Inequality, Stress, and Obesity:

Socioeconomic Disparities in the Short- and Long-Term Effects of the Covid-19 Pandemic

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ABSTRACT

In a longitudinal study of a large sample of Americans, we found that people with a low socioeconomic status (SES) gained more weight during the Covid-19 pandemic, further exacerbating their vulnerability to the SARS-CoV-2 virus. The association between SES and weight gain was mediated by stress, but not by the other environmental or psychological factors suggested by prior research (e.g., temporal focus). A serial mediation model demonstrated that stress both decreased energy expenditures (through reduced physical activity) and increased energy intake (through higher and less healthy food intake). A follow-up study revealed that the early effects of the pandemic on weight and behavioral changes persisted 20 months later. Furthermore, stress levels decreased among people with a higher SES, but remained high for those with a lower SES. These findings demonstrate how the COVID-19 pandemic exacerbated health inequalities and provides insights for market-based and government solutions.

Keywords: Covid-19 pandemic, Obesity, Socioeconomic status, Inequality

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The COVID-19 pandemic presents a unique opportunity to explore the link between obesity and socioeconomic status (SES) and to discern the underlying mechanisms that drive this strong connection. Obesity is more prevalent among people with a lower SES than among those with a higher SES, a phenomenon known as the socioeconomic gradient of obesity (McLaren 2007). Obesity and low SES are also among the most prominent risk factors strongly associated with COVID-19. Not only do individuals with obesity, as well as those living in poverty, have increased risk of infection by the SARS-CoV-2 virus, but they also exhibit worse COVID-19 related health outcomes and a higher probability of death (Patel, et al. 2020; Popkin, et al. 2020). Little is known, on the other hand, about whether the pandemic itself influenced the association between SES and obesity.

In this research, we first examine whether the pandemic increased socioeconomic disparities in obesity during the early months of the pandemic; that is, whether it led to higher weight gain among those with a lower SES when compared to those with a higher SES. We then examine whether these changes persisted more than one year and a half after the start of the pandemic. Furthermore, we test the mechanisms suggested by the literature to explain the larger weight gain in those with a low SES at two levels of analysis. First, we compare the role of three psychological factors (stress, temporal focus, and wellbeing expectations) and two environmental factors (time spent outdoors and food scarcity) in mediating the link between SES and weight gain. After providing evidence for the mediating role of stress, we examine whether it influenced weight gain by influencing the nutritional quality or quantity of food intake during the pandemic, or levels of physical activity.

To answer these questions, we conducted a longitudinal study of a large sample of Americans, where we measured SES, weight change, and the environmental and psychological

factors that may influence their association over a 20-month period. Unlike most of the literature, which relies on a cross-sectional design, we used a cross-lagged multi-wave design in which the antecedents and mediators are measured in earlier waves than the dependent variable, thereby helping address some causality concerns, such as reverse causality. We found that individuals with a low SES gained more weight during the pandemic because they experienced higher levels of stress. We also found that stress led to weight gain because it reduced exercise, increased food intake, and reduced nutritional quality. Finally, we found that early changes in weight and behavioral responses persisted 20 months later – and that the elevated level of stress for people with a low SES persisted for more than one year, whereas the stress of those with a higher SES abated with the passing of time.

These findings have important implications for understanding the short- and long-term effects of the pandemic on the health and wellbeing of Americans, and how marketers and regulators should adapt to it. First, they indicate that the pandemic itself has exacerbated the already higher vulnerability that those with a lower SES exhibit to the virus. Second, the persistence of the effects suggests that there is a need for governmental interventions specifically targeted at people with a lower SES, as well as a market for products and services that alleviate the higher stress of those with a lower SES. Finally, these results shed new light on the unresolved question in the literature on the drivers of the socioeconomic gradient of obesity, where studies typically examine only one or two factors at a time and have therefore not estimated the relative importance of the five factors that we studied (Claassen, Klein, Bratanova, Claes & Corneille 2019).

The American Psychological Association defines socioeconomic status (SES) as the social standing or class of an individual, as can be measured by their education, income, or occupation (Saegert, et al. 2007). SES and obesity are strongly associated in high- and middle-income countries (Dinsa, Goryakin, Fumagalli & Suhrcke 2012; McLaren 2007). For example, the proportion of American women with obesity is 47.1% among those who only have a high school degree compared to 29.6% among those with a college degree (Hales, et al. 2018). The socioeconomic gradient of obesity has been steadily increasing in the United States prior to the pandemic (Frederick, Snellman & Putnam 2014), resulting in greater health inequality.

Mediators of the link between socioeconomic status and obesity

Claassen, et al. (2019) reviewed 22 studies investigating the factors that mediate the link between SES and obesity. In addition to physical factors that are not under the control of respondents, they identified key environmental and psychological factors (e.g., stress, temporal focus) that may underlie the SES-obesity relationship.

Stress. Multiple studies have established a strong link between experienced stress and food consumption behaviors in children and adults (Hill, Moss, Sykes-Muskett, Conner & O'Connor 2018). In a recent meta-analysis, Hill, et al. (2021) found that elevated stress is associated with both an increase in unhealthy food consumption as well as a decrease in healthy food consumption. Another recent systematic review revealed a consistent, significant negative association between high stress levels with diets high in fat, sugar, and fast food, and low in fruits, vegetables, and fish (Khaled, Tsofliou, Hundley, Helmreich & Almilaji 2020).

