.5 - 24.9       | 629       | 65.8%      |
| Overweight = 25 - 29.9            | 168       | 17.6%      |
| Obesity = BMI of 30 or greater    | 112       | 11.7%      |

Table 2 Frequency of GI Symptom Severity Found across all Participants (n=956)

| GI Symptom Severity | Belly Pain | Constipation | Diarrhea | Gas/Bloating | Nausea/Vomiting | Ref. |
|---------------------|------------|--------------|----------|--------------|-----------------|------|
| Within Normal Limits (1) | 750 (78.5%) | 845 (88.4%) | 870 (91%) | 608 (63.6%) | 699 (73.1%) | 8!   |
| Mild (2)            | 99 (10.4%) | 77 (8.1%)   | 53 (5.5%) | 247 (25.8%) | 142 (14.9%) | 4!   |
| Moderate (3)        | 91 (9.5%)  | 34 (3.6%)   | 32 (3.3%) | 99 (10.4%)  | 105 (11%)    | 1!   |
| Severe (4)          | 16 (1.7%)  | -            | 1 (0.1%)  | 2 (0.2%)    | 10 (1%)      | 1    |
| Presenting with Symptoms | 206 (21.6%) | 111 (11.7%) | 86 (8.9%) | 348 (36.4%) | 257 (26.9%) | 6!   |

Note. Levels of severity were interpreted using the threshold range guidelines developed by the NIH to be used with their PROMIS measures. Within Normal Limits = T-scores < 55; Mild = T-Scores between 55 and 60; Moderate = T-Scores between 60 and 70; Severe = T-scores > 70. There was no endorsement for severe constipation within the sample.
### Table 3 Summary of Statistical Model Fit Statistics Used for Model Selection

| Model               | BIC     | $L^2$     | df  | $p$  | Entropy |
|---------------------|---------|-----------|-----|------|---------|
| Baseline 1-Class Model | 6798.2738 | 1185.6210 | 940 | 1.00 | 1.00    |
| 2-Class Model       | 6339.2847 | 603.0833  | 922 | 0.0020 | 0.7033 |
| 3-Class Model       | 6344.9257 | 485.1760  | 904 | 0.0980 | 0.6426 |
| 4-Class Model       | 6426.8327 | 443.5345  | 886 | 0.0640 | 0.6548 |
| 5-Class Model       | 6518.9844 | 412.1377  | 868 | 0.0119 | 0.6022 |
| 6-Class Model       | 6624.2116 | 393.8164  | 850 | 0.0142 | 0.6939 |
| 7-Class Model       | 6722.1687 | 368.2251  | 832 | 0.0103 | 0.7045 |

*Note.* Comparison between the 2-Class and 3-Class are shown with values in bold indicating optimal values. The 4-Class and higher models did not meet the minimum group size criteria. BIC = Bayesian information criterion; $L^2$ = Likelihood-ratio; df = degrees of freedom; $p = p$-value; Entropy = quality of predicting model classification with values closer to 1 preferred.

$a$ $p$ value calculated using bootstrap method.

### Table 4 Comparison of GI Symptom Groups and Psychosocial Variables

| Variables | Latent classification GI group Mean (SD) | MANOVA main effect | Post hoc test Mean difference sigr |
|-----------|------------------------------------------|--------------------|-----------------------------------|
|           | Normal (n=648)  | Mild (n=258)  | Moderate (n=50) | $F$  | $p$  | $\eta^2$ | Normal (v) | Normal (v) | Mild (v) | Moderate (v) | Mil (v) | Moderate at |
| PHQ-9     | 4.90 (4.57) | 8.47 (5.63) | 10.30 (6.525) | 47.924 | $< 0.001$ | 0.092 | *** | *** | * |
| GAD-7     | 3.95 (4.43) | 7.57 (5.58) | 10.60 (4.45) | 54.438 | $< 0.001$ | 0.103 | *** | *** | ** |
| SF-36PF   | 85.24 (10.85) | 78.12 (13.69) | 68.91 (18.37) | 61.194 | $< 0.001$ | 0.092 | *** | *** | ** |

*Note.* Post-hoc comparisons were evaluated using Tukey’s HSD and are marked according to the degree of significant difference. PHQ-9 = Patient Health Questionnaire; GAD-7 = Generalized Anxiety Disorder; SF-36PF Summary scale for physical functioning. * $p < .05$. ** $p < .01$. *** $p < .001$. |
The Biopsychosocial Model of FGIDs Adapted from D.A. Drossman [1].

Figure 1

Coding Symptom Severity Range from PROMIS T-Score Note. Symptom severity ratings were based on the recommended PROMIS T-Score ranges, using the mean of 50 and standard deviation (SD) of 10. Normal limits (1) = t-scores < 55; Mild (2) = t-scores between 55 – 60; Moderate (3) = t-scores between 60 – 70; Severe (4) = t-scores > 70. Adapted from http://www.healthmeasures.net/score-and-interpret/interpret-scores/promis
Figure 3

3-Class Model Profile Plot Using Conditional Mean T-Scores per Class Note.

PROMIS T-Score ranges for GI symptoms include Normal limits = < 55; Mild = between 55 – 60; Moderate = between 60 – 70; Severe = > 70.