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Appetite 178 (2022) 106158

Contents lists available at ScienceDirect

Appetite

journal homepage: www.elsevier.com/locate/appet

Subjective socioeconomic disadvantage is indirectly associated with food portion selection through perceived disruption of personal resources during a nationwide COVID-19 stay-at-home order

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ARTICLE INFO

Keywords:
COVID-19
Lockdown
Subjective socioeconomic status
Social inequality
Portion size selection
Eating behavior

ABSTRACT

In addition to its public health implications, the global COVID-19 pandemic has also produced significant disruptions to individuals' socioeconomic resources and opportunities. Prior research has suggested that low subjective socioeconomic status (SSES) may stimulate appetite and motivate increased energy intake. Here, we tested whether individuals experiencing lower levels of SSES (SSES disadvantage) during a nationwide stay-at-home order for COVID-19 exhibited preferences for larger food portion sizes through perceived disruptions to personal financial and material resources. Data was collected near the conclusion of a nationwide partial lockdown (Singapore's "Circuit-Breaker" from April to June 2020). Participants (N = 295) completed an online survey involving a measure of SSES, the Coronavirus Impacts Questionnaire, and a food portion selection task where participants estimated the portion size they prefer to consume for a range of common foods. SSES disadvantage was associated with selection of smaller average portion sizes. Yet, a significant indirect effect of coronavirus impact was observed in this relationship, such that participants experiencing greater SSES disadvantage selected larger portion sizes through the effect of greater perceived impacts of COVID-19 to one's financial/material resources (controlling for one's actual level of income). These findings further support the idea that perceived deprivation and insecurity of important resources (financial, social, material) may influence intentions to consume greater amounts of energy. Consequently, systematic societal disruptions to such resources may reinforce and perpetuate potentially obesogenic eating behaviors of populations that are especially vulnerable to such shocks (i.e., people experiencing SSES disadvantage).

1. Introduction

The COVID-19 pandemic was met with strict enforcement of stay-at-home and lockdown measures across countries worldwide. Although these measures were intended to suppress the transmission of the virus, they produced both immediate and downstream disruptions to societal and economic systems, such as unemployment, bankruptcies of individuals and companies, dysregulation of supply chains, and psychological strain. Prior research has suggested that perceived scarcity and subjective experiences of socioeconomic insecurity (independent of objective socioeconomic resources) may stimulate appetite and preferences for energy dense foods (Bratanova, Loughnan, Klein, Claassen, & Wood, 2016; Briers, Pandelaere, Dewitte, & Warlop, 2006; Cheon & Hong, 2017). The objective of the current study is to test the relationship between perceptions of socioeconomic disadvantage on intentions for increased energy intake within the context of personal financial/material resource uncertainties during a COVID-19 lockdown.

1.1. Perceived socioeconomic disadvantage and appetite

Although a large body of research has identified objective socioeconomic disparities in diet quality and risk of obesity (for reviews see (Darmon & Drewnowski, 2008; Newton, Braithwaite, & Akinyemiju, 2017; Sobal & Stunkard, 1989)), subjective socioeconomic status (SSES) has also been associated with diverse health outcomes independent of objective socioeconomic status (Adler, Epel, Castellazzo, & Ickovics,

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https://doi.org/10.1016/j.appet.2022.106158
Received 14 October 2021; Received in revised form 18 June 2022; Accepted 28 June 2022
Available online 30 June 2022
0195-6663/Published by Elsevier Ltd.

2000; Boyce, Brown, & Moore, 2010; Cundiff & Matthews, 2017). SSES refers to one's overall perceived or subjectively experienced socioeconomic standing relative to other people in society (Singh-Manoux, Adler, & Marmot, 2003). Thus, people reporting low SSES may perceive their socioeconomic resources to be inadequate or inferior compared to others, leading to a sense of deprivation, insecurity, or wanting for such resources. Indeed, prior research has demonstrated that SSES may be associated with unhealthier dietary patterns, eating behaviors, and increased metabolic health risk independent of one's actual socioeconomic resources or access to healthier foods (Boyce et al., 2010; Cardel et al., 2020; Tang, Rashid, Godley, & Ghali, 2016; Wijayatunga et al., 2019).

Recent experimental research has suggested a potential causal relationship between SSES and motivations for greater energy intake. In such studies, participants who were experimentally-induced to experience an acute state of SSES disadvantage or social inequality subsequently consumed more energy from both snacking and meal contexts (Bratanova et al., 2016; Cardel et al., 2016; Cheon & Hong, 2017), demonstrated greater taste-based sensitivity to the presence of energy in beverages (Cheon, Lim, McCrickerd, Zaihan, & Forde, 2018; Lim, Forde, & Cheon, 2020), and the selection of larger intended portion sizes for a diverse range of foods (primarily meal vs. snack items, fruits/vegetables, low vs. high energy dense foods, amorphous vs. unit-based foods) (Sim, Lim, Forde, & Cheon, 2018).

One implication of these findings is that perceived deprivation to critical non-food resources may co-activate appetite along with energy need (Cheon & Hong, 2017). SSES is experienced as a summary assessment of the relative adequacy of one's economic, social, and material resources (Singh-Manoux et al., 2003), which for humans, represent key resources that confer advantages for survival, reproduction, and growth. If so, then a large-scale societal disruption that generates uncertainty about socioeconomic outcomes may be a common mechanism that exacerbates this relationship between SSES disadvantage and motivations for increased energy intake. Providing initial support for this idea, participants who were experimentally-induced to believe that their future SSES attainment is threatened subsequently exhibited increased circulating levels of the appetite stimulating hormone ghrelin and reported reduced satiation after consuming an equicaloric snack compared to a control condition (Sim, Lim, Leow, & Cheon, 2018).

