Published in final edited form as:

Int J Eat Disord. 2020 October ; 53(10): 1647–1656. doi:10.1002/eat.23369.

Latent trajectories of eating disorder treatment response among female patients in residential care

Hallie Espel-Huynh, Ph.D.^{1,2,3}, Fengqing Zhang, Ph.D.¹, James F. Boswell, Ph.D.⁴, J. Graham Thomas, Ph.D.^{2,3}, Heather Thompson-Brenner, Ph.D.⁵, Adrienne S. Juarascio, Ph.D.¹, Michael R. Lowe, Ph.D.¹

¹Drexel University, Philadelphia, PA;

²Weight Control and Diabetes Research Center, The Miriam Hospital, Providence, RI;

³Alpert Medical School of Brown University, Providence RI;

⁴University at Albany—SUNY, Albany, NY;

⁵Boston University, Boston, MA

Abstract

OBJECTIVE: Eating disorder (ED) treatment outcomes are highly variable from beginning to end of treatment, however little is known about differential trajectories during the course of treatment. This study sought to characterize heterogeneous patterns of eating disorder (ED) treatment response during residential care.

METHOD: Participants were adolescent girls and adult women ($N = 360$) receiving residential ED treatment for anorexia nervosa, bulimia nervosa, binge-eating disorder, other specified feeding or eating disorder, unspecified feeding or eating disorder, or avoidant/restrictive food intake disorder. Self-report symptom assessments were completed at admission, discharge, and approximately weekly throughout the residential stay to assess curvilinear patterns of change. Latent growth mixture modeling was applied to identify subgroups of patients with similar treatment response trajectories.

RESULTS: Three latent groups emerged, including gradual response (58.3%; steady improvements from admission to discharge), rapid response (23.9%; steep early improvements that were maintained through discharge), and low-symptom static response (17.8%; nearly non-clinical self-reported symptoms at admission that remained static through discharge). Groups differed on important clinical characteristics, such as body mass index, endorsement of compensatory behaviors, severity of global ED psychopathology at admission, and degree of symptom improvement by end of treatment.

Correspondence regarding this manuscript can be directed to Hallie Espel-Huynh, current affiliation: Weight Control and Diabetes Research Center, The Miriam Hospital, and the Department of Psychiatry and Human Behavior, Alpert Medical School of Brown University; affiliation address: 196 Richmond St., Providence, RI 02903; hallie_espel-huynh@brown.edu.

Conflicts of Interest: Drs. Espel-Huynh and Boswell served as paid research consultants to The Renfrew Centers during the time of data collection. Drs. Thompson-Brenner and Lowe continue to serve as paid research consultants at time of manuscript submission.

Data Availability: Research data are not shared.

DISCUSSION: Patients follow heterogeneous response patterns in residential ED treatment, and these patterns are associated with differential treatment outcome. Future work should explore whether these trajectories are associated with differential outcomes at follow-up and whether tailoring clinical intervention to a patient's trajectory type can improve treatment response.

Keywords

feeding and eating disorders; outcome and process assessment; residential treatment

Eating disorders (EDs) are among the most medically compromising psychiatric illnesses (Harris & Barraclough, 1998; Smink, van Hoeken, & Hoek, 2013) and are characterized by substantial heterogeneity in symptoms (Dechartres et al., 2011; Forbush & Wildes, 2016). When patients are grouped into empirically-derived latent groups according to their symptom profiles, group membership is predictive of symptom remission, readmission, and mortality (Escobar-Koch et al., 2010; Peterson et al., 2013; Sysko, Hildebrandt, Wilson, Wilfley, & Agras, 2010). Latent group membership often outperforms outcome prediction using traditional diagnostic classification (American Psychiatric Association, 2013; Crow et al., 2012; Wildes & Marcus, 2011).

Treatment response patterns are also heterogeneous and associated with differential overall outcomes. One well-studied pattern is rapid early treatment response, which predicts more favorable overall treatment outcome. A review and meta-analysis conducted by Linardon, Brennan, and de la Piedad Garcia (2016) indicated that larger early improvements in behavioral and cognitive ED symptoms were associated with significantly better end-of-treatment outcomes (Linardon et al., 2016). Notably, this review included studies with a range of rapid response definitions, including those contingent only upon reductions in binge eating and/or vomiting (e.g., 65% reduction in binge frequency by week) and others emphasizing self-report measures such as the Eating Disorder Examination—Questionnaire. Rapid improvements in related symptom targets like emotion regulation may also confer improved prognosis (D. E. MacDonald, Trottier, & Olmsted, 2017). Further, rapid response is facilitated with targeted cognitive-behavioral intervention (D. E. MacDonald, McFarlane, Dionne, David, & Olmsted, 2017). Thus, varying treatment response rates are associated with differential outcomes, and that response rate is a modifiable patient characteristic.

Prior research has focused primarily on binary treatment response classification (i.e., rapid versus non-rapid). This approach may unintentionally discount other response patterns that are also relevant to outcome. Although research on other ED treatment response trajectories is more limited, recent investigations provide evidence for additional clinically relevant patterns (Hilbert et al., 2018; Jennings, Gregas, & Wolfe, 2018; Makhzoumi et al., 2017). For example, Hilbert and colleagues (2018) examined early trajectories of binge eating in outpatient binge-eating disorder treatment. Binge eating symptoms were best characterized by a three-trajectory model that emphasized symptom severity at the initiation of treatment and the early direction of change; the patterns identified included moderate-level decreasing, low-level decreasing, and low-level but stable binge eating trajectories. Trajectory class membership was more predictive of ultimate treatment outcome than was rapid response group membership (according to a previously published, empirically-derived definition), and

rapid responders were equally dispersed among the three groups (Hilbert et al., 2018). Thus, these treatment response trajectories provide key information about expected outcome, beyond that captured by rapid response alone.

