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The Effects of the COVID-19 Pandemic on Disordered Eating Symptoms in Women: A 49-Day, Daily Study Before and During the Outbreak in the USA

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Abstract

Longitudinal data are needed to examine effects of the COVID-19 pandemic on disordered eating. We capitalized on an ongoing, longitudinal study collecting daily data to examine changes in disordered eating symptoms in women across 49 days that spanned the time before and during the COVID-19 outbreak in the USA. Women from the Michigan State University Twin Registry (N = 402) completed daily questionnaires assessing a range of symptoms (e.g., binge eating, weight/shape concerns, liking/wanting of palatable food (PF) and whole foods, hunger). Dates of the first US COVID-19 case, first case in each participant's state, and onset of the initial stay-at-home orders (SHOs) were used to categorize women into those who completed all daily assessments prior to, during, or after these dates. We used mixed linear models and Specification-Curve Analysis to examine between-person (i.e., differences between women assessed before vs during/after COVID-19) and within-person (i.e., changes in symptoms from days before to days after the dates) effects of the pandemic. Results showed significantly higher levels of binge-related pathology (e.g., odds of binge eating, liking/wanting of PF) in women who completed assessments during/after COVID-19 events, and significantly increased liking/wanting of PF in the days following the pandemic onset. By contrast, minimal between- or within-person differences were observed for other variables, including weight/shape concerns, compensatory behaviors, hunger, or liking/wanting whole foods. Overall, results suggest a specific effect of the pandemic on binge-related phenotypes in women.

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General Scientific Summary

This study shows that the onset of the COVID-19 pandemic in the United States was associated with increased binge-eating pathology in women. The effects appear to be specific to binge eating and not present for other types of symptoms including body weight and shape concerns, compensatory behaviors, or overall levels of eating disorder symptoms.

Keywords

COVID-19; binge eating; eating disorders; weight/shape concerns; palatable food

Emerging data suggest the COVID-19 pandemic is associated with worsening symptoms, increased hospital admissions, and stalled recoveries in individuals with eating disorders (EDs; Linardon et al., 2022). A limited number of studies also indicate increased binge eating (Linardon et al., 2022), emotional eating (Al-Musharaf, 2020), loss of control over eating (Ramalho et al., 2021), eating to cope with stress (Cummings et al., 2021; Mason et al., 2021), food addiction symptoms (Cummings et al., 2021), weight/shape concerns (Keel et al., 2020; Linardon et al., 2022) and weight gain (Lin et al., 2021) in non-clinical samples. Most authors attributed these symptoms to increased stress and decreased social support and access to food, particularly during stay-at-home orders (SHOs), due to established associations between these factors and risk for EDs during non-pandemic times (Linardon et al., 2022).

Nonetheless, limitations of existing studies constrain conclusions that can be drawn. Most studies are cross-sectional, examining symptoms after the pandemic onset only, and lack data on symptom prevalence/trajectories pre-pandemic. The few longitudinal studies tend to use pre-post pandemic comparisons across two assessments that may span months/years (e.g., Keel et al., 2020; Linardon et al., 2022). These studies lack the temporal resolution needed to examine within-person changes in trajectories. They also are unable to isolate particular pandemic events (e.g., first case reports, lockdowns/SHOs) that may be critical. This makes it difficult to determine whether the stress associated with the pandemic's onset, later events such as lockdowns, or both have contributed to ED symptoms.

In the current study, we capitalized on an ongoing project examining daily changes in disordered eating across 49 consecutive days in a community-based sample of women in the United States (US). This study began in 2017 and was active in January 2020 when the first US COVID-19 case was identified. Because daily assessments are conducted online, we were able to continue data collection during all phases of the pandemic's onset (i.e., 1st US case, 1st case in each participant's state, lockdowns/SHOs) without interruptions or data loss. We used these data to conduct between-person (i.e., comparing women who completed assessments prior to versus during/after pandemic onset) and within-person (i.e., comparing days before and after COVID-19 events in the same participant) analyses. To our knowledge, this is the first study to examine daily changes in symptom trajectories across critical COVID-19 events.

Given past studies showing COVID-19 increases in all ED symptoms, it was difficult to decide *a priori* which symptoms (e.g., binge eating, restraint, weight/shape concerns) or COVID-19 events to study. To address this issue, we conducted exploratory analyses and used Specification-Curve Analysis (Simonsohn et al., 2019) to analyze all symptoms and several COVID-19 events. This exhaustive modeling approach seeks to avoid the noise and bias introduced by different data decision points (e.g., which symptom or COVID-19 events to analyze) by jointly evaluating all reasonable specifications and providing summary statistics of significant effects. These analyses decrease both the risk of Type 1 error and the chance of missing important effects, as they avoid focusing *a priori* on a limited and arbitrary set of ED symptoms and COVID-19 events.

Methods

Participants and Study Groups

Participants—Analyses included 402 women (ages 15–29; $M = 21.69$, $SD = 2.89$) from the *Twin Study of Exogenous Hormone Exposure and Risk for Binge Eating*. Most women were recruited from the Michigan State University Twin Registry (MSUTR) based on birth records (66%) (see Burt & Klump, 2019), although some were recruited via community/university advertisements (20%), social media (8%), and community events (5%) (recruitment source missing = 4 women (1%)). Because the parent study focuses on combined oral contraceptive (COC) use in twin pairs, eligibility criteria included: 1) COC use for ≥2.5 months by at least one twin; 2) no pregnancy in past 12 months or lactation in past 6 months; 3) no genetic/medical conditions or medications known to influence hormones/appetite/weight; and 4) in participants not taking COCs ($n = 63$, 15.7%), regular menses for ≥3 months and no other hormonal contraceptive use.