1.2. COVID-19 pandemic and social inequality

Widespread disruptions to the normal flow of social and economic life caused by the COVID-19 pandemic and its associated lockdowns may be a suitable context to study this relationship between SSES and eating behavior. Along with the health-related costs of the pandemic, measures to tackle the transmission of the virus, such as mass quarantines and lockdowns have caused substantial shocks to societies, industries, and livelihoods of individuals across the globe (Nicola et al., 2020; Pak et al., 2020; Polyakova, Kocks, Udalova, & Finkelstein, 2020).

Notably, there may be disparities in the distribution of these social and economic consequences of COVID-19 that perpetuate existing socioeconomic inequalities. People of higher SES backgrounds may have enjoyed more resources and opportunities that provided economic and psychological resilience against the disruptions from the pandemic. Lockdowns may have been less effective for protecting the spread of COVID-19 among socially and economically disadvantaged people given that they are more likely to live and work in crowded conditions and have less flexibility to work from home (Bajos et al., 2021; Green, Fernandez, & MacPhail, 2021; Patel et al., 2020).

In addition to greater vulnerability to contracting (and potentially dying from) COVID-19, people of lower SSES backgrounds were also at greater risk of psychological distress associated with financial and lifestyle disturbances caused by COVID-19. For instance, Wu, Li, Lu, and Hout (2021) observed that during the lockdown in Wuhan China, higher SES was associated with not only lower likelihood of COVID-19 infection, but also with better psychological well-being. These authors (Wu et al., 2021) identified that this relationship was mediated by resources afforded by socioeconomic advantage, such as greater access to daily supplies and protective equipment. Conversely, people who experienced upheavals to personal socioeconomic resources, such as loss of employment, reduced income, and inability to afford housing, reported increased levels of stress compared to those who did not encounter such difficulties (Wang, Devjani, Chillakanti, Dunton, & Mason, 2021). Together, these findings demonstrate that COVID-19 may have been a powerful force that exacerbated social inequalities. In this context, individuals experiencing SSES disadvantage may have been especially vulnerable to perceived threats to personal financial or material resources. Here, we tested whether these processes may have downstream consequences on increasing motivation to consume greater quantities of energy in the form of larger food portion sizes.

1.3. The effect of COVID-19 on diet and eating behaviors

Recent studies conducted during the COVID-19 pandemic and associated lockdowns have suggested changes to people's dietary patterns and eating behaviors during this period. In regards to whether the pandemic produced more unhealthy diets and eating behaviors, there has been mixed evidence (Deschasaux-Tanguy et al., 2021; Miller et al., 2021), with some studies even suggesting improvements to dietary practices, such as increased health consciousness and attitudes favoring healthy nutrition (Aksoy, Kabadayi, & Alan, 2021), and greater preparation of home-cooked meals that involve participation of children (Philippe, Chabanet, Issanchou, & Monnery-Patris, 2021).

Yet among studies that documented increased motivations towards or adoption of unhealthy eating behaviors, stress associated with the pandemic or lockdowns was identified as a contributing factor. COVID-19 related stress was positively correlated with a variety of behaviors that may lead to excess energy intake, such as eating/drinking to cope, greater intake of palatable yet energy dense comfort foods, stronger willingness to expend effort for food, and symptoms associated with food addiction (Cummings, Ackerman, Wolfson, & Gearhardt, 2021; Smith et al., 2021; Wang et al., 2021). Interestingly, this relationship was even stronger among those who perceived themselves as more personally vulnerable to disease (Cummings et al., 2021). This period also produced increased frequencies of daily meals, snacking (including ultra-processed foods), and self-reports of overeating (Bonaccio et al., 2021; Robinson et al., 2021). Furthermore, COVID-related mass quarantines and lockdowns may have encouraged greater overall quantity of food intake, especially among individuals with lower dispositions for craving control (Buckland et al., 2021; Buckland & Kemps, 2021). Additionally, parental feeding practices of children and regulation of the home food environment may have been affected by COVID-19 related disruptions. Parents reported increased permissiveness of children's eating behaviors and greater frequency of using food as a reward and a means to sooth children (Coulthard, Sharps, Cunliffe, & van den Tol, 2021; Wang et al., 2021).

Together, these findings contribute to the concern that COVID-19 may worsen the epidemic of obesity and related comorbidities (Clemmensen, Petersen, & Sørensen, 2020). Indeed, increased body weight has been observed during the COVID-19 pandemic, especially among those who experienced more pandemic-related stress or were pre-disposed to potentially maladaptive coping strategies such as emotional eating (Bonaccio et al., 2021; Coulthard et al., 2021; Wang et al., 2021). Given worse impact of COVID-19 to livelihoods and resources of those who experience greater levels of socioeconomic vulnerabilities, these individuals may have also been at greater risk for maladaptive or obesogenic eating behaviors during the pandemic.

1.4. Present study

The present study tested the relationship between SSES and intended

quantities of energy intake (portion size selection) within the context of a COVID-19 related stay-at-home order. The study consisted of an online survey assessing participants' SSES, perceived personal impacts of COVID-19 (financial, material, and psychological impacts), and desired portion sizes across a range of common foods. Participants were pre-screened and recruited to represent 3 objective socioeconomic backgrounds based on household income (low, middle, and high). Data for the survey was collected in the latter half of a national partial lockdown in Singapore ("circuit breaker") to suppress the community spread of COVID-19. The circuit breaker lasted from April 7th to June 1st of 2020 and the measures included full home-based learning for schools, and the closure of most physical workplace premises, recreation venues, attractions, and places of worship. Exceptions were provided for businesses providing essential services and selected economic sectors which are critical for local and global supply chains. To curb the spread of infection, the public was advised to minimize movements and interactions in public and private places and stay home unless going outside was necessary for essential purposes.