Since stress is consistently higher among people with a lower SES (Cohen, Doyle & Baum 2006) and has been associated with negative health consequences (Ridley, Rao, Schilbach

& Patel 2020), these results suggest that stress should be a strong mediator of the link between SES and obesity. Yet, fewer than half of the studies that tested this mediation found support for it (Claassen, et al. 2019). As these authors point out, this may be driven by sex differences in the samples studied, since stress appears to be a stronger mediator among women than men. The heterogeneity across findings might also be explained by the type of stress being studied; for example, work and childhood stressors do not appear to mediate the relationship between SES and body mass index (BMI). However, adult studies have established evidence for the link between SES and stress, where the stress hormone, cortisol, was used to capture stress – researchers found that higher SES levels were linked to lower concentrations of total cortisol through the day (Cohen, et al. 2006).

Temporal focus. Past research has demonstrated that the healthiness of dietary choice decisions is influenced by whether people focus on the future versus the past or present. Winterich and Haws (2011) found that people consume less unhealthy food when engaged in future-focused positive emotions, such as hopefulness, compared to when engaged in past- or present-focused emotions, like pride or happiness. Chang, Claassen, and Klein (2020) further demonstrated that the decrease in unhealthy consumption brought about by focusing on the future was stronger among people with a higher body mass.

Given that exhibiting a lower future-oriented focus is strongly associated with having a lower SES (Fieulaine & Apostolidis 2015) and with a higher BMI (Barlow, Reeves, McKee, Galea & Stuckler 2016), temporal focus could mediate the link between SES and obesity. Only one study examined this link and it found no mediation (Guthrie, Lessl, Ochi & Ward 2013), but this could be driven by the relatively low sample size (N=265).

Expectations for the future. In addition to focusing on the future, having positive expectations about the future is a strong predictor of the likelihood of engaging in behaviors that have benefits in the long-term, such as healthy eating and exercising, over activities that exhibit more immediate rewards (McDade, et al. 2011). Because lower SES groups tend to have lower expectations for the future, these expectations could play a role in explaining health disparities across socioeconomic groups, including obesity. In a study conducted on middle-aged Swedish women, Wamala, Wolk, and Orth-Gomér (1997) found that expectations for one's future quality of life mediated part of the association between SES and BMI.

Time spent outdoors. Many studies have focused on time spent outside, as it is one of the variables related to the physical environment that is most under the control of an individual. Time spent outdoors has been linked to various health outcomes in children (McCurdy, Winterbottom, Mehta & Roberts 2010) – and children living in low-income areas spend less time partaking in outdoor activities (Oreskovic, Kuhlthau, Romm & Perrin 2009). One study found that outdoor play time decreased children's BMI scores and their risk of obesity (Ansari, Pettit & Gershoff 2015). However, this was only conducted among children of low-income families and no such study exists for adults of various socioeconomic backgrounds.

Food scarcity. Food scarcity, or experiencing a shortage in access to fresh and preferred foods at the grocery store, can play a significant role in driving weight gain, particularly in those with reduced access to resources, such as those with lower SES. Access to fresh and nutritious foods has been associated with both SES (Aggarwal, Monsivais, Cook & Drewnowski 2011) and obesity in the United States (Wilde & Peterman 2006). Rather than actual access to food, it is the perception of lack of access that is most reliably linked to obesity (Claassen, et al. 2019). According to the "resource scarcity hypothesis", the perception of food scarcity increases low

SES populations' desire for caloric resources in environments where calorically-dense foods are prominent (Dhurandhar 2016).

In the context of the COVID-19 pandemic, in particular, the resource scarcity hypothesis could take on various, potentially orthogonal forms. To date, most research has focused on food insecurity, rather than food scarcity, as a potential driver for the effects of SES on weight gain and obesity. Food insecurity is defined as, "limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways", and it is directly linked with financial resources in the process of obtaining foods (Life Sciences Research Office 1990) – and past research has found that food insecurity mediates the relationship between SES and BMI in women (Beydoun & Wang 2010). Given multicollinearity concerns between SES and food insecurity, as well as the widespread shortages brought on by supply chain disruptions and excessive stockpiling, the pandemic created a unique environment to study food scarcity in particular, as the experience of food scarcity during the pandemic may relate to, but is by no means synonymous with, SES.

Effects of the Covid-19 pandemic

The pandemic created unique conditions that are particularly conducive to the study of the link between SES and obesity. One of the difficulties of existing studies is that they lacked enough power to detect differences between people of varying levels of SES on key mediators. The pandemic and its response (e.g., "stay at home" policies as well as store and school closures) created stress and reduced expectations about what the future would hold for all, but particularly for people with a lower SES, who exhibited disproportionally higher risks of job loss and infection due to their work and/or domestic conditions (Dooley, Bandealy & Tschudy 2020; Patel, et al. 2020).

Overall, there is limited evidence regarding socioeconomic disparities in weight gain caused by the pandemic and their antecedents. More generally, no study has assessed the relative importance of the five mediators of the socioeconomic gradient of obesity highlighted by Claassen, et al. (2019). In addition, we do not know whether the link between SES and weight gain can be explained primarily through differences in energy expenditures (e.g., exercise) or in energy intake (i.e., what or how much people eat), or both. Cheon and Hong (2017) found that feelings of lower SES relative to others stimulated appetite and resulted in greater preferences for calorically dense foods, but they did not examine the link between SES and calorie expenditures. Finally, most of the published studies relied on cross-sectional data, rather than employing a cross-lagged longitudinal design, which, if utilized, helps reduce the risk that results are driven by reverse causality.