Study Groups—We were interested in assessing the effects of the *initial* COVID-19 outbreak on disordered eating. Thus, we focused on participants who completed their assessments by April 26th, 2020. All states represented in our sample had SHOs in place until this date, and the COVID-19 outbreak and SHOs were still recent events.

Between-Person Analyses.: We defined three groups based on whether participants completed their assessments before versus during/after the COVID-19 events. For the 1st US case, the pre-group included participants who completed all daily assessments before the 1st US case was announced on January 21st, 2020 (US Centers for Disease Control, 2020) ($n = 335$, 83.3% of total sample). The post-group included participants who completed any daily assessments after January 21st, 2020 ($n = 67$, 16.7%). Notably, our approach to the post-COVID-19 group was relatively conservative, as half of the participants in this group ($n = 34$) completed some of their assessments before January 21st, 2020. However, this approach increased the size of the post-group (and statistical power) and was supported by the fact that participants whose assessments spanned January 21st, 2020 had scores similar to participants who completed all assessments after this date (see Table S2 in Supplemental Material).

The 1st state case groups were made using dates from Lardieri (2020), while the SHO groups were coded using online data (Ballotpedia, 2020). We constructed these groups in the same

manner as for the 1st US case. Participants who completed all daily assessments before the first case in their state were in the "pre" group (n = 362, 90.1%), while participants who completed any daily assessments after the first state case were in the "post" group (n = 40, 10.0%). Likewise, for SHO, the "pre" group included participants who completed all assessments before SHOs in their region (n = 380, 94.5%), while the "post" group included participants who completed any daily assessments after SHOs in their state (n = 22, 5.5%).

Within-Person Analyses.: These analyses focused only on participants whose assessments included days both before and after the COVID-19 events (1st US case n = 34; 1st state case n = 31; SHO n = 22). These highly informative samples allowed us to examine whether there were within-person changes in disordered eating in the days following COVID-19 events.

Procedures

Symptom ratings were made each evening after 5:00 pm for 49 consecutive days using an online system or scantrons. Three additional study visits occurred at the start ("intake assessment"), midpoint (~day 23; "intermediate assessment"), and end of data collection (after day 49; "final assessment"). Each visit included study measures, re-assessment of eligibility, and height/weight measurements. Starting on March 11th, 2020, all assessments were conducted virtually. Prior to this date, some participants completed their intake, intermediate, and/or final assessments in person and some completed them virtually, depending upon participant preference and distance from the university.

Between assessments, staff contacted participants 1x/week to answer questions and confirm adherence. These procedures were effective for minimizing drop-outs (0.5%) and missing data (89% of daily assessments completed), and identifying participants who were no longer eligible (3%).

Measures

We analyzed a range of ED symptoms and appetitive processes (e.g., liking/wanting of food) to fully characterize COVID-19-eating pathology associations. Because most study measures are standard in the field, their psychometric properties are described in Supplemental Material.

Measures Administered at Intake Only—We used the 30-item Minnesota Eating Behavior Survey (MEBS; von Ranson et al., 2005)[1] to examine overall levels of disordered eating via the *total score*, as well as *body dissatisfaction*, *weight preoccupation*, *binge eating*, and *compensatory behaviors* via the MEBS subscales.

[1]The Minnesota Eating Behavior Survey (MEBS; previously known as the Minnesota Eating Disorder Inventory [M-EDI]) was adapted and reproduced by special permission of Psychological Assessment Resources, 16204 North Florida Avenue, Lutz, Florida 33549, from the Eating Disorder Inventory (collectively, EDI and EDI-2) by Garner, Olmstead, Polivy, Copyright 1983 by Psychological Assessment Resources. Further reproduction of the MEBS is prohibited without prior permission from Psychological Assessment Resources.

Measures Administered at Intake, Intermediate, and Final Assessments

Disordered Eating.: We used the *total score*, *weight concerns, shape concerns,* and *restraint scales* of the Eating Disorder Examination Questionnaire (EDEQ; Fairburn & Beglin, 1994) to assess disordered eating over the past 28 days. We also examined the EDEQ *subjective binge eating* (SBE; believing that one has eaten too much food and lost control over eating), *self-induced vomiting, laxatives, and diuretics* (combined into a single purging variable), *excessive exercise*, and *fasting* (i.e., ≥8 waking hours without eating) items. Notably, we did not analyze the *eating concerns* subscale given its more limited validity/reliability (Grilo et al., 2015). Consistent with prior work (Klump et al., 2014), we focused on daily reports of objective binge eating (OBE; eating a large amount of food in a short period of time in an uncontrollable way) and emotional eating (see below) instead of the retrospective (i.e., over the past 28 days) EDEQ *OBE* item.

Body Mass Index (BMI).: BMI (kilograms/meters^2) was calculated from height and weight measured during in-person assessments using a wall-mounted ruler and digital scale, respectively. Self-reported height and weight were used for virtual assessments. As noted above, height/weight measures were collected three times over the data collection period; differences in BMI were minimal and non-significant across the 49 days of the study (mean change = .007 kg/m2; SD = 1.15; p = .909).