We hypothesized that SES (both objective and subjective) will be associated with participants' overall portion selection patterns. Specifically, we predict that lower objective SES (household income group) will be associated with selection of larger average portion sizes (Hypothesis 1). Likewise, lower subjective SES (greater perceived SSES disadvantage) will be associated with selection of larger average portion sizes (Hypothesis 2). Given that these data was collected near the end of the national COVID-19 lockdown, which may have caused insecurities about socioeconomic disruptions, we provisionally tested whether perceived impacts to personal resources (financial and material) due to COVID-19 may mediate the relationship between SSES disadvantage and selection of larger portion sizes (Hypothesis 3).

2. Methods

2.1. Participants

Singaporean participants (n = 300) from three income (SES) cohorts (low, middle, and high) were recruited for an online survey through the market research company Dynata. We estimated a required sample size of approximately 250 participants based on a one-way comparison of means between 3 groups, with an estimated small-medium effect size (f = .20) based on conventions recommended by Cohen (1992), alpha of .05, and power of .80 (Faul, Erdfelder, Buchner, & Lang, 2009). We used a conventional estimate of effect size rather than basing the effect size estimate on prior data. We took this approach because of limited prior published research that directly examined the relationship between SES categories and portion selection patterns. Although there are cross-sectional studies on the relationship between SES and broader dietary patterns, there is limited work focusing on behavioral measures that isolate portion selection like the computerized task used in our study. Additionally, we were examining these relationships during a pandemic-related lockdown – a circumstance that may be atypical or have disrupted usual relationships between SES and portion size. Thus, we used a more general estimate of an effect size of (f = .20) representing a small to medium effect based on Cohen's (1992) recommendations.

Participants were required to be a Singapore citizen and between the age of 21 and 65 years old. Participants were instructed to complete the survey using a computer or tablet, instead of a mobile phone. Eligible participants were pre-screened for study inclusion criteria. A screening survey was then provided to these participants to assess and categorize them according to their actual income. The personal income of participants was calculated from their monthly household income divided by household size. Participants were then divided into three different income cohorts based on whether their adjusted household income was less than $2131 SGD per month (low income), between $2131 to $4036 SGD per month (middle income), or greater than $4036 SGD per month (high income).[1] Five participants were excluded from data analysis for using the wrong type of device to complete the study survey (e.g., smartphones). The final sample for analysis consisted of 295 participants (134 females, M_{age} = 34.08, SD = 8.79, M_{BMI} = 22.48, SD = 4.21). Participants consisted of 261 Chinese, 25 Malay, 5 Indian and 4 others. Sixteen participants were permanent residents of Singapore while the rest of the cohort were Singaporean citizens.

2.2. Procedures

The study was designed to compare average portion sizes selected by participants across 3 income groups (low, middle, high), and test associations between SSES disadvantage and portion size. This study was approved by the institutional review board (IRB) of a Singaporean university (reference number 2019-03-003). The study consisted of a single 30-min online survey that was developed on Qualtrics online survey software. Recruitment of participants and administration of the online survey was managed by Dynata, a global online market research firm, which maintains an internal system for vetting and verifying recruited participants. Participants first provided their informed consent before beginning this survey. The sections/questionnaires within the online survey were presented in the order described below.

2.3. Materials/measures

2.3.1. Baseline appetite ratings

Baseline appetite of participants were measured at the start the study. Participants were asked to rate how hungry and how full they felt right now using a series of 100-point visual analogue scales (VAS). The participants were presented with a slider bar without any numbers of marks except for labels at the two ends ("not at all" and "extremely"). Participants made ratings by clicking or moving a slider to the desired location on the bar (similar VAS scales also used in Cheon, Sim, Lee, & Forde, 2019). They were also asked to rate their satiation level, desire to eat, and amount of food they think they could eat. A composite baseline appetite rating was originally obtained by averaging these ratings after reverse-scoring responses for the question on fullness and satiation level, but the reliability of the measure was low (α = .58) due to lower associations between the items on fullness and satiation level with the other items. Thus, these two items were removed to substantially improve overall reliability and create a baseline appetite composite based on the average of the question on hunger, desire to eat, and amount of food participants think they could eat (α = .73).

Following the baseline appetite ratings, participants also completed supplemental measures related to how they conceive satiety and meal completion. This included free-response questions in which participants wrote up to three (but at least one) statements they would make to indicate that they were finished consuming a meal (e.g., "I'm full," "that was delicious," *etc.*). Analyses of these questions did not pertain to the current research objectives, so are not discussed here. Yet these free-response questions were used as a check for invalid responses (e.g., due to response programs or bots). Inspection of these free responses did not reveal any suspicious responses (e.g., strings of nonsense text or irrelevant text).

2.3.2. Portion selection task

Food portion size selections were measured using a simplified version of a computerized portion selection task (Cheon et al., 2019;

[1] This range of incomes representing the middle income group was based on average monthly household income for household member estimated by the Department of Statistics of Singapore for year 2019. We defined the middle income group as income ranges between the 4th decile ($2131) to the 7th decile ($4036). Incomes in the 1st to 3rd deciles were classified as low incomes while incomes in the 8th to 10th deciles were classified as high income.