Others have found evidence for differential weight gain trajectories during treatment for anorexia nervosa (Berona, Richmond, & Rienecke, 2018; Jennings et al., 2018; Makhzoumi et al., 2017). One study examined latent weight trajectories among individuals receiving inpatient treatment and detected four groups: weight gain, treatment resistance, weight plateau, and fluctuating weight (Jennings et al., 2018). The second, involving patients with anorexia nervosa treated in an integrated inpatient-partial hospital program (Makhzoumi et al., 2017), found evidence for three trajectories (fast, optimal, and slow). In both studies, weight trajectory class membership was predictive of end-of-treatment weight outcomes (Jennings et al., 2018; Makhzoumi et al., 2017). A final study of 102 adolescents and young adults with anorexia nervosa or subthreshold anorexia nervosa examined weight trajectories in partial hospital treatment (Berona et al., 2018); results generally replicated the three-trajectory pattern found by Makhzoumi et al. (2017).

Results from the above studies suggest that a patient's response trajectory may also provide key information about expected outcome. To date, trajectory classification has been limited to single-symptom investigations (e.g., binge eating frequency or weight change) and is therefore applicable to only a subset of all ED diagnostic groups encountered in routine treatment. This limits generalizability to community and private treatment settings, where providers often work with patients transdiagnostically (Brown et al., 2018; Hayes, Welty, Slesinger, & Washburn, 2019; Twhig, Bluett, Torgesen, Lensegrav-Benson, & Quakenbush-Roberts, 2015). Characterizing heterogeneous trajectories and using them to inform treatment planning in transdiagnostic populations may be particularly clinically useful in intensive settings, where treatment is more costly and resource-intensive (Striegel-Moore & Leslie, 2000; Williamson, Thaw, & Varnado-Sullivan, 2001). Tailoring treatment to individual patients' needs could lead to more effective and efficient care, thus reducing costs.

Pragmatic Research Setting

This project capitalized on a large dataset of routine ED treatment outcomes among patients at two residential ED treatment facilities owned by The Renfrew Centers, a large, private ED treatment network in the United States. To extend upon its prior efforts to introduce and evaluate evidence-based treatment practices (Thompson-Brenner, Boswell, Espel-Huynh, Brooks, & Lowe, 2018; Thompson-Brenner, Brooks, et al., 2018), Renfrew introduced infrastructure for routine progress monitoring within its residential programs. Augmenting its existing practice of assessing comprehensive ED and comorbid symptoms at admission and discharge, Renfrew implemented weekly progress assessments using a validated measure of transdiagnostic constructs relevant to intensive ED treatment outcome (Espel-Huynh et al., 2020). Eventually, Renfrew planned to deliver assessment feedback to clinicians in real-time to inform individualized patient care during treatment.

Study Objectives and Hypotheses

The primary aim of this study was to characterize heterogeneous patterns of treatment response from admission to discharge among patients receiving residential treatment for a primary ED. Eventually, it was hoped that such information may be used to inform patient care. Treatment response data were collected weekly as part of the new progress monitoring initiative. Use of this weekly progress assessment allowed for a fine-grained analysis of treatment response within the brief timeframe of residential ED treatment.

It was expected that, on average, patients would make significant improvements during treatment, as evidenced by a fixed negative slope effect of time on global symptom severity. Furthermore, it was hypothesized that a quadratic fixed effect of time on outcome would provide the best fit for the data. This corresponds to more rapid improvements during the earlier phases of treatment, followed by progressively slower progress toward discharge. This is consistent with the methods of Hilbert et al. (2018) and with modeling approaches used in general psychotherapy research, including with psychiatric inpatients (Barkham, Stiles, & Shapiro, 1993; Clapp et al., 2013). No *a priori* hypotheses were made regarding the number of latent trajectory classes present.

Methods

Participants & Procedures

Participants were adolescent girls and adult women presenting for ED treatment at one of The Renfrew Centers' two residential facilities. The Renfrew Centers treat female patients only. Patients completed a standard battery of self-report assessments at admission and discharge, in addition to a brief progress assessment administered weekly throughout treatment. Facility research staff then integrated key clinical information from the patient's electronic health record (see Measures).

Use of Renfrew patients' de-identified data for research purposes requires that patients provide written informed consent. Patients were approached by Renfrew research staff during admission to discuss this opportunity and either accept or decline participation. All research activities were approved by the Institutional Review Boards of Renfrew and Drexel University.

Data were collected between February 2016 and June 2017. In total, 1055 patients were admitted. Of these, 1009 consented to have de-identified data included in research. Data were available from 920 admissions during the data collection period. Patients were excluded if they had a length of stay < 21 days ($n = 139$), failed to complete the admission ($n = 167$) or discharge ($n = 55$) assessment, or had fewer than four observations available ($n=188$), which is not optimal for robust evaluation of curvilinear change (Francis, Fletcher, Stuebing, Davidson, & Thompson, 1992; Raudenbush & Liu, 2001). Common reasons for missed assessments included factors related to the pragmatic nature of the research: limited research staff to oversee assessment completion, bedrest orders upon admission, prioritization of a patient's therapy schedule over assessments, unanticipated discharge, etc. In total, $N = 360$ cases had adequate data for inclusion in the trajectory analyses. This

included 11 cases with two admissions and two separate trajectories; for these cases, only data from the first admission was used. No formal power analysis was conducted; however, prior simulation studies suggest that an absolute minimum of 100 cases is required for accurate LGMM specification, with more cases required for data with relatively few level-1 observations per case or highly overlapping classes (Park & Yu, 2018). The present study sample size was determined to be adequate for the planned analysis.

Patient Characteristics—Participants' ages ranged from 13–60 years ($M = 25.41$; $SD = 13.1$). The majority of participants identified their race as White ($n = 323$; 89.7%), with the remainder identifying as Asian/Pacific Islander ($n = 8$; 2.2%), African-American ($n = 4$; 1.1%), Native American ($n = 2$; 0.5%), Multiracial ($n = 12$; 3.3%), or Other ($n = 8$; 2.2%). Fourteen participants (3.9%) specified Hispanic ethnicity. Three participants chose not to report. Primary clinical diagnoses included anorexia nervosa—restricting type ($n = 101$; 28.1%), anorexia nervosa—binge/purge type ($n = 51$; 14.2%), bulimia nervosa ($n = 100$; 27.9%), binge-eating disorder ($n = 16$; 4.5%), other specified feeding or eating disorder ($n = 81$; 22.6%), unspecified feeding or eating disorder ($n = 3$; 0.8%), and avoidant-restrictive food intake disorder ($n = 7$; 1.9%). Diagnosis was missing for one participant.

