

Healthy diets, lifestyle changes and well-being during and after lockdown: longitudinal evidence from the West Midlands

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ABSTRACT

Background ‘Lockdowns’ to control the spread of COVID-19 in the UK affected many aspects of life and may have adversely affected diets. We aimed to examine (1) the effect of lockdowns on fruit and vegetable consumption, as a proxy for healthy diets more generally, and on weight and well-being, (2) whether any subgroup was particularly affected and (3) the barriers and facilitators to a healthy diet in lockdown.

Methods We conducted a mixed-method longitudinal study, involving an online survey of 1003 adults in the West Midlands, UK, 494 of whom were surveyed at two different points in time. Our first time point was during stringent COVID-19 lockdown and the second during a period of more relaxed restrictions. We asked quantitative questions about fruit and vegetable consumption; physical activity, sociodemographic characteristics, body mass index and well-being and qualitative questions about the reasons behind reported changes.

Results We find no evidence for decreased fruit and vegetable consumption during lockdown compared with afterwards. If anything, consumption increased by half a portion daily among women, particularly among those who normally have a long commute. This finding, combined with a significant increase in physical activity, suggests that behaviours were healthier during lockdown, consistent with higher self-reported health. However, well-being deteriorated markedly, and participants reported being heavier during the lockdown as well. Our qualitative data suggest that an abundance of resources (more time) supported higher fruit and vegetable consumption during lockdown, despite increased access issues.

Conclusions Our results may assuage concerns that lockdowns adversely affected diets. They may point to the impact of commuting on diet, particularly for women. We add longitudinal evidence to a growing body of literature on the adverse effect of lockdown on mental health.

BACKGROUND

Coronavirus Disease 19 (COVID-19) first appeared in Wuhan, China in December 2019 and within 3 months spread around the world causing a pandemic, officially declared on March 11, 2020.¹ There is much variety in the clinical presentation of COVID-19, and

WHAT IS ALREADY KNOWN ON THIS TOPIC

- ⇒ Mental health was negatively affected by COVID-19 lockdown.
- ⇒ There is inconclusive evidence on the effect of COVID-19 lockdown on lifestyle and dietary behaviour.

WHAT THIS STUDY ADDS

- ⇒ People felt they consumed less fruit and vegetables during COVID-19 lockdown. However, actual consumptions did not change.
- ⇒ This study confirms the detrition in mental health during lockdown among people living in the West Midlands area in the UK.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

- ⇒ Long travel commute may have a negative impact on dietary behaviour. There is a research need to evaluate the effect of commuting (among the workforce) on healthy dietary behaviour.
- ⇒ Policy and research should prioritise interventions aimed to improve mental health that was negatively affected by COVID-19 lockdown.

clear risk factors regarding susceptibility to and severity of infection, including age, body mass index (BMI) and underlying health conditions including respiratory disease and diabetes mellitus.^{2 3}

In response to the pandemic, several governments implemented national ‘lockdowns’, in which travel and social activities were restricted, in an attempt to control viral spread. The UK Prime Minister announced a national lockdown on 23 March 2020 in which people were confined to their homes, unless they were deemed critical workers, except for exercise one time per day and other limited exceptions.⁴

The full implications of the ‘lockdown’ on the health and well-being of the population are not yet known. However, there have been

concerns that lockdown has adversely affected physical and mental health as well as health behaviours, possibly due to stress, changes in financial circumstances and lack of access to products and services. Emerging international literature, based predominantly on cross-sectional evidence, has partially supported these fears.^{5–12} In the UK, the food sector experienced strained supply and distribution resulting from unusual shopping activities such as panic-buying and stock-piling, affecting major retailers, online stores and local supermarkets.¹³ In response, food retailers decreased their range of products and focused on products that were in greater demand such as long-life milk, pasta and rice.¹⁴

Further concern has been expressed that unintended consequences of lockdowns may disproportionately affect some population groups, including those who are already disadvantaged, for example, those with overweight or obesity.¹⁵ International evidence suggests polarisation in attitudes towards food consumption during the lockdown, such that some people become unhealthier in their lifestyle, whereby others adopt prohealthy attitudes. For example, evidence from Poland,¹⁶ Spain^{17 18} and Qatar,¹⁹ indicates that at least some individuals' diets benefit from the imposition of a national lockdown.