STUDY 1: UNDERSTANDING THE LINK BETWEEN SES AND WEIGHT GAIN DURING THE EARLY MONTHS OF THE COVID-19 PANDEMIC

We conducted a cross-lagged multi-wave study, where we sent three questionnaires to a panel of U.S. residents via Prolific during the early months of the pandemic (wave 1 started on March 30, wave 2 on April 10, and wave 3 on May 5, 2020), which we supplemented a year and a half later with a fourth wave that began on November 8, 2021. A total of 892 respondents (510 female) participated in all three waves and provided information on their weight change, SES, sex, and age. We focused on weight change, rather than food choices, to respond to the call for more externally valid studies of obesity in psychology (Loyka, et al. 2020)

We implemented the cross-lagged design by measuring weight change in wave 3 and its psychological antecedents in earlier waves. This precludes responses to weight change from influencing ratings measured earlier. Although it cannot fully replace a true experiment with

randomization, a cross-lagged longitudinal design, which measures key variables at distinct timeframes for the same set of respondents – as we did – can help rule out spurious correlation as well as potential sources of common method variance (Burkholder & Harlow 2003; Spector 2019).

Measures

Socioeconomic status. Drawing on prior studies (Cheon & Hong 2017), we measured SES in wave 2 using the MacArthur Scale of Subjective Social Status (Adler, Epel, Castellazzo & Ickovics 2000). This scale asks respondents to place themselves on a 10-point ladder where the top of the ladder represents the people who are the best off (i.e., the most money, education, and respected jobs) while the bottom of the ladder consists of people who are the worst off. This measure comprises our key independent variable and embodies subjective SES, as opposed to objective SES – this is because past research demonstrates that subjective social standing and perceived inequality may be stronger determinants of health outcomes, above and beyond objective measures, such as income (Adler, et al. 2000; Wilkinson 1999).

Dependent variables. We measured weight change during the pandemic in wave 3 by asking respondents to report how much weight they had gained or lost since the start of the pandemic. Respondents were instructed to choose between seven categories in 5-pound increments ("lost 15 lbs. or more", "lost about 10 lbs.", "lost about 5 lbs.", "stayed about the same", "gained about 5 lbs.", "gained about 10 lbs.", "gained 15 lbs. or more"). They could also indicate that they had no idea. To measure changes in consumption quantity, they were asked whether they are eating [more food] [about the same amount of food] or [less food] than usual. For consumption healthiness, the options were: "I am eating [more healthy] [about the same] or

[less healthy] right now than usual. For exercise, the options were "I am exercising [more than usual] [about the same as usual] or [less than usual] right now".

Psychological mediators. We measured stress using the 8-item, 7-point modified stress scale developed by Durante and Laran (2016), which includes items such as, "I find myself getting agitated". To improve the reliability of the measure, and use stress measures collected prior to the dependent variable, we averaged the measures of stress collected in waves 1 and 2, but the results are unchanged when also using the stress data collected in the third wave. We examined the evolution of stress across subsequent waves in the follow-up study. To avoid contaminating the stress variables, the other psychological mediators were measured in wave 3.

Like Winterich and Haws (2011), we measured temporal focus in wave 3 by subtracting the past-focus index score (which consists of items such as, "I replay memories of the past in my mind") from the future-focus index score (with items such as, "I focus on my future") of the Temporal Focus Scale (Shipp, Edwards & Lambert 2009). We measured respondents' expectations about their future quality of life using the Cantril (1965) Self-Anchoring Scale; this consists of a 10-point ladder scale where the top is described as representing their best possible life and the bottom as their worst possible life. We asked respondents to indicate where they thought they would stand on the ladder in a year's time (Spring 2021).

Environmental mediators and other questions. To measure outdoor time, we asked respondents to report the number of minutes that they spent in nearby outdoor spaces (including, but not limited to, their backyard, garden, balcony, etc.) in the past couple of days. We measured food scarcity in waves 1 and 2 by asking respondents to indicate whether they were experiencing difficulties finding: 1) fresh, perishable foods and 2) their preferred foods at their local grocery store(s). We then averaged their responses over the two measures and the two waves.

For exploratory purposes, the questionnaires included additional questions about changes in health-oriented behaviors, specific sources of stress (financial or health-related), diet/eating styles, as well as respondents' food preferences and pandemic experiences. To manipulate stress, participants in wave 3 were exposed to exploratory photo stimuli of either soothing or stressful scenes. However, this exploratory intervention failed to influence stress (p=.46), which is not surprising in hindsight given the high stress created by the pandemic itself. Including the intervention as a covariate did not influence the results.

Results: Main effects

To provide an intuitive grasp of the effects, we report in Figure 1 descriptive statistics about the changes in weight, exercise and eating behaviors, and the environmental and psychological measures for respondents with low, medium, and high SES (categorized via a three-way equal split). All statistical tests use the continuous measure of SES, as reported in the analyses below.

Weight change. For illustrative purposes, we categorized the measure of weight gain used in subsequent analyses to indicate whether respondents had gained weight (i.e., reported gaining 5 pounds or more), maintained the same weight (gaining or losing less than 5 pounds), or lost weight (losing 5 pounds or more) between the start of the pandemic and May 2020.

The top left panel of Figure 1 shows that the proportion of respondents who gained weight decreases as SES increases (from 34% in the lowest SES to 30% in the highest SES tier). Conversely, the proportion of respondents who lost weight during the pandemic increases with SES (from 16% for the lowest tier to 20% for the highest tier). The proportion of respondents who maintained their weight is constant at 50% across the three SES levels.

Exercising and consumption. The top right panel of Figure 1 shows that SES is associated with the amount of exercise that respondents engaged in during the pandemic. In particular, the proportion of respondents who made use of the pandemic to exercise more than usual strongly increases with SES (from 13% for the lowest tier to 33% for the highest tier). Although the relationship is non-monotonous because of the medium SES group, the proportion of respondents who exercised less than before the pandemic is lower in the high SES group (31%) than in the low SES group (37%).

Similarly, consumption healthiness is positively related with SES. The proportion of respondents who responded to the pandemic by eating more healthily is higher in the top SES group than in the bottom group and, conversely, the proportion of those who ate less healthily is lower in the high SES group than in the low SES group. In contrast, the association between SES and consumption quantity is inconclusive, as the proportions of respondents who responded to the pandemic by eating more and by eating less both increase with SES.