Treatment Setting

Residential treatment followed the Unified Treatment Model, an emotion-focused, cognitive-behavioral treatment approach that has shown effectiveness in this setting (Thompson-Brenner, Boswell, et al., 2018; Thompson-Brenner, Brooks, et al., 2018). Treatment consisted of interdisciplinary care, including manualized group and individual therapy sessions with masters- or doctoral-level therapists, individualized nutrition counseling and structured meals, psychiatry and medical monitoring, and supplemental therapies (e.g., art therapy).

Measures

Time.—Number of weeks since admission was measured based on the date on which each assessment was completed. The date of admission assessment completion (typically within 48 hours of admission) was set to $T=0$. Time for each weekly assessment and the final discharge assessment was calculated as the number of days since the patient's T_0 date.

Weekly ED symptoms (for trajectory analysis).—Symptom severity was assessed throughout treatment using the Progress Monitoring tool for Eating Disorders (PMED; Espel-Huynh et al., 2020). The PMED is a 26-item measure of symptoms related to residential treatment outcome across five factors/domains (Weight and Shape Concern, ED Behaviors/Urges, Emotion Avoidance, Adaptive Coping, and Relational Connection). The measure was developed specifically for use with transdiagnostic patient populations in intensive ED treatment settings, demonstrates convergence with other well-validated measures of ED symptoms and emotional functioning, and is sensitive to change during a treatment episode (Espel-Huynh et al., 2020). Patients rate the extent to which each item has applied to them in the past week on a 5-point Likert scale (0="Never"; 5="Always"). Total scores represent a sum of all item-level ratings and range from 26–131, with higher scores indicating greater symptom severity. The PMED was administered at admission, discharge,

and approximately weekly during treatment to capture symptom change throughout admission. Scale reliability for the total score was in the good to excellent range at admission ($\alpha = 0.87$, 95% CI [0.85, 0.89]) and discharge ($\alpha = 0.92$, 95% CI [0.91, 0.93]).

Other clinical characteristics.—Post hoc group comparisons were conducted using additional clinical variables of age, body mass index (BMI; kg/m²), length of stay, and charted ED diagnoses (assigned by the patient's treating psychiatrist via semi-structured interview of ED diagnostic criteria according to the Diagnostic and Statistical Manual of Mental Disorders (American Psychiatric Association, 2013)).

ED symptoms from admission to discharge (for trajectory group comparisons).—Consistent with other literature in the field, baseline global ED psychopathology, binge-eating, vomiting, and laxative use were assessed using the widely used and validated Eating Disorder Examination—Questionnaire (EDE-Q; Fairburn & Beglin, 1994). Change during treatment was defined as raw change in the EDE-Q global score from admission to discharge. Raw change was selected over use of residual change scores due to the assumption that the sample included heterogeneous patient groups (and, hence, nonhomogeneous regression slopes from admission to discharge). Baseline EDE-Q subscale α s ranged 0.75–0.92.

Analyses

Data screening.—Multilevel analyses assume that data are missing at random (Enders, 2010). This assumption is not directly testable, however, systematic predictors of missingness can be evaluated. Although weekly assessments were desirable, the need to integrate assessments into patients' schedules without impeding essential therapeutic activities led to occasional unequal spacing of assessments. An average span of more than 10 days was set as a threshold to indicate prolonged assessment lag—a proxy for missingness. Individuals with missing responses were compared to those with more complete data on age, length of stay, treatment site, baseline ED severity, baseline total PMED score, and comorbidity.

Latent treatment response trajectory exploration.—Latent growth mixture modeling (LGMM) with robust full information maximum likelihood was conducted to identify trajectory groups, using the *lcmm* package in R (Proust-Lima, Philipps, & Lique, 2017). LGMM is an extension of mixed effects linear modeling and allows for estimation of within-person change patterns present among latent subgroups within a larger heterogeneous population (Muthén & Muthén, 2000; Ram & Grimm, 2009). LGMM allows measurement occasions to vary in number and frequency across individuals and can handle missing observations within individual cases (Muthén & Muthén, 2000).

Fixed and random (observations nested within individuals) intercept, first-order (linear), and second-order (quadratic) effects of time on outcome (ED symptom severity as measured by the PMED) were tested in a series of models with a progressively increasing number of latent classes. A linear link function was used. Each LGMM was run with 15 random starts to ensure that absolute rather than local solutions were reached. Class membership was

assigned to cases for each model using posterior probabilities. Progressive nested models were compared on fit indices of Akaike Information Criterion, (AIC), Bayesian Information Criterion (BIC), sample size-adjusted BIC (SABIC), and log-likelihood. Entropy was assessed as a measure of classification accuracy. Log-likelihood, AIC, BIC and SABIC are model-specific parameters, therefore no global criteria for interpretation of absolute model fit exist. Guidelines for model selection in growth mixture modeling recommend selecting models with the lowest relative information criterion values, maximizing classification quality as illustrated by posterior predicted probabilities, and maximizing practical utility of the latent classes identified (Muthén & Muthén, 2000).

Post hoc latent group comparisons.—Continuous variable comparisons used analysis of variance (ANOVA) and Tukey's Honestly Significant Difference pairwise contrasts. For continuous variables whose distributions deviated substantially from the Gaussian distribution or when group variances were nonhomogeneous, a Kruskal-Wallis rank sum test was applied, and pairwise comparisons were made using Dunn's Test. Binge eating, compensatory behavior, and laxative use frequencies were zero-inflated and skewed; distributions could not be satisfactorily corrected with square-root or logarithmic transformations. For this reason, groups were compared on presence or absence of these symptoms using Pearson's Chi-Square test. Furthermore, given heterogeneity in symptom presentation among patients in many ED diagnostic groups, this approach allowed us to determine whether certain symptom profiles were more likely to be related to one treatment response trajectory versus another.