Measures Administered Daily across 49 Days

Disordered Eating.: Participants reported whether they had *dieted* (yes/no) and the frequency of *OBEs* (0–9+ episodes) each day. Because very few participants reported more than one OBE on any day, OBEs were coded dichotomously (0 = no OBEs; 1 = ≥1 OBEs on that day). A detailed definition of OBEs was provided during the intake assessment, and participants were required to pass quizzes on their understanding of OBEs prior to starting data collection (see Supplemental Material for details). No explicit definitions or quizzes of dieting were provided.

Daily *emotional eating* and *weight preoccupation* were assessed using the emotional eating scale from the Dutch Eating Behavior Questionnaire (DEBQ; van Strien et al., 1986) and the MEBS weight preoccupation scale, respectively. Instructions for both scales were modified with permission to refer to that day.

Hunger and Food Liking/Wanting.: Daily *hunger* was measured using a 0–100 visual analogue scale (0 = “I am not hungry at all”; 100 = “I have never been more hungry”). A self-report questionnaire was used to assess daily *“liking”* (i.e., how much the participant enjoyed the actual taste of foods) and *“wanting”* (i.e., how much the participant craved/desired foods) of food examined in prior work (Monteiro et al., 2010; White et al, 2002): “sweets” (e.g., brownies), “carbohydrates” (e.g., bread), “fast food” (e.g., French fries), and “whole” foods (e.g., plain chicken/fish). Daily liking and wanting were assessed with four items per food category adapted from Born et al. (2011). The first item asked if the participant consumed any foods from the category that day. If yes, they were then asked, “How much did you *like* the taste of the food when you were eating them TODAY?” and “How much did you *want* the food today?” Responses were recorded on a 0 (*Not at all*) to 9

(*Extremely*) scale. If the participant did not consume the food that day, then they used the 0–9 scale to answer, "How much did you *want* the food TODAY, even though you did not eat it?" Participants were provided with definitions of liking, wanting, and the food categories and were required to pass quizzes on these definitions prior to starting data collection (see Supplemental Material for quiz descriptions).

Statistical Analyses

Specification-Curve Analyses—We first identified the set of reasonable decisions/specifications (i.e., which COVID-19 date(s) and symptom(s) should be analyzed?) and generated an exhaustive combination of those decisions. When examined across all possible combinations of each COVID-19 definition (1st US case, 1st state case, SHO) and ED symptom, there were 206 specifications in primary analyses (see Table S1 in Supplemental Material for all specifications), and 509 specifications when including post-hoc analyses.

We used mixed linear models (MLM) to run all possible combinations in between- and within-person analyses. We then summarized MLM results across all specifications to obtain estimates of overall effect sizes for categories of ED symptoms (see Table 1). As recommended in previous work (Burt et al, 2021; Simonsohn et al., 2019), we focused on summary statistics for each category, including the median effect size and 95% confidence intervals (CIs), the mean *Z*-score, the proportion of *p*-values less than .05, and the median *p*-value. To determine the statistical significance of our effects, we evaluated three indicators, reasoning that universal agreement among them would clearly indicate the effect size is statistically significant. An effect was deemed significant if the median 95% CIs did not overlap with zero, the median *p*-value was less than .05, and the average *Z*-score was ≥1.96.

Between-Person Analyses—MLMs examined differences in disordered eating between women in pre- versus post-COVID-19 groups. We included a random intercept at the twin pair level to control for the relatedness of participants within twin pairs and added age and recruitment source as covariates to control for group differences on these variables (see Descriptive Statistics below). We used average scores across the 49-days for daily measures (i.e., emotional eating, daily weight preoccupation, liking/wanting food, hunger), and averaged EDEQ scales across the intake, intermediate, and final assessments. In our MLM framework, between-person differences in variables averaged across occasions can be conceptualized as differences in people's baseline levels of a variable, independent of day-to-day fluctuations (e.g., whether one person tends to be higher on a trait than another) (see Hoffman & Stawski, 2009). Emotional eating, MEBS binge eating, and MEBS compensatory behaviors were log-transformed prior to analysis due to positive skew. All continuous variables were z-scored.

The full MEBS was administered at intake only and could only be examined for the 1st US case, as very few participants completed their intake assessment after the 1st state case or SHOs (ns = 0–5). Because the intake session predated the daily assessments, there were some participants (n = 45; 67.2%) whose MEBS was completed before the 1st US case, even though their daily assessments spanned or occurred after the date of the 1st US case. Thus,

these participants were grouped in the pre-1st US case group for analyses of the MEBS only; for all other analyses, their data were included in the post-1st US case group.

Several variables were measured categorically, including daily OBEs, daily dieting, and the EDEQ SBE and purging items. We analyzed dieting, OBEs, SBEs, fasting, and exercise as an odds ratio (i.e., the likelihood that the participant reported the behavior on any day of the study) as well as continuously (i.e., the number of days the participant reported the behavior). For the EDEQ purging variable, we only examined the odds of reporting purging at any point in the study, due to low symptom frequency.

Within-Person Analyses—MLMs examined within-person changes in disordered eating in the days prior to versus after COVID-19 events in women whose assessments spanned these dates. We included random intercepts that accounted for clustering of days within participants and participants within twin pairs, and an AR(1) residual structure to account for autocorrelation. We used a dichotomous indicator to examine changes in daily variables from before (coded 0) to after (coded 1) the 1st US case, 1st state case, or SHO.