This longitudinal mixed-methods study is focused on the effect of the UK lockdown on fruit and vegetable (F&V) consumption, as a proxy for healthy diets more generally. The WHO recommends that we consume 400 g or 5 portions of 80 g of fruits and vegetables daily. As a major source of fibre, consumption of F&V is associated with health benefits, including improved insulin sensitivity, reduced cardiovascular risk, reduced colorectal carcinoma risk, improved gastrointestinal function and reduced mortality.²⁰ F&Vs are also a source of vitamins and minerals. F&V's consumption has been shown to be associated with both physical health²¹ and subjective well-being.^{22 23}

In this study, we aimed to examine the following research questions:

1. Was F&V's consumption during the lockdown lower than during normal times in the West Midlands, UK?
2. Was the effect of the lockdown on F&V's consumption different for different population subgroups defined by individual characteristics? Here, we have a specific interest in whether more vulnerable or less healthy subgroups were more likely to reduce their F&V's consumption during lockdown than other groups.
3. Were well-being, physical activity, behaviour, self-reported weight and self-rated health different during lockdown compared with other times?
4. What were the barriers and facilitators of F&V's consumption during lockdown?

METHODS

We used an observational study design consisting of two online surveys. Participants were recruited through the Prolific platform for online research studies.²⁴ Prolific is

a reputable company with data protection and privacy policies in line with the General Data Protection Regulations. Participants were selected based on their residency of the West Midlands. We developed an online questionnaire using Qualtrics to capture dietary intake of F&Vs (our primary outcome), self-reported height and weight, physical activity and measures of physical health, mental health and well-being (our secondary outcomes) as well as sociodemographic characteristics. We collected baseline measures (T0) in May 2020 and follow-up measures (T1) in September 2020. These dates were chosen to correspond to 'during lockdown' and 'post lockdown' periods. The same participants completed both baseline (T0) and follow-up (T1) questionnaires, so that we were able to measure within-person changes. This approach helps to overcome a common issue with cross-sectional surveys and studies on health behaviours, where an observed relationship may be spurious due to (perhaps unobserved) differences in the composition of the sample in different time periods. We received ethical approval under the DR@W2 agreement from the Humanities and Social Sciences Research Ethics Committee at the University of Warwick (reference number 168/19–20).

Our target population was adults living in the West Midlands (approximately 6 million), and our sampling frame were those West Midlands adults that are registered with Prolific. The West Midlands region is interesting as a case study because of its socioeconomically diverse populations, particularly in terms of age and income levels.²⁵ There were no exclusion criteria. We aimed to recruit 1000 respondents for survey at baseline and within a day we had recruited 1003 and the survey closed automatically. For the second survey, only respondents to the baseline survey were eligible to participate. We aimed to recruit 500 respondents for the follow-up, considering that attrition rates tend to be high, particular when surveys are more than a few weeks apart. However, we very quickly (again within a day) filled our quota and closed the survey. After eliminating a handful of invalid responses, we ended up with a sample of 494 (49.3% of 1,003) of respondents that completed both surveys.

