Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Changes in appetite during quarantine and their association with pre-COVID-19 mental and physical health

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ABSTRACT

Background: The COVID-19 Pandemic resulted in high levels of fear, anxiety, and stress. People with pre-existing physical and mental health conditions may have been more affected by the sudden changes in daily habits during the initial months of global quarantine imposed during the COVID-19 pandemic.
Methods: We designed the Quarantine, Anxiety, and Diet (QUAD) Survey to investigate the effect of pre-existing health conditions on the relationship of COVID-19 stress and food behavior. The anonymous survey was distributed online and only adults were eligible to participate.
Results: The results showed that responders with pre-existing health conditions differed from healthy participants in eating behavior during this time of stress. Compared to those classified as healthy, fewer people with pre-existing physical illness showed an increase in appetite with stress during the COVID-19 pandemic. Responders with pre-existing psychiatric illness were more likely to show increases or decreases in appetite with stress compared to healthy responders. Furthermore, higher BMI was associated with higher rate of increased appetite, whereas low BMI showed a higher rate of decreased appetite, both compared to normal BMI.
Conclusion: The QUAD Survey demonstrated that individuals with pre-COVID-19 psychiatric conditions are at a higher risk of maladaptive food behavior under stress. Since pre-existing psychiatric illnesses and acute stressors are known risk factors for eating disorders, special attention should be placed on those at risk to mediate the psychological and physical effects of stress and anxiety.

1. Introduction

The quarantine imposed by the COVID-19 pandemic provides an opportunity to examine the impact of stress induced by sudden environmental and social changes on eating patterns. Eating behaviors are guided primarily by habitual learning and food availability, and are affected by contextual cues, mood and emotional state (Furtjes et al., 2020; Kabir, Miah, & Islam, 2018; Macht & Simons, 2000). It has been shown that mental health can modify eating patterns. In particular, it is known that anxiety and stress impact hunger, desire to eat, and food choices (Reichenberger et al., 2018; Zysberg, 2018). Studies that showed increases in food consumption demonstrated increases in motivation to eat during periods of negative emotions, along with more intense bodily symptoms of hunger (Oliver, Wardle, & Gibson, 2000; Tan & Chow, 2014). Such stress-induced increased drive to eat palatable food has been demonstrated in people with varied BMI (Groesz et al., 2012). It has been suggested that low nutrient dense foods can offer immediate pleasure and relief from discomfort (Dallman, Pecoraro, & la Fleur, 2005). However, not everyone shows an increase in appetite and food consumption with stress. Among those who are affected by stress, about two thirds exhibit increases and one third demonstrate decreases in appetite and food consumption (Michael Macht, 2008; Zellner et al., 2006). The factors that mediate this stress-eating paradox, that stress can lead to both under- and over-eating, remain unclear (Stone & Brownell, 1994).

The COVID-19 quarantine was effective in reducing the virus spread but, as shown, had high psychological costs due to fear and worry of infection, contamination, economic consequences, xenophobia, and

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traumatic stress in the general population (Ahorsu et al., 2020; Mertens, Gerritsen, Duijndam, Salemink, & Engelhard, 2020). Forced social distancing from family, friends and co-workers, as well as changes in the rhythm of life have also shown to be associated with psychological and physical distress (Brooks et al., 2020). At the time of the initial pandemic, the unknown length of quarantine, change of routines, and new financial burdens contributed to anxiety and stress (Brooks et al., 2020). Studies examining the effect of the pandemic on mental health have shown that elevated stress, anxiety and depression were most pronounced among young and middle-aged adults whereas adults over the age of 65 were less affected by the quarantine in spite of the fact that they were at significantly higher risk due to the infection (Son, Hegde, Smith, Wang, & Sasangohar, 2020).