Psychological and environmental factors. The bottom of Table 1 reports the correlations and standard deviations of the five mediators. None of the correlations is so high as to warrant concerns about multicollinearity (all VIF's<1.12). For illustrative purposes, Table 1 also reports the average level of the mediators across the three socioeconomic groups (but the statistical tests are performed in subsequent analyses using the continuous measure of SES).

Additional analyses revealed a consistent, negative correlation between SES and stress measured in each wave ($r_{\text{wave 1}}$=-.08, p=.013; $r_{\text{wave 2}}$=-.12, p<.001; and $r_{\text{wave 3}}$=-.11, p=.001), which is not surprising given the high correlation between the measures of stress collected in the three waves (all r's>.71). The 8-item stress scale was significantly correlated with the more specific measure of financial stress in all three waves ($r_{\text{wave 1}}$=-.35; $r_{\text{wave 2}}$=-.32; and $r_{\text{wave 3}}$=-.32, p<.001 for

all 3 waves) and with the measure of health-related stress ($r_{\text{wave 1}}$=-.06, p=.068; $r_{\text{wave 2}}$=-.10, p=.003; and $r_{\text{wave 3}}$=-.12, p<.001), although only marginally for wave 1.

Results: Mediation effects

To test for differences in weight gain by SES, we used Hayes' PROCESS (2018) model 4 (bootstrap sample=10,000, 95% CI) using the continuous measure of SES as the independent variable and age and sex as covariates (additional analyses available from the authors did not illustrate moderation by sex, with all p's>0.60). The top panel of Figure 2 shows that the continuous measure of SES had a statistically significant effect on all mediators except food scarcity, which was unrelated to SES. Stress was the only mediator to significantly predict weight change. It was also the only factor to mediate the effects of SES on weight change during the pandemic (*CI*=[-.065; -.006]). Furthermore, the residual effects of SES were not statistically significant (p=.32). Compared to men, women experienced greater food scarcity and higher stress. Additionally, the time spent outdoors increased with age, while stress and expected future wellbeing decreased with age.

We obtain the same results, where stress is the sole mediator, of all the proposed mediators, to significantly mediate the effects of SES on weight gain, when using mediation model 4 and stress collected in wave 3, rather than in waves 1 and 2. For robustness, we also incorporate stress averaged from waves 1 through 3 in model 4, and obtained the same results once again. Finally, to examine the alternative explanation that weight change (measured in wave 3) could have influenced stress (measured in waves 1 and 2), we estimated a model in which weight change mediates the effects of SES on stress, rather than stress mediating the effects of SES on weight change. The mediation effect in that model was not statistically significant (*CI*=[-.014;.001]), ruling out the alternative explanation of reverse causality.

To examine whether stress led to weight gain by reducing exercise or influencing the amount or nutritional quality of energy intake, we conducted a serial mediation analysis using PROCESS model 81 (bootstrap sample=10,000, 95% CI). As shown in the bottom panel of Figure 2, stress decreased physical activity (p=.03), increased food consumption quantity (p=.006), and reduced the quality of foods consumed (p<.001). Stress mediated the effects of SES on consumption quantity, while the direct residual effect of SES on consumption quantity was not statistically significant (p=.59). SES had a direct positive residual effect on exercise (p<.01) and eating more healthily (p=.039). More importantly, the three indirect mediations by stress were all statistically significant (*CI*=[-.018; -.003] for SES→Stress→Eating Healthier→Weight Gain, *CI*=[-.013; -.001] for SES→Stress→Eating More→Weight Gain, and *CI*=[-.013; -.001] for SES→Stress→Exercising→Weight Gain). Finally, the residual effect of SES on weight gain was not statistically significant (p=.69).

Discussion

Analyses of the early months of the pandemic reveal that people with a low SES gained more weight than people with a higher SES, and that this was mediated by a higher level of stress, and not by the fact that they were less focused on the future, had worse expectations about the future, spent less time outdoors, or by food scarcity. These analyses also demonstrate that stress drove weight gain because it led people to eat more, eat worse, and exercise less.

These results raise the question of whether the effects of the pandemic persisted in the long term, resulting in chronic stress, or solely gave rise to acute stress, which is expected to diminish over time – and whether these effects varied across socioeconomic groups. It is particularly important to examine whether the COVID-19 pandemic created more chronic stress for people with a lower SES, who exhibited the highest levels of stress to begin with, as long-

term stress is associated with inflammation that can cause several diseases, such as cancer and diabetes, and impact the musculoskeletal, respiratory, cardiovascular, endocrine, gastrointestinal, nervous, and both male and female reproductive systems (Mariotti 2015).

STUDY 2: LONG-TERM EFFECTS OF THE PANDEMIC ON STRESS AND WEIGHT GAIN ACROSS SOCIOECONOMIC GROUPS

Method

We sent a fourth questionnaire to our participants on November 8, 2021, which included the same key questions as those in the previous surveys, but also introduced a few additional questions about weight change, our central dependent variable. We received 269 complete responses (151 from female respondents). The high attrition rate is not surprising given that many of the original respondents were no longer active on Prolific 18 months after the third wave. However, we found no differences between respondents who did or did not complete wave 4 on the key variables of SES (p=.75), weight gain as measured in wave 3 (p=.67), stress (p=.98), and sex (p=.68). The respondents who participated in all four waves tended to be older than those who dropped out (M=37.8 vs. M=30.4, p<.01), and thus age was added as a covariate in all analyses.

A power analysis based on the effect size of stress in waves 1-3 revealed that a sample of 580 respondents would be necessary to achieve 80% power with α=.05. Given that only about half as many respondents participated in wave 4, we cannot conduct the mediation analyses estimated on the 892 respondents who participated in the first three waves. Therefore, we use the data collected in the fourth wave to examine whether the early reactions to the pandemic captured in the first three waves had reverted to the mean or persisted 18 months later.