Outcomes

We collected information on sociodemographics, living and working arrangements, mental health, well-being, exercise, dietary intake of F&Vs and self-reported height, weight and health. We administered the Office for National Statistics well-being tool to measure subjective well-being²⁶ and the short version of the Warwick-Edinburgh Mental Wellbeing Scale (SWEMWBS) to measure mental well-being.²⁷ To measure F&V's consumption, we used slightly modified questions from the Health Survey for England (HSE).²⁸ Consumption of F&Vs is aggregated according to dietary recommendations, as described in the HSE documentation. For broad categories of vegetables (salad, pulses, other vegetables, dishes made mostly from vegetables) and fruit (juice, fresh fruit, dried, frozen, tinned fruit, dishes made mostly from fruit), the

questions asked participants whether they consumed any of these during the last 24 hours. If participants answered 'yes', then we also asked how many (bowls, pieces, tablespoons, glasses) they consumed for each type of fruit/vegetable within these categories. Since this was an online survey, we limited the possible answers to the 4–6 most common types of F&Vs in each category and added an 'other' option (questionnaire in online supplemental file 1). We then converted the natural quantities reported to the equivalent standard 80 g portions, based on the 5 a-day approach according to the HSE documentation, and aggregated over types within categories and over categories. At follow-up, we added free-text questions about the reasons for reported changes in F&Vs consumptions and weight compared with during lockdown.

Analysis

Quantitative outcomes

Descriptive data for continuous measures are presented as means and SDs. Descriptive data for categorical measures are presented as fractions. We tabulated changes in outcomes 'after' versus 'during' lockdown using information collected from our two surveys (T1 and T0, respectively) and 'during' versus 'before' lockdown using retrospective questions where it was possible to ask these. In all cases, changes refer to outcomes reported by the same individual at different points in time, so that our results reflect true changes in outcomes and are not driven by changes in the composition of the sample. For our main outcomes (F&V's consumption, and mental health as a secondary outcome), we also cross-tabulate these changes with individual characteristics to explore heterogeneity in the changes in outcomes across subgroups along observable dimensions. The quantitative analysis was executed using the statistical software package Stata (V.17.0).

Qualitative outcomes

We applied thematic analysis²⁹ to analyse the qualitative data. This analysis was carried out by two reviewers (PH, LA-K) independently, using an inductive coding approach. One author generated subcodes and main codes, which were reviewed by the second reviewer. Discussions helped resolve any disagreement around the coding scheme. A further review of the coding scheme generated descriptive and analytic themes. These themes were reviewed by the second reviewer independently, with further discussion of any discrepancies.

Sample validation

Our sample consisted of 1003 participants, 494 of whom were interviewed at both T0 and T1. We validated this sample along two dimensions. First, we showed that our sample, including the selected sample of participants who responded to both surveys, gives a useable picture of F&V's consumption in the population in the West Midlands. Second, we showed that there was a substantial change in living and working arrangements between T0

(during lockdown) and T1 (post lockdown) periods, in which participants were interviewed.

Our participants were recruited through an online survey company, and our sample is, therefore, not a representative sample from the population. To show that our data paint an accurate picture of outcomes in the population, we compare demographic characteristics and F&V's consumption in our data to the HSE. This comparison is shown in [table 1](#).

Participants in our sample are younger and included more women compared with the population of the West Midlands according to the HSE. However, we match relatively well the prevalence of overweight and obesity, and patterns in F&V consumption, both over subcategories of F&Vs, and between sexes. The distribution of F&V's consumption is very similar as well (online supplemental file 2). There is very little evidence of sample selection in the follow-up survey with respect to the baseline survey. Although participants who are included in the follow-up survey are significantly older than participants at baseline, the difference is small (38.3 vs 35.2 years), and there are no significant differences between the samples in terms of the gender ratio, obesity rates and F&V consumption.

Survey timepoints

The dates of our two surveys were chosen at the end of the periods when the UK was under a national lockdown in spring 2020 and when restrictions were relatively relaxed over the summer and early autumn ([figure 1](#)).

