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Mixture Modeling to Characterize Anorexia Nervosa: Integrating Personality and Eating Disorder Psychopathology

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Abstract

BACKGROUND: Efforts to examine alternative classifications (e.g., personality) of anorexia nervosa (AN) using empirical techniques are crucial to elucidate diverse symptom presentations, personality traits, and psychiatric comorbidities.

AIM: The purpose of this study was to use an empirical approach (mixture modeling) to test an alternative classification of AN as categorical, dimensional, or hybrid categorical–dimensional construct based on the co-occurrence of personality psychopathology and eating disorder clinical presentation.

METHOD: Patients with AN (N = 194) completed interviews and questionnaires at treatment admission and 3-month follow-up. Mixture modeling was used to test whether indicators best classified AN as categorical, dimensional, or hybrid.

RESULTS: A four-latent class, one-latent dimension mixture model that was variant across groups provided the best fit to the data. Results suggest that all classes were characterized by low self-esteem and self-harming and suicidality tendencies. Individuals assigned to Latent Class 2 (LC2; n = 21) had a greater tendency toward being impulsive and easily angered and having difficulties controlling anger compared with those in LC1 (n = 84) and LC3 (n = 66). Moreover, individuals assigned to LC1 and LC3 were more likely to have a poor outcome from intensive

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Dr. Jennings conceptualized the study, carried out the initial analyses, drafted the initial manuscript, and reviewed and revised the manuscript. Dr. Wildes designed the study, coordinated and supervised data collection, and reviewed and revised the manuscript for important intellectual content. Dr. Crosby supervised data analyses and reviewed and revised manuscript for important intellectual content. Drs. Bodell and Haynos reviewed and revised manuscript for important intellectual content. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Declaration of Conflicting Interests

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Supplemental Material

Supplemental material for this article is available online.

treatment compared with those in LC4 (n = 21). Findings indicate that the dimensional aspect within each class measured frequency of specific eating disorder behaviors but did not predict treatment outcomes.

CONCLUSION: These results emphasize the complexity of AN and the importance of considering how facets of clinical presentation beyond eating disorder behaviors may have different treatment and prognostic implications.

Keywords

anorexia nervosa; classification; eating disorders; mixture modeling; personality

Introduction

Revisions to the *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition* (*DSM-5*), and International Classification of Diseases (ICD-11) have advanced eating disorders (ED) classification, improved the diagnostic process, and provide a common language for clinicians and researchers (Crosby et al., 2011; Keel, Brown, Holland, & Bodell, 2012). However, treatment response rates within ED continue to vary, with anorexia nervosa (AN) having the highest chronicity, service utilization, and costs of all ED (Hay et al., 2014; Watson & Bulik, 2013), and up to half of patients with AN remain ill at 6-year follow-up (Smink, van Hoeken, & Hoek, 2013). Moreover, substantial within-diagnosis heterogeneity contributes to diagnostic crossover within AN (Lavender et al., 2011; Wildes, Forbush, & Markon, 2013). Thus, an examination of within-group differences may lead to targets for novel interventions and promote positive treatment responses.

In an attempt to unravel within-diagnosis heterogeneity, studies have used empirical techniques to investigate alternative classifications of AN based on dietary restraint and negative affect (Forbush, Hagan, Salk, & Wildes, 2017), or either homogenous ED psychopathology (Peterson et al., 2016; Wildes et al., 2013) or personality features (Gazzillo et al., 2013; Haynos et al., 2018; Keel et al., 2012; Lavender et al., 2013; Wildes et al., 2011). One study examined ED symptoms as indicators and identified three homogenous AN subtypes (fat-phobic restricting, fat-phobic binge eating/purging, non-fat-phobic restricting), which were stable over 1-year follow-up (Wildes et al., 2013). Empirical approaches to AN classification based on comorbid psychopathology consistently have identified three personality subtypes: underregulated (e.g., emotionally, behaviorally dysregulated; high on self-harm, aggression/opposition, impulsivity; stimulus seeking/exhibitionism), overregulated (e.g., compulsive, inhibited), and normative (e.g., low levels of personality pathology; Farstad, McGeown, & von Ranson, 2016; Gazzillo et al., 2013; Keel et al., 2012; Lavender et al., 2013; Wildes et al., 2011). Importantly, these personality subtypes have demonstrated clinical utility in predicting treatment outcomes (Wildes et al., 2011).

