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The usage of different types of food outlets was not significantly associated with body mass index during the third COVID-19 national lockdown in the United Kingdom

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Abstract

Background: The United Kingdom (UK) implemented several national lockdowns during the coronavirus pandemic during which restaurants were closed and people were advised to stay at home if possible. These restrictions were eased and reapplied multiple times between March 2020 and May 2021. The change in restaurant access and prolonged restriction of activity may have an impact on body weight.

Aim: The aim of this study was to examine the impact of multiple lockdowns on body mass index (BMI) change from pre-pandemic till during the third lockdown and on the use of different types of food outlets and their association with BMI change.

Materials and Method: Surveys of usage of different types of food outlets were distributed online before the lockdown between 06 January and 12 December 2019 and during the third national lockdown between 29 March and 25 April 2021. The food outlet usage surveys were filled out for seven consecutive days. Self-reported BMI was reported before the pandemic and during the third phase of the lockdown. The total number of individuals who started the study before the pandemic was 681, and 60 participants completed the surveys during the third phase of lockdown.

Results: For the 60 participants in both surveys mean BMI was significantly higher during the third lockdown (28.6 ± 5.9 kg.m^2) in comparison with the mean BMI before the pandemic 2019 (28.0 ± 5.5 kg.m^2) (paired $T = 3.09$, $p < 0.003$). There was a significant positive association between BMI change, total number of days spent in lockdown ($\beta = 0.05$, $p < 0.01$, $R^2 = 9.99$), and age ($\beta = 0.06$, $p < 0.007$, $R^2 = 11.8$). There was no significant association between change in BMI and change in the frequency of using fast food restaurants (FFRs), full-service restaurants (FSRs), and delivery and takeaways.

Conclusion: BMI was increased significantly during the lockdown in comparison with prior to the pandemic. Individuals gained more weight the longer they stayed at home during lockdowns, and physical activity was reduced to approximately half. However, the BMI change was not related to the change in use of different types of food outlets. This pattern does not support the widespread belief that visiting restaurants or using delivery and takeaway services has a significant impact on body weight.

KEYWORDS
BMI change, COVID-19 lockdown, food outlet usage, lockdown, obesity

1 | INTRODUCTION

The novel severe acute respiratory syndrome coronavirus 2 (SARS-Cov-2) pandemic is viewed as the greatest threat to global public health since the influenza pandemic that occurred in 1918, which infected 30% of the world's population and killed at least 50 million people.[1,2] Nations around the globe are implementing different forms of "social distancing" and "lockdowns" as policies to reduce the spread of the virus. The core aim of these policies is to keep people apart from each other by restraining them to their homes to lessen contact rates and the spread of infection.[2,3] Moreover, businesses such as restaurants, pubs and cafes are often required to shut down to prevent public gathering.[4] Shutting down these outlets and advising people to stay at home may affect behaviors likely to be involved in regulation of body weight—namely physical activity levels and dietary behavior.

Previously, many studies suggested that eating out at restaurants might elevate the risk of obesity.[5–8] For instance, a study conducted in 2018 suggested that frequent consumption of food at restaurants increases BMI among individuals in the United States.[9] A study in the United Kingdom concluded that takeaways are connected to the increases in BMI.[10] In contrast, the previous work that was done by Albalawi et al. 2020 in the United Kingdom showed that apart from fish and chip shops, the density of fast food restaurants (FFRs) and full-service restaurants (FSRs) had no association with BMI, waist to hip ratio or %fat among males and females after adjustment for several sociodemographic factors.[11] Moreover, an online survey was used to examine the association between utilization of different types of food outlets and BMI in Scotland and found that frequent use of FFRs, FSRs, and takeaways and delivery services was not associated with BMI.[12]

Due to restrictions during lockdown, eating behavior is very likely to have changed as people could not access restaurants and cafes. However, fast food delivery (premises that have services where a customer orders from her/his location and receives the order via food delivery company or personnel from the same restaurant)[13] and takeaways (outlets where meals can be cooked and prepared to be ready for immediate consumption, outside of the establishment)[14] were still available in many UK cities and may have been utilized more frequently as an easier option than cooking at home.[15]

Although regulations have differed slightly between the different nations within the United Kingdom, and there have also been some isolated regional lockdowns, the United Kingdom has so far had three periods of national lockdown. The first lasted from 26 March 2020 until 23 June 2020, the second lasted from the 31 October until the 2 December 2020 and the third lockdown lasted from 6 January 2021 until the 19 July 2021. Hence of the 480 days between 26 March 2020 and 19 July 2021, individuals in the United Kingdom were subjected to national lockdowns for 314 days (65.4% of the time). Prior to the implementation of the lockdowns in the UK restaurant usage and self-reported BMI were measured for 681 individuals living in and around Aberdeen, a city on the Northeast coast of Scotland, UK.[12] These people were previously re-contacted and asked to complete the same survey during the first UK lockdown between 22 April 2020 and 3 June 2020 to establish the change in food outlet usage during the lockdown.[16] Two hundred and six participants responded, and the results showed that their BMI was not significantly changed despite the significant decrease in restaurant access and increase in the use of food delivery services.[16] No association was observed between the change in BMI and the change in the usage of FFRs and FSRs(16). The absence of any impact of the changed behavior on BMI in that previous survey could have been because the period of lockdown (30–60 days) had not been long enough to impact BMI. The purpose of the present follow-up study was to investigate the accumulated impact of the more prolonged periods of lockdown restrictions on food outlet usage and BMI.