Pink & Cheon, 2021). This task displayed a series of twelve different food images to participants, one at a time. The foods were items that are common in Singapore and consisted of: fried kway teow noodles, mixed fruit salad, french fries, mixed salad with dressing, Pringles brand potato chips, beehoon noodles, yang chow fried rice, laksa noodles, Hainanese-style chicken rice, penne pasta with tomato sauce, chicken briyani, and char siew rice. For each food item displayed on screen, participants were shown a VAS scale with the smallest portion (20 kcal) on the leftmost anchor and the biggest portion (1000 kcal) on the rightmost anchor (Fig. 1). No information about the actual calorie content of the portion was provided. Participants were asked to select the typical portion size they will serve themselves for each of the foods presented by dragging the slider to an appropriate point of the VAS scale that represents their estimated portion size relative to the portion sizes presented at the two ends of the scale (between the smallest and largest portions depicted). A composite variable reflecting overall intended portion size across all test foods (in mean kcals) was computed by averaging portion sizes selected across the foods ($\alpha = .90$). Prior validation research (Pink & Cheon, 2021) has suggested similar simplified versions of portion selection tasks provide close estimates and correspondences to portion sizes selected on virtual/computerized portion selection tasks involving a greater range of incremental portion size images (Forde, Almiron-Roig, & Brunstrom, 2015; Kim, Chen, & Cheon, 2019; Sim & Cheon, 2019; Wilkinson et al., 2012).

2.3.3. Ratings of test foods

Three questions (fillingness, liking, and frequency of consumption) were asked to assess participant's general ratings of each of the food items presented in the portion selection task. These ratings were measured on a 100-point VAS-style scale with anchors labeled with "not at all filling" and "very filling." An average score was calculated for each characteristic by averaging the corresponding rating across all foods (fillingness $\alpha = .86$; liking $\alpha = .79$; frequency $\alpha = .88$).

2.3.4. Cognitive restraint

The cognitive restraint subscale from the Three-Factor Eating Questionnaire (TFEQ) R-18 (Karlsson, Persson, Sjöström, & Sullivan, 2000) was administered to measure individual differences in restrained eating. A composite score of the six questions corresponding to cognitive restraint was calculated ($\alpha = .82$).

2.3.5. Food insecurity

Participants were asked to complete a food insecurity scale adapted from the six-item short form of the U.S. household food security survey (Blumberg, Bialostosky, Hamilton, & Briefel, 1999). The original food security scale involved categorical 'yes'/'no' responses to questions. The modified version in this survey used in the present study instead used a Likert-scale self-report format for all questions. A total of five questions about general household food insecurity was used (i.e., "Overall in the past 12 months, how much have you been worried that the food you bought wouldn't last and you would not be able to get more?"). Participants responded using 7-point rating scales ranging from "not at all" to "a great deal". A composite food insecurity score was calculated by averaging ratings for all items ($\alpha = .92$).

2.3.6. Coronavirus Impacts Questionnaire (COVID-19 impact)

The COVID-19 Impact scale (Conway III et al., 2020) is a self-report questionnaire that measured personal disruption caused by COVID-19 across 3 domains of impact (2 questions per domain): financal impact ("The COVID-19 has impacted me negatively from a financial point of view"), resource impact ("It has been difficult for me to get the things I need due to the COVID-19"), and psychological impact ("I have become depressed because of the COVID-19"). Participants made their responses on a 7-point scale labeled with the anchors, "Not at all true of me" and "Very true of me." Two composite scores were also created by averaging all three impact scores (total impact $\alpha = .82$) and averaging finance and resources impact scores (finance-resource impact $\alpha = .74$). Participants were also divided into three impact groups (low, middle, high) through a tertile split using the two scores for further analysis.

2.3.7. Demographics and SES measures

Demographics questions of gender, age, race (Singaporean Chinese, Singaporean Malay, Singaporean Indian, or other), ethnicity (free-reponse), and self-reported height (in meters) and weight (in kilograms) were included at the end of the survey. Body mass index (BMI) was computed based on height and weight data.[2] Participants also indicated whether they were currently dieting or trying to restrict/regulate what they ate.

A measure of subjective SES (SSES) (Adler et al., 2000) was included within the demographics section of the survey. Participants were shown an image of a ladder with 10 rungs, which described to represent their society (Singapore). The top of the ladder represented the people who were the best off on socioeconomic indicators (i.e., have the most money, most education, and most respected jobs), while the bottom of the ladder represented the people who were worst off on the same socioeconomic indicators. Participants were asked to place themselves on the rung of the ladder that corresponded to their position relative to other people in Singapore. Since we sought to quantify and analyze perceived SSES disadvantage (rather than advantage), we reverse-scored this measure, such that self-placement on higher rungs of the SSES ladder ended-up being represented by lower scores/values of SSES disadvantage and self-placement on lower rungs of the SSES ladder were represented by higher scores/values of SSES disadvantage.

Objective SES was also measured based on gross monthly household income. Yet, there were many suspicious values for monthly household income, ranging from the upper ends of five-figure salaries (e.g., $80,000+) all the way to millions of dollars per month. Some participants may have entered annual household income (although monthly income is the typical unit for describing income in Singapore) or may have included total assets and savings in their responses. Given potential inaccuracies and inconsistencies in how household income was reported, we did not use this variable in our analyses. Instead, we used participants' income category as the measure of objective SES (see the *Participants* section on information regarding the classification of the income categories).

2.3.8. Debriefing

Finally, participants were presented with a debriefing screen where further information about the aims of the study and contact information for researchers and the IRB were displayed. Participants were also provided an open text box where they could report any comments or issues they encountered during the survey.