Chronic stress and anxiety may also alter eating patterns and are known as risk factors for eating disorders (EDs) (Hardaway, Crowley, Bulik, & Kash, 2015; Smith, Ortiz, Forrest, Velkoff, & Dodd, 2018). Pre-existing health conditions are associated with increased chronic stress and, therefore, may increase risk for changes in appetite and food consumption in times of acute stress or extreme changes. Previous studies had shown that psychiatric history is associated with greater increase of psychological distress after either natural or manmade disasters (Bromet et al., 2017). Measuring mood disorders 4–6 weeks following 2 weeks of isolation among participants suspected to be infected with Middle East Respiratory Syndrome (MERS) revealed that preexistent psychiatric disorder was a risk factor for increased anxiety and anger (Jeong et al., 2016). Similarly, COVID-19 related stress has been significantly higher among individuals with pre-morbid mental conditions (Taylor, Landry, Paluszek, & Asmundson, 2020). Furthermore, individuals who reported anxiety disorders prior to the pandemic had more adverse consequences of COVID-19 than individuals who had no prior mental health conditions (Asmundson et al., 2020). For example, Hao et al. (Hao et al., 2020) reported that psychiatric patients under strict lockdown scored significantly higher in depression, anxiety and stress scales at the peak of the pandemic. Thus, changes in eating patterns due to the COVID-19 pandemic are expected to be seen more among individuals with pre-existing psychiatric conditions. Similarly, physical health issues related to food such as obesity and diabetes are more likely to exacerbate unhealthy eating habits, including emotional eating and snacking (Macht & Simons, 2000). Individuals with chronic physical diseases or history of medical conditions showed increases in anxiety and stress symptoms and reported greater fear of infection and diminished access to medical care (Xiong et al., 2020). Comorbidity of pre-existing physical and mental health conditions in young adults also lead to higher levels of anxiety and depression during the first weeks of the pandemic (Alonzi, La Torre, & Silverstein, 2020). These studies suggest that pre-existing mental and/or physical health conditions are likely to result in increased anxiety and stress during the COVID-19 pandemic. In the present study, we investigated factors (i.e., BMI, exercise, demographic variables) that are associated with both increases and decreases in appetite during the initial stages of COVID-19 pandemic. We examined these associations among healthy individuals and in those with different pre-existing physical and mental health characteristics.

Numerous surveys were conducted early during the COVID-19 pandemic to assess the multifaceted effects of quarantine, including food security and food availability, physical activities (Ammar et al., 2020; CUNY, 2020; Di Renzo et al., 2020; Mitchell, Yang, Behr, Deluca, & Schaffer, 2020; Robinson, Gillespie, & Jones, 2020; Rolland et al., 2020). Very few studies, however, investigated the effect of the emotional state on eating behaviors during the pandemic. A positive association between COVID-19 related-stress and increased intake of sweet foods was observed in individuals with high emotional overeating (Sadler et al., 2021). Similarly, a positive association of stress during the pandemic and increased motivation to eat was reported (Smith et al., 2021). However, to the best of our knowledge, no previous study has examined the influence of pre-existing mental and physical disorders on the relationship between COVID-related stress and food behavior. The Quarantine, Anxiety, and Diet (QUAD) Survey was designed to address this question and to better understand the interaction between food behavior and mental health under the sudden and unprecedented changes during the COVID-19 Pandemic. We expect that changes in food behaviors would be seen more among those reporting increases in stress and anxiety, especially in those with pre-existing conditions. Specifically, we expect that stress will impair control over food consumption and will be seen as increased in overall appetite. Understanding the effect of quarantine on food behaviors could help the public better prepare for periods of self-isolation and home-working environment.

2. Methods & materials

2.1. Participants

The QUAD Study was conducted between April 23 and May 17, 2020, using Qualtrics software (Qualtrics, Provo, UT, USA, https://qualtrics.com). The survey was distributed in English, Spanish, and French; only adults over the age of 18 who could consent participated. Other than age and language, there were no inclusion or exclusion criteria. The survey was distributed on Internet, social media, e-mail, and text via an anonymous link that did not record IP addresses or any personal identifying information in order to protect participants' confidentiality. At the end of the survey, participants were asked to share the link with their friends and families. While the survey was widely circulated, the number of participants from countries other than the USA (27 countries) was small (n = 100). Because each country varied in terms of COVID-19 related circumstances and restrictions, and the number of responses for each country was very small, data was not sufficient to make statistical inferences based on these responses. Therefore, the current report was restricted to data from the 488 respondents from the USA. The study was approved by the New York State Psychiatric Institute Review Board.

2.2. Survey measures

The survey included questions on demographics (age, geographic location, gender, occupation, and education), self-report of physical and mental health conditions, appetite and eating habits, mental state and mood before and during the early months of the COVID-19 pandemic. The full survey is available from the authors upon request.

2.2.1. Pandemic-related changes in appetite/stress

Self-assessed changes in food behavior related to pandemic stress were measured using the question "In the past week, how has stress impacted your appetite?" The answer options were: 1) I have been more stressed, so I have had a bigger appetite. 2) I have been more stressed, so I have had a smaller appetite. 3) I have been less stressed, so I have had a bigger appetite. 4) I have been less stressed, so I have had a smaller appetite. 5) There has been no change.

2.2.2. Mental health

Mental health history (prior diagnosis) was assessed by asking "Do you currently have a diagnosis of any psychiatric or mood disorder? (for example, an anxiety disorder, eating disorder, depression, etc.)." If participant answered yes, they were asked to specify the name of the disorder. Current anxiety level relative to pre-pandemic was assessed by the Generalized Anxiety Disorder Questionnaire (GAD-7) (Spitzer, Kroenke, Williams, & Lowe, 2006) which is a widely used standard measure, by asking: "Compared to before COVID-19, how often have you been bothered by any of the following problems?" Responses for the GAD-7 were scored based on the standard protocol (Spitzer et al., 2006) and were categorized such that 0–5 was considered mild, 6–10 was moderate, 11–15 was moderately severe, and 16–21 was severe anxiety.