The changes in national policy between the dates of the baseline and follow-up surveys are reflected in substantial differences in working and living arrangements reported by our participants. Among people working during both surveys, the percentage that was working from home dropped from 75% to 62% between the baseline and follow-up surveys, of which 94% versus 82% were working at home full time. The actual difference in working arrangements was even larger than these numbers suggest because many participants lost their job between the first and second surveys. Including unemployed workers, the percentage of workers who were based at home dropped from 76% to 60% (66 vs 29% full time). Participants' reports of shopping behaviour changed dramatically. Home delivery (including by volunteers) doubled from 14% to 29% during the lockdown, and then fell back slightly to 23% in our sample. These changes in working and living arrangements make it worthwhile to explore changes in F&V's consumption and other outcomes as well.

RESULTS

Quantitative insights

Changes in outcomes between T0 and T1 as well as T0 versus retrospective self-report of before lockdown are presented in [figure 2](#). Based on the F&V portions that participants reported consuming at T0 and T1, the average change in consumption of F&Vs after the lockdown

Table 1 Summary statistics

Sample	HSE, UK (2017)		HSE, W Midl		Survey (T0, 2020)		Survey, matched (T0 and T1)		P value
N (number of observations)	9982		982		1003		494		
Variables	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
% female	55	50	54	50	63	48	62	49	0.52
Age (years)	42.7	24.5	42.5	24.4	35.2	12.8	38.3	13.6	0.00
% overweight	32	46	33	47	27	44	30	46	0.03
% obese	22	42	26	44	16	37	17	38	0.25
% sev obese	3	17	3	18	3	16	2	15	0.61
F&V (por/day)	3.70	2.77	3.24	2.70	4.61	4.08	4.65	3.95	0.77
Gender stratified statistics									
Variables	Females		Males		Females		Males		
Age (years)	43.0	42.3	42.8	42.2	35.1	35.6	38.1	38.6	
% overweight	29	35	30	36	22	35	22	42	
% obese	22	22	27	25	17	14	19	15	
% sev obese	4	2	4	2	4	1	4	0	
F&V (por/day)	3.82	3.54	3.47	2.98	4.70	4.48	4.95	4.19	
Salad (por/day)	0.43	0.36	0.37	0.30	0.47	0.42	0.50	0.40	
Pulses (por/day)	0.26	0.28	0.25	0.24	0.50	0.63	0.52	0.69	
Veg, other (por/day)	0.84	0.81	0.75	0.66	1.78	1.68	1.88	1.42	
Veg, dish (por/day)	0.13	0.12	0.14	0.10	0.30	0.21	0.26	0.15	
Fruit juice (por/day)	0.31	0.33	0.27	0.27	0.48	0.57	0.51	0.52	
Fresh fruit (por/day)	1.64	1.45	1.49	1.24	1.43	1.44	1.55	1.51	
Dried fruit (por/day)	0.12	0.11	0.08	0.09	0.06	0.07	0.08	0.07	
Frozen fruit (por/day)	0.01	0.01	0.02	0.00	0.10	0.07	0.11	0.05	
Tinned fruit (por/day)	0.02	0.03	0.02	0.02	0.05	0.05	0.05	0.04	
Fruit dish (por/day)	0.06	0.06	0.09	0.07	0.04	0.04	0.03	0.03	

Last column is the p-value of a t-test for a difference in the mean of each variable between the matched survey sample and the non-matched sample. Values above 0.05 indicate that there is no evidence at a 5% significance level that the matched sample is selected. F&V, fruit and vegetable; por, portion; sev, severely; Veg, vegetables; W Midls, West Midlands.

restrictions were released is not significant. Changes were computed for T0 (during lockdown) relative to T1 (after lockdown), so that a positive sign corresponds to a higher level during lockdown. For F&V consumption, the sign is positive, indicating that consumption was similar or, if anything, higher (by a quarter portion per day) during lockdown compared with after lockdown. This is true for both total F&V consumption and across all its subcategories. Participants were also asked at T1 whether they had changed their consumption of F&Vs since T0, and by how much. This was also insignificant, but with the change slightly negative, indicating that participants reported to have had (slightly) lower consumption during lockdown.