2.4. Statistical analyses

The analyses compared participants across the three income groups (objective SES) on background individual differences associated with appetite and eating behaviors, as well as on SSES, COVID-19 impact, and average selected portion sizes using non-parametric Kruskal-Wallis H tests given non-normal distribution of variables (see results below). Pairwise comparisons were run using Mann-Whitney U tests (two-tailed). Partial correlations (controlling for baseline appetite and gender) were conducted to identify associations between our primary variables of interest. To test whether perceived financial/resource impact of COVID-19 mediated the relationship between perceived SSES disadvantage and portion selection patterns, we used model 4 of PROCESS (version 3.5) for SPSS (Hayes, 2017). SSES disadvantage was

[2] Two participants were excluded from analyses involving BMI due to extremely low (2.49) or high (54.30) BMI scores, which may represent errors in self-report of height and/or weight.

Fig. 1. Sample stimuli from the portion selection task. Participants were asked to move the slider (black dot) to an appropriate point of the VAS scale that represents their desired portion size relative to the minimum (20 kcal) and maximum (1000 kcal) portion sizes depicted at the two ends of the scale.

entered as the predictor variable (X), mean portion size selected as the outcome variable (Y), and composite of finance-resource impact of COVID-19 as the mediator (M), with a bootstrap sample of 10,000. We also tested this model with psychological impacts of COVID-19 as a mediator to determine whether broader psychological distress attributed to the pandemic that was not specific to socioeconomic or resource concerns also mediates the relationship between SSES disadvantage and portion selection. Baseline appetite and gender were entered in the model as covariates since participant appetite was not experimentally standardized, males may consume larger portion sizes than females, and gender was not evenly distributed across income groups.

3. Results

3.1. Participant characteristics

Given that many of our key variables of interest were not normally distributed (Shapiro-Wilk tests of $p < .05$), we compared participant demographic and diet/appetite related background individual differences across the three income groups using non-parametric Kruskal-Wallis H tests. Chi-squared test revealed that the distribution of males/females significantly differed across conditions, $\chi^2(2, N = 295) = 8.34$, $p = .02$, with the samples of the low, middle, and high income groups comprised of 57.14%, 38.00%, and 41.24% females, respectively. There were no significant differences in BMI, baseline appetite, cognitive restraint, food insecurity, how filling foods were perceived to be, liking of foods, and frequency of consuming foods between the three income groups (see Table 1 for comparison of descriptive values for participant characteristics). There were also no differences in the distribution of current dieters between the three income cohorts. However, there were significant differences in the distribution of males/females between groups. Age of participants across the 3 income groups also significantly differed. Participants in the low income group were significantly younger (*Median* = 29.00, *Interquartile range* = 15.25) than the middle income group (*Median* = 33.00, *Interquartile range* = 15.00), $U(N_{\text{low income}} = 98, N_{\text{middle income}} = 100) = 3914.50$, $Z = -2.45$, $p = .01$, and the high income group (*Median* = 35.00, *Interquartile range* = 15.00), $U(N_{\text{low income}} = 98, N_{\text{middle income}} = 97) = 3510.00$, $Z = -3.16$, $p = .002$. Given that mean age increased along with the income of the 3 groups, the differences in age may be a by-product of younger workers/students earning less income than older workers in the sample.

3.2. Comparisons between groups on SSES, COVID-19 impact, and portion size

Participants across the 3 income groups significantly differed in reported SSES disadvantage (see Table 1), such that participants in the low income group (*Median* = 6.00, *Interquartile range* = 2.00) reported significantly more disadvantage compared to those in the middle income group (*Median* = 5.00, *Interquartile range* = 2.00), $U(N_{\text{low income}} = 98, N_{\text{middle income}} = 100) = 3497.00$, $Z = -3.55$, $p < .001$, and those in the high income group (*Median* = 5.00, *Interquartile range* = 2.00), $U(N_{\text{low income}} = 98, N_{\text{high income}} = 97) = 3472.50$, $Z = -3.32$, $p < .001$. There was no significant difference in SSES disadvantage between the middle and high income groups.

There was a significant difference in reported levels of negative financial impacts of COVID-19, such that participants in the low income group (*Median* = 4.50, *Interquartile range* = 2.00) reported significantly greater financial impact compared to the middle income group (*Median* = 3.50, *Interquartile range* = 3.00), $U(N_{\text{low income}} = 98, N_{\text{middle income}} = 100) = 3615.00$, $Z = -3.20$, $p = .001$ (see Table 1). The three income cohort groups did not differ in their self-reported resource impact or psychological impact of COVID-19. Although the total composite for COVID-19 impact did not significantly differ between the three income groups, there was a significant difference between groups in the finance-resource impact composite, such that participants in the low income group (*Median* = 4.50, *Interquartile range* = 1.50) reported significantly greater finance-resource impact compared to the middle income group (*Median* = 3.63, *Interquartile range* = 2.19), $U(N_{\text{low income}} = 98, N_{\text{middle income}} = 100) = 3710.50$, $Z = -2.96$, $p = .003$.

We observed significant differences between the income cohorts on overall portion sizes selected for the test foods (see Table 1). But contrary to patterns expected from prior research on SES and eating behaviors, participants in the high income group (*Median* = 61.67, *Interquartile range* = 27.21) selected larger portion sizes than both the low income group (*Median* = 53.96, *Interquartile range* = 20.67), $U(N_{\text{low income}} = 98, N_{\text{high income}} = 97) = 3893.00$, $Z = -2.18$, $p = .03$, and middle income groups (*Median* = 52.71, *Interquartile range* = 24.46), $U(N_{\text{middle income}} = 100, N_{\text{high income}} = 97) = 3830.00$, $Z = -2.55$, $p = .01$.