Results

Data Availability

A total of 1925 PMED assessments were completed across participants. The median number of days between assessments was 8.5 (range 5.8 – 22.8). Approximately one-third of patients (32.5%; $n = 117$) completed only four assessments. Most patients completed five to seven (58.1%; $n = 209$), and the remainder had eight or more (9.4%; $n = 34$).

Although the dependency of missingness on outcome cannot be examined directly, steps were taken to examine whether patients with substantial missing PMED data differed systematically from those with complete data. Patients were classified into two groups: “missed assessment” (average time between assessments > 10 days) and “complete” (10-day average lag between assessments). A total of 73 patients (20.3%) were classified into the “missed assessment” group ($M_{lag} = 12.39$, $SD = 2.5$), compared to 287 participants with “complete” weekly data ($M_{lag} = 8.07$, $SD = 1.0$). Groups did not differ significantly on age, EDE-Q global scores, or PMED total scores at admission ($ps > .16$). Patients with missing data tended to have greater psychiatric comorbidity (result for comparison of log-transformed count data: $t(117.07) = 2.30$, $p = .01$), tended to be treated at the residential program that had fewer research staff on-site ($\chi^2(1) = 10.85$, $p = .02$), and had longer length of stay ($t(103.67) = 3.51$, $p < .001$, 95% CI_{diff} [2.74, 9.88]). Although some group differences were detected, patients with missing data did not differ systematically on the outcome or on core ED features. Thus, data were assumed to be missing at random.

Latent Trajectory Analysis

A single-class (non-latent) mixed effects growth model was fitted, then two-, three-, and four-class were tested, using weekly PMED total scores as the outcome variable (see Table 1 for summary). The one-class model generated the poorest fit.

In the two-class model, both patient subgroups experienced significant declines in symptoms, which were initially more rapid and slowed over time. One subgroup's pattern was characterized by a much more rapid initial decline (20.0% of sample), while the second group's change trajectory was more gradual (80.0%). This model yielded slightly improved fit versus the one-class model but performed worse than the three- and four-class models on all fit measures.

The three-class model generally replicated the rapid and gradual response trajectory groups from the two-class model. Additionally, a third group was characterized with low baseline symptoms and minimal improvement during treatment ("low-symptom static response"). This model improved upon the two-class model on all fit statistics and was more well-balanced in terms of class membership (gradual response: 58.3%; rapid response: 23.9%; low-symptom static response: 17.8%).

The four-class model retained the low-symptom static response group and rapid response groups and included two gradual response groups—one with higher and one with lower baseline symptom severity. Class membership was sparser in the four-class model, with a minimum of 14.7% of the sample ($n = 53$) assigned to the "rapid response" group. The largest number of patients was assigned to a "high-baseline-symptom/gradual-steady response" class ($n = 142$, 39.4%), comprised of patients entering treatment with high symptom severity that improved very gradually during treatment. The "low-symptom static response" class was replicated ($n = 98$; 27.2%), and a new class emerged as "high-baseline-symptom/fast-steady response" ($n = 67$; 18.6%), which involved overall improvements comparable to rapid responders by end of treatment, but with gradual linear change until discharge, rather than rapid change in the first two weeks and stable symptoms thereafter. Fit statistics for the four-class model were similar to those of the three-class model, with a lower AIC (indicating better fit according to AIC) and SABIC but a higher BIC value and lower entropy (indicating poorer classification accuracy). AIC typically reaches a minimum in models that characterize the maximum number of true latent classes within a population, whereas BIC reaches its minimum in the model with the smallest possible number of clearly separable classes (Nylund, Asparouhov, & Muthén, 2007) and is typically the preferred information criterion measure to use for model selection, although SABIC has also been recommended more recently (Swanson, Lindenberg, Bauer, & Crosby, 2012). Per recommendation of Muthén and Muthén (2000), we considered IC values alongside posterior probabilities and practical utility of the classes identified.

Examination of posterior classification probabilities supported selection of the three-class model. For the three-class model, mean posterior probabilities exceeded 0.70 (range: 0.79 – 0.88). Out-of-class mean reciprocal posterior probabilities for the three-class model also hovered near 0.10 (range: 0.08 – 0.13). In contrast, mean posterior probabilities in the four-class model tended to be lower (range: 0.67 – 0.77), with one value falling below the 0.70

threshold recommended by Nagin (2005). Mean reciprocal posterior probabilities for out-of-class categorization were also more variable (range: 0.02 – 0.19). Further, the three-class model was identified as the most pragmatic, given that the clearer separation of classes could lend to easier interpretation by clinicians. Table 2 summarizes parameter estimates for the final three-class model. Observed (visualized using a localized regression smoothing algorithm) and predicted symptom trajectories for the three-group model are depicted in Figure 1.

Latent Group Comparisons

Significant group differences were detected for the following admission variables: PMED Total scores, EDE-Q Global scores, and the proportion of patients endorsing vomiting and laxative use (see Table 3). Patients in the low-symptom group tended to enter treatment with lower PMED and EDE-Q scores than both other groups, and patients in the rapid response group had significantly lower scores than gradual response. In addition, patients in the low-symptom group were less likely to endorse vomiting or laxative misuse and were more likely to be diagnosed with anorexia—restricting type. The rapid response group had a greater proportion of patients endorsing vomiting and laxative misuse at admission and had less-frequent diagnosis of anorexia—restricting. Groups did not differ significantly on age or presence of binge eating symptoms at admission.

Trajectory groups also differed on degree of improvement in ED symptoms during treatment and length of stay. Patients in the rapid response group made significantly greater treatment gains than those in the gradual response group, and in turn the gradual response group made greater improvements than those in the low-symptom group. Length of stay followed a similar pattern.

Discussion

Results from this study indicate that symptom change during residential ED treatment is best characterized by a three-class model consisting of: (1) a “gradual response” pattern with steady improvement through treatment; (2) a “rapid response” pattern with marked early improvements that leveled off by discharge; and (3) a “low- symptom, static response” pattern exhibited by patients with low self-reported symptom severity at admission and minimal improvement during treatment.