2 | METHODOLOGY

2.1 | Study design

The participants who took part in the previous investigation in 2019 were invited (prior the pandemic) via text messages to continue a follow up survey during the third lockdown. Participants recorded their phone numbers which allow us to remind them to fill out the coming surveys, age, sex, ethnicity, employment status, workplace,

place of living, number of people per household, dietary habits, whether have allergy and physical activity level. The BMI was estimated based on participants' self-reported weight in kilograms divided by their self-reported height in meters, squared. Also, the participants recorded their postcode district which gives an estimate deprivation level based on Carstairs index. This index represents deprivation level based on four factors from the UK Census: lack of vehicle ownership, low or poor social class, male unemployment and overcrowding. The index represents the deprivation status of a district compared with the remainder of Scotland. Carstairs indices can be positive which suggests a greater level of deprivation or negative which indicates a higher level of affluence.

The food outlet usage surveys (survey 2) were sent to participants each day over seven consecutive days. The participants in this survey were asked whether they used any food outlets giving them five options, FFRs, FSRs, delivery or takeaways. auto reminder text messages were set up with a link to this survey (food outlet usage survey) on 8.30 PM during the study period. To stimulate the participants to report their usage of food outlets, an auto-reminder text messages were sent to them via encrypted website (www.textmagic.com), this method was used previously.[12,16] In this study, the BMI was compared before the first UK lockdown between 06 January and 12 December 2019 and during the third period of national lockdown between 29 March and 25 April 2021. Also, the usage of different types of food outlets was compared during the same periods and how these were potentially linked to change in BMI. The total number of days the participants spent in lockdown was calculated. A question was added to assess whether they felt anxious during the lockdown. Also, they were asked if they felt that they want to snack more or less while staying at home. For those who wished to stop their participation, they were able to send the word "NO" and they then stopped receiving further reminders.

This investigation only included males and females who were 18 years old or over with no serious physical or mental issues. An invitation was sent to participate to all the participants who were in the database from the previous work in 2019 (n = 681).[12] Six hundred and seven participants did not respond. The total number of participants who responded was 74 but 13 were subsequently excluded due to incomplete surveys and one dropped out without giving a reason. The total number of participants who completed the surveys in phase three lockdown and were included in the present analysis was 60 individuals (31 females and 29 males; 10% of participation rate from 681 participants pre-lockdown) (Figure 1).

2.2 | Statistical analysis

All the responses of the participants were anonymized and coded by using Microsoft Excel. The sociodemographic data (age, sex, ethnicity, employment status, workplace, number of people per household, dietary habits, and physical activity level) were summarized as mean, standard deviation (SD), and total percentage. The descriptive data of the participants who responded to this study and the data of the original cohort are presented in Table 1 to investigate if there was any bias in the recruitment. Table 2 represented the difference in the physical activity of the participants who took part in the lockdown study with their physical activity prior the lockdown.

Paired t-test was used to compare the self-reported BMI before the pandemic (from 06 January 2019 to 12 December 2019) to that during the third lockdown (from 29 March 2021 to 25 April 2021). Change in BMI from before the pandemic until during the third lockdown was calculated. Because this investigation was constrained in sampling to those individuals who had taken part in the previous survey prior to the pandemic, the low response rate in the current survey (n = 60 respondents) was a concern. Therefore, a retrospective power analysis was performed to establish the power to detect a change in the primary outcome of mean BMI of 0.5 units using a paired t-test and the observed variances. With alpha = 0.05 and a two-sided test the power was 71.9% to detect an effect of 0.5 units with a sample of 60 individuals. This suggested that despite the low response rate the sample was sufficient for the primary outcome. The BMI change was compared between participants who reported that they had more snacks during the lockdown and those who reported that their snacking behavior did not change. It was explored if there was an association between the BMI change and age of the participants and the total number of days spent in the lockdown using least squares linear regressions and multiple linear regressions. The association between sociodemographic factors and BMI change was further explored using general linear model (GLM) (Table 4).

The number of reported meals in the seven days of continuous monitoring from delivery and takeaway services were counted before the pandemic and during the third lockdown. Paired sample-t-tests were used to compare the number of uses over seven days of delivery and takeaways before the pandemic and during the third lockdown. The frequency of use of FFRs and FSRs were counted for seven consecutive days before the pandemic. The use of these establishments fell to zero as these establishments were closed during the third lockdown. The change in BMI from before to during the third lockdown was regressed against the change in usage of FFRs, FSRs, and delivery and takeaways from before till during the third lockdown using least squares linear regressions and multiple linear regressions. The BMI change was further adjusted for possible potential confounding factors (total days spent in lockdown, age, household size, employment, ethnicity, level of deprivation, workplace, dietary habits, and physical activity) using stepwise method and re-regressed against the change in FFRs, FSRs, and delivery and takeaways using least squares linear regressions and multiple linear regressions.

The statistical software used for this analysis was SPSS version 24 (IBM Corp, Armonk, New York, NY, U.S.) and $p < 0.05$ was considered statistically significant.

The ethical approval for this longitudinal follow-up study was obtained from the Ethics Review Board of the College of Life Sciences and Medicine from the University of Aberdeen (CERB/2020/4/1941). The ethical approval for the previous work was obtained from CERB committee (CERB/2018/08/1601). The survey had an electronic consent statement attached before commencing the questions.