In addition, we asked a series of questions in order to assess the

current emotional state, with a focus on negative emotions related to the COVID-19 pandemic. We used a visual analogue scale (VAS) to assess *current* level of stress, loneliness and feeling anxious. Furthermore, we included questions about participants' *mood states* to capture multiple emotions, such as loneliness, isolation, worries, and hopelessness, or optimism, that, at the time, were associated with COVID-19 stress. First, we asked: "Has there been a change in your anxiety levels compared to before COVID-19?" with these possible answers a) I am more anxious, b) No change, c) I am less anxious. Then we asked the following questions: "In the past week, you have felt joyful, cheerful, or optimistic", "In the past week, you have felt anxious, irritable, or tense", "In the past week, you have felt depressed, hopeless, or trapped". For each of these questions the answer options were: a) All of the days, b) Most of the days, c) Some of the days d) None of the days. During scoring, we reversed coded the response 1–4 for the positive question, to make it consistent with the other questions. Finally, we asked about their *worries* regarding the impact of COVID-19: "Are you worried you will get sick with Coronavirus?" and "Are you worried that a loved one will get sick with the Coronavirus?" For both questions the response options were: a) Extremely worried, b) Very worried, c) Somewhat worried, d) A little worried, e) Not worried at all. Based on these responses, we created a Composite Emotion Score (CES) combining scores for current emotional state, anxiety and mood, and worried measures specific for the COVID-19 pandemic. The correlations between individual items included in the score are shown in Supplemental Table 1. Cronbach's alpha was 0.76, demonstrating sufficient internal consistency. The Low, Moderate, and High CES were defined as 0–12, 13–25, and 26–38 scores, respectively. The CES scores and the GAD-7 scores were strongly correlated but not co-linear ($r = 0.64$) indicating that they measure overlapping, but not identical constructs.

2.2.3. Physical health and health habits

Prior diagnosis of physical disorder was defined dichotomously based on participant self-report of chronic physical conditions, including heart disease, hypertension, asthma, COPD, and diabetes. BMI category was calculated based on self-reported height and weight, and classified according to: BMI <18.5 as underweight, 25 > BMI >18.5 as healthy weight, >30 BMI >25 as overweight and BMI >30.0 as obese. Exercise level was assessed using the questions: "Before COVID-19, I exercised …." and "During the COVID-19 pandemic, I exercise …" with the following answer options: a) Never b) Once a week c) Twice a week d) 2–3 times a week e) 4–5 times a week and f) Every day. The variable "exercise change" was created as the difference in exercise frequency before and during the COVID-19 pandemic, with increase and decrease in exercise indicated by positive and negative scores, respectively, and no change indicated by a score of 0.

2.3. Data analysis

Demographic characteristics, health habits, and pandemic related changes in appetite/stress were tabulated overall and by the participant's report of pre-existing physical and/or mental health diagnoses. We used multinomial logistic regression to estimate the independent associations of pre-existing physical and mental health diagnoses and health habits (BMI category and exercise change) with pandemic related changes in appetite/stress. We limited the level of the outcome to 3 categories: "more stressed, bigger appetite", "more stressed, smaller appetite" and "No change" due to the low proportion of responses (4%) in the "less stressed" categories. A single regression model (Model 1) included indicators for pre-existing mental and physical health diagnoses, BMI category, exercise change, and also adjusted for age group, sex, education, and race/ethnicity. Two additional models investigated the impact of current, rather than pre-existing mental health status by substituting the mental health diagnosis variable in Model 1 by the GAD-7 score (Model 2) or the CES (Model 3). We used pairwise deletion to exclude missing values in the models, and therefore, the sample size varied across the three models.

3. Results

3.1. Sample demographics and health habits

The demographic characteristics and health habits of the sample are shown in Table 1 (column 1). Our sample reflects a specific population of mostly (75%) females, with approximately half under the age of 34, living primarily in urban or suburban communities with middle and upper middle class family income and education levels. At the time of the survey, most participants were required to follow social distancing guidelines outside their homes (70%) and to shelter, stay in place, or quarantine (88%), with most of them already have been following those guidelines for 5–12 weeks (data not shown).

Overall, 37% of the participants reported "no change" to exercise frequency, while 34% reported decreases and the 28% reported increases in exercise frequency with respect to before the pandemic. Based on BMI, approximately half were of normal weight, with 5% underweight, and the remainder overweight or obese.