Patients in each group exhibited differential baseline characteristics and treatment outcome. Gradual responders (the most common group) entered treatment with higher-severity ED symptoms, had more heterogeneous symptom presentations, longer length of stay, and made modest symptom improvements by end of treatment. Given that gradual responders made less marked treatment gains relative to rapid responders, one might consider whether promoting rapid early response in this group is possible via supplemental intervention. Preliminary research suggests that this may be possible, though further study is warranted (D. E. MacDonald, McFarlane, et al., 2017).

A meaningful minority of patients followed the rapid response and low-symptom trajectories. The rapid group exhibited greater treatment gains over a shorter length of stay.

They were also more likely to endorse compensatory behaviors at admission and included fewer patients with anorexia—restricting type. This group most closely reflects the “rapid response” pattern characterized elsewhere in the literature, which is often observed among patients who engage in compensatory behaviors (Linardon et al., 2016; D. E. MacDonald, McFarlane, et al., 2017; D. E. MacDonald, Trottier, et al., 2017). In the residential setting, it is possible that patients who engaged in compensatory behaviors prior to admission were more prone to rapid symptom improvement due to the structured treatment setting; locked bathrooms and staff supervision typically preclude engagement in compensatory behaviors. Regardless of what may predispose patients to this trajectory group, this study is one of the first to replicate this response pattern in a transdiagnostic, residential ED sample.

In contrast, the low-symptom static response trajectory appears to represent a novel clinical group that has received little attention to date. Despite the fact that these patients had severe EDs requiring residential care, they reported nearly non-clinical ED symptoms upon admission, entered treatment with lower average BMI than the other two groups, had more patients with anorexia—restricting diagnoses, and improved less during treatment. Self-report alone may be insufficient to capture the degree and type of psychopathology experienced by these patients. Symptom assessment via other means (e.g., clinical observation, treatment engagement, and/or weight restoration—where applicable) may more accurately define treatment progress for these patients. Furthermore, given the low baseline severity endorsed, floor effects may have limited the possibility of observing improvements for this group.

Low symptom reports in full-threshold EDs have been observed elsewhere, including in intensive or usual-care ED treatment. For example, the low-symptom, static trajectory observed in this study is similar to the “static” weight change pattern observed in patients with anorexia nervosa during inpatient described by Jennings and colleagues (2018), and the “low binge eating stable” pattern observed in binge eating treatment by Hilbert and colleagues (2018). Results from this study are also consistent with descriptions of “treatment resistance” and its correspondence with symptom denial (Abbate-Daga, Amianto, Delsedime, De-Bacco, & Fassino, 2013; Vitousek, Watson, & Wilson, 1998). Rather than ignore the low-symptom group as an anomalous artifact of self-report, we recommend further inquiry into methods for brief and accurate assessment of this important patient subgroup.

This study is one of the first to demonstrate differential weekly change patterns among patients receiving intensive ED treatment. Knowledge of different symptom trajectories may prove clinically meaningful if underlying group characteristics can be used to elucidate varying treatment needs among subgroups. Important differences emerged among the three groups which may signify differential clinical needs during treatment. For example, the gradual response group, which was the most common, tended to make steadier and more gradual improvements throughout treatment relative to the rapid response group. For these patients, traditional treatment models that provide early skills education (e.g., regularizing eating patterns and incorporating feared foods, addressing body image, emotional coping; Brown et al., 2018; Thompson-Brenner, Brooks, et al., 2018), and encourage progressively greater autonomy in practicing these skills, may be appropriate.

For patients with less common trajectories, such as those in the rapid or static response groups, an adjusted treatment approach may be warranted. Indeed, given that rapid responders achieved most symptom improvements early on, these patients may benefit from a greater emphasis on post-treatment maintenance of the gains made early in residential care. In contrast, if static responders truly do represent a patient group with lower insight and/or readiness for change, treatment may require emphasis on motivation enhancement before behavioral and psychological skill integration. Such interventions have shown benefit (Dray, Gilchrist, Singh, Cheesman, & Wade, 2014; P. Macdonald, Hibbs, Corfield, & Treasure, 2012)—particularly for patients with anorexia nervosa or greater treatment ambivalence (Geller, Zaitsoff, & Srikameswaran, 2005; Vitousek et al., 1998).

Strengths and Limitations

Study strengths include a large patient sample, inclusion of a transdiagnostic population in usual care, and frequent assessment allowing evaluation of curvilinear change during treatment. The analysis involved a rigorous mixed modeling analysis, accounting for variability both within and between trajectory groups. Important limitations include limited sample diversity in terms of race/ethnicity and gender, data availability for a small subset of all presenting cases, lack of follow-up data, use of self-report outcomes only, lack of data describing prior treatment or illness chronicity, and uncertainty regarding generalizability to other levels of care (e.g., inpatient, day/partial hospital, and/or outpatient). Finally, although the three-class latent trajectory model was the best-fitting and most parsimonious model for these data, the four-class model demonstrated similar performance on some metrics. To enhance confidence in these results, findings should be replicated in a larger patient sample using confirmatory model testing.

Future Directions

Future work should assess trajectories among more diverse samples, at other levels of care, and should examine whether class membership predicts differential outcomes at follow-up. Replication in larger, more diverse samples would enhance confidence in the three-class model. Additionally, given the novel characterization of the low-symptom static response group, further qualitative and quantitative work is recommended to evaluate the chief clinical characteristics and treatment needs of this unique patient group. For example, archival content analysis of intake reports documented in the electronic medical record may clarify why a residential level of care was deemed necessary for these patients despite low self-reported symptoms. Future use of patient- or observer-rated impairment and quality of life measures may also provide insight into these patients' experiences of their symptoms.

Future inquiry should explore whether patients in each trajectory group may benefit from personalized intervention to maximize treatment response, tailored to response type. Importantly, one cannot individualize care during treatment unless a patient's expected trajectory is known prior to end of treatment. As a first step toward supporting individualized treatment adaptations, future work should also develop prediction models that anticipate a patient's expected outcome. If expected trajectory information was provided to clinicians during treatment, this could facilitate more individually-informed and tailored patient care.

Acknowledgements

The authors wish to thank the patients, clinicians, and residential treatment staff who contributed to this research, without whom this work would not be possible.

Funding Statement

This work was partially supported by the National Heart, Lung, and Blood Institute of the National Institutes of Health under grant number T32 HL076134.