Daily continuous variables (i.e., emotional eating, EDEQ scales, weight preoccupation, liking/wanting of PF and whole foods, hunger) were standardized within-person (i.e., the value for a given day was subtracted from a person's individual mean, then *z*-scored). Within-person standardization allowed us to examine how variables changed relative to an individual's equilibrium across COVID-19 events. Because the EDEQ was administered three times across the study, we used the intermediate visit EDEQ data for study days between the intake and intermediate assessments, and the final EDEQ scores for days between the intermediate and final assessments. We examined OBEs and dieting categorically by calculating the odds that the participant reported an OBE or dieting on each day. The smaller sample size of participants spanning COVID events combined with the relative rarity of SBEs and purging prevented within-person analyses of these variables. Note that sample sizes were considerably larger for between-person analyses of SBEs and purging, as all participants who completed the study pre-COVID were included, and behaviors on all days of the study could be counted toward the total outcomes (rather than dividing these over pre- and post-COVID periods).

Results

Descriptive Statistics

Descriptive statistics are provided in Table S3 in Supplemental Material. In the full sample, participants predominantly identified as white (90.3%) and non-Latina (96.5%), with smaller percentages identifying as Black/African American (5.1%), Asian/Asian American (0.6%), or multiracial (4.2%). Pre- and post-1st US case groups differed significantly on age (p = .005, d = .381); participants in the post-1st US case group were significantly older. Participants also differed significantly on recruitment source (p's < .001), where participants who completed the study during/after the 1st US case, 1st state case, and SHO were more likely to have been recruited through methods other than birth records. Participants pre- and post-1st state case also differed on Latina ethnicity, but notably, the total number of Latina participants was very small (n = 14 total participants), and these differences were

not observed for the other COVID-19 groups.[2] There were no significant group differences on race, educational attainment, income, COC use, or BMI (*p's* >.05). There was ample variability in disordered eating for all COVID-19 groups and, in the full sample, 8.7% (*n* = 35) of participants scored above the clinical cut-off on the MEBS total score (von Ranson et al., 2005).

Specification-Curve Analyses

Between-Person Differences—Relatively few between-person differences emerged in the Specification-Curve Analyses, and when differences were present, they were clustered within binge-eating phenotypes. As shown in Table 2, the median *p*-value was non-significant (all *p's* >.05) for compensatory behaviors, restraint/dieting, weight/shape concerns, liking/wanting of whole foods, and hunger. Strikingly, in most cases, no *p*-values (0%) were significant for any of the specifications, strongly suggesting that COVID-19 events were not associated with significant between-person differences in these symptoms.

Binge eating showed a different pattern of results. A significantly greater odds of OBEs was observed in participants assessed after the COVID-19 dates (ORs = 4.276–5.685; *p's* = .010-.021; see Table 2). The percent of *p*-values <.05 was 100%, indicating that pandemic events were uniformly associated with greater odds of OBEs and SBEs.

Findings for the continuous binge-eating variables were similar, although group differences were only at a trend-level (*p's* = .055-.076, except for 1st state case, where *p* = .253), and the percent of *p*-values <.05 was lower (i.e., 25–50%; see Table 2). To understand this heterogeneity, we examined MLM results for each variable included in the continuous binge-eating category. The MEBS binge-eating score (β = .518, *p* = .033) and proportion of days with an SBE (β's = .473-.780, *p*'s = .001-.003, median *p* = .002, % *p*-values <.05 = 100%) were significantly higher in participants who completed assessments post-COVID-19. There was also a trend for a higher proportion of OBE days in post-COVID-19 participants (β's = .220-.411, median *p* = .076). By contrast, emotional eating did not differ significantly across groups for any COVID-19 definition (β's = .031-.049, median *p* = .844, % *p*-values <.05 = 0%). Although not part of the binge eating category per se, liking sweets (β's = .386-.409, median *p* = .031, % *p*-values <.05 = 67%) and liking and wanting fast food (β's = .419-.554, median *p* = .014, % *p*-values <.05 = 100%) were significantly higher in post-COVID-19 participants. Data suggest that COVID-19 may be more strongly associated with behaviors closely tied to binge eating and reward processes (e.g., OBEs, SBEs, liking/wanting sweets) than emotional eating or general food intake/hunger.

Within-Person Changes—Findings for within-person changes mirrored some between-person results. There were no significant changes in global ED symptoms, weight/shape concerns, or hunger in the days after versus before pandemic events (see Table 3); effect sizes were largely non-significant, and only 0–33% of *p*-values were <.05. Within-person changes in liking/wanting of whole foods were also non-significant (median *p*'s >.15)

[2]To ensure that group differences did not unduly influence results, we re-ran all analyses for the 1st state case with ethnicity as an additional covariate. The pattern of results was identical (see Table S4 in Supplemental Materials), and thus, we focused on models with age and recruitment source as covariates.

except for SHO (see Table 3). However, we did observe significant within-person changes in liking and wanting of PF, with increases in the aggregate category for these variables after COVID-19 (see Table 3). The median *p*-value for the "All" COVID-19 category was significant ($p = .019$), with 60% of *p*-values <.05. Effects were particularly strong for the 1st US case (median $p < .001$, 94% of *p*'s <.05), but less strong for the other definitions (see Table 3). Once again, to understand heterogeneity in results, we examined individual PFs. The strongest effects were observed for liking/wanting of sweets as an overall category; liking and wanting of sweets were significantly greater in the days after pandemic events for the "All" definition, the 1st US case, and SHO (median β's = .218-.318, median $p = .01$-.002, 67–75% of *p*-values <.05), and were of trend-level significance for the 1st state case (median $\beta = .172$; median $p = .063$; 50% of *p*-values <.05). Liking/wanting of carbohydrates (median $\beta = .140$, median $p = .047$, 50% of *p*-values <.05) and fast food (median $\beta = .131$, median $p = .214$, 42% of *p*-values <.05) showed more variable results.