3.2. Mental and physical health

Table 1 (columns 2–4) shows the distribution of participant characteristics by the presence of mental and/or physical disorders. Although our sample comprised mostly of young adults, 24% reported having physical diseases, that includes hypertension (14%), asthma (12%), diabetes (4%), heart disease (2%), and COPD (1%), some of which occurred in the same individuals. Eleven percent reported pre-existing mental health disorders, including anxiety disorders (4%), and depression (3.1%), or anxiety comorbid with other mental health disorders (7.5%), and 9% reported both mental and physical diagnoses. The BMI of half of the participants was within the normal range, while 5%, 28%, and 14% and were underweight, overweight and obese respectively.

The distributions of characteristics differed by physical and mental health disorder status. As expected, those with only physical diagnoses tended to be older (>45+ y/o), while those with mental health conditions alone or comorbid with physical health conditions were more likely to be in the younger age groups (<34 y/o). There was also some variation of sex distribution, such that those with only mental health disorders or both mental health and physical disorders were more likely to be female than those with only physical diagnoses or neither. The distribution of education or income levels did not vary as a function of mental health and physical disorder status. Responders with prior mental health diagnosis have the same BMI distribution as responders with no other health conditions. In contrast, responders with pre-existing physical diagnosis were more likely to be obese or overweight, suggesting the high BMI is associated with their overall health (for more details see Table 1).

3.3. Pandemic-related changes in appetite/stress

Changes in appetite as a result of stress during the COVID-19 were observed such that overall, 55% of the sample reported that increased stress affected their appetite and only 4% that decreased stress affected their appetite (Table 2). As expected, increases in stress were reported in conjunction with both increases and decreases of appetite. Specifically, increases in stress were accompanied with increases in appetite in 35% and with decreases in appetite in 20% of the sample. Considering prior physical and/or mental health disorders shows that increased appetite with more stress was less likely to occur among those with physical conditions only relative to healthy responders. In contrast, smaller appetite with more stress was more prevalent among those with pre-existing mental health conditions (alone, or with physical health conditions as well) relative to healthy to respondents without either type of

Table 1
Demographic characteristics and health habits by prior diagnosis with mental health and physical disorders.