Although studies to date provide evidence for distinct AN subgroups based on ED psychopathology or personality features, no study has integrated ED symptoms and personality traits into one model. Integrating both features in empirical AN classifications may help elucidate the extent to which there are patterns in the co-occurrence of personality

features and ED symptom presentations and explain additional within-diagnosis heterogeneity. More precise subgroups of individuals with AN could inform novel treatments that map on to specific clinical presentations. Thus, an examination of the co-occurrence of ED symptoms and personality traits, within an AN sample, and its influence on treatment outcomes is warranted.

Furthermore, prior latent structure studies have focused on categorical models, dichotomized ED behaviors, and have not incorporated a dimensional aspect into alternative classifications. A dimensional aspect suggests that psychopathology exists on a continuum and reflects differences in degree rather than groups within a population, which may better capture the heterogeneity in AN. Mixture modeling incorporates aspects of factor and latent class analyses (LCA) to test whether associations among a set of observable criteria can be characterized in terms of categories (i.e., categorical), dimensions (i.e., dimensional), or a combination of categories and dimensions (i.e., hybrid categorical–dimensional). To our knowledge, one study has used mixture modeling to test the latent structure of AN on the basis of quality-of-life and ED history and pathology (Wildes et al., 2016). This three-factor, two profile model suggests that individuals with AN can be classified on ED behaviors and quality of life and that chronicity varies dimensionally within each class.

The purpose of this study was to use mixture modeling to evaluate whether AN is best represented by a categorical, dimensional, or hybrid categorical–dimensional model based on the co-occurrence of ED symptoms and personality psychopathology, and to evaluate the relationship between the best-fitting model and treatment response. We predicted that the best-fitting model would include both latent categories and latent dimensions; and, hypothesized that three empirically derived AN subgroups would emerge, namely, AN-R with fat phobia and overcontrolled personality, AN-BP with fat phobia and undercontrolled personality, and AN-R without fat phobia and low personality psychopathology.

Method

Sample

Participants were recruited from consecutive admissions ($N = 256$) to the inpatient and day hospital ED programs at an academic medical center between April 2008 and April 2011. After hearing a study description, 194 individuals (75.8%) consented to participate. Inclusion criteria were: age ≥16 years, admission body mass index (BMI) <18.5 or BMI percentile <10 (aged 16-19 years), and medical stability. AN diagnoses were made using *DSM-IV* criteria except amenorrhea was not required. Additionally, individuals who denied fear of fatness *and* had a BMI <17.5 were included ($n = 27$; 14%) because research has suggested a subgroup of individuals who are underweight and deny weight phobia (“non-fat-phobic”) in Western and non-Western environments, and this subtyping scheme (with and without intense fear of weight gain or becoming fat) was considered but not adopted for inclusion in *DSM-5* (Racine & Wildes, 2015; Wildes et al., 2013). One participant was excluded because of missing data, resulting in a final sample of 193 participants. Table 1 provides sample characteristics.

Procedures

The study was approved by the institutional review board, adhered to the latest version of the Declaration of Helsinki, and individuals provided informed consent (or assent for individuals below the age of 18 years). Participants completed baseline questionnaires and interviews within 2 weeks of admission and discharge, and at 3, 6, and 12 months post discharge. Follow-up assessments were conducted in-person or by phone and mail. Interviewers were research clinicians trained and supervised by two experienced psychologists.

Measures

An investigator-designed questionnaire was administered to assess demographics and treatment history. Medical charts were reviewed at discharge to obtain: (a) days in intensive treatment, (b) level of care (i.e., inpatient, day treatment, or both), and (c) discharge type (i.e., planned, against medical advice). Height and weight were measured to calculate BMI. Participants were weighed on a digital scale in a hospital gown without footwear, and height was measured with a stationary stature board.

The Structured Clinical Interview for *DSM-IV-TR* Axis I Disorders (First, Spitzer, Gibbon, & Williams, 2007) was used to diagnose lifetime and current eating, mood, anxiety, and substance use disorders. Interrater reliabilities were good ($\kappa = 0.64$ to $\kappa = 1.00$).