References

- Abbate-Daga G, Amianto F, Delsedime N, De-Bacco C, & Fassino S (2013). Resistance to treatment in eating disorders: A critical challenge. *BMC Psychiatry*, 13, 294. doi:10.1186/1471-244X-13-294 [PubMed: 24199620]
- American Psychiatric Association. (2013). *The Diagnostic and Statistical Manual of Mental Disorders* (5th ed.). Arlington, VA: American Psychiatric Association.
- Barkham M, Stiles WB, & Shapiro DA (1993). The shape of change in psychotherapy: Longitudinal assessment of personal problems. *Journal of Consulting and Clinical Psychology*, 61(4), 667–677. doi:10.1037/0022-006X.61.4.667 [PubMed: 8370863]
- Berona J, Richmond R, & Rienecke RD (2018). Heterogeneous weight restoration trajectories during partial hospitalization treatment for anorexia nervosa. *International Journal of Eating Disorders*, 51(8), 914–920. doi:10.1002/eat.22922 [PubMed: 30058155]
- Brown TA, Cusack A, Anderson LK, Trim J, Nakamura T, Trunko ME, & Kaye WH (2018). Efficacy of a partial hospital programme for adults with eating disorders. *European Eating Disorders Review*, 26(3), 241–252. [PubMed: 29542211]
- Clapp JD, Grubaugh AL, Allen JG, Mahoney J, Oldham JM, Fowler JC, ... Frueh BC (2013). Modeling trajectory of depressive symptoms among psychiatric inpatients: a latent growth curve approach. *Journal of Clinical Psychiatry*, 74(5), 492–499. doi:10.4088/JCP.12m07842
- Crow SJ, Swanson SA, Peterson CB, Crosby RD, Wonderlich SA, & Mitchell JE (2012). Latent class analysis of eating disorders: Relationship to mortality. *Journal of Abnormal Psychology*, 121(1), 225–231. doi:10.1037/a0024455 [PubMed: 21707126]
- Dechartres A, Dechartres A, Huas C, Godart N, Pousset M, Pham A, ... Falissard B (2011). Outcomes of empirical eating disorder phenotypes in a clinical female sample: Results from a latent class analysis. *Psychopathology*, 44(1), 12–20. doi:10.1159/000315362 [PubMed: 20980783]
- Dray J, Gilchrist P, Singh D, Cheesman G, & Wade TD (2014). Training mental health nurses to provide motivational interviewing on an inpatient eating disorder unit. *Journal of Psychiatric and Mental Health Nursing*, 21(7), 652–657. doi:10.1111/jpm.12163 [PubMed: 24842409]
- Enders CK (2010). *Applied Missing Data Analyses*. New York: Guilford Press.
- Escobar-Koch T, Banker JD, Crow S, Cullis J, Ringwood S, Smith G, ... Schmidt U (2010). Service users' views of eating disorder services: An international comparison. *International Journal of Eating Disorders*, 43(6), 549–559. [PubMed: 19718664]
- Espel-Huynh HM, Thompson-Brenner H, Boswell JF, Zhang F, Juarascio AS, & Lowe MR (2020). Development and validation of a progress monitoring tool tailored for use in intensive eating disorder treatment. *European Eating Disorders Review*, 28(2), 223–236. doi:10.1002/erv.2718 [PubMed: 31994259]
- Fairburn CG, & Beglin SJ (1994). Assessment of eating disorders: Interview or self-report questionnaire? *International Journal of Eating Disorders*, 16(4), 363–370. doi:10.1002/1098-108X(199412)16:4<363::AID-EAT2260160405>3.0.CO;2-# [PubMed: 7866415]
- Forbush KT, & Wildes JE (2016). Application of structural equation mixture modeling to characterize the latent structure of eating pathology. *International Journal of Eating Disorders*, 2017(50), 542–550.