Results

Weight change. We measured weight change using two methods in the fourth wave: 1) the same 7-point measure of weight change collected in wave 3, and 2) inquiring about respondents' weight in March 2020 and at the time of the fourth wave survey in November 2021, and then subtracting the former from the latter. Both measures of weight change were highly correlated (r=.81, p<.01).

The correlations between weight change measured in wave 3 and the two measures of weight change collected in wave 4 were positive and statistically significant (r=.159, p=.01 and r=.162, p<.01). Among the respondents who had reported gaining weight between the start of the pandemic and wave 3, the average weight change in November 2021 was a gain of 3.0 pounds. Likewise, among the respondents who had reported losing weight by wave 3, the average weight change in November 2021 was a loss of 3.7 pounds. Among the respondents who had reported maintaining their weight by wave 3, the average weight change since the start of the pandemic was 0.04 pounds. The weight changes were statistically significant across these three groups ($F_{2,260}$=3.4, p=.03). These results suggest that the weight changes incurred in the early months of the pandemic persisted 18 months later.

To examine whether the persistence of weight change varied by SES group, we regressed the 7-point scale measure of weight change on the number of days elapsed since March 1, 2020 at the time of each wave (i.e., 9 days for wave 2, 34 days for wave 3, 586 days for wave 4), and repeated these analyses for high, medium, and low SES groups. There was no statistically significant difference in the persistence of weight change within the low (t =-.01, p=.99), medium (t =.27, p=.79), and high SES (t =.26, p=.80) groups.

Stress. Stress was the only psychological measure that was collected in each of the four phases. Figure 3 demonstrates that stress remained high throughout all of the phases for

respondents with a low SES, but decreased slightly for those with a medium SES, and decreased more strongly for those with a high SES. To determine whether these trends are statistically significant over time, we took the same approach as we did in determining the persistence of weight change over time, where we regressed stress on the number of days elapsed for each SES group. We found a statistically significant trend over time in the high SES group (t =-2.30, p=.02). In this group, the level of stress decreased by 16.6% between March/April 2020 and November 2020. However, there were no significant trends for neither the medium (t=-.04, p=.70) nor low SES groups (t=-.53, p=.60). Stress levels remained constant, reducing by an insignificant 7.2% between waves 1 and 4 in the medium SES group and by only 3.5% in the low SES group.

Exercise and food consumption. The correlation between the measures taken in wave 4 and in earlier waves was statistically significant for consumption quantity (r=.23, p<.01), consumption quality (r=.21, p<.01), and exercise (r=.17, p<.01). Further analyses show that the consumption habits implemented in the early months of the pandemic had not disappeared 18 months later, despite some expected amount of regression to the mean. Among those who had reacted to the pandemic by eating less in the early months when compared to before the pandemic, 31% still reported eating less by wave 4 (vs. 53% who reported eating the same amount as before and 16% who reported eating more than before the pandemic). Among those who reported eating more than before the pandemic in wave 3, 28% still reported eating more by wave 4 (vs. 62% eating the same amount and 11% eating less).

Consumption quality revealed a similar pattern. Among those who had reacted to the pandemic by eating healthier in the early months, 32% still reported eating healthier by wave 4 (vs. 47% who ate as healthfully as before and 22% who ate less healthfully). Among those who

had reported eating less healthfully in the early months, 38% continued to eat worse than before the pandemic by wave 4 (vs. 50% who ate the same and 12% who ate better).

For exercise, the degree of persistence depends on the early response. Among those who reacted to the pandemic by exercising less than usual in the first few months, 49% still indicated exercising less than before the pandemic in wave 4 (vs. 34% who reported exercising as much and 17% who reported exercising more than before). However, the pattern was different among those who had exercised more than usual in the early months of the pandemic. Among them, only 31% still reported exercising more, whereas 39% reported exercising the same, and 31% reported exercising less than before the pandemic. Overall, there was greater habit persistence among people who reduced their amount of exercise in the early months of the pandemic than among those who exercised more.

To examine whether the persistence of these behaviors over time varied by SES, we used the same regression as for weight change and stress but with consumption quantity, consumption quality, or exercise as the dependent variable. The independent variable comprised of the number of days elapsed since March 1, 2020. There was no statistically significant difference in the persistence of consumption quality within the low (t =.51, p=.61), medium (t =.58, p=.56), and high SES (t =-.83, p=.40) groups. However, there was a significant trend over time in the low (t =-2.20, p=.03) and medium (t =-2.46, p=.01) SES groups on food quantity, where the quantity of food intake decreased, with no such trends in the high SES group (t =-.32, p=.75). This is most likely attributed to the costs associated with purchasing and consuming more food, along with the additional economic hardships, such as job insecurity, that accompanied the COVID-19 pandemic. With regards to exercise, there was no statistically significant difference in the

persistence of physical activity within the low (t =1.53, p=.13), medium (t =.51, p=.61), and high SES (t =-1.09, p=.28) groups.

Discussion

Surveying the respondents 20 months after the start of the pandemic revealed that the pattern of reactions to the pandemic adopted in the first two months generally persisted over time. People who initially reacted to the pandemic by eating more, eating less healthily, and exercising less were likely to continue the same trend. People who ate less and better, and to a smaller degree, who exercised more than before the pandemic, also continued along the same trajectory. As a result, people who had gained weight in the early months retained most of it and those who had lost weight did not regain it. This persistence was unrelated to SES.