	Overall % (N)	Physical Diagnosis only % (N)	Mental Health Diagnosis only % (N)	Physical and Mental Health Diagnosis % (N)	No Diagnosis % (N)
Total Sample	**100 (488)**	**24 (116)**	**11 (51)**	**9 (41)**	**56 (269)**
A. DEMOGRAPHIC CHARACTERISTICS					
Gender					
Female	74.95 (365)	72.41 (84)	80.39 (41)	90.24 (37)	73.13 (196)
Male	23.61 (115)	25.86 (30)	19.61 (10)	7.32 (3)	25.75 (69)
Other	0.62 (3)	0.86 (1)	0 (0)	2.44 (1)	0.37 (1)
Prefer not to answer	0.82 (4)	0.86 (1)	0 (0)	0 (0)	0.75 (2)
Age					
18-24	29.51 (144)	12.07 (14)	39.22 (20)	34.15 (14)	33.09 (88)
25-34	18.85 (92)	13.79 (16)	33.33 (17)	24.39 (10)	17.84 (48)
35-44	11.68 (57)	8.62 (19)	9.8 (5)	7.32 (3)	14.13 (38)
45-54	13.11 (64)	18.97 (22)	7.84 (4)	4.88 (2)	13.38 (36)
55-64	14.34 (40)	18.97 (22)	1.96 (1)	17.07 (7)	14.87 (40)
65-74	9.22 (34)	18.1 (21)	7.84 (4)	7.32 (3)	5.95 (16)
75 or older	3.28 (16)	9.48 (11)	0 (0)	4.88 (2)	0.74 (2)
Ethnicity					
White/Caucasian	57.89 (242)	56.25 (54)	64.29 (27)	76.47 (26)	54.04 (127)
Black or African. American	6.22 (26)	11.46 (11)	2.38 (1)	2.94 (1)	5.53 (13)
Asian or Pacific Islander	9.09 (38)	4.17 (4)	7.14 (3)	8.82 (3)	11.49 (27)
Hispanic or Latino	13.64 (57)	12.5 (12)	16.67 (7)	5.88 (2)	13.37 (34)
Other races	2.39 (10)	3.13 (3)	0 (0)	2.94 (1)	3.83 (9)
Mixed races	7.9 (33)	10.41 (10)	7.14 (3)	2.94 (1)	8.09 (19)
Prefer not to answer	2.87 (12)	2.08 (2)	2.38 (1)	0 (0)	2.55 (6)
Community before COVID-19					
City or urban community	59.75 (291)	51.3 (59)	60.87 (31)	73.17 (30)	61.34 (165)
Suburban community	36.96 (180)	43.48 (50)	33.33 (17)	24.39 (10)	36.8 (99)
Rural community	6.15 (16)	5.22 (6)	5.88 (3)	2.44 (1)	1.86 (5)
Community during COVID-19					
City or urban community	43.24 (211)	37.93 (44)	39.22 (20)	48.78 (20)	46.1 (124)
Suburban community	50.61 (247)	50.86 (59)	54.9 (28)	46.34 (19)	50.19 (135)
Rural community	6.15 (30)	11.21 (13)	5.88 (3)	4.88 (2)	3.72 (10)
Total household income					
$150,000 or more	33.61 (163)	37.93 (116)	33.33 (17)	7.32 (3)	14.98 (40)
$100,000 to $149,999	15.46 (75)	14.66 (72)	9.8 (5)	7.32 (3)	4.49 (12)
$75,000 to $99,999	10.93 (53)	11.21 (55)	13.73 (7)	14.63 (6)	4.87 (13)
$50,000 to $74,999	9.69 (47)	7.76 (42)	5.88 (3)	4.88 (2)	5.99 (16)
$35,000 to $49,999	5.57 (27)	6.9 (33)	1.96 (1)	9.76 (4)	11.24 (30)
$20,000 to $34,999	5.77 (28)	3.45 (25)	9.8 (5)	17.07 (7)	9.74 (26)
Less than $20,000	4.74 (23)	3.45 (21)	7.84 (4)	14.63 (6)	15.73 (42)
Prefer not to answer	14.23 (69)	14.66 (17)	17.65 (9)	24.39 (10)	32.96 (88)
Highest education completed					
Graduate degree	41.56 (202)	50.86 (59)	39.22 (20)	42.5 (17)	38.43 (103)
Bachelor's degree	31.89 (155)	25.86 (30)	37.25 (19)	25 (10)	34.7 (93)
Associate degree	3.5 (17)	4.31 (5)	1.96 (1)	5 (2)	3.36 (9)
Some college	17.08 (83)	10.34 (12)	17.65 (9)	17.5 (7)	19.4 (52)
High school or equivalent	4.53 (22)	6.03 (7)	3.92 (2)	7.5 (3)	2.99 (8)
Less than high school degree	1.44 (7)	2.59 (3)	0 (0)	2.5 (1)	1.12 (3)
B. HEALTH HABITS					
BMI Category					
Underweight	4.92 (24)	1.72 (2)	5.88 (3)	2.44 (1)	5.95 (16)
Normal	50.41 (246)	39.65 (46)	56.86 (29)	41.46 (17)	55.39 (149)
Overweight	28.28 (138)	33.62 (39)	25.49 (13)	26.83 (11)	27.51 (74)
Obese	14.34 (70)	24.14 (28)	9.8 (5)	26.83 (11)	9.29 (25)
Exercise Change					
Decrease	34.22 (167)	35.34 (41)	23.53 (12)	43.9 (18)	33.83 (91)
Increase	28.69 (140)	25 (29)	37.25 (19)	26.83 (11)	29 (78)
No Change	37.09 (181)	39.66 (46)	39.22 (20)	29.27 (12)	37.17 (100)

Note: Percentages were calculated based on the number of responses for each question. 11 participants were missing information on mental health or physical health diagnosis.

condition (Table 2).

3.4. Association of mental and physical health with pandemic related changes in appetite/stress

Tables 3a and 3b presents results of the models for the changes in appetite with increased stress (increased or decreased appetite with more stress, versus no change) in relationship to mental health measures, prior physical diseases, BMI, and exercise changes while controlling for other demographic variables (see Methods).

In the "more stressed-bigger appetite" models, responders with pre-existing physical disorders showed approximately half the odds of reporting increased appetite/more stress than did responders without physical diagnoses (Table 3a). Reporting increases in exercise, versus no change in exercise, was also associated with decreased odds of reporting more stress-bigger appetite consistently across models. Conversely, higher levels of current anxiety or stress (GAD-7 and CES; Models 2 and 3, respectively) were associated with increased odds of having more stress-bigger appetite; the presence of prior mental health diagnosis (Model 1) showed an association that was in the same direction but not statistically significant ($p > 0.05$). Finally, BMI showed a dose-response pattern with more stressed-bigger appetite changes, such that increasing

Table 2
Appetite changes with stress by health status.