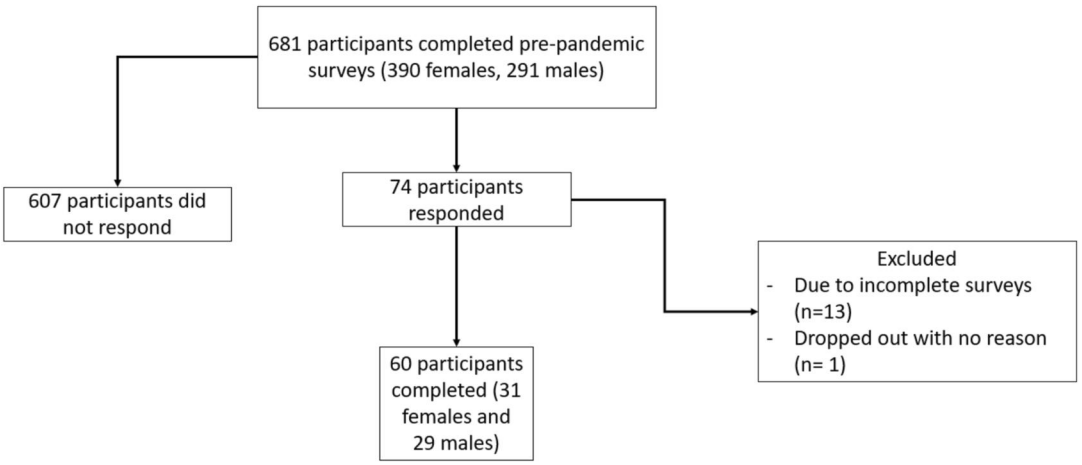

FIGURE 1 Flow chart of participation

3 | RESULTS

3.1 | Characteristics of the participants

The descriptive data of the 60 participants who responded in comparison to the original data pre-lockdown group are presented in Table 1. This comparison is to see if there was any bias from the original data. The mean age of the 60 participants was 34 ± 7.7 years old while the mean age of the original group was 25.6 ± 9.8. The total number of females was 31 (51.6%) and 29 males (48.3%) in the lockdown group and it was 391 (57.3%) females and 291 (42.7%) males in the pre-pandemic cohort. The mean household size during the pandemic was 3.1 ± 1.4 and was 2.9 ± 1.7 before the pandemic in original (681) group. The employed participants represented 81.6%, unemployed 10% and students 8.3% in the lockdown group, while the employed represented 64.2%, unemployed 5.1% and students 30.6% before the pandemic in the original group (Table 1). Before the pandemic in the pre-pandemic cohort 467 (68.55%) were living in Aberdeen and 214 (31.4%) were living in Aberdeenshire, whilst the number of respondents who were in the pandemic group and live in Aberdeen was 45 (75%) and 15 (25%) in Aberdeenshire.

With respect to workplace, before the lockdown, 90.6% of the participants used to travel to their work and 4.4% used to work from home and 5.1% have flexible work (premises change daily) (Table 1). During the lockdown, 96.6% reported that they work from home in Aberdeen and/or Aberdeenshire, and those who reported that they travel to their worksites represented only 3.3% (Table 1).

The deprivation level in the study area averaged −0.64 (6 on Carstairs decile) (Table 1), while in the pre-pandemic group the deprivation level was −1.3 (6 on Carstairs decile). Ethnicities in the data were divided into three categories, Asian, White and Mixed, where the Whites were dominant 85%, Asian were 10%, the Mixed represented 5% in the lockdown sample, and Whites represented in the original sample 72.9%, Asian 8.8%, and Mixed 15.7% (Table 1). No individuals self-identifying as Black participated in the lockdown study, but they were 2.6% of the pre-lockdown participants.

Regarding dietary habits, in the lockdown sample, 81% reported that they follow a regular diet with no specific restrictions, while 15% reported that they were vegetarians, and in comparison, with the pre-pandemic group, the percent of the individuals who reported that they follow regular diet was 81.7% and 13% were vegetarian. Pescatarians represented 1.6% and vegetarians who avoid eggs and milk represented 1.6% in the lockdown cohort, while pescatarians in the original data represented 3.5% and vegetarians who avoid eggs and milk represented 0.1% (Table 1). Also, the participants during the lockdown were asked whether they had any food allergy, and the answer was 95% with no allergy and 5% with allergy, whilst the percent of individuals with allergy was 12.5% and with no allergy was 88% in the pre-pandemic sample (Table 1). Overall, these data suggest that there were no strong biases among the 60 participants who responded compared to the original study population.

3.2 | The effect of the lockdown on anxiety, self-reported physical activity level, and snacking

Out of 60 participants, 34 of them (56%) reported that they suffered from anxiety during the lockdown. The percentage of the individuals who reported that they had snacks more often while staying at home was 33 (55%). The self-reported physical activity of the 60 participants who were in lockdown was compared to their self-reported physical activity prior the pandemic. Before the lockdown, 10% reported that they were highly active, 36% moderately active, 48% slightly active and 5% inactive (Table 2). During the third lockdown, the percent of highly active dropped from 10% to 6.6% (Table 2). No significant change in the percent of participants who reported that they were moderately active (36%). The percent of slightly active participants had decreased from 48% to 16.6% (Table 2). Inactive participants increased from 5% to 40% (Table 2).

TABLE 1 Descriptive statistics: sociodemographic characteristics of the study participants who consented to take part in the second part of the study in comparison with the original data of 681 prior pandemic

Sociodemographic factors	During the third lockdown (60 participants)	Prior the pandemic (681 participants)
Age: Mean (standard deviation)	34.6 (7.7)	25.6 (9.8)
Sex: Number (%)		
Females	31 (51.6%)	391 (57.3%)
Males	29 (48.3%)	291 (42.7%)
BMI: Mean (standard deviation)		
Females	28.3 (6.6)	25.4 (4.1)
Males	28.9 (5.1)	27.1 (3.9)
Household size: Mean (standard deviation)	3.1 (1.4)	2.9 (1.7)
Employment: Number (%)		
Employed	49 (81.6%)	438 (64.2%)
Unemployed	6 (10%)	35 (5.1%)
Student	5 (8.3%)	209 (30.6%)
Place of living: Number (%)		
Aberdeen	45 (75%)	467 (68.5%)
Aberdeenshire	15 (25%)	214 (31.4%)
Workplace: Number (%)		
Travel to work in Aberdeen and/or Aberdeenshire	2 (3.3%)	617 (90.6%)
Work from home in Aberdeen and/or Aberdeenshire	58 (96.6%)	30 (4.4%)
Flexible work (premises change daily)	–	35 (5.1%)
Deprivation level (Carstairs index): Mean (decile Scale)	−0.64 (6)	−1.3 (6)
Race: Number (%)		
White	51 (85%)	497 (72.9%)
Asian	6 (10%)	60 (8.8%)
Mixed	3 (5%)	107 (15.7%)
Black	–	18 (2.6%)
Dietary habits: Number (%)		
Regular diet	49 (81.6%)	557 (81.7%)
Vegetarian	9 (15%)	89 (13%)
Vegetarian but avoid eggs and milk	1 (1.6%)	1 (0.1%)
Pescatarian	1 (1.6%)	24 (3.5%)
Allergy		
Yes (%)	3 (5%)	81 (12.5%)
No (%)	57 (95%)	599 (88%)