Finally, somewhat unexpected results were found for OBEs, emotional eating, and dieting. We did not observe significantly increased odds of OBEs in the days after COVID-19 (see Table 3), although we did observe non-significantly higher odds of OBEs during SHO (OR = 1.562). Perhaps more strikingly, we observed significant *decreases* in emotional eating after all COVID-19 dates (*p*'s <.001-.002; see Table 3), and a significantly *decreased* odds of daily dieting (*p's* = .029-.001) for all COVID-19 definitions except the 1st US case (see Table 3).

Post-Hoc Analyses

Enlarging the Sample Size.: One possible explanation for unexpected within-person findings regarding OBEs, emotional eating, and dieting is that smaller sample sizes for within-person analyses (*n*'s = 22–34) unduly influenced results. To address this possibility, we conducted a second set of Specification-Curve Analyses that examined days before and after COVID-19 events from all participants in the sample (N = 402). In these models, the days before the pandemic events included daily data from women whose assessments were completed before the pandemic began, as well as the pre-pandemic days in women whose data collection spanned the pandemic dates. The days after the pandemic event included the daily data from the women who completed their assessments after the pandemic dates, as well as the post-pandemic days from women whose participation spanned pandemic dates. For the 1st US and state cases, these additions increased the number of daily observations by 16,454–17,777 for pre-pandemic days and 454–1,630 for post-pandemic days. Increases in sample sizes for SHOs were more modest; although there were 18,659 more pre-SHO daily observations, there were no additional post-SHO observations because no participants completed all assessments after SHOs.

Findings were remarkably similar to the original models, with more evidence of significant increases in liking/wanting of PF, and significant decreases in emotional eating and dieting in the days after COVID-19 (see Table S5 in Supplemental Material). Changes in the odds of OBEs were non-significant (*p's* = .161-.618), although the odds ratio in the SHO group was higher (OR = 1.836; $p = .161$). Changes in nearly all other ED variables were non-significant (median *p*'s >.05; % *p's* <.05 = 0–33%).

Moderation by Levels of Eating Pathology.: Another possible explanation is that within-person changes in symptoms vary by pre-existing eating pathology. To explore this possibility, we re-ran all within-person MLMs including the MEBS total score and binge eating subscale as moderators. We focused on the MEBS because it was administered at the intake session that predated COVID-19, and the total score and binge eating scales provide measures of overall as well as binge-related pathology, respectively. Two-way interactions between our dichotomous COVID-19 indicator and MEBS scores were non-significant in nearly all cases, including OBEs and emotional eating (see Table S6 in Supplemental Material). We did observe significant interactions for the odds of dieting, suggesting that participants with greater overall eating pathology demonstrated greater decreases in dieting (see Table S6 and Figure S1). Overall, these analyses suggest moderation by levels of eating pathology are unlikely to account for our results.

Discussion

To our knowledge, this is the first longitudinal study examining daily changes in disordered eating across the onset of COVID-19 and SHOs. Findings were significant in showing that these events were associated with binge-related pathology in women. Between-person analyses revealed higher levels of binge eating in participants completing their assessments after the onset of COVID-19 that were not observed for other ED symptoms. Results for within-person analyses were more variable but showed significant increases in liking/wanting of PF in the days after COVID-19 that, once again, were not observed for other ED variables. Because these later analyses were longitudinal and within-person, they suggest the pandemic may have served as a “risk” event for increasing liking/wanting of PF commonly consumed during binges (Ayton et al., 2020). Nonetheless, within-person analyses also showed significant *decreases* in emotional eating and dieting, highlighting the complexity of symptom changes. Taken together, results suggest a specific effect of COVID-19 on changes in binge-eating-related pathology in women that may have substantially impacted psychological health.

A strength of our study was the examination of multiple COVID-19 events, including SHOs that might impact disordered eating most strongly. Our results were generally consistent across different COVID-19 events, suggesting the spread of COVID-19 (with or without SHOs) was likely stressful and associated with increased dysregulated eating. Past studies show strong effects of stress on increased binge eating in humans and animals that are mediated through alterations in brain reward pathways (see Adam & Epel, 2007) and decreased inhibitory control (Arnsten, 2015) that may together precipitate loss of control over eating. It is possible that COVID-related stress made it more difficult to control PF intake, particularly for PFs commonly consumed during a binge (e.g., sweets). Additional studies are needed to replicate our findings, although a recent study also found specific effects of COVID-19 on binge-eating disorders (Baenas et al., 2021).

We did find some evidence that SHOs may have been particularly associated with binge-related phenotypes. The effect sizes for binge eating during SHOs tended to be larger than those for the other COVID-19 events (see Table 3). These findings highlight the potential effects of stress associated with the onset of SHOs (e.g., decreased social interactions and

food access, increased food insecurity) (Becker et al., 2017; Cooper et al., 2020; Rodgers et al., 2020; Vullier et al., 2021) on binge eating in women from the community. It may be that the stress of SHOs, coupled with decreased access to food, was associated with increased desirability of PF and urges to binge eat.