Figure shows point estimates and 95% CIs

We examined whether the change in F&V consumption between T0 and T1 is different in specific population subgroups, with the findings presented in [figure 3](#).

[Figure 3](#) shows point estimates and 95% CIs.

Most of the variables that we consider do not seem to be associated with differences in the change in F&V

consumption. The only characteristics for which we observe different changes in consumption during lockdown that are significant at the 5% level are some of the budget measures ('cannot afford to buy the F&Vs I want in my usual shops' and 'lack of money prevents me from eating healthily') and having a long commute (more than 30 min), which associate with a larger increase in consumption during lockdown (a larger drop in consumption after lockdown ended). We also found that female participants and participants reporting low levels of well-being may have experienced higher increases in F&V consumption during lockdown, and older people (and perhaps participants with overweight or obesity as well) may have increased their consumption less, or even consumed less fruits and vegetables, during lockdown. These differences across gender and budget are not statistically significant, but the effect sizes are large, and neither men nor participants who did not feel their budget were tight reported any difference in their F&V consumption.

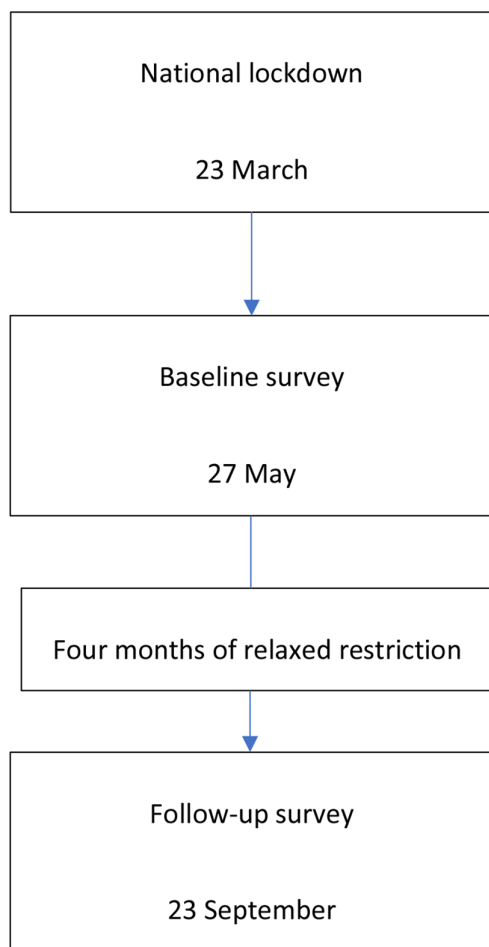


Figure 1 Survey timelines.

Based on the descriptive evidence as reported above, we identified characteristics that may be associated with higher or lower F&V consumption during lockdown and explored these further in a multivariable analysis. We regressed the change in F&V consumption on measures of a low budget for food shopping, age and overweight as potential risk factors, and we estimate the regression separately for women and men. The results are reported in [table 2](#).

To capture the difference between participants with a long versus no or a short commute, we hypothesised that this may be due to participants using the time saved commuting during lockdown to cook. To test this hypothesis, we include a measure for time saved in the regressions. Time saved commuting is calculated by multiplying a respondent's usual commute in minutes with the change in the fraction of time working from home.

The first three columns in [table 2](#) refer to female, the last three columns refer to male participants. The other differences across columns are in the measures we entered into the models to examine the effect of age and overweight (dummies for over 65 years and obese vs age and BMI and tight budget (dummies for 'cannot afford to buy the F&Vs I want in my usual shops', 'buying more F&Vs would be difficult on my budget' and 'lack of

money prevents me from eating healthily' vs dummy for 'no access to a garden or outdoor space').

The multivariable results suggest that it was mostly female participants who saved time commuting who increased their consumption of F&Vs during lockdown. Adjusting for time saved commuting, time spent at home is not a significant determinant of F&V consumption. Neither time saved commuting nor time spent at home matters for F&V consumption reported by male participants.