3.3 | Comparison between BMI and food outlet usage before the pandemic and during the third lockdown

The mean BMI of the 60 participants who consented to the present survey increased from 28.0 ± 5.5 kg.m^2 before the lockdowns to 28.6 ± 5.9 kg.m^2 during the third phase of lockdown (paired $T = 3.09$, $p < 0.003$) (Figure 2). The percent of participants with normal range of BMI (18.5 to 24.9) decreased from before the pandemic from 35% to 25%. The participants with overweight range (between 25 and 29.9) increased from 33.3% to 36% during the third lockdown, and with obesity (above 30) increased from 31.6% pre-pandemic to 36.6% during the third lockdown.

The usage of FFRs and FSRs fell to zero as all the outlets were closed during the period of the third phase of lockdown. The usage of

TABLE 2 Comparison of self-reported physical activity level between the participants before the pandemic and during the third lockdown (60 participants)

Physical activity level	During third lockdown (2021): number (%)	Before the pandemic (2019): number (%)
Highly active	4 (11%)	6 (10%)
Moderately active	22 (36%)	22 (36%)
Slightly active	10 (16.6%)	29 (48%)
Inactive	24 (40%)	3 (5%)

Abbreviation: BMI, body mass index.
$p < 0.05$ considered significant.

TABLE 3 Multiple linear regression analysis of the association between unadjusted BMI change and change in food outlet usage

Type of food outlet	β	T-value	p-value	R^2
Change in the usage of FFRs	0.059	0.27	0.79	3.29
Change in the usage of FSRs	0.164	0.81	0.42	
Change in the usage of delivery services	−0.005	−0.04	0.96	
Change in the usage of takeaway services	0.115	0.75	0.45	

Abbreviations: BMI, body mass index; FFRs, fast food restaurants; FSRs, full-service restaurants.
Significance is where $p < 0.05$.

delivery services significantly increased during the lockdown to just over double the usage pre-lockdown per week (Delivery 2019 = 0.68 ± 0.13 vs. delivery 2021 = 1.4 ± 1.3: paired $T = 3.04$, $p < 0.004$). However, there was no significant difference in the usage of food takeaway services from before the pandemic and during the third lockdown (Takeaway 2019 = 0.71 ± 0.10 vs. Takeaway 2021 = 0.91 ± 0.16: paired $T = 1.06$, $p = 0.29$).

3.4 | Unadjusted BMI change versus change in usage of different types of food outlets

The change in the usage of FFRs, FSRs, delivery and takeaways was calculated before the pandemic and during the third lockdown and regressed these variables against the self-reported BMI change. In a multiple linear regression model, there was no significant association between unadjusted BMI change and change in the usage of FFRs, FSRs, delivery or takeaway services F (4, 55) = 0.47, $p = 0.75$, $R^2 = 3.29\%$ (Table 3). Moreover, no significant association was observed between unadjusted BMI change and the change in the usage of the food outlets individually (FFRs: $\beta = 0.06$, $p = 0.76$, $R^2 = 0.15$; FSRs: $\beta = 0.20$, $p = 0.27$, $R^2 = 2.09$; delivery: $\beta = 0.01$, $p = 0.91$, $R^2 = 0.02$; takeaway: $\beta = 0.14$, $p = 0.30$, $R^2 = 1.83$) (Figure 3).

3.5 | BMI change versus sociodemographic factors, age, days spent in lockdown and snacking

There were no significant associations between BMI change and sociodemographic factors (deprivation, household size, employment, sex, workplace, place of living, ethnicity, dietary habits, and physical activity) (Table 4).

It was found that BMI change was significantly associated with the total number of days spent in lockdown and was positively significantly associated with age in both multiple regression model and individually in Least Squares linear regressions (multiple linear regression model: days spent in lockdown: $\beta = 0.04$, $p < 0.03$; age, $\beta = 0.05$, $p < 0.01$; F (2, 57) = 6.53, $p < 0.003$, $R^2 = 15.7$, Table 5) (least squares linear regression models: days spent in lockdown: $\beta = 0.05$, $p < 0.01$, $R^2 = 9.99$; age, $\beta = 0.06$, $p < 0.007$, $R^2 = 11.8$, Figure 4). Individuals who reported that they had higher snacking times while staying at home during the third lockdown had significantly higher BMI change in comparison with the ones with low snacking times (T-value = 2.72, $p = 0.009$) Figure 4.

3.6 | Adjusted BMI change versus change in usage of different types of food outlets

The regressions were repeated against the change in the usage of FFRs, FSRs, and delivery and takeaway services after adjusting the BMI change for total number of days spent in lockdown, age, and snacking times at home (these three factors were the only significant factors associated with the BMI change). In a multiple linear regression model, no significant associations were observed between the change in the usage of FFRs, FSRs, delivery and takeaway services and the adjusted BMI change F (4, 55) = 1.31, $p = 0.27$, $R^2 = 2.04$ (Table 6), nor individually (FFRs: $\beta = 0.09$, $p = 0.59$, $R^2 = 0.48$; FSRs: $\beta = 0.24$, $p = 0.10$, $R^2 = 4.36$; delivery: $\beta = 0.11$, $p = 0.19$, $R^2 = 2.88$; takeaway: $\beta = 0.11$, $p = 0.31$, $R^2 = 1.76$) (Figure 5).