- Francis DJ, Fletcher JM, Stuebing KK, Davidson KC, & Thompson NM (1992). Analysis of change: Modeling individual growth In Kazdin AE (Ed.), *Methodological Issues & Strategies in Clinical Research* (2nd ed., pp. 607–630): American Psychological Association.
- Geller J, Zaitsoff SL, & Srikameswaran S (2005). Tracking readiness and motivation for change in individuals with eating disorders over the course of treatment. *Cognitive Therapy and Research*, 29(5), 611–625. doi:10.1007/s10608-005-5774-1
- Harris EC, & Barraclough B (1998). Excess mortality of mental disorder. *The British Journal of Psychiatry*, 173(1), 11–53. [PubMed: 9850203]
- Hayes NA, Welty LJ, Slesinger N, & Washburn JJ (2019). Moderators of treatment outcomes in a partial hospitalization and intensive outpatient program for eating disorders. *Eating Disorders*, 27(3), 305–320. doi:10.1080/10640266.2018.1512302 [PubMed: 30204570]
- Hilbert A, Herpertz S, Zipfel S, Tuschen-Caffier B, Friederich H-C, Mayr A, ... de Zwaan M (2018). Early change trajectories in Cognitive-Behavioral Therapy for binge-eating disorder. *Behavior Therapy*, 50, 115–125. [PubMed: 30661552]
- Jennings KM, Gregas M, & Wolfe B (2018). Trajectories of change in body weight during inpatient treatment for anorexia nervosa. *Journal of the American Psychiatric Nurses Association*, 24(4), 306–313. doi:10.1177/1078390317726142 [PubMed: 28817991]
- Linardon J, Brennan L, & de la Piedad Garcia X (2016). Rapid response to eating disorder treatment: A systematic review and meta-analysis. *International Journal of Eating Disorders*, 49(10), 905–919. doi:10.1002/eat.22595 [PubMed: 27528478]
- MacDonald DE, McFarlane TL, Dionne MM, David L, & Olmsted MP (2017). Rapid response to intensive treatment for bulimia nervosa and purging disorder: A randomized controlled trial of a CBT intervention to facilitate early behavior change. *Journal of Consulting and Clinical Psychology*, 85(9), 896–908. doi:10.1037/ccp0000221 [PubMed: 28569520]
- MacDonald DE, Trottier K, & Olmsted MP (2017). Rapid improvements in emotion regulation predict intensive treatment outcome for patients with bulimia nervosa and purging disorder. *International Journal of Eating Disorders*, 50(10), 1152–1161. doi:10.1002/eat.22766 [PubMed: 28833314]
- Macdonald P, Hibbs R, Corfield F, & Treasure J (2012). The use of motivational interviewing in eating disorders: A systematic review. *Psychiatry Research*, 200(1), 1–11. doi:10.1016/j.psychres.2012.05.013 [PubMed: 22717144]
- Makhzoumi SH, Coughlin JW, Schreyer CC, Redgrave GW, Pitts SC, & Guarda AS (2017). Weight gain trajectories in hospital-based treatment of anorexia nervosa. *International Journal of Eating Disorders*, 50(3), 266–274. doi:10.1002/eat.22679 [PubMed: 28186654]
- Muthén B, & Muthén LK (2000). Integrating person-centered and variable-centered analyses: Growth mixture modeling with latent trajectory classes. *Alcoholism: Clinical and Experimental Research*, 24(6), 882–891.
- Nagin D (2005). *Group-Based Modeling of Development*. Cambridge, MA: Harvard University Press.
- Nylund KL, Asparouhov T, & Muthén BO (2007). Deciding on the number of classes in latent class analysis and growth mixture modeling: A Monte Carlo simulation study. *Structural Equation Modeling: A Multidisciplinary Journal*, 14(4), 535–569. doi:10.1080/10705510701575396
- Park J, & Yu H-T (2018). Recommendations on the sample sizes for multilevel latent class Models. *Educational and Psychological Measurement*, 78(5), 737–761. doi:10.1177/0013164417719111 [PubMed: 32655168]
- Peterson CB, Crosby RD, Wonderlich SA, Mitchell JE, Crow SJ, & Engel S (2013). Predicting group cognitive-behavioral therapy outcome of binge eating disorder using empirical classification. *Behaviour Research and Therapy*, 51(9), 526–532. doi:10.1016/j.brat.2013.05.001 [PubMed: 23820157]
- Proust-Lima C, Philipps V, & Lique B (2017). Estimation of extended mixed models using latent classes and latent processes: the R package lcmm. *Journal of Statistical Software*, 78(2), 1–56. doi:10.18637/jss.v078.i02
- Ram N, & Grimms KJ (2009). Growth mixture modeling: A method for identifying difference in longitudinal change among unobserved groups. *International Journal of Behavioral Development*, 33(6), 565–576. doi:10.1177/0165025409343765. [PubMed: 23885133]

- Raudenbush SW, & Liu X-P (2001). Effects of study duration, frequency of observation, and sample size on power in studies of group differences in polynomial change. *Psychological Methods*, 6(4), 387–401. [PubMed: 11778679]
- Smink FR, van Hoeken D, & Hoek HW (2013). Epidemiology, course, and outcome of eating disorders. *Current Opinion in Psychiatry*, 26(6), 543–548. doi:10.1097/ycp.0b013e328365a24f [PubMed: 24060914]
- Striegel-Moore RH, & Leslie D (2000). One-year use and cost of inpatient and outpatient services among female and male patients with an eating disorder: Evidence from a national database of health insurance claims. *International Journal of Eating Disorders*, 27(4), 381–389. doi:10.1002/(SICI)1098-108X(200005)27:4<381::AID-EAT2>3.0.CO;2-U [PubMed: 10744844]
- Swanson SA, Lindenberg K, Bauer S, & Crosby RD (2012). A Monte Carlo investigation of factors influencing latent class analysis: An application to eating disorder research. *International Journal of Eating Disorders*, 45(5), 677–684. doi:10.1002/eat.20958 [PubMed: 21882219]
- Sysko R, Hildebrandt T, Wilson GT, Wilfley DE, & Agras WS (2010). Heterogeneity moderates treatment response among patients with binge eating disorder. *Journal of Consulting and Clinical Psychology*, 78(5), 681–690. doi:10.1037/a0019735 [PubMed: 20873903]
- Thompson-Brenner H, Boswell JF, Espel-Huynh H, Brooks GE, & Lowe MR (2018). Implementation of transdiagnostic treatment for emotional disorders in residential eating disorder programs: A preliminary pre-post evaluation. Corrected version. *Psychotherapy Research*, 29(8), 1045–1061. doi:10.1080/10503307.2018.1446563 [PubMed: 29553881]
- Thompson-Brenner H, Brooks GE, Boswell JF, Espel-Huynh HM, Dore R, Franklin DR, ... Lowe MR (2018). Evidence-based implementation practices applied to the intensive treatment of eating disorders: A research summary and examples from one case. *Clinical Psychology: Science and Practice*, 25(1), e12221. doi:10.1111/cpsp.12221
- Twohig MP, Bluett EJ, Torgesen JG, Lensegrav-Benson T, & Quakenbush-Roberts B (2015). Who seeks residential treatment? A report of patient characteristics, pathology, and functioning in females at a residential treatment facility. *Eating Disorders*, 23(1), 1–14. doi:10.1080/10640266.2014.959845 [PubMed: 25298220]
- Vitousek K, Watson S, & Wilson GT (1998). Enhancing motivation for change in treatment-resistant eating disorders. *Clinical Psychology Review*, 18(4), 391–420. doi:10.1016/s0272-7358(98)00012-9 [PubMed: 9638355]
- Wildes JE, & Marcus MD (2011). Development of emotion acceptance behavior therapy for anorexia nervosa: A case series. *International Journal of Eating Disorders*, 44(5), 421–427. doi:10.1002/eat.20826 [PubMed: 20721894]
- Williamson DA, Thaw JM, & Varnado-Sullivan PJ (2001). Cost-effectiveness analysis of a hospital-based cognitive-behavioral treatment program for eating disorders. *Behavior Therapy*, 32(3), 459–477. doi:10.1016/S0005-7894(01)80031-9

Figure 1.