The Eating Disorder Examination (EDE, 16th edition; Fairburn, Cooper, & O'Connor, 2008), a semistructured interview, assessed frequency and severity of ED behaviors and cognitions. Internal consistencies of EDE subscales (Restraint, Eating Concern, Shape Concern, and Weight Concern) and Global scale ranged from .65 to .94 in the current sample.

The Schedule for Nonadaptive and Adaptive Personality (Second Edition; Clark, Simms, Wu, & Casillas, 2014), a 390-item questionnaire, measured personality traits. Extreme scores ($t < 35$ or $t > 65$) suggest the presence of psychopathology and moderate scores ($t =$ 35-45 or $t =$ 55-65) suggest a tendency toward personality dysfunction. Four subscales (Self-Harm, Impulsivity, Exhibitionism, and Aggression) were used as indicators in the mixture modeling, because they reflect basic dimensions of personality that are common to models of personality functioning (Widiger, Livesley, & Clark, 2009) and have been used in previous ED research to distinguish between undercontrolled and overcontrolled personality subtypes (Farstad et al., 2016). In the current sample, internal consistencies ranged from .82 to .89.

The McKnight Follow-up of Eating Disorders (Agras, Crow, Mitchell, Halmi, & Bryson, 2009; Wildes et al., 2011) assessed service use after discharge, including admission(s) to intensive treatment and receipt of outpatient psychotherapy and psychotropic medications. Interrater agreement for categorical ratings of any treatment was excellent ($\kappa s = 1.00$).

Statistical Analyses

Indicators.—Indicator variables were identified from prior studies of latent structure analyses in AN. For ED presentation, indicators included baseline variables including: 3-month frequency of objective binge-eating episodes, subjective binge-eating episodes, and purging (i.e., self-induced vomiting, laxative, or diuretic misuse), fear of weight gain (≥4 on the fear of weight gain item), overvaluation of weight and shape (≥4 on overvaluation of weight and shape items), length of AN illness (years), and BMI. For fear of weight gain and overvaluation of weight and shape, categorical data were used to minimize model complexity related to the sample size (Collins & Lanza, 2010). Indicators for personality traits were *t* scores on four Schedule for Nonadaptive and Adaptive Personality, Second Edition subscales (Self-harm, Exhibitionism, Aggression, Impulsivity). Outliers (i.e., values >3 times the interquartile range) were identified using boxplots for frequency of ED behaviors and recoded to the next highest value.

Mixture Modeling.—Mixture modeling incorporates a sequence of LCA, factor analyses (FA), and factor mixture analyses (FMA) to characterize a set of observable criteria in terms of distinct subgroups (LCA), a single group with multiple dimensions (FA), or a combination of subgroups and dimensions (FMA). Analyses were conducted in M*plus* Version 7 (Muthén & Muthén, 1998-2015), and missing data were handled using full information maximum likelihood estimation. Based on previous research (Keel, Crosby, Hildebrandt, Haedt-Matt, & Gravener, 2013; Wildes et al., 2016), a series of models that included length of illness, BMI, ED symptoms, and comorbid personality psychopathology were compared with LCA models ranging from 2 to 4 classes, FA models ranging from 1 to 2 factors, and FMA models combining 1 to 2 factors and 2 to 4 classes. Time until assessment was included as a covariate to minimize the influence of between-subject differences in the number of days between admission to treatment and initiation of study procedures. AN subtype was also included as a covariate to minimize the influence of *DSM*AN diagnosis. Models were compared on multiple fit indices—Akaike information criterion (AIC), Consistent AIC (cAIC), Bayesian information criterion (BIC), and adjusted BIC (aBIC) with the lowest values indicating the best-fitting model. For categorical models, entropy was used to determine model fit with higher values indicating the ability to assign individuals to a latent category with high confidence.

Analyses of variance with Tukey's honestly significant difference post hoc test for continuous variables or chi-square tests for categorical variables were performed using SPSS© software version 22 (IBM, released 2013) to characterize length of AN, baseline BMI, ED pathology, and personality traits among latent classes. Differences among latent classes in baseline demographics and clinical characteristics were examined using similar analyses. Homogeneity of variance was confirmed; and, if the assumption was not met, a nonparametric test was used. To protect against Type I error, α was set at .01.