TABLE 4 General linear model analysis: BMI change versus sociodemographic factors

Factors	β	Mean	SD	p-value	R^2
Deprivation	0.006	−0.6	2.8	0.93	0.01
Household size	−0.01	3.1	1.4	0.91	0.02
Employment				0.10	7.6
Employed	0.49	0.6	1.4		
Unemployed	−1.01	−0.5	1.8		
Student	0.83	1.3	1.1		
Sex				0.11	4.18
Females	−0.30	0.3	1.4		
Males	0.30	0.9	1.5		
Workplace				0.66	0.33
Travel to work in Aberdeen and/or Aberdeensire	0.10	0.6	1.6		
Work from home in Aberdeen and/or Aberdeenshire	−0.10	0.4	1.2		
Place of living				0.66	1.37
Live in Aberdeen	−0.39	26.9	4.6		
Live in Aberdeenshire	−0.86	26.4	4.3		
Ethnicity				0.29	4.15
White	0.57	0.7	1.4		
Asian	−0.27	−0.1	1.6		
Mixed	−0.30	−0.1	1.4		
Dietary habits				0.11	9.9
Regular diet	0.02	0.7	1.5		
Vegetarian	−0.45	0.2	1.3		
Vegetarian but avoid eggs and milk	2.26	*	*		
Pescatarian	−1.82	*	*		
Physical activity				0.68	2.5
Highly active	−0.13	0.4	1.13		
Moderately active	−0.20	0.3	1.5		
Slightly active	−0.002	0.5	1.4		
Inactive	0.33	0.8	1.6		

Abbreviations: BMI, body mass index; SD, standard deviation.
*$p < 0.05$ is considered significant.

4 | DISCUSSION

This study found there was a significant increase in the mean BMI during the lockdown compared with before the pandemic. Also, the increase in the BMI was significantly associated with age. It was noticed that there was a decrease in self-reported level of physical activity, whereby approximately half of the participants reported that they were physically inactive during the lockdown. However, the level of self-reported physical activity was not associated with the change in BMI. Participants who reported that they had more snacks while staying home during the pandemic had higher increases in BMI than those who reported their snacking behavior did not change during the lockdown.

This study also, found there was a significant increase in the BMI change associated with the total number of days spent in the lockdown. In contrast, the previous work of the authors during the first lockdown suggested no impact on weight change and the number of days spent in lockdown.[16] This could be due to the short time gap between the beginning of the first lockdown and the previous survey.[16] The current data are consistent with a recent systematic

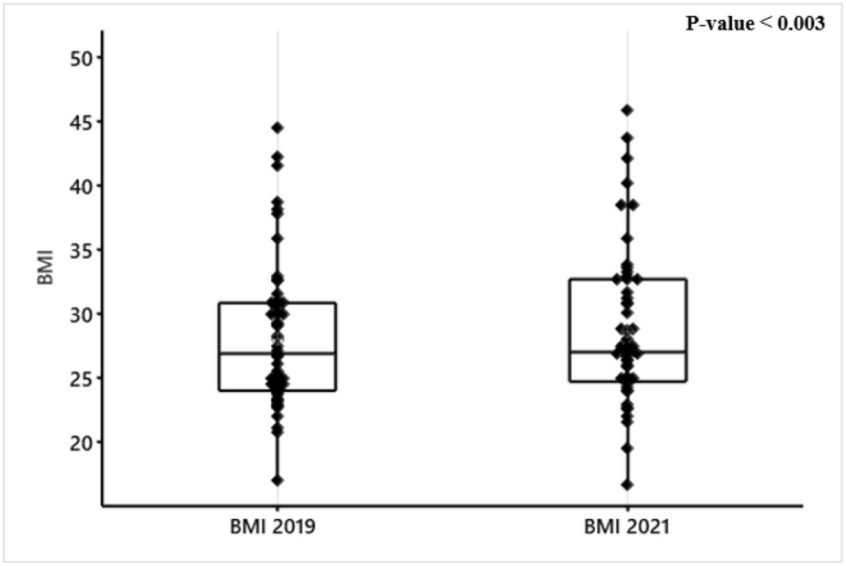

FIGURE 2 Comparison between the mean BMI in 2019 (between 06 January and 12 December 2019) before the COVID-19 pandemic and during the third phase of lockdown (between 29 March and 25 April 2021)