Observed (panel A) and model-predicted (panel B) trajectories of symptom improvement during residential ED treatment. Observed trajectories in panel A are depicted using a locally-weighted regression (LOESS; locally estimated scatterplot smoothing) algorithm. Model-predicted trajectories are based on the three-class, quadratic latent mixture model selected as the best fit for the data. PMED = Progress Monitoring Tool for Eating Disorders (Espel-Huynh et al., 2020).

Table 1

Fit Indices for One- to Four-Class Growth Mixture Models for PMED (N = 360)

Fit Indices	1 Class	2 Classes	3 Classes	4 Classes
# Parameters	7	11	15	19
Max. Log-likelihood	-7346.19	-7296.64	-7278.23	-7271.13
AIC	14706.37	14615.28	14586.45	14580.25
BIC	14733.57	14658.03	14644.74	14654.09
SABIC	14815.25	14623.13	14597.16	14593.81
Entropy	--	0.61	0.63	0.54
Class Membership Proportions	--	Class 1: 80.0% Class 2: 20.0%	Class 1: 23.9% Class 2: 58.3% Class 3: 17.8%	Class 1: 39.4% Class 2: 14.7% Class 3: 18.6% Class 4: 27.2%
Mean Posterior Prob.	--	Class 1: 0.90 Class 2: 0.80	Class 1: 0.79 Class 2: 0.88 Class 3: 0.79	Class 1: 0.77 Class 2: 0.75 Class 3: 0.67 Class 4: 0.74
% Posterior Prob. > 0.80	--	Class 1: 81.3% Class 2: 56.9%	Class 1: 58.1% Class 2: 75.7% Class 3: 59.4%	Class 1: 47.2% Class 2: 43.4% Class 3: 23.9% Class 4: 44.9%

Table 2

Growth Factor Parameter Estimates for 3-Class Model (n = 360)

<i>Model Parameter</i>	Rapid Response		Gradual Response		Low-Symptom Static Response	
	<i>Est. (SE)</i>	<i>p</i>	<i>Est. (SE)</i>	<i>p</i>	<i>Est. (SE)</i>	<i>p</i>
<i>Fixed effects—class membership model</i>						
Intercept	0.29 (0.35)	.41	1.10 (0.27)	<.0001	(not estimated; reference class)	
<i>Fixed effects—longitudinal model</i>						
Intercept	(constrained to 0)		0.86 (0.31)	.005	−2.95 (0.39)	<.0001
Linear time (weeks)	−2.61 (0.21)	<.0001	−0.69 (0.06)	<.0001	−0.63 (0.14)	<.0001
Quadratic time (weeks)	0.38 (0.04)	<.0001	0.03 (0.008)	<.0001	0.06 (0.02)	.008
<i>Link function</i>						
Intercept	79.21 (1.76)	<.0001				
Standard error	7.00 (0.15)	<.0001				

Table 3

Clinical Characteristics of Latent Response Patient Groups - Three-Class Model

Clinical Variables	Rapid Response (RR; n=86)			Gradual response (GR; n=210)			Low-Symptom Static Response (LS; n=64)			Group Comparison Result
	Mean	SD		Mean	SD		Mean	SD		
Age	26.49	10.8		24.57	10.2		26.70	12.7		$H(2,357) = 1.50, p = .29$
Admission BMI	21.88	5.9		22.07	6.1		19.30	5.6		$H(2,354) = 5.53^*, LS < RR, LS < GR$
Primary ED diagnosis	AN-R 16.3% AN-BP 18.6% BN 34.9% BED 7.0% OSFED/UFED 23.2% ARFID 0%		AN-R 28.7% AN-BP 12.9% BN 27.3% BED 3.3% OSFED/UFED 26.8% ARFID 1.0%				AN-R 42.2% AN-BP 12.5% BN 20.3% BED 4.7% OSFED/UFED 12.5% ARFID 7.8%			Pearson $\chi^2(6) = 13.84^*$; AN-R more common in LS and less common in RR. Note: BED, OSFED, and ARFID categories were collapsed for analysis to allow sufficient cell size for chi-square analysis.
PMED Total (adm)	82.01	10.2		87.13	10.6		56.76	9.4		$H(2,355) = 212.1^{***}, GR > RR > LS$
PMED Total (discharge)	51.35	13.9		67.55	14.5		47.31	12.4		$H(2,355) = 73.02^{***}, GR > RR, GR > LS$
EDE-Q Global (adm)	4.26	1.2		4.59	1.0		2.01	1.4		Kruskal $\chi^2(2) = 108.95^{***}, GR > RR > LS$
EDE-Q Global change (adm to discharge)	-2.39	1.3		-1.49	1.2		-0.72	1.0		$H(2,357) = 38.49^{***}, RR > GR > LS$ (in order of greatest improvement to least improvement)
Binge eating endorsed (adm)	58.1%			52.9%			45.3%			Pearson $\chi^2(2) = 2.42, p = .30$
Vomiting endorsed (adm)	65.1%			54.3%			36.5%			Pearson $\chi^2(2) = 12.03^*$; more common in RR patients, less common in LS patients
Laxative misuse endorsed (adm)	38.4%			31.4%			12.7%			Pearson $\chi^2(2) = 12.09^*$; more common in RR patients, less common in LS patients
Length of stay (days)	32.58	8.41		40.49	11.67		36.14	10.03		Kruskal $\chi^2(2) = 34.40^{***}, RR < LS < GR$

Notes. ** $p < .001$; * $p < .05$. PMED=Progress Monitoring Tool for Eating Disorders; adm=admission (assessed at admission); EDE-Q=Eating Disorder Examination Questionnaire; BMI=Body Mass Index; AN-R=anorexia nervosa-restricting type; AN-BP=anorexia nervosa-binge/purge type; BN=bulimia nervosa; BED=binge-eating disorder; OSFED=other specified feeding or eating disorder; UFED=unspecified feeding or eating disorder; ARFID=avoidant/restrictive food intake disorder. Note on Group Comparison Result values: for continuous values, result indicates is from a one-way ANOVA F -test with Tukey's Honestly Significant Difference post hoc pairwise comparisons. In cases when continuous data did not meet assumption of homogeneity of variance, the Kruskal-Wallis rank sum test was applied instead with Dunn post hoc comparisons. For frequency variables, Pearson's chi-square test was applied