Response to Treatment and Risk for Readmission.—To evaluate differences among latent classes in response to intensive treatment, the following outcomes were used: discharge against medical advice and poor outcome at discharge, which was a categorical rating adapted from the Morgan–Russell criteria (Morgan & Russell, 1975). A "poor"

outcome at discharge was based on BMI ≤17.5 or ≥4 binge-eating/purging episodes during the past 28 days regardless of weight status. Analyses were conducted to identify covariates based on previous research and clinical relevance. Next, multivariate analyses were performed using a sequential approach, with significant covariates entered in the first step and planned contrasts comparing latent classes in the second step. Improvement in model fit from Step 1 to Step 2 served as an index of the utility of latent classes as predictors of treatment response relative to existing predictors. Logistic regressions were conducted to examine poor outcome at discharge, discharge against medical advice, and readmission to intensive treatment within 3 months of discharge.

Results

Latent Structure Analyses

Table 2 presents the model fit statistics for LCA, FA, and FMA. Table 3 includes the means and ranges for the posterior probabilities. The one dimension, four latent class model was the best-fitting model, suggesting that AN was best conceptualized as four distinct categories and a dimension representing frequency of behaviors or severity.

To address whether the dimension was comparable across classes, metric invariance analyses comparing a model in which the latent dimension was equal across the latent classes (invariance) and a model in which the latent dimension was free to vary across latent classes (noninvariance) were conducted. The noninvariance model provided improved fit (log likelihood = −6363.23, parameters = 74, AIC = 12874.45, cAIC = 13189.89, BIC = 13115.89, aBIC = 12881.48, entropy = .879) compared with the invariance model (log likelihood = −6685.23, parameters = 70, AIC = 13510.58, cAIC = 13808.97, BIC = 13738.97, aBIC = 13517.23, entropy = .996). Thus, the latent dimension was comparable within but not across latent classes.

Characterization of Latent Classes

Using the proportions for the latent classes based on most likely latent class membership statistics, participants were assigned to Latent Class 1 (LC1; $n = 84$), Latent Class 2 (LC2; $n = 21$), Latent Class 3 (LC3; $n = 67$) or Latent Class 4 (LC4; $n = 21$). Table 4 presents distributions of ED pathology and personality traits and Table 4 presents demographic and clinical characteristics.

Regarding eating behaviors, LC1 had decreased frequency of objective binge eating and purging compared with the other classes and decreased frequency of subjective binge eating compared with LC4. Consistent with the *DSM* subtypes, LC1 included individuals with AN-R and the other three classes included individuals with AN-BP. Of the three latent classes consisting of AN-BP, LC4 had significantly greater frequency of objective binge eating compared with LC2 and LC3. Additionally, LC2 and LC4 had significantly greater frequency of purging compared with LC3. There were no significant differences among latent classes for BMI, AN duration, fear of weight gain, and overvaluation of weight and shape. Overall, findings suggest that frequency of purging and objective binge eating contributed to categorical distinctiveness.

There were differences in personality psychopathology among the classes. LC2 had a higher mean Aggression *t* score compared with LC1 and LC3 (M = 62.89 vs. 50.73 and 52.34, respectively). Specifically, the mean *t* score for LC2 was moderately elevated (t = 55-65) and the mean *t* scores for LC1 and LC3 were within normal range (t = 45-55). Additionally, LC2 and LC4 had higher mean Impulsivity *t* scores compared with LC1 and LC3. However, only the mean *t* score for LC2 was moderately elevated (t = 55-65) suggesting a tendency toward being more impulsive. LC1 had a lower mean Self-Harm *t* score compared with LC2 and LC4 (M = 64.98 vs. 79.69 and 80.24, respectively). The mean Self-Harm *t* score for LC1 was moderately elevated (t = 55-65) suggesting a tendency toward dysfunction in this domain and the mean Self-Harm *t* scores for LC2 and LC4 were elevated (t > 65) indicating presence of psychopathology. There were no significant differences in mean Exhibitionism *t* scores with scores ranging from normal to moderately low. Overall, results suggest that personality traits of impulsivity and aggression contributed to categorical distinctiveness.