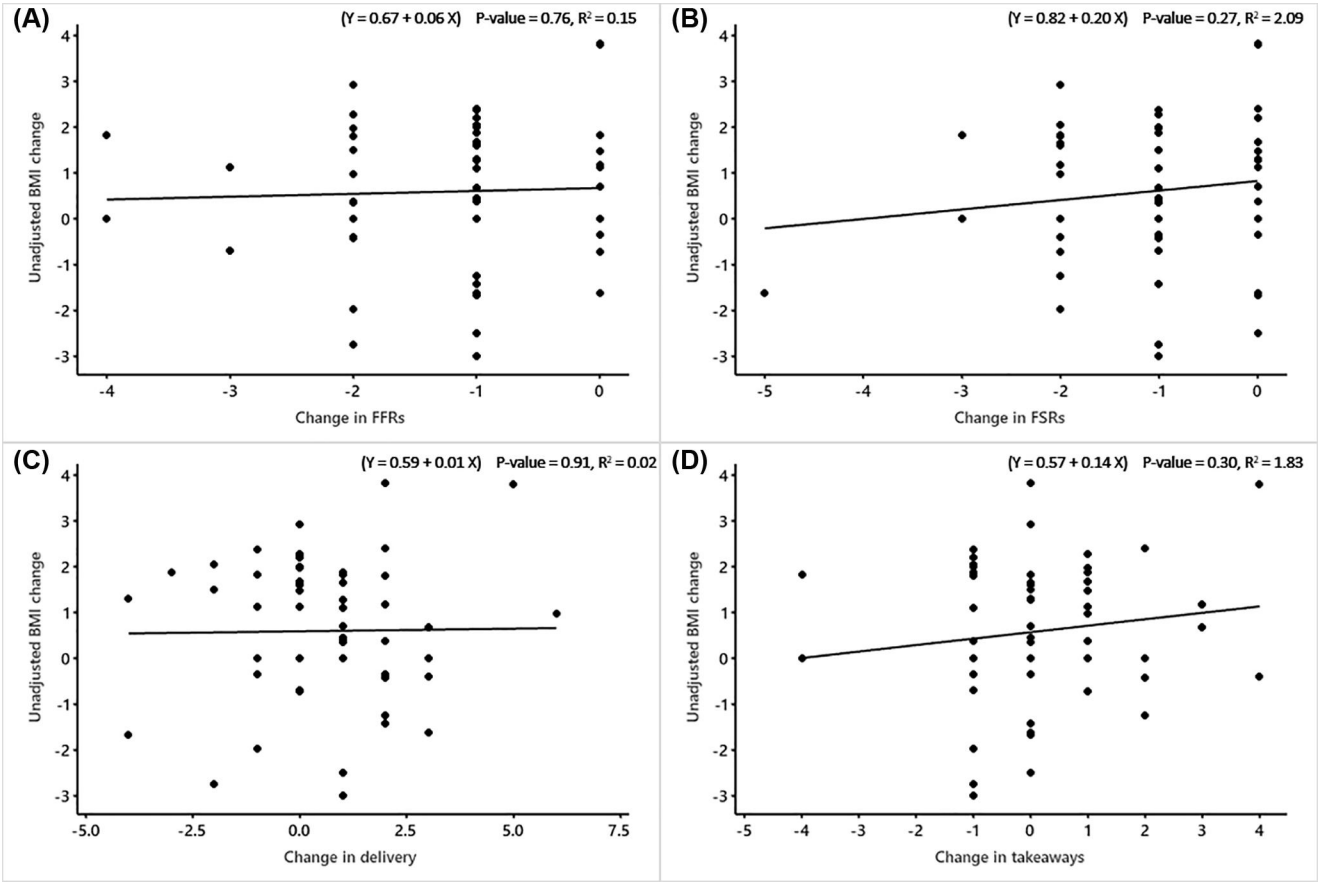

FIGURE 3 Regression analysis of the association between the unadjusted BMI change before the pandemic and during the third lockdown and the change in the usage of FFRs, FSRs, delivery and takeaway of the same period. BMI, body mass index; FFRs, fast food restaurants; FSRs, full-service restaurants. $p < 0.05$ considered significant

review of 36 observational studies which suggested greater time spent in lockdown was related to significant weight gain, potentially due to disturbances of lifestyle.[17]

A potential reason for the increased BMI during the third lockdown was snacking and that could be due to anxiety. Fifty six percent of the participants reported that they were suffering from anxiety.

TABLE 5 Multiple linear regression analysis of the association between BMI change and total number of days spent in the lockdown and age

Variables	β	T-value	p-value	R^2
Total number of days spent in lockdown	0.04	2.19	<0.03	15.7
Age	0.05	2.46	<0.01	

Abbreviations: BMI, body mass index; SD, standard deviation.
$p < 0.05$ is considered significant.