On the other hand, we found large socioeconomic disparities in the persistence of stress. People with a low SES only experienced a small drop in stress between the second and third waves of the study, which coincided with the April 2020 distribution of COVID-19 stimulus payments (USAGov 2022). Therefore, stimulus payments may have been instrumental in providing some level of stress relief in those with a lower SES; however, these alleviating effects did not persist over time, as those with a low SES continued to display high levels of stress even 20 months after the start of the pandemic. In comparison, those with a high SES, who exhibited lower stress levels to begin with, experienced a significant decrease in stress over time. These findings reveal a persisting and increasing socioeconomic disparity in experienced stress during the pandemic.

GENERAL DISCUSSION

During the COVID-19 pandemic, Americans with a lower SES experienced higher levels of stress, which led them to exercise less, eat more, and eat less healthfully, consequently leading

to a higher likelihood of weight gain. Additionally, we found that these socioeconomic disparities in the effects of the pandemic persisted 20 months after the start of the pandemic. Worse, the gap between low and high SES Americans, in terms of stress levels, increased over time. Although samples, such as ours, that were obtained through Prolific Academic, may not be representative of the population as a whole, researchers that recruited French and British respondents through various platforms witnessed similar weight gain trends in their sample populations during the COVID-19 pandemic (Marty, de Lauzon-Guillain, Labesse & Nicklaus 2021; Robinson, Gillespie & Jones 2020).

These findings highlight the way in which inequality was further exacerbated during the pandemic and provide greater insights for understanding the socioeconomic gradient of obesity. Future research should examine the various psychological and physiological mechanisms behind why the SARS-CoV-2 virus, and the downstream effects it caused, led to stronger and longer-lasting stress among people with a lower SES. Research should also explore whether other behaviors during the Covid-19 pandemic (e.g., social media usage) may be contributing to the persistent chronic stress experienced by those with a lower SES. One particularly important and challenging issue will be to identify the role played by the infection itself and the governmental responses to it, such as school closures and unemployment. Finally, this research focused specifically on weight gain, an antecedent to obesity, rather than obesity itself – and given that obesity is often a result of long-term weight gain, research would also benefit from exploring how the pandemic may have influenced obesity rates in the long run.

Developing a better understanding of the long-term impact of the pandemic on consumption behaviors can assist firms in the development of innovative solutions that help consumers cultivate greater stress resilience as well as sustainable health habits. These solutions

should be customized to address the specificities of low SES consumers. For example, cognitive nudges that inform people about the healthiness of various behaviors, such as nutrition labels, are less effective among people with a low SES (Campos, Doxey & Hammond 2011). In contrast, programs that offer financial rewards for engaging in healthy behaviors appear to be particularly effective among people with a low SES (John, Loewenstein & Volpp 2012).

Our findings have direct implications for governmental responses to the consequences of the COVID-19 pandemic. They suggest that, in addition to environmental responses, such as improving outdoor access and reducing food deserts, programs that directly target the higher and persistent levels of stress in low SES households are critical in addressing socioeconomic disparities exacerbated by the pandemic. More generally, our results demonstrate a need for governmental responses that incorporate socioeconomic differences. For example, recent research has shown that, compared to people with a normal weight, people with obesity are more responsive to marketing tactics designed to frame food as healthy; these tactics include using claims or brand names that give the impression that foods with a poor nutritional quality are healthy (Cornil, et al. 2022). Therefore, these results suggest that regulating these tactics would be particularly useful to respond to the pandemic effects. More generally, nudge interventions tend to be more effective among people with lower SES levels due to lower numeracy and financial literacy (Mrkva, Posner, Reeck & Johnson 2021). Nudges should therefore be a primary target of government interventions in driving healthier habits in lower-income households.