There were no differences among latent classes in age, sex, race, lifetime history of mood disorder, and lifetime history of anxiety disorder (Table 5). However, there was a difference in lifetime substance use disorder, $\chi^2(3) = 23.60$, $p < .001$. LC4 had more individuals who endorsed a lifetime history of substance use disorder compared with other latent classes.

Latent Classes and Response to Intensive Treatment[1]

Preliminary analyses were conducted to characterize treatment between latent classes ($\alpha = .01$). There were no differences in rate of weight gain ($p = .98$), level of care ($p = .18$), and discharge BMI ($p = .24$). Individuals in LC4 spent fewer days in acute treatment compared with those in LC1 (M = 32.76 vs. 52.01), but this effect was not significant after controlling for level of care, $F(2, 188) = 3.41$, $p = .02$, partial $\eta^2 = .05$.

Three variables were significant univariate predictors of poor outcome at discharge (i.e., age, repeated hospitalizations, and discharge against medical advice) and were included as covariates in regression analyses. Latent classes contributed significantly to the model predicting poor outcome from intensive treatment, Step 2 $\chi^2(2) = 8.84$, $p = .03$, Δ Cox and Snell $R^2 = .04$; Overall $\chi^2(7) = 58.91$, $p < .001$, Cox and Snell $R^2 = .28$. Specifically, individuals assigned to LC1 and LC3 were more likely to have a poor outcome from intensive treatment compared with those in LC4. Number of days in intensive treatment was the significant univariate predictor of discharge against medical advice. Latent classes did not contribute to the model predicting discharge against medical advice, controlling for the covariate.

Latent Classes and Readmission to Intensive Treatment

One hundred fifty-eight participants (81.9%) provided 3-month follow-up data. There were no significant differences among latent classes in rate of follow-up ($p = .05$, Cohen's $d = .20$). Three variables were significant univariate predictors of readmission to intensive treatment within 3 months after discharge (EDE Global discharge score, length of AN

[1] *DSM-IV* AN subtype did not contribute to models predicting poor outcome, risk of discharge against medical advice, and risk for readmission, after controlling for covariates.

illness, repeated hospitalizations). Latent classes did not contribute to the model predicting readmission to intensive treatment, controlling for covariates.

Dimension, Response to Intensive Treatment, and Readmission Within 3 Months After Discharge

Class-specific dimension scores derived from the best-fitting mixture model were used to validate the dimension within each class.[2] First, correlations between dimension scores and indicators were evaluated. For LC1, the dimension score was positively correlated with frequency of purging ($r = .91$, $p < .001$). Frequency of purging was positively correlated with LC2's dimension score ($r = 1.00$, $p < .001$) and impulsivity was negatively correlated ($r = -.45$, $p = .04$). The LC3 dimension score was positively correlated with frequency of purging ($r = 1.00$, $p < .001$), frequency of subjective binge eating ($r = .42$, $p = .001$) and Self-Harm t scores ($r = .256$, $p = .04$). Finally, the LC4 dimension score was positively correlated with frequency of purging ($r = 1.00$, $p < .001$) and frequency of objective binge eating ($r = .57$, $p < .007$). Based on these correlations, the dimension scores for LC1 and LC4 may assess frequency of behaviors versus severity of illness; whereas, scores for LC2 and LC3 may be more multidimensional and measure severity of illness based on frequency of behaviors and personality. Dimension scores within each class did not contribute to the models predicting discharge against medical advice, poor outcome, and readmission to intensive treatment.

Discussion

This study tested a novel approach to characterizing within-diagnosis heterogeneity in AN that incorporated both ED symptoms and personality traits. Using mixture modeling, patients with AN were grouped into classes that differed with respect to the co-occurrence of ED symptoms and personality traits. Moreover, within each class, there was dimensional variability based on ED behaviors (i.e., binge eating, purging) and personality features (i.e., impulsivity, self-esteem, self-harm, and suicidality), which recognizes further within-group heterogeneity in clinical presentation. Latent classes predicted poor outcome from intensive treatment, whereas scores on the dimension within each class did not predict treatment outcomes or follow-up. These results emphasize the complexity of AN and the importance of considering how facets of clinical presentation affect treatment progression and outcome and prognostic implications.