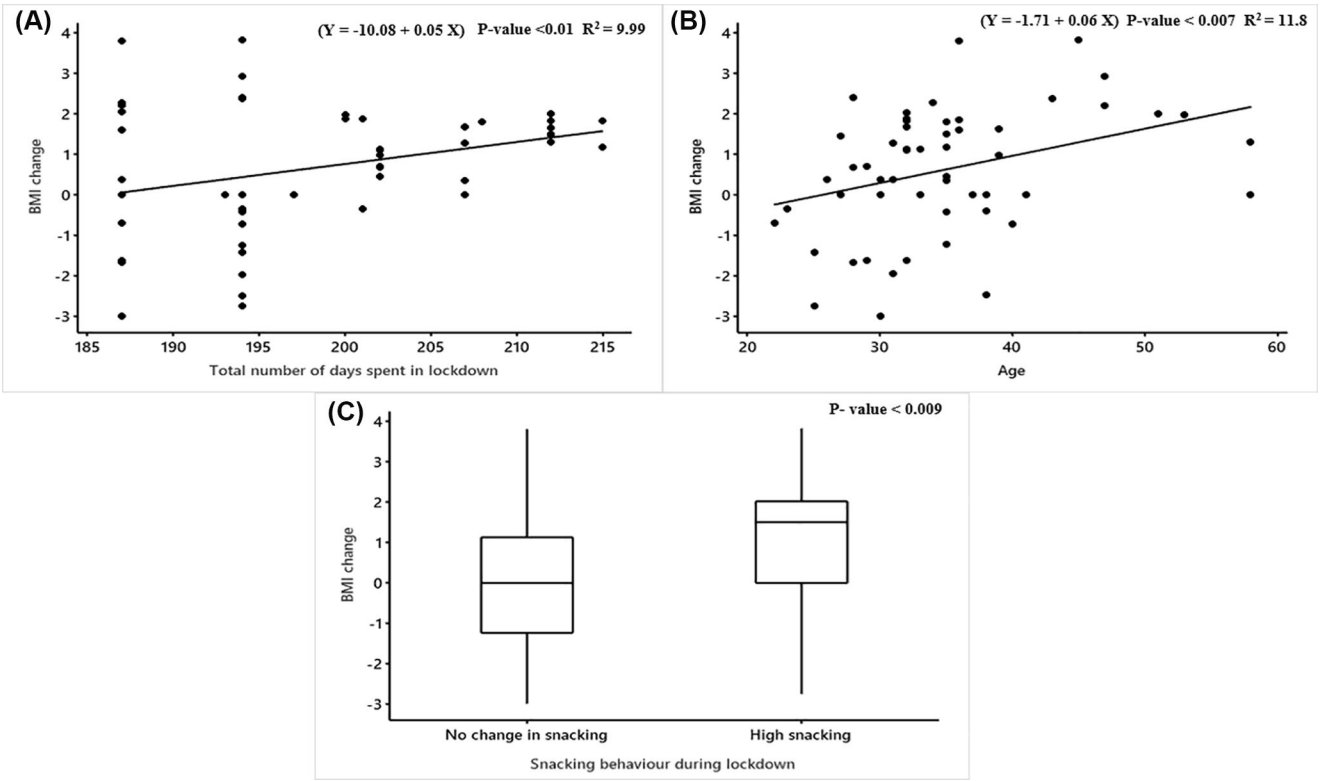

FIGURE 4 Analysis of association: (A) Change in BMI from before the pandemic to during the third lockdown regressed against the total number of days spent in the lockdown and (B) participant age. (C) Comparison in BMI change between individuals with high snacking versus no change in snacking behavior during the third lockdown. BMI = Body Mass Index. $p < 0.05$ is considered significant

TABLE 6 Multiple linear regression analysis of the association between adjusted BMI change and change in food outlet usage

Type of food outlet	β	T-value	p-value	R^2
Change in usage of FFRs	0.04	0.24	0.81	2.04
change in usage of FSRs	0.27	1.70	0.09	
Change in usage of delivery services	0.13	1.39	0.16	
Change in usage of takeaway services	0.01	0.13	0.89	

Abbreviations: BMI, body mass index; SD, standard deviation.
$p < 0.05$ is considered significant.

They described that anxiety and staying at home for longer time made them more likely to eat more snacks. The extent of self-reported snacking was positively linked to the increase in BMI. Similarly, Poelman et al.[18] noted that people consumed more snacks during the lockdown which may put them at risk of weight gain and obesity. The results of this study are consistent with a French study that found more than 63% of people who stayed at home during the pandemic for longer period increased their snacking times due to stress.[19] Several other studies have suggested that the pandemic lockdowns have had a negative impact on psychological wellbeing and that is associated with anxiety which influenced dietary behavior.[20–23] However, this contradicts other studies that found people during the lockdown made healthier food choices and slightly increased their physical activity.[24,25] Nevertheless, these latter studies did not show the long-term effect of multiple implications of lockdown.

In theory preventing people from accessing FFRs and FSRs restaurants should have a protective effect from development of obesity if attending these premises is a risk factor for elevated BMI as