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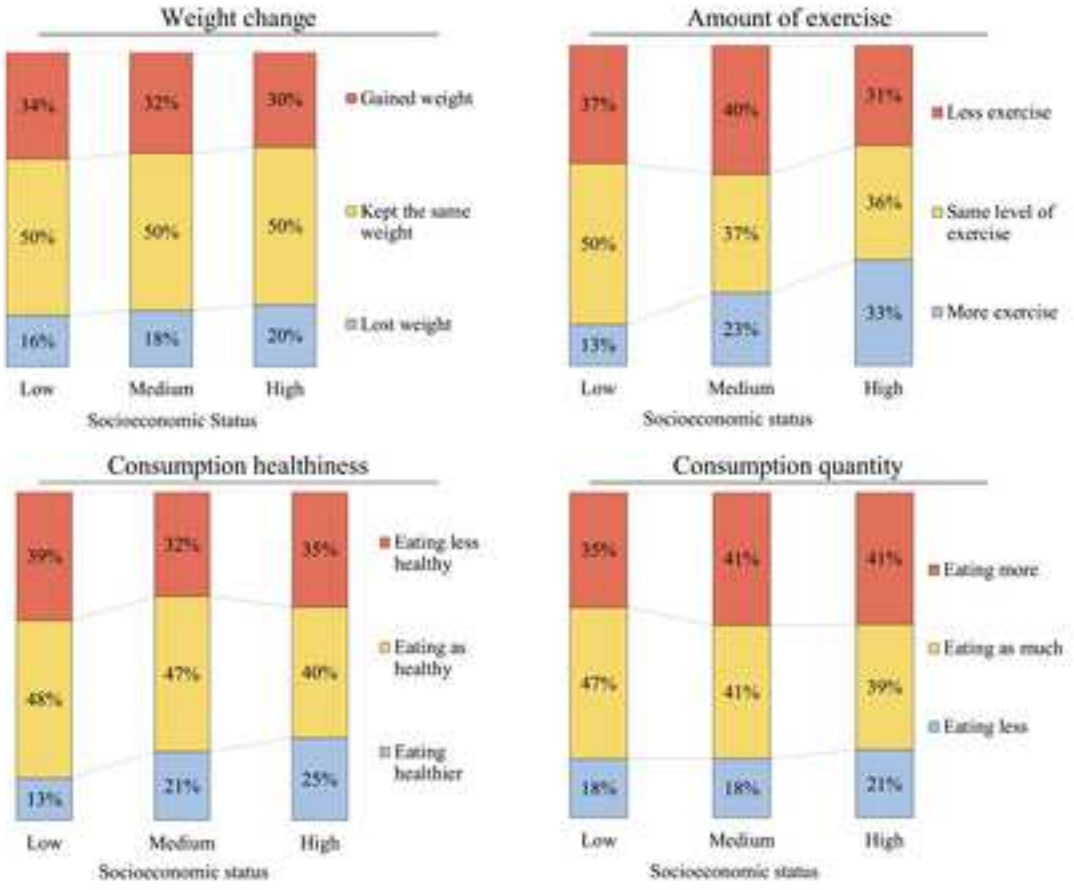
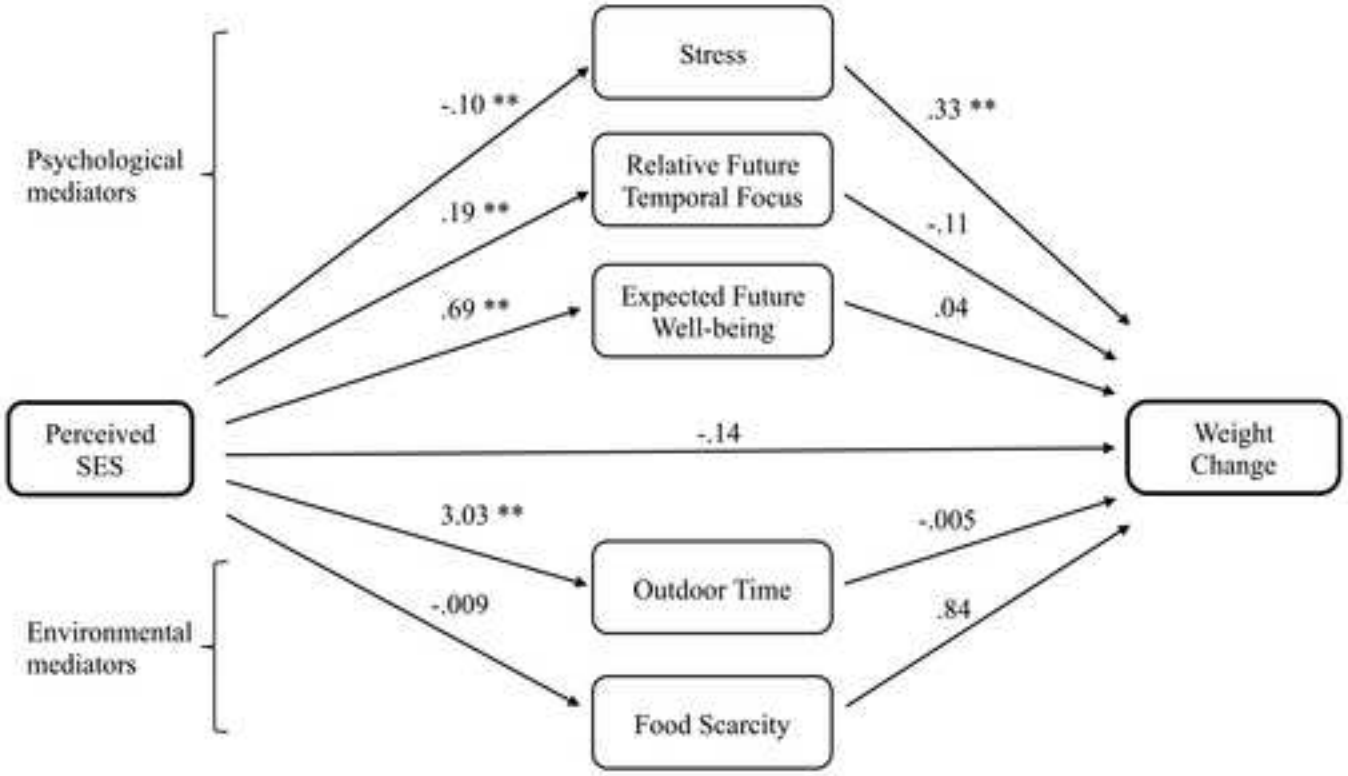
Figure 1. Post-Pandemic Changes in Weight, Exercise, Consumption Quantity and Quality. Note: The number of respondents in the low, medium, and high SES groups was 271, 330, and 291, respectively.

Figure 2. Mediators of the Association between SES and Weight Change During the Pandemic. Note: Age and sex were included as covariates. Statistically significant at the .05 (*) and .01 (**) levels.

Figure 3. Evolution of Stress During Confinement (Waves 1—3) and One Year Later (Wave 4). Note: The number of observations is 892 for the first three waves, and 269 for the fourth wave.





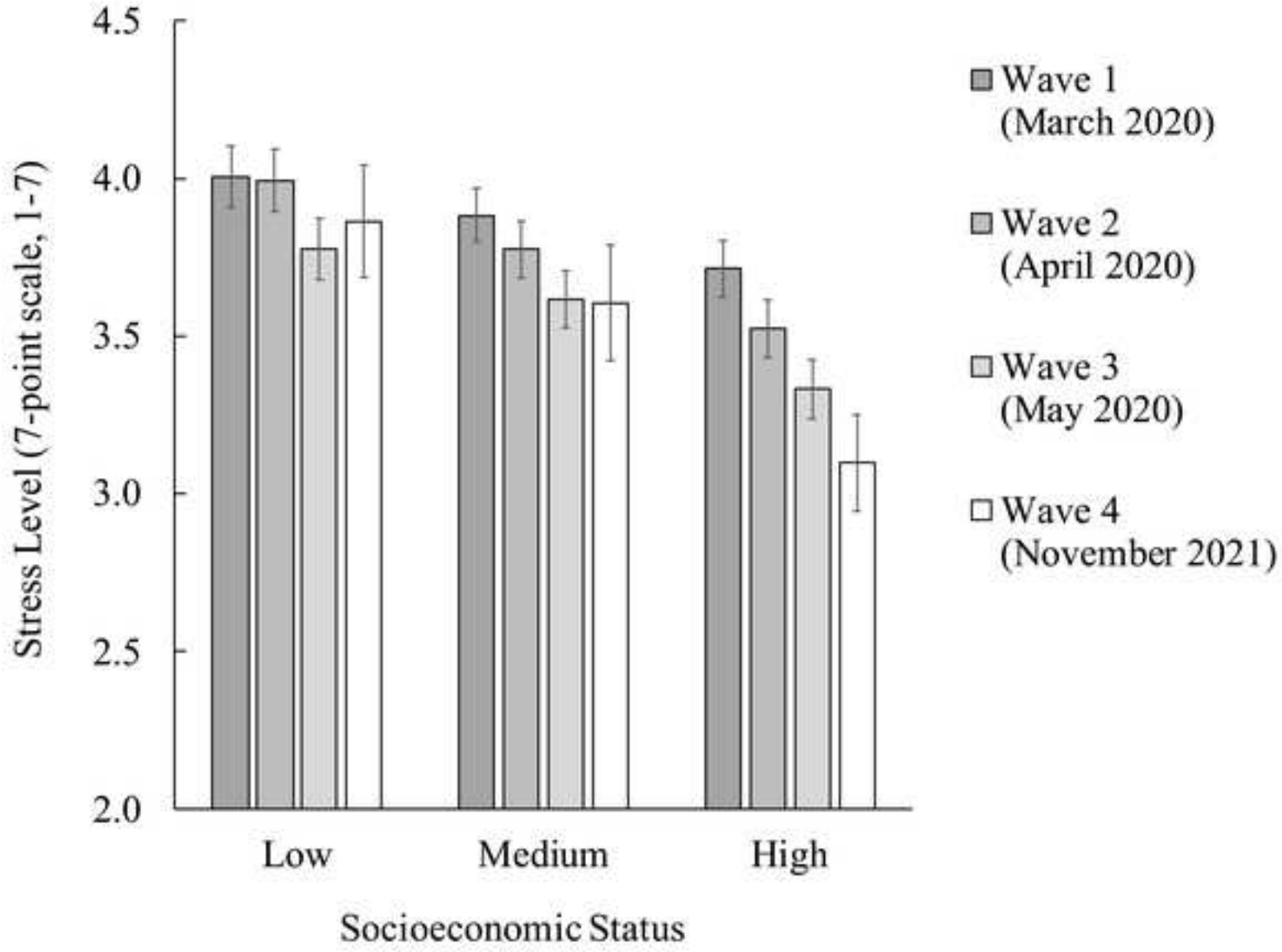


Table 1

Psychosocial Factors and Environmental Mediators

	Stress[1]	Relative future focus[2]	Expected future well-being[3]	Outdoor time[4]	Food scarcity[5]
Means by socioeconomic status group					
Low	4.00	0.08	4.78	39	.51
Medium	3.83	0.61	6.50	45	.48
High	3.62	0.87	7.60	50	.46
Standard deviations (diagonal) and correlations (off diagonal)					
Stress	(1.49)				
Relative future focus	-.18**	(1.45)			
Expected future well-being	-.13**	.26**	(1.72)		
Outdoor time	-.08*	.11**	.17**	(36.18)	
Food scarcity	.23**	-.04	-.07*	-.03	(.34)

Note: [1] 8-item, 7-point modified stress scale (Durante & Laran 2016), average of the measures collected in waves 1 and 2. [2] Focus on the future minus focus on the past of the 7-point Temporal Focus Scale (Shipp, et al. 2009) measured in wave 3. [3] Expected well-being in one year on the Self-Anchoring Scale (Cantril 1965), measured in wave 3. [4] Number of minutes spent in outdoor spaces in the past two days, average of the measures collected in waves 1 and 2. [5] Difficulty in finding fresh and preferred grocery items, average of the measures collected in waves 1 and 2.

*** denotes significance at the 0.01 level (2-tailed).*
** denotes significance at the 0.05 level.*

ONLINE APPENDIX A.
VARIABLES USED IN THE ANALYSES

Variable	Measurement
Age (covariate)	Continuous measure collected via Prolific Academic
Diet quality	Categorical measure (eating healthier, less healthy, or same quality as usual)
Exercise activity	Categorical measure (more, less, or same exercise activity as usual)
Expected future well-being	10-point Self-Anchoring Scale (Cantril 1965)
Food quantity	Categorical measure (eating more, less, or same amount as usual)
Outdoor time	Number of minutes spent outdoors in the past two days
Perceived food scarcity	Difficulty finding fresh and preferred grocery items (average of two binary measures)
Sex (covariate)	Categorical measure collected via Prolific Academic
Socioeconomic Status (SES)	MacArthur Scale of Subjective Social Status (Adler et al. 2000)
Stress	8-item, 7-point modified stress scale (Durante and Laran 2016)
Temporal focus via relative future focus	Past-focus index score minus average score of the future-focus index score from the 7-point Temporal Focus Scale (Shipp et al. 2009; Winterich and Haws 2011)
Weight change	7-point categorical measure of weight gain or loss in 5-pound increments (from “lost 15 lbs or more”, “lost about 10 lbs”, “lost about 5 lbs”, “stayed about the same”, “gained about 5 lbs, “gained about 10 lbs”, to “gained 15 lbs or more”)