	Overall % (N)	Physical Diagnosis only % (N)	Mental Health Diagnosis only % (N)	Both Physical & Mental Health Diagnosis % (N)	No Physical or Mental Health Diagnosis % (N)
Total Sample	**100 (488)**	**24 (116)**	**11 (51)**	**9 (41)**	**56 (269)**
More stressed, Bigger appetite	34.84 (170)	26.72 (31)	35.29 (18)	36.59 (15)	38.29 (103)
More stressed, Smaller appetite	20.08 (98)	18.1 (21)	31.37 (16)	29.27 (12)	17.1 (46)
Less stressed, Bigger appetite	2.05 (10)	3.45 (4)	3,92 (2)	0 (0)	1.49 (4)
Less stressed, Smaller appetite	2.05 (11)	0.86 (1)	1.96 (1)	2.44 (1)	2.97 (8)
No change	40.78 (199)	50.86 (59)	27.45 (14)	31.71 (13)	40.15 (108)

Table 3
Odds ratio comparisons between three models for Appetite Changes with Stress adjusted for all baseline characteristics. Mental Health corresponds to Mental Health Diagnosis (Model 1), modified GAD-7 (Model 2) and Composite Stress Score (Model 3).

	Model 1 (N = 393)			Model 2 (N = 386)			Model 3 (N = 357)		
	Odds Ratio	CI	P-value	Odds Ratio	*CI*	*P-value*	*Odds Ratio*	*CI*	*P-value*
A. MORE STRESSED, BIGGER APPETITE									
Exercise Change Decrease	0.920	0.512, 1.652	0.779	0.736	0.396, 1.368	0.333	0.498	0.248, 0.999	0.050
Exercise Change Increase	0.547	0.292, 1.025	0.060	0.469	0.243, 0.907	0.026	0.374	0.178, 0.785	0.009
Physical Diagnosis = "Yes"	0.519	0.295, 0.914	0.023	0.458	0.251, 0.834	0.012	0.432	0.222, 0.841	0.014
Mental Health Diagnosis = "Yes"	1.673	0.853, 3.280	0.134						
Modified GAD-7	–	–	–	1.190	1.119,1.266	<0.001	–	–	–
Composite Emotion Score	–	–	–	–	–	–	1.165	1.116, 1.216	<0.001
BMI = "Obese"	2.032	0.935, 4.416	0.073	1.990	0.870, 4.551	0.103	2.523	0.940, 6.774	0.066
BMI = "Overweight"	1.765	0.987, 3.158	0.055	1.471	0.805, 2.688	0.209	1.664	0.850, 3.260	0.138
BMI = "Underweight"	0.196	0.022, 1.757	0.145	0.228	0.024,2.153	0.197	0.220	0.022, 2.192	0.197
B. MORE STRESSED, SMALLER APPETITE									
Exercise Change Decrease	1.458	0.707, 3.008	0.308	1.170	0.550, 2.490	0.684	0.690	0.299, 1.592	0.385
Exercise Change Increase	1.503	0.722, 3.127	0.276	1.268	0.591, 2.721	0.542	0.934	0.401, 2.177	0.875
Physical Diagnosis = "Yes"	1.033	0.532, 2.009	0.923	0.935	0.469, 1.866	0.849	1.116	0.522, 2.384	0.778
Mental Health Diagnosis = "Yes"	2.608	1.240, 5.484	0.012						
Modified GAD-7				1.212	1.132, 1.297	<0.001			
Composite Stress Score							1.193	1.134, 1.255	<0.001
BMI = "Obese"	1.113	0.399, 3.103	0.839	1.300	0.455, 3.711	0.625	1.472	0.422, 5.132	0.544
BMI = "Overweight"	1.920	0.951, 3.874	0.069	1.567	0.754, 3.257	0.229	1.871	0.839, 4.170	0.126
BMI = "Underweight"	3.632	1.109, 11.892	0.033	3.939	1.108, 14.222	0.034	4.607	1.181, 17.972	0.028

Reference Categories for the Odd Ratios were Exercise change: No change; Physical Diagnosis: No; Mental health Diagnosis: No; BMI: Normal. Models are also adjusted for: gender, education, race/ethnicity, and age group.

BMI categories were associated with higher odds of this outcome, however OR estimates for individual BMI strata were not statistically significant.

In models for the "more stressed-smaller appetite" outcome, previous mental health diagnosis (Model 1), higher GAD-7 scores (Model 2) or higher CES scores (Model 3) were associated with higher odds of reporting experiencing more stress/smaller appetite (Table 3b). Similarly, being underweight, compared to having a healthy BMI, was associated with three-to four-fold increases in the odds of this outcome.