3.3. Partial correlations between SSES, COVID-19 impact, and portion size

Similar to the relationship we observed between participants' income group and mean portion size selected above, we observed that perceived SSES disadvantage was negatively correlated with portion sizes selected ($r(291) = -.13$, $p = .02$) (Table 2). Contrary to our

Table 1
Medians and interquartile ranges (in parentheses) of sample characteristics across income groups.

Measure	Low Income (N = 98)	Middle Income (N = 100)	High Income (N = 97)	Kruskal-Wallis H Test
Gender[a]	42 males 56 females 57.14% female	62 males 38 females 38.00% female	57 males 40 females 41.24% female	$\chi^2(2, N = 295) = 8.34$, $p = .02$
Age[b]	29.00 (15.25)	33.00 (15.00)	35.00 (15.00)	$\chi^2(2, N = 295) = 11.21$, $p = .004$
BMI	21.88 (5.97)	21.80 (4.16)	21.97 (3.76)	$\chi^2(2, N = 293) = .77$, $p = .68$
SSES Disadvantage[b]	6.00 (2.00)	5.00 (2.00)	5.00 (2.00)	$\chi^2(2, N = 295) = 15.83$, $p < .001$
COVID Finance Impact[b]	4.50 (2.00)	3.50 (3.00)	4.00 (3.00)	$\chi^2(2, N = 295) = 9.52$, $p = .009$
COVID Resource Impact	4.00 (1.63)	4.00 (3.00)	4.00 (2.50)	$\chi^2(2, N = 295) = 2.22$, $p = .33$
COVID Psychological Impact	4.00 (2.50)	3.50 (3.00)	4.00 (3.00)	$\chi^2(2, N = 295) = .57$, $p < .75$
COVID Finance-Resource Impact[b]	4.50 (1.50)	3.63 (2.19)	4.25 (1.75)	$\chi^2(2, N = 295) = 8.72$, $p = .01$
COVID Total Impact	4.17 (1.50)	3.67 (2.29)	4.00 (2.00)	$\chi^2(2, N = 295) = 5.33$, $p = .07$
Selected Portion Size[b]	53.96 (20.67)	52.71 (24.46)	61.67 (27.21)	$\chi^2(2, N = 295) = 7.67$, $p = .02$
Baseline Appetite	47.63 (29.94)	47.75 (22.94)	50.50 (30.25)	$\chi^2(2, N = 295) = .45$, $p = .80$
Cognitive Restraint	2.50 (.83)	2.67 (.79)	2.50 (.83)	$\chi^2(2, N = 295) = 2.30$, $p = .32$
Food Insecurity	3.60 (2.25)	2.80 (2.20)	3.00 (2.60)	$\chi^2(2, N = 295) = 3.47$, $p = .18$
Food Filling	67.88 (20.77)	66.13 (22.83)	73.50 (18.42)	$\chi^2(2, N = 295) = 3.23$, $p = .20$
Food Liking	60.42 (17.60)	57.92 (18.81)	61.58 (18.42)	$\chi^2(2, N = 295) = 5.07$, $p = .08$
Food Frequency	42.17 (25.73)	38.96 (22.85)	43.42 (29.50)	$\chi^2(2, N = 295) = 3.13$, $p = .21$
Currently Dieting?	79 'no' 19 'yes'	82 'no' 18 'yes'	79 'no' 18 'yes'	$\chi^2(2, N = 295) = .06$, $p = .97$

COVID Finance-Resource Impact = mean of COVID-19 financial and resource impact, COVID Total Impact = composite average of COVID-19 impact variables, Selected Portion Size = mean portion size selected from test foods, Food Filling = mean rating of perceived fillingness of test foods, Food Liking = mean rating of liking of test foods, Food Frequency = mean rating of frequency of consuming test foods.

[a] Distribution of responses differ between groups on chi-squared test, $p < .05$.

[b] Values differ between groups on Kruskal-Wallis H test, $p < .05$.

predictions, participants reporting greater SSES disadvantage overall selected smaller intended potion sizes across diverse foods. Perceived SSES disadvantage was positively correlated with financial impact ($r(291) = .23$, $p < .001$), psychological impact ($r(291) = .14$, $p = .02$), and composite finance-resource impact ($r(291) = .12$, $p = .04$, but not resource impact of COVID-19 ($r(291) = -.04$, $p = .48$). Mean portion size selected was positively correlated with resource impact ($r(291) = .18$, $p = .002$), and composite finance-resource impact ($r(291) = .16$, $p = .007$).

Table 2
Partial correlations between main study variables (controlling for participant gender and baseline appetite).

	1	2	3	4	5	6
1. SSES Disadvantage	1					
2. COVID Finance Impact	.23***	1				
3. COVID Resource Impact	−.04	.40***	1			
4. COVID Psychological Impact	.14*	.48***	.48***	1		
5. COVID Mean Finance-Resource Impact	.12*	.86***	.82***	.58***	1	
6. Mean Portion Size Selected	−.13*	.09	.18**	.04	.16**	1

*$p < .05$, **$p < .01$, ***$p < .001$.

3.4. Mediating role of financial-resource impact

Using bootstrapped mediation anlyases, there was a significant indirect effect of SSES (controlling for gender and baseline appetite) on overall portion sizes selected through the effect of finance-resource impact of COVID-19, *ab* path (standardized indirect effect) = .02 (SE = .01) (CI: .001 to .054) (Fig. 2). As participants perceived themselves as having greater socioeconomic disadvantage relative to others (higher values for SSES), they experienced greater personal financial/resource related impacts of COVID-19, which then predicted selection of larger overall portion sizes across a range of foods.