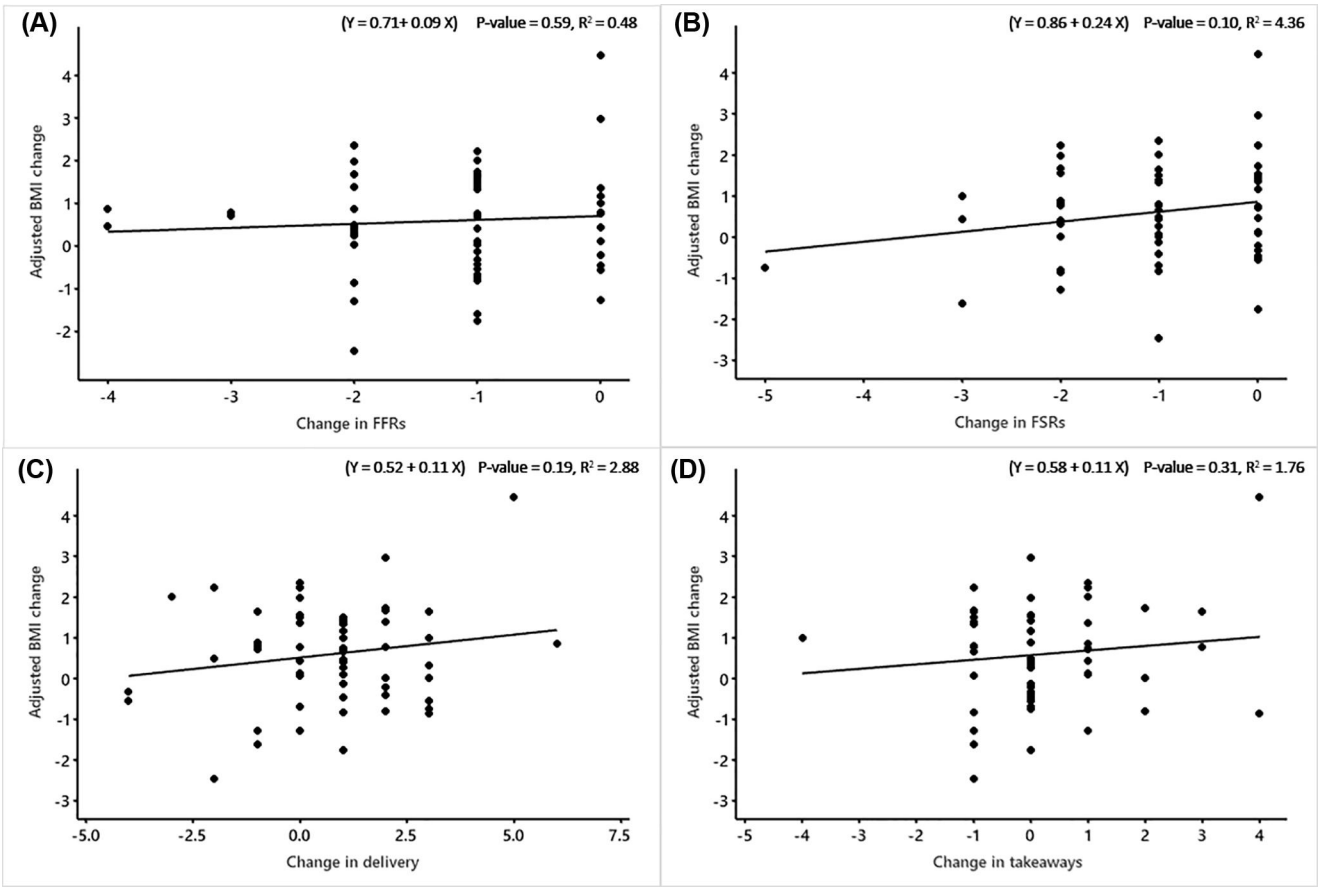

FIGURE 5 Regression analysis of the association between the adjusted BMI change before the pandemic and during the third lockdown and the change in the usage of FFRs, FSRs, Delivery and Takeaway of the same period. BMI, body mass index; FFRs, fast food restaurants; FSRs, full-service restaurants. $p < 0.05$ considered significant

suggested by several studies.[5,26–28] Although in-restaurant dining fell to zero because establishments were closed delivery and takeaway services were continued. However, the reduction in in-restaurant dining was not completely compensated by elevations in the use of these other food sources. One might anticipate that the effect on BMI of being unable to dine out would be greatest in those individuals who had previously utilized these food sources the most. The present study confirmed the results from previous work in 2020 (after the short period of lockdown exposure) where the study showed there was no relationship between change in BMI and change in FFRs and FSRs.[16] This might suggest consumption of foods from fast-food and FSRs is not a key factor driving obesity. This outcome is consistent with a previous study exploring the impact of a regulation in 2008 to ban FFRs in South Los Angeles. After one year of the ban, the prevalence of obesity was higher than prior to the ban.[29]

However, such an interpretation is compromised by several other confounding factors that result from the pandemic lockdowns. In particular as noted above there are elevations in stress and anxiety that may lead to increased snacking behavior, plus being confined to home may reduce greatly the levels of physical activity. This study shows that the participants who reported they were inactive during the lockdown represented 40%, and 56% reported that they ate more snacks while staying at home and 96% of the population were working from home which may put them at risk of weight gain.

In a literature review, one of the factors that contributed to weight gain among participants during the pandemic, was reduced physical activity and increased sedentary behaviors.[30] Reduction in physical activity and sedentary lifestyle were positively associated with energy balance in self-quarantine participants as stated by Zachary et al.[30] Although the links between physical activity, and energy expenditure and obesity development are unclear.[31,32] It is possible at least in theory that reduced physical activity and snacking could offset the reduced intake from FFRs and FSRs.

A strength of this study was the use of the TextMagic website to generate automated messages to remind the participants to report their usage of food outlets. This strategy was implemented previously, and it was used in this investigation to reduce the risk of memory error.[12] Another strong point is that the frequency of using different types of food outlets were counted before the pandemic providing a pre-pandemic baseline to compare to the behavior during the lockdown. However, there are some limitations that need to be mentioned. First, the height and weight of the participants were self-reported and are subject to potential error and

misreporting. Nevertheless, a Scottish study involving weights and heights of 1836 Scottish individuals to examine their validity established that the Scottish population have low error and unbiased reporting which would be satisfactory for monitoring the prevalence of weight change.[33] Second, there was a slight bias in age in the follow-up group in comparison with the original data, and the participation rate was low as only 10% of the original participants were consented to continue in this follow-up study. Third, because the lockdowns were nationally implemented there was no control group who did not experience the lockdown. There is a small annual increase in BMI with age,[34] and hence it isn't possible to establish if the increase that was reported would not have happened anyway because the participants were getting older. Moreover, individuals were not continuously in lockdown for the whole period between the baseline and follow-up measurements. One cannot therefore separate the impacts of lockdown from the impacts of behaviors between the successive lockdown periods. Individuals may have greatly elevated their food consumption at FFRs and FSRs during the periods of release. This is particularly possible because during August 2020 the UK government instituted a national program to encourage people to eat out: the 'eat out to help out' program.

5 | CONCLUSION

In a sample of 60 individuals monitored before and during the final phase of the multiple UK lockdowns there was an increase in BMI. Change in BMI was associated with participant age with older subjects putting on more weight. But it was not associated with the change in the usage of FFRs, FSRs, delivery, and takeaways. Increased BMI was associated with increased self-reported stress, anxiety, and snacking behavior.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Conceptualization, Ahmad Albalawi, John R. Speakman and Catherine Hambly; methodology, Ahmad Albalawi and John R. Speakman; Software, Ahmad Albalawi and John R. Speakman, validation; John R. Speakman, Catherine Hambly and Ahmad Albalawi; formal analysis, Ahmad Albalawi, John R. Speakman and Catherine Hambly; investigation, Ahmad Albalawi, John R. Speakman and Catherine Hambly; resources: Ahmad Albalawi dataset; data curation; Ahmad Albalawi and John R. Speakman; writing—original draft preparation, Ahmad Albalawi; writing—review and editing, John R. Speakman and Catherine Hambly; visualization, Ahmad Albalawi; supervision, John R. Speakman and Catherine Hambly; All authors have read and agreed to the published version of the manuscript.

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