4. Discussion

The COVID-19 Pandemic resulted in a natural condition of heightened anxiety and stress, and thus provides the opportunity to measure the effect of stress on food behavior. Our data showed that there was an immediate increase in stress, which probably related to the unknown nature of the virus, anxiety about contracting it, and fear of its spread. The QUAD Survey, like other surveys showed that overall anxiety was associated not only with the physical health impacts of the virus, but also the ensuing social isolation, economic, and uncertainty regarding the consequences of global quarantine (CUNY, 2020; Torales, O'Higgins, Castaldelli-Maia, & Ventriglio, 2020). These findings suggest that the pandemic induced emotional and social stress. Indeed, when asked about the greatest challenge of the pandemic, respondents most commonly used the words "family", "friends", "people", "worry", "lack", and "uncertainty". The way food behavior was related to the increased stress due to the COVID-19 pandemic had been the focus of a few studies (Sadler et al., 2021; Smith et al., 2021). For example, an increased motivation to eat sweet foods was associated with reported increased stress during the pandemic (Smith et al., 2021). Our QUAD survey also pointed to increased appetite, which can serve as a proxy for increase in motivation to eat and consumption of food. Sadler et al. (2021) observed that increased stress due to COVID-19 was associated with increased intake of sweets and desserts, regular chips, savory snacks, and fast foods among those who are typically emotional eaters. Although this study used psychological traits to assess changes in eating behavior in relation to emotional eating under stress, the influence of pre-existent physical and psychiatric conditions in relation to stress and eating behaviors remains less explored (Sadler et al., 2021).

Our data demonstrated that stress could decrease or increase appetite in those with pre COVID-19 physical and/or mental health disorders. This is consistent with previous studies that point out the bidirectional way in which stress affects eating behaviors. It has been shown that most individuals increase their appetite and food intake during stress, but a smaller group (about 30%) experience decreases in appetite and food intake (Epel et al., 2004; Stone & Brownell, 1994). In our QUAD survey, the majority of the participants reported changes in appetite with increased stress, with 40% of the respondents reporting an increase in appetite and 20% reporting a decrease in appetite (Table 2). These changes in mood (increased negative emotions) affected appetite among those with pre-existing mental health conditions more than among those who did not have prior mental health diagnosis. Indeed, the multinomial models showed that pre-existing conditions demonstrated a differential distribution of increase or decrease appetite. Participants with

pre-existing physical disorders showed only increases in appetite with more stress, which was less than the increase seen among healthy participants in the three models. This may be attributed to an increased awareness of diet and lifestyle in those with pre-existing physical disorders that require daily medical or physical management. In that sense, this group is more protected from using food to cope with the increased stress in sudden changes in environment or daily life. On the other hand, responders with pre-existing psychiatric disorders showed both increased (in Models 2 and 3) and decreased appetite (in the three models), and both were to a larger degree than the change in appetite among the healthy participants. Hence, pre-existing mental conditions, especially those related to stress and anxiety, may be risk factors for hyperphagia and hypophagia. Thus, the QUAD study demonstrated a relationship between current and pre-existing psychological distress and decrease or increase in the desire for food. These results are in agreement with studies situating mental health disorders as risk factors for changes in eating pattern with stress (Bulik & Allison, 2002; Hardaway et al., 2015).

There is a growing body of literature suggesting that stress and anxiety play a critical role in the development and maintenance of EDs. Hardaway et al. (Hardaway et al., 2015) have postulated that anxiety disorders may represent an etiological pathway into EDs, as patients with higher rates of anxiety experience EDs with increased severity and chronicity. Furthermore, anxiety and other mood states such as anger, sadness, and stress are often coupled with both obesity and EDs (e.g., binge eating and anorexia) (Gariepy, Nitka, & Schmitz, 2010; Silva, 2015). It has been shown that the onset of anxiety disorders precedes the onset of an ED, and early traumatic experiences are associated with increases in EDs later on life (Bulik & Allison, 2002; Molendijk, Hoek, Brewerton, & Elzinga, 2017). For example, anorexia and bulimia nervosa are associated with GAD, separation anxiety and panic disorders as well as to PTSD symptoms counts (Gleaves, Eberenz, & May 1998; Hinrichsen, Waller, & Emanuelli, 2004; Kaye et al., 2004; Piran, Kennedy, Garfinkel, & Owens, 1985). A meta-analysis showed that depression also increases the risk of becoming obese by 58% (Luppino et al., 2010). In a 20-year longitudinal study, Needham found that large increases in BMI were significantly more likely among participants who had initial depressive symptoms than among those who did not (Needham, Epel, Adler, & Kiefe, 2010). Notably, the two commonly reported psychiatric illnesses in our QUAD study were anxiety disorder and depression. The increased prevalence of change in appetite in our study are congruent with the high rate of comorbidity of psychiatric disorders, including EDs.