Nevertheless, our findings of increased binge eating were more pronounced for between-person analyses, as within-person changes in OBEs were non-significant. Discrepant results may reflect a gradual pace of changes in binge eating during COVID-19. Between-person differences show that, on average, there were higher binge-eating scores across the post-pandemic days. But the lack of significant within-person changes suggest that changes from one day to the next were more modest. In other words, it may be that binge eating did not increase suddenly across important COVID-19 events, but rather increased gradually around these dates as stress accumulated. These findings align with some data in anxiety/depression. In a two-week, ecological momentary assessment study conducted immediately after SHO onset in the Netherlands, Fried et al. (2021) found minimal changes (or even small decreases) in anxiety, worry, and anhedonia from one assessment to the next. By contrast, overall depression scores rated at the start and end of the study increased during this same time period, and students rated their overall mental health as adversely affected by the pandemic. Other (largely cross-sectional) studies have found increased rates of depression post-COVID-19 (Bueno-Notivol et al., 2021). In combination with our findings, these data suggest that changes in mental health may have occurred gradually after COVID-19 events, rather than all at once. Similarities in findings across symptom types highlight a need to examine this possibility in future work, particularly since more gradual changes may delay treatment seeking and lead to prolonged distress.

We also observed significant *decreases* in emotional eating in the within-person models. Although emotional eating and binge-eating are significantly correlated (van Strien et al., 2005), a loss of control over eating is required for OBEs/SBEs but not for emotional eating. It is possible that these definitional differences account for discrepant findings, particularly given that associations between emotional eating and binge eating were more modest in our data (r = .350; 12% shared variance). If loss of control is at the heart of COVID-19/binge-eating associations, then binge eating may have increased even if emotional eating did not. Indeed, it is possible that participants decreased eating in response to negative emotions at the same time as they increased binge eating for other reasons, such as increased hedonic response to PF. This interpretation is supported by research discussed above suggesting that one of the primary pathways through which stress impacts eating is by increasing the hedonic value of PF through altered reward responding (Adam & Epel, 2007).

While the above may inform why binge eating and emotional eating showed different patterns of results, it may not fully explain why emotional eating would *decrease* in within-person analyses. One possible explanation is that persistently high negative affect during COVID-19 may have decreased perceptions that eating was driven by negative emotions. However, similar to Fried et al. (2021), we did not observe significant changes in negative affect in within-person analyses (β = .001 to −.208, p's = .560-.986 for Positive and Negative Affect Schedule negative affect subscale scores; Watson et al., 1998). An additional explanation is that decreases in emotional eating were due to self-monitoring,

as daily reporting can decrease the frequency of negatively viewed behaviors through increased self-awareness (Barta et al., 2012; Nelson & Hayes, 1981). Consistent with this, we conducted another set of post-hoc analyses and observed decreases in emotional eating across the study in participants who completed all assessments prior to the pandemic (e.g., January 21st, 2018/2019 and March 10th, 2018/2019) (β's = −.326, −.254; all *p*'s < .001). Importantly, we did not observe consistent changes in OBEs (ORs = 0.531–1.722; median *p* = .160) or PF liking/wanting (β's = −.004-.190; *p*'s = .010-.773) across these non-pandemic days, especially for liking/wanting of sweets that showed the strongest changes across pandemic events (β's = .032-.095; median *p* = .354). Taken together, these data suggest that increases in self-awareness may have impacted attributions for eating related to negative emotions (i.e., emotional eating) specifically without impacting binge eating or the experience of loss of control over eating related to hedonic value of food.

Finally, we also observed significant *decreases* in dieting, particularly in women with higher pre-existing levels of overall disordered eating. We failed to observe significant changes in dieting across non-pandemic dates and, if anything, slight increases were present (median ORs = 1.727, median *p* = .063). This suggests that decreases in dieting were specific to the pandemic period. Women may have felt less pressure to diet to conform to thin body ideals during the pandemic, particularly during SHOs when social interactions were reduced and effect sizes were the largest (see Table 3). In addition, women may have given themselves permission to consume PF to cope with the loss of other rewarding activities. These findings highlight the potential positive effects of the pandemic (at least initially) on decreased dieting and a need for more nuanced studies of differential effects of COVID-19 on EDs.

Although our study had many strengths (e.g., daily measures, Specification-Curve Analyses), there were also limitations. Sample sizes for within-person analyses were smaller and may have limited our ability to detect significant effects, particularly for SHOs. Post hoc power analyses (see Supplemental Material) indicated that although we had ≥80% power to detect small effect sizes (*d* = .30) across the 1st US case, our power was lower in models of SHOs (80% power to detect *d* ≥ .50). This lower power may have been particularly problematic for detecting changes in OBEs, despite the presence of effect sizes that mirrored findings from between-subject analyses.

We used Specification-Curve Analysis to comprehensively examine a range of symptoms and COVID-19 events. This approach is ideal for avoiding the noise and bias that comes from different data decision points and reduces the potential for Type 1 error by focusing on effect sizes and median *p*-values. Nonetheless, no statistical approach completely obviates the potential for false positive findings. Replication studies are needed to confirm that COVID-19 events impact binge-related pathology.

Our inclusion criteria and US-based sample led to a sample comprised primarily of white, non-Latinx, and middle-to-upper middle class women, which may limit generalizability to non-US and more diverse samples. This is a critically important future research question given differences in COVID-19 experiences across countries and demographic groups and the disparate and highly deleterious impacts of COVID-19 on marginalized groups in the US (e.g., Chakrabarti et al., 2021).

We examined ED symptoms rather than diagnoses. Although many symptoms are risk factors for, and key features of, EDs, our findings may not generalize to persons with clinical pathology. Indeed, there may be a worsening of all symptoms in persons with EDs rather than a specific increase in binge-eating (e.g., Monteleone et al., 2021). Because we were unable to examine SBEs or purging behaviors in within-person models, and we did not explicitly define dieting for participants, additional research on these symptoms is warranted.