Conditional on the effect of time saved commuting, we find no evidence for an additional effect of any of the other potential determinants of diets that we explored, except perhaps that older men may have had lower consumption of F&Vs during lockdown. There does not seem to be any association at all for obesity and overweight, nor for measures of low income or tight food budgets, for either women or men. While these determinants were associated with higher or lower F&V consumption during the lockdown in the univariate analysis, these associations were not retained in the multivariable analysis, indicating that time saved commuting is correlated with these other factors and is the main driver of heterogeneity in increased F&V consumption.

Well-being outcomes

Subjective well-being and mental well-being were lower during lockdown than afterwards ([figure 2](#)).

In the first survey during lockdown, participants rated their life satisfaction on average lower by almost 0.1 point, and this change was significant ($p=0.039$). The same trend emerges from a retrospective question from the second survey after lockdown was released, asking participants to compare their lives during and after to before the lockdown, again on a 5-point scale, this time ranging from 'much less satisfied' (1) to 'much more satisfied' (5). In hindsight, participants rated their life satisfaction almost 0.5 points lower (on a 1-to-5 scale) during the lockdown, which partially, but not fully recovered after lockdown was eased. Both changes are statistically significant (p value <0.01). Lower well-being during lockdown manifested itself as lower mental well-being measured using SWEMWBS as well. During lockdown, the reported mental well-being score was on average 0.6 points lower than when restrictions were lifted afterwards, and this change was statistically significant (p value <0.01). Young people in full-time education suffered the largest drop in well-being during the lockdown, see online supplemental file 3 [figure 2](#).

Health and weight

Lower well-being, however, did not translate to worse self-reported health overall, although there was a small self-reported weight gain during lockdown. Health, self-reported on a scale from 'very bad' (1) to 'very good' (5), was higher during lockdown, based on the significant decrease by 0.14 points when lockdown restrictions were released. Self-reported weight decreased, by 0.1 kg on