Partly similar to prior AN research (Gazzillo et al., 2013; Lavender et al., 2013; Wildes et al., 2011), one of the latent classes represented an "underregulated" phenotype (LC2) and was characterized by lower self-esteem and greater self-harm/suicidality compared with LC1, greater aggressiveness compared with LC1 and LC3, and greater impulsivity compared with the other three latent classes. However, overregulated and low personality psychopathology subgroups did not emerge in the current study suggesting that the co-occurrence of personality and ED presentation may be more complex for individuals with AN who are not underregulated. It is possible that we did not find overregulated and low

[2]Based on the best-fitting noninvariance FMA model, factors contributed to the severity dimension within, but not across, latent classes

personality psychopathology subgroups like a similar study using this sample (Wildes et al., 2013, 2011) because of differences in the analytic approach (mixture modeling vs. latent class/profile analyses; co-occurrence of ED pathology and personality features vs. personality pathology only as indicators).

Results from this study were consistent with previous research suggesting that subtypes of bulimic syndromes are distinguished by frequency of binge eating and purging (Keel et al., 2013; Peterson et al., 2016). Specifically, LC2 demonstrated greater frequency of purging compared with LC1 and LC3 and greater frequency of objective binge eating compared with LC1. It is important to note that LC1 included individuals with AN-R only and the other three classes included individuals with AN-BP only. Key features that distinguished the three subgroups consisting of individuals with AN-BP were frequencies of objective binge eating and purging, with greater frequency of objective binge eating in LC4 compared with LC2 and LC3 and greater frequency of purging in LC3 compared with LC2 and LC4. However, unlike a prior study that used the same sample (Wildes et al., 2013), results from this study did not find a non-fat-phobic subtype. An explanation may be that we used indicators that were based on the presence/absence of ED cognitions and the *frequency* of ED behaviors versus categorical criterion of presence/absence for ED behaviors and cognitions as done in Wildes et al. (2013). For example, if two individuals do not endorse a fear of weight gain and endorse objective binge-eating episodes but differ in frequency of objective binge eating, they may be categorized differently based on indicators using continuous or dichotomous data. It also is possible that we did not find a non-fat-phobic subgroup like Wildes et al. (2013) because analytic approaches were different (mixture modeling vs. latent class/profile analyses). Finally, there is the possibility that overlapping aspects of ED pathology and personality features are captured through the examination of the co-occurrence of these factors.

Similar to Keel et al. (2013), our findings supported a single latent dimension. Within each latent class, there was dimensional variability based on frequencies of ED behaviors (i.e., objective binge eating for LC4, subjective binge eating for LC3, purging for all four classes) and personality features (i.e., impulsivity for LC2, self-esteem and self-harm/suicidality for LC3). For example, frequency of purging not only distinguished LC3 from other classes but also loaded significantly onto the latent dimension within LC3. This finding suggests that the dimensional aspect is based on frequency of ED behaviors versus severity of AN for the latent classes. However, dimensional variability also was based on indices of personality for LC2 and LC3 suggesting that dimensionality may be more multidimensional for these two latent classes.

Contrary to Keel et al. (2013), the dimensional variability in the current study was within, not across, latent classes. It is possible that sample and assessment differences between the studies contributed to differences in the latent dimension. We examined a clinical sample with AN and used frequency of ED behaviors, whereas Keel et al. (2013) examined a community sample with bulimic syndromes and used categorical “yes/no” criteria for ED behaviors. Moreover, this result may explain why the dimension score did not predict poor outcome, discharge type, and readmission to intensive treatment.

Subgroups in the current study were associated with differential responses to treatment. Individuals assigned to LC1 and LC3 were more likely to have a poor treatment response compared with those in LC4. This finding provides information about individuals with AN who may be more likely to have a negative treatment outcome. Results suggest that categories and dimensions may be useful for different purposes and highlight the importance of establishing validity of classification systems as different systems may be useful for different purposes (Crosby et al., 2011; Wonderlich, Joiner, Keel, Williamson, & Crosby, 2007).