Our between-person analyses were cross-sectional and may reflect differences in "third variables". We confirmed that groups did not differ on many key characteristics (e.g., BMI) and controlled for several covariates. Importantly, 93% of participants in the post-COVID-19 groups were recruited before the 1st US case, and 85% were recruited prior to January 1st, 2020. Thus, differences across COVID-19 groups are unlikely due to selection effects related to individuals' willingness to participate in the study during the pandemic.

We focused on the initial COVID-19 events rather than the longer-term effects of SHOs and waves of COVID-19 outbreaks. It is possible that other symptom changes may be observed, e.g., initial increases in binge eating during the pandemic onset may contribute to greater dietary restraint and weight/shape concerns during the SHOs and later pandemic waves. Future directions in our ongoing study include examining the longer-term effects of the COVID-19 pandemic using our extensive measures of SHOs, pandemic-related stressors (e.g., testing positive, social isolation, food insecurity, unemployment), and vaccination experiences.

Current findings have significant implications for women's mental health. Binge eating and EDs tend to be chronic conditions associated with substantial morbidity and comorbidity (Kessler et al., 2013; Mond & Hay, 2007). The onset or worsening of these symptoms during COVID-19 could have long-lasting consequences for women. Indeed, binge eating is difficult to stop, even with appropriate care (Linardon & Wade, 2018). These longer-term consequences, coupled with the stress of the on-going pandemic, suggest a need for careful screening and tracking of binge eating in women during the pandemic and a recognition that other large-scale stressors/events may have particular effects on binge-related pathology in women.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Individual Scales/Scores in each Disordered Eating Symptom Category

Category	Between-Person Analyses	Within-Person Analyses
Global disordered eating	MEBS total score DEQ total score	EDEQ total score
Binge eating	Continuous: MEBS binge eating DEBQ emotional eating OBEs – proportion of days with OBE EDEQ SBEs – proportion of days with SBE Categorical: OBEs – odds of OBEs during study EDEQ SBEs – odds of SBE during study	Continuous: DEBQ emotional eating Categorical: OBEs – odds of OBEs on that day
Weight/shape concerns	MEBS body dissatisfaction MEBS weight preoccupation EDEQ weight concerns EDEQ shape concerns	EDEQ weight concerns EDEQ shape concerns Daily MEBS weight preoccupation
Dieting and restraint	Continuous: EDEQ restraint Dieting – proportion of days dieted Categorical: Dieting – odds dieted during study	Continuous: EDEQ restraint Categorical: Dieting – odds of dieting on that day
Compensatory behaviors	Continuous: MEBS compensatory behaviors EDEQ fasting – proportion of days with fasting EDEQ excessive exercise – proportion of days with exercise Categorical: EDEQ fasting – odds of fasting during study EDEQ excessive exercise – odds of exercise during study EDEQ purging – odds of self-induced vomiting, diuretic use, or laxative use during study	Continuous: None Categorical: None
Hunger	Hunger VAS	Hunger VAS
Liking/wanting of palatable food (PF)	Liking/wanting carbohydrates Liking/wanting sweets Liking/wanting fast food Combined PF category of liking/wanting all three	Liking/wanting carbohydrates Liking/wanting sweets Liking/wanting fast food Combined PF category of liking/wanting all three
Liking/wanting of whole foods	Liking/wanting whole foods	Liking/wanting whole foods

Note. DEBQ = Dutch Eating Behavior Questionnaire; EDEQ = Eating Disorder Examination Questionnaire; VAS = visual analogue scale; MEBS = Minnesota Eating Behavior Survey; OBE = objective binge eating; SBE = subjective binge eating. For detailed descriptions of specifications for each category, see Table S1 in Supplemental Material.

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Table 2

Between-Person Differences in Disordered Eating Variables across COVID-19 Definitions

COVID-19 Definitions and Statistics		Global DE	Binge Eating (contin.)	Binge Eating (OR)	Compens Behav (contin.)	Compens Behav (OR)	Restraint/ Dieting (contin.)	Dieting (OR)	Wt/Shape Concerns	PF Liking/ Wanting	Whole Foods Liking/ Wanting	Hunger
All	Median ES	−.018	.292	**4.649**	.255	1.200	.072	.976	.009	.299	.093	.248
	95% CIs	−.47, .40	−.04,.61	**1.50, 16.05**	−.16, .60	.35, 5.44	−.31, .43	.29, 2.27	−.45, .35	−.06, .70	−.24, .46	−.11, .61
	Median *p*-value	.677	.076	**.017**	.220	.417	.719	.955	.606	.101	.580	.177
	% $p < .05$	0%	25%	**100%**	0%	11%	0%	0%	0%	31%	0%	0%
	Avg *Z*-score	−.153	1.641	**2.663**	1.235	.661	.307	−.153	−.010	1.564	.515	1.317
1st US Case	Median ES	.142	.383	**4.276**	.196	1.663	.078	.976	.024	.299	.093	.250
	95% CIs	−.27, .56	.01, .70	**1.55, 12.38**	−.11, .50	.47, 3.44	−.25, .40	.42, 2.27	−.30, .35	−.03, .62	−.24, .42	−.05, .55
	Median *p*-value	.537	.055	**.010**	.214	.412	.647	.955	.459	.072	.580	.107
	% $p < .05$	0%	50%	**100%**	0%	0%	0%	--	0%	44%	0%	--
	Avg *Z*-score	.635	1.780	**2.865**	.677	.857	.480	−.060	.232	1.792	.510	1.610
1st State Case	Median ES	−.154	.220	**4.756**	.223	1.050	.068	.806	−.124	.316	.178	.248
	95% CIs	−.53, .23	−.16, .60	**1.47, 16.05**	−.14, .59	.35, 5.44	−.31, .44	.29, 2.22	−.50, .25	−.06, .70	−.20, .55	−.11, .61
	Median *p*-value	.426	.253	**.021**	.316	.417	.732	.677	.519	.101	.362	.177
	% $p < .05$	0%	25%	**100%**	0%	0%	0%	--	0%	31%	0%	--
	Avg *Z*-score	−.800	1.450	**2.620**	1.210	.407	.350	−.420	−.630	1.455	.820	1.350
SHO	Median ES	−.018	.411	**5.685**	.283	1.260	.021	1.010	.009	.316	.033	.227
	95% CIs	−.47, .43	−.04, .86	**1.41, 25.27**	−.17, .73	.34, 8.62	−.44, .48	.29, 3.46	−.45, .46	−.14, .77	−.42, .49	−.22, .68
	Median *p*-value	.937	.076	**.019**	.220	.727	.930	.987	.606	.177	.833	.321
	% $p < .05$	0%	25%	**100%**	0%	33%	0%	--	0%	19%	0%	--
	Avg *Z*-score	−.080	1.810	**2.505**	1.240	.720	.090	.020	.200	1.444	.215	.990