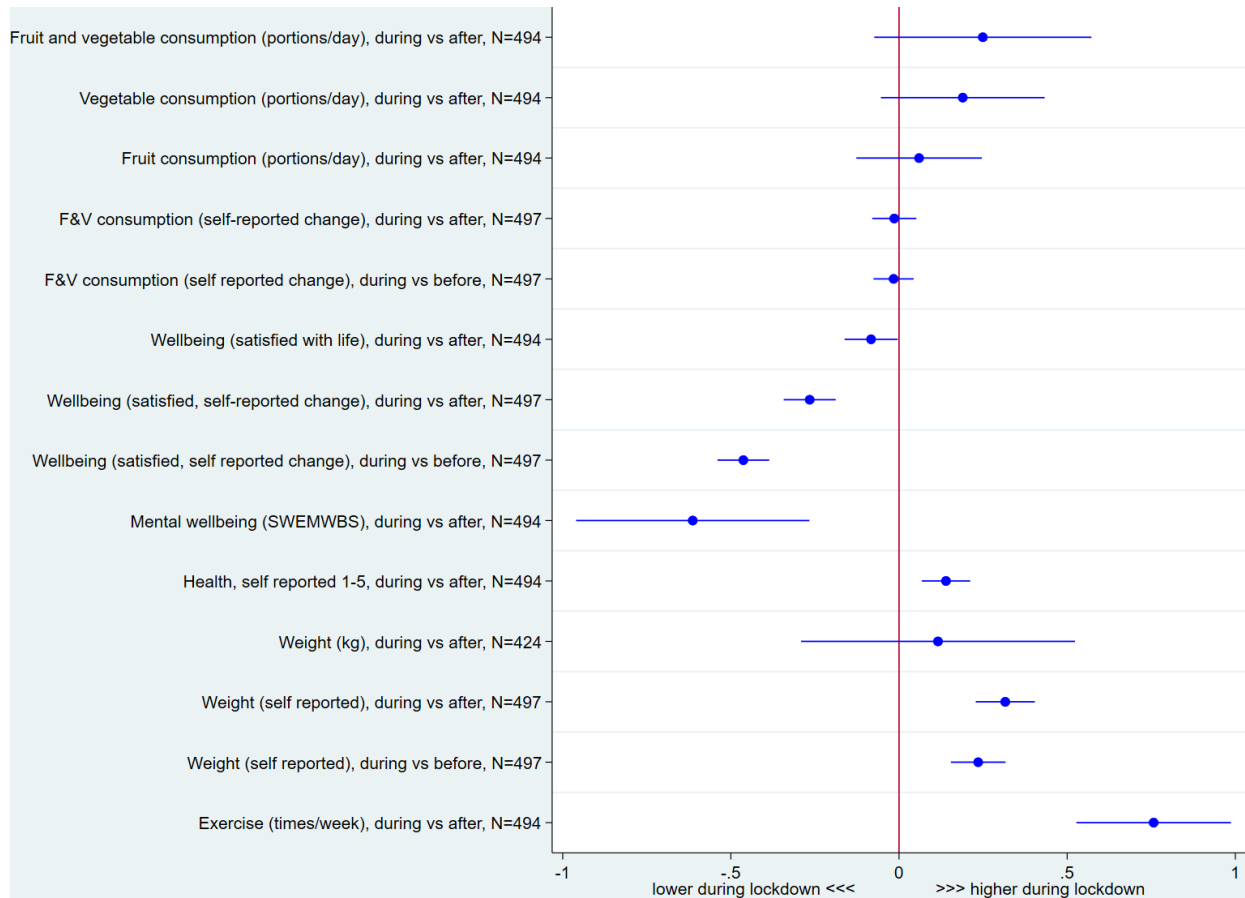


Figure 2 Changes in fruit and vegetable (F&V) consumption and other outcomes during lockdown. SWEMWBS, Warwick-Edinburgh Mental Wellbeing Scale.

average, when lockdown ended. Although this change is not significant, it is consistent with participants retrospectively reporting to have gained weight during lockdown and lost it again when lockdown ended (retrospective weight change is shown in [figure 2](#)). Physical activity was significantly (p value <0.01) higher during lockdown, with participants on average exercising 0.8 times per week more often. Combined with our earlier finding that F&V consumption increased most for women who saved the most time commuting, this result suggests that healthy behaviours may have improved during lockdown because people had more time.

Qualitative insights

The free text questions were completed by 330 participants. Qualitative data generated two overarching themes, change in F&V consumption during and after lockdown and weight change. See online supplemental file 4 for quotes.

F&V consumption during lockdown

Participants reported various reasons for reduced F&V consumption during lockdown, with two main emerging themes: *access issues* and *behavioural change*. On the other hand, factors facilitating increased consumption of F&V were informed subthemes of *abundance of resources* and *successful change*.

Access issues and behavioural change

Participants reported various factors that affected their usual shopping habits and access to shops or food stores. Change in the mode of shopping was a barrier to F&V purchases. For instance, online delivery slots were not as frequent as 'usual' shopping behaviour, the pickers may not have chosen F&Vs according to shelf life as participants would have done if they were choosing the products themselves in the shop, and the long waiting time to receive a food delivery had a knock-on effect on shelf life.

People were not comfortable with online selections as they did not have the choice to inspect items or received items of poor quality.

There was a frequent reporting of financial barriers to purchasing fresh produce. They also raised concerns around the costs of fresh F&Vs, for instance, one participant could not justify the costs of items with a short shelf life with another participant concerned with overall income.

Worries were reported around the risk of infection from purchasing fresh produce, one participant reported

The behaviour of participants changed during national lockdown, with possible contributors, including lack of motivation, increased stress, deterioration in mental health and lack of general interest. There was a consistent migration towards unhealthy dietary habits. Regarding