The current study used a novel approach to examine the empirical classification of AN derived from ED pathology and personality features. Additional strengths include a large sample for a single site investigation of AN, structured interview assessments, and a set of external validators that predicted treatment response and readmission. However, limitations need to be considered. First, despite the advanced statistical methods used and relatively large sample, two subgroups consisted of 21 participants per group. Thus, replication in an even larger sample is needed to parse heterogeneity within AN. It also is possible that a larger sample would have allowed us to further examine differences among individuals with AN-BP. Furthermore, there may be other personality pathology or ED behaviors that were not included in our models that would be more helpful in explaining heterogeneity in AN (e.g., driven exercise). This study also was conducted with a relatively homogeneous sample from a specific treatment program, and it is possible that findings may not generalize to other subsamples or interventions.

Conclusions

The current study further supports the notion of heterogeneity within AN. Overall, results suggest that alternative AN classifications that include either ED symptoms or emphasize personality, may be missing meaningful variability. Therefore, in considering prognostic factors, such as poor outcome (i.e., BMI ≤ 17.5 or ≥4 binge-eating/purging episodes during the past 28 days regardless of weight status) at discharge, psychiatric nursing and other providers may want to consider the co-occurrence of ED symptoms and personality traits.

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Table 1.

Sample (N = 193) Characteristics.

Variable	*n*	%
Female	184	95.3
Caucasian	184	95.3
≥1 previous ED hospitalization	92	47.7
AN subtype		
Restricting	84	43.5
Binge eating/purging	109	56.5
Treatment		
Inpatient only	120	62.2
Day hospital only	22	11.4
Both	51	26.4
	***M* (*SD*)**	**Range**
Age (years)	26.5 (10.2)	16-62
Body mass index	15.71 (1.82)	9.39-18.42
Duration of ED symptoms (years)	8.5 (9.0)	<1-45

Note. AN = anorexia nervosa; ED = eating disorder.

Table 2.

Model Fit Statistics for Latent Class Analyses, Factor Analyses, and Factor Mixture Analyses.

Model	Log L	Parameters	AIC	cAIC	BIC	aBIC	Entropy
Latent class analyses							
2 Class	−6901.84	34	13871.67	14016.60	13982.60	13874.90	.99
3 Class	−6829.06	46	13750.12	13946.20	13900.20	13754.49	.99
4 Class	−6751.02	58	13618.04	13865.27	13807.27	13623.54	.99
Factor analyses							
1 Dimension	−6250.61	26	12553.23	12664.06	12638.06	12555.70	
2 Dimension	−6929.63	46	13951.26	14147.34	14101.34	13955.62	
Factor mixture analyses							
1 Dimension							
2 Class	−6811.46	48	13718.92	13923.53	13875.53	13723.48	.99
3 Class	−6615.28	61	13352.53	13612.56	13551.56	13358.33	.92
4 Class	**−6363.23**	**74**	**12874.45**	**13189.89**	**13115.89**	**12881.48**	**.99**
2 Dimension							
2 Class	−6695.34	59	13508.69	13760.18	13701.18	13514.29	.98
3 Class	−6636.97	72	13417.94	13724.86	13652.86	13424.78	.96

Note. AIC = Akaike information criterion; aBIC = adjusted BIC; BIC = Bayesian information criterion; cAIC = consistent AIC; Log L = log likelihood. Bold indicates the best-fitting model.

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Table 3.

Mean (Range) for the Posterior Probabilities Associated With the Four-Class Model.

Latent class	*N*	1	2	3	4
1	84	1.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
2	21	0.00 (0.00)	1.00 (0.00)	0.00 (0.00)	0.00 (0.00)
3	67	0.00 (0.00)	0.00 (0.02)	0.99 (0.04)	0.00 (0.03)
4	21	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.00 (0.00)

Note. Posterior probabilities are the probability that an individual belongs to the assigned profile and to no other profiles. Values are the average posterior probabilities and the ranges (in parenthesis) associated with the profiles to which individuals were assigned.

Table 4.

Distribution of Personality Psychopathology and Eating Disorder Symptoms Across Latent Classes.