Since a significant direct effect of the relationship between SSES disadvantage and portion size persisted, the findings were consistent with partial mediation by finance-resource impact. Furthermore, this significant direct effect (a negative relationship) was in the opposite direction of a relatively smaller indirect effect (a positive relationship). Despite the larger direct effect, this indirect effect is meaningful because it reveals a pathway for a positive relationship beteween SSES disadvantage and portion size that only emerges when COVID-19 impact is examined as a mediator. This relationship between these variables is otherwise obfuscated by a more robust, yet negative total and direct effects of SSES disadvantage on portion size. This pattern of mediation is sometimes referred to as "competitive mediation," which does not have the same properties of a "full mediation" that may be expected based on Baron and Kenny's (1986) approach (Rucker, Preacher, Tormala, & Petty, 2011; Zhao, Lynch, & Chen, 2010). This pattern implies the presence of a potentially competing and negative indirect effect in the relationship between SSES disadvantage and portion size (greater SSES disadvantage predicting smaller portion sizes through this indirect effect).

Additionally, we also examined the R^2 change when the mediator (financial/resource impacts of COVID) was included into the model of SSES disadvantage predicting portion selection patterns (including the covariates of gender and baseline appetite). There was a significant, change in R^2 for the model, $F(4, 290) = 12.82$, $p < .001$, R^2 change = .03, p for R^2 change = .003, when including the mediator of financial/resource impacts ($B = .17$, $p = .003$), suggesting that the mediator predicts a unique, yet small, proportion of the variance of portion size independent of SSES disadvantage.

This indirect effect of finance-resource impact on the relationship between SSES disadvantage and portion size was observed even when participants' income group (reflection of objective social class within our sample) was entered into the model as an additional covariate (along with gender and baseline appetite), *ab* path (standardized indirect effect) = .02 (SE = .01) (CI: .003 to .051) (Table 3). This indirect effect was also observed when participants' age, which significantly differed across income groups, was entered into the model as a covariate (with gender and baseline appetite), *ab* path (standardized indirect effect) = .02 (SE = .01) (CI: .001 to .053). This indirect effect was not observed when

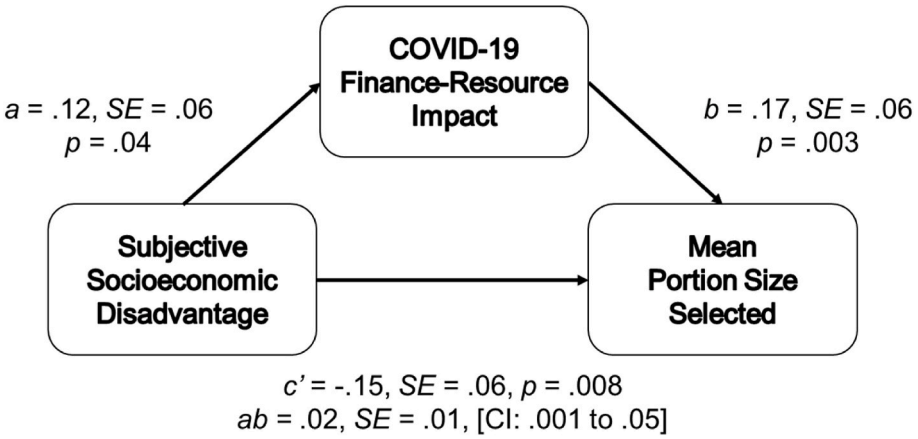

Fig. 2. Indirect effect of perceived finance-resource impacts of COVID-19 on the relationship between SSES disadvantage and selection of larger intended portion sizes across a range of foods (controlling for gender and baseline appetite). Coefficients are standardized. *c'* = the direct effect. *ab* = the indirect effect. *SE* = standard error.

Table 3
Results from supplemental mediation analyses controlling for additional covariates of income group or age (in addition to gender and baseline appetite) or treating COVID-19 psychological impact as the mediator. Coefficients are standardized and values in parentheses represent standard errors.

Predictor (X)	Mediator (M)	Outcome (Y)	*a* path	*b* path	Direct effect (*c'*)	Indirect effect (*ab*)	Covariates
SSES Disadvantage	COVID-19 Finance-Resource Impact	Mean Portion Size Selected	.11 (.06)	.17 (.06)	−.14 (.06)	.02 (.01) [CI: .001 to .054]	income group, gender, appetite
SSES Disadvantage	COVID-19 Finance-Resource Impact	Mean Portion Size Selected	.12 (.06)	.17 (.06)	−.14 (.06)	.02 (.01) [CI: .0003 to .051]	age, gender, appetite
SSES Disadvantage	COVID-19 Psychological Impact	Mean Portion Size Selected	.14 (.06)	.05 (.06)	−.13 (.06)	.007 (.01) [CI: −.009 to .031]	age, gender

psychological impacts (e.g., depression, anxiety) were tested as the mediator, *ab* path (standardized indirect effect) = .007 (SE = .01) (CI: −.009 to .031) (Table 3).

4. Discussion

The present study sought to build upon prior research on the effects of subjective socioeconomic disadvantage on the stimulation of appetite and motivations for increased energy intake, by examining this relationship within the context of socioeconomic disruptions linked to the COVID-19 pandemic. We observed mixed support for our hypotheses. Contrary to prior findings, we observed that lower levels of both objective and subjective SES were associated with the selection of smaller average portion sizes (Hypotheses 1 and 2 unsupported). Yet, we did observe an indirect effect of SSES disadvantage on the selection of larger portion sizes through the mediating role of perceived financial/resource impacts of COVID-19 (Hypothesis 3 supported).