We also observed that changes in appetite with stress were related to BMI. Compared to responders with healthy BMI, overweight and obese responders were more likely to report increased appetite with stress, while underweight responders were more likely to report decrease appetite with stress. These findings were not modified by the presence of mental health disorders, as interactions between BMI and pre-existing health condition variables tested by the addition of product terms to regression models yielded no significant results (p-values for interaction<0.05, not shown). One study measuring cortisol and interleukin-6 responses to stress found that BMI and body fat are associated with dysregulated cortisol responses to stress (McInnis et al., 2014). Additionally, subjects with high markers of adiposity experienced less efficient hypothalamic-pituitary-adrenal (HPA) axis habituation, suggesting maladaptive physiologic stress responses in this population (McInnis et al., 2014). HPA axis dysregulation and abnormal cortisol response, in turn, have been shown to lead to increased appetite and weight gain (Hewagalamulage, Lee, Clarke, & Henry, 2016). Those with low BMI, however, may be more sensitive to cortisol's lipolytic effects, as studies have shown that lean subjects have a slower suppression and recovery of cortisol levels (Cakir, Sari, Tosun, & Karayalcin, 2005). Although the mechanisms underlying individual differences in response to stress are not clear, dysregulation of the HPA axis has been suggested to be responsible for both increases and decreases in appetite during stress (Yau & Potenza, 2013). Stone and Brownell (1994) reported that the likelihood of eating less increases as the severity of stress increases, possibility because the stress dampens one's desire to eat. In addition, the reward system also responds to stress and is involved in motivation and drive towards food by increasing food appetite (Adam & Epel, 2007). In this case, stress may promote irregular eating patterns and strengthen networks towards hedonic overeating, effects that may be exacerbated in overweight and obese individuals (Yau & Potenza, 2013).

Several limitations of the QUAD study must be acknowledged. First, our findings are based on self-reported data. As with all self-reported data, there may be inaccuracy in memory or reporting, and verification of information is unattainable. Similarly, there may be inaccuracy in the self-report responses of changes in appetite with stress during COVID-19, especially given a lack of longitudinal changes in appetite measured at two time points. Second, we distributed the survey via internet and asked participants to send the link to friends and family. This limited the sample to responses mainly from the United States, most of which were middle-class individuals who had access to internet and time to participate. The results are therefore not generalizable to a global or diverse population. Although a limitation, this also minimized food insecurity as a possible confounder of added stress and anxiety, as more than 80% of participants responded were not worried about access to food or funds for food. However, worry about unknown futures, job loss, or new financial burdens could have played a role in the reported increased stress. Third, the study is limited in its measures of stress and food behavior. The GAD-7 was a modified measure of general anxiety related to pre-pandemic anxiety levels. Furthermore, the CES index combined multiple measures of stress and emotions emerging during and because of the COVID-19 Pandemic, but is not a standardized instrument. Other potential variables that could induce stress were not presented here such as changing in living conditions and locations, which were indicated in our survey. Sudden changes in stress level and environment may specially affect eating patterns in different ways according to the individual characteristics and environment. For example, moving back home with parents can be stressful for some young people but nurturing for others. Fourth, the changes in appetite with stress could result in a change of BMI over time. Although this was unlikely in our study since our survey took place in the initial months of the pandemic, we did not have self-reported BMI measures obtained before the pandemic to compare with the pandemic values. Finally, the effect of stress on food habits was greater in women than in men (ORs<1.0 for males vs. females, for both "more stressed, bigger appetite" and "more stressed, smaller appetite" outcomes), but these associations were not statistically significant. It may be that we would require a larger sample size to detect significant differences by gender.

In summary, the COVID-19 Pandemic has brought unprecedented emotional and physical challenges. Food behavior and emotional states were affected in variable and individualized ways. Our study demonstrated that the increased stress among those with a pre-existing psychiatric condition were more likely to show increase or decrease in food behavior than healthy people. Since participants with physical illnesses are less prone than healthy controls to increase their appetite with stress, we can postulate that psychiatric illness is more related to unhealthy changes in food behavior during stress than physical illness. Together, these results suggest that both mental and physical health histories play a role in the way stress impacts food behavior. Our study suggests that anticipating and preparing for times of heightened stress may be an intervention point in the promotion of self-care and healthy habits for those with psychological distress. Focusing on the younger age group that showed to have the largest increased anxiety and depression symptoms, in our and other studies, should be further investigated to mitigate long term physical and mental health consequences and to implement a quick response to changing mental health needs. It is expected that management of stress reactions during such global stress could ameliorate unhealthy change in eating behaviors.

Ethical statement

This study was conducted with the approval of the New York State Psychiatric Institute's Institutional Review Board. This project has neither been published nor is under consideration for publication elsewhere.

Declaration of competing interest

The authors report no financial disclosures or conflict of interest.

Data availability

Data that support the finding of the manuscript are available from the corresponding author upon a reasonable request.

The lead author has full access to the data reported in the manuscript.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appet.2022.106104.

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