	LC1 (*n* = 84)		LC2 (*n* = 21)		LC3 (*n* = 66)		LC4 (*n* = 21)		Test statistic		
Variable	***M***	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***	***F***	***p***	**Effect size**
Body mass index	15.49	0.20	16.10	0.40	15.82	0.22	15.84	0.40	0.86	.47	.01
Length of illness (years)	8.17	1.0	8.00	1.98	9.12	1.11	8.57	1.98	0.16	.92	.003
Self-harm (SNAP-2 *t* score)	64.98_a	1.83	79.69_b	3.64	71.68	2.04	80.24_b	3.64	7.66	<.001	.11
Exhibitionism (SNAP-2 *t* score)	44.20	1.34	47.72	2.26	43.99	1.26	46.95	2.26	1.09	.35	.08
Aggression (SNAP-2 *t* score)	50.73_a	1.23	62.89_b	2.44	52.34_a	1.37	54.05	2.44	6.75	<.001	.10
Impulsivity (SNAP-2 *t* score)	46.43_a	1.02	61.78_b	2.02	49.10_a	1.13	54.82_b	2.02	17.55	<.001	.22
Frequency of OBE over the past 3 months	0.036_a	1.25	15.19_b	2.49	4.18_b	1.41	100.52_c	2.49	460.68	<.001	.88
Frequency of SBE over the past 3 months	2.80_a	1.32	13.86	2.63	6.35	1.48	17.86_b	2.63	11.39	<.001	.16
Frequency of purging over the past 3 months	0.072_a	7.36	221.76_b	14.62	48.65_c	8.31	194.81_b	14.62	91.77	<.001	.60
	n	**%**	***n***	**%**	***n***	**%**	***n***	**%**	χ^2	***p***	**Effect size**
Overvaluation of weight and shape	71	84.5	20	95.2	65	98.5	19	90.5	8.44	.04	.21
Fear of weight gain	71	84.5	21	100	53	80.3	18	85.7	4.84	.18	.16
AN-BP subtype	0*a*	0	21_b	100	67_b	100	21_b	100	193	<.001	1.00

Note. AN-BP = anorexia nervosa-binge eating/purging subtype; LC = latent class; OBE = objective binge eating; SBE = subjective binge eating; SNAP-2 = Schedule for Nonadaptive and Adaptive Personality, Second Edition. Effect sizes for analyses of variance are partial η^2 and for chi-squares are ϕ. To protect against Type I error, α was set at .01. Subscripts that differ represent pairwise differences between the subtypes at $p < .01$.

Table 5.

Distribution of Demographic and Clinical Characteristics Across Latent Classes.

	LC1 (*n* = 84)		LC2 (*n* = 21)		LC3 (*n* = 67)		LC4 (*n* = 21)		Test statistic		
Variable	***M***	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***	***F***	***p***	**Effect size**
Age (years)	26.82	1.11	24.95	2.23	26.99	1.25	24.95	2.23	0.40	.75	.006
Frequency of self-induced vomiting	0.06_a	9.49	191_b	18.98	32.45_c	10.63	209.95_b	18.98	52.07	<.001	.45
Frequency of laxative misuse	0.00_a	2.11	32.48_b	4.22	16.08_b	2.40	5.81	4.22	19.41	<.001	.24
Frequency of diuretic misuse	0.01	1.12	12.57	2.22	2.64	1.24	0.29	2.22	8.86	<.001	.12
Baseline EDE global score	2.72_a	0.16	3.94_b	0.31	3.09	0.17	3.42	0.31	4.71	.003	.07
	n	**%**	***n***	**%**	***n***	**%**	***n***	**%**	χ^2	***p***	**Effect size**
Gender (female)	78	92.9	21	100	65	97.0	20	95.2	2.61	.46	.12
Caucasian	81	96.4	20	95.2	62	92.5	21	100	2.43	.49	.11
≥2 Eating disorder hospitalizations	33	39.3	12	57.1	34	50.7	13	61.9	5.08	.17	.17
Lifetime mood disorder	58	69.0	17	81.0	57	85.1	20	95.2	9.80	.02	.23
Lifetime anxiety disorder	49	58.3	12	57.1	44	65.7	16	76.2	2.85	.42	.12
Lifetime substance disorder	8	9.5	3	14.3	9	13.4	11	52.4	23.60	<.001	.35

Note. LC = latent class; EDE = Eating Disorder Examination. Effect sizes for analyses of variance are partial η^2 and for chi squares are ϕ. To protect against Type I error, α was set at .01. Subscripts that differ represent pairwise differences between the subtypes at $p < .01$.

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