Note. DE = disordered eating; contin = continuous scores; OR = odds ratio; Compens Behav = compensatory behaviors; Wt = weight; PF = palatable food; Avg = average; All = analyses across all COVID-19 definitions; SHO = stay-at-home orders; ES = effect size; 1st US Case *N* = 335 pre-COVID, 67 post-COVID; 1st State Case *N* = 362 pre-COVID, 40 post-COVID; SHO *N* = 380 pre-COVID, 22 post-COVID. Variables included in each category are described in Table 1. A dashed line "--" indicates that no value is available for this cell, as the category only has one score; the ES, 95% CIs, *p*-values, and *Z*-scores are the observed values for this score.

Table 3

Within-Person Differences in Disordered Eating Variables across COVID-19 Definitions.

COVID-19 Definitions and Statistics		Global DE	Emotional Eating	Binge Eating (OR)	Restraint Only	Dieting (OR)	Weight/Shape Concerns	PF Liking/ Wanting	Whole Foods Liking/ Wanting	Hunger
All	Median ES	−.001	**−.298**	.744	−.001	**.535**	−.001	**.186**	.150	.112
	95% CIs	−.03, .03	**−.42, −.17**	.37, 1.50	−.04, .03	**.31, .94**	−.04, .03	**.03, .35**	−.07, .32	−.02, .25
	Median *p*-value	.472	**<.001**	.305	.743	**.029**	.696	**.019**	.159	.102
	% $p < .05$	0%	**100%**	0%	33%	**67%**	0%	**60%**	25%	33%
	Avg *Z*-score	−.030	**−4.270**	−.367	−.587	**−2.033**	−.109	**2.479**	1.542	1.323
1st US case	Median ES	−.001	**−.298**	.744	−.001	.820	<.001	**.260**	.050	.112
	95% CIs	−.03, .03	**−.42, −.17**	.37, 1.50	−.03, .03	.49, 1.38	−.03, .03	**.12, .40**	−.10, .19	−.02, .25
	Median *p*-value	.971	**<.001**	.409	.961	.457	.958	**<.001**	.467	.102
	% $p < .05$	--	**--**	--	--	--	0%	**94%**	0%	--
	Avg *Z*-score	−.040	**−4.620**	−.830	−.050	−.740	.033	**3.708**	.760	1.640
1st State Case	Median ES	−.016	**−.337**	.540	**−.046**	**.535**	−.007	.143	.104	.012
	95% CIs	−.06, .02	**−.47, −.21**	.21, 1.37	**−.09, −.002**	**.31, .94**	−.05, .03	−.03, .31	−.04, .28	−.13, .16
	Median *p*-value	.441	**<.001**	.195	**.042**	**.029**	.696	.104	.192	.872
	% $p < .05$	--	--	--	--	--	--	44%	25%	--
	Avg *Z*-score	−.770	**−5.060**	−1.300	**−2.040**	**−2.180**	0%	1.690	1.595	.160
SHO	Median ES	.017	**−.26**	1.562	.008	**.365**	.019	.140	**.217**	**.179**
	95% CIs	−.03, .06	**−.42, −.10**	.67, 3.66	−.04, .05	**.20, .68**	−.03, .07	−.03, .34	**.02, .42**	**.02, .34**
	Median *p*-value	.472	**.002**	.305	.743	**.001**	.399	.109	**.041**	**.030**
	% $p < .05$	--	**--**	--	--	--	--	44%	**50%**	--
	Avg *Z*-score	.720	**−3.130**	1.030	.330	**−3.180**	.450	2.038	**2.270**	**2.170**

Note. DE = disordered eating; OR = odds ratio; Wt = weight; PF = palatable food; Avg = average; All = analyses across all COVID-19 definitions; SHO = stay-at-home orders; ES = effect size; 1st US Case $N = 34$, 1st State Case $N = 31$, SHO $N = 22$. Variables included in each category are described in Table 1. A dashed line "--" indicates that no value is available for this cell, as the category only has one score; the ES, 95% CIs, *p*-values, and *Z*-scores are the observed values for this score.