Prior research suggests that perceived inequality and relative deprivation compared to others may contribute to selection of larger portion sizes and food intake (Cheon & Hong, 2017; Sim, Lim, Forde, & Cheon, 2018;). Yet, the current findings (Hypothesis 3) suggest that within the real-life context of the COVID-19 pandemic and associated lockdowns, the experience of threats to personal financial and material resources may contribute to the mechanisms involved in translating the experience of SSES deprivation into motivations for larger amounts of energy intake. Otherwise, without adjusting for COVID-19 impacts (Hypothesis 2), participants reporting more SSES disadvantage selected smaller average portion sizes during the lockdown. Other studies on changes in dietary patterns during the lockdowns have also included observations of reduced food intake and healthier behaviors (Bacevičiene & Jankauskiene, 2021; Deschasaux-Tanguy et al., 2021). Yet, given that feelings of relative deprivation and undergoing stressful periods may increase intended food portion sizes (Lim, Sim, Forde, & Cheon, 2018; Sim, Lim, Forde, & Cheon, 2018;), it remains unclear why greater SSES disadvantage during the pandemic-related lockdown would be correlated with smaller portion sizes. Notably, participants from high objective SES backgrounds (high income group) selected larger portion sizes than those of objectively lower SES backgrounds as well. Given this, one possibility is that within the context of a lockdown where access to food may be disrupted by restrictions and dysregulation of supply chains, those experiencing socioeconomic insecurity (either subjective or objective) may have engaged in selecting and consuming to smaller portion sizes to cope with anticipated difficulty accessing food (e.g., rationing food). Qualitative research on the experiences of other populations facing socioeconomic distress have indicated the use of such coping strategies to disrupted food supply during the pandemic (Singh et al., 2021).

The present research contributes numerous broader insights and impacts. First, it adds to recent research on the impact of COVID-19 on diet, nutrition and eating behaviors by identifying how the pandemic and its lockdowns may affect appetite (measured through desired meal portion sizes). Such methods and findings complement existing studies examining self-reported dietary patterns during the pandemic, which may not adequately capture appetite during the pandemic due to external constraints and restrictions on the availability and accessibility of food items (e.g., supply chain disruptions, hoarding and panic buying of food, restrictions against leaving home). Second, the current study further expands on growing literature on the unique role that the psychosocial experience of inequality may have on regulating appetite. Our mediation model suggested that participants reporting greater SSES disadvantage experienced more financial-resource disruptions due to COVID-19, which in turn contributes to intentions to consume larger portions of food. This finding reinforces the idea that perceived deprivation or inadequacy of critical non-food resources (experienced as SSES) may also stimulate appetite and motivations for increased energy intake (Bratanova et al., 2016; Briers et al., 2006; Cheon et al., 2018;

Sim, Lim, Forde, & Cheon, 2018; ; Sim, Lim, Leow, & Cheon, 2018;).

There are several limitations with the current study. Although the data was collected during a national stay-at-home order, it was cross-sectional in nature. Thus, we were not able to assess actual changes in portion selection patterns compared to a pre-pandemic baseline. We were also not able to experimentally manipulate or test the causal influence of SSES disadvantage on our outcomes of interest. Additionally, the study did not measure actual eating behavior or food intake patterns. Yet, this would have been challenging given the lockdown and the necessity for remote online data collection. Finally, the indirect effect of financial-resource impacts of COVID-19 contributing to a positive relationship between SSES disadvantage and portion sizes we observed were modest. Yet it provides initial insights into one mechanism through which SSES disadvantage may be contributing to judgments about how much to eat during a pandemic-related lockdown, which otherwise displayed a negative relationship in our sample. The observed pattern of a competitive mediation suggests the presence of another pathway in which increased socioeconomic disadvantage may contribute to selection of smaller portion sizes. Identifying the variables that account for this process may be promising target for future studies.

In conclusion, this study offers further insights into how the COVID-19 pandemic may exacerbate existing social and health disparities. Our findings support prior research suggesting that those experiencing disparities were especially vulnerable to further loss of livelihood and resources that granted security and social status (Bajos et al., 2021; Patel et al., 2020; Wu et al., 2021), and demonstrate how these processes may have downstream consequences on intended eating behaviors that may risk excess energy intake. These findings reveal how disparities generated by the COVID-19 pandemic could potentially worsen the existing epidemic of obesity by contributing to socioeconomic disparities that may heighten motivations for increased energy intake.

Author contributions

BKC conceptualized and designed the study and provided supervision. LL contributed to conceptualization/design and provided project management support in collection, organization, and management of data. Both BKC and LL performed and interpreted analyses. BKC wrote the manuscript with contributions from LL.

Research ethics statement

This research was approved by the Institutional Review Board (IRB) of Nanyang Technological University (Protocol # IRB-2019-03-003-03).

Declaration of competing interest

The authors have no conflicts of interest to declare.

Data availability

Data will be made available on request.

Acknowledgements

We would like to thank Ciaran Forde and Edwin Chia for preparation of the computerized portion selection task stimuli and Aimee Pink for feedback. This research was funded by a Ministry of Education Academic Research Fund Tier 1 Grant (2018-T1-002-024) awarded to BKC. BKC's contribution to this work was supported by the Intramural Research Program of the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development. Portions of this work were completed during BKC's prior affiliation with the School of Social Sciences of Nanyang Technological University and the Singapore Institute for Clinical Sciences of the Agency for Science, Technology and Research (A*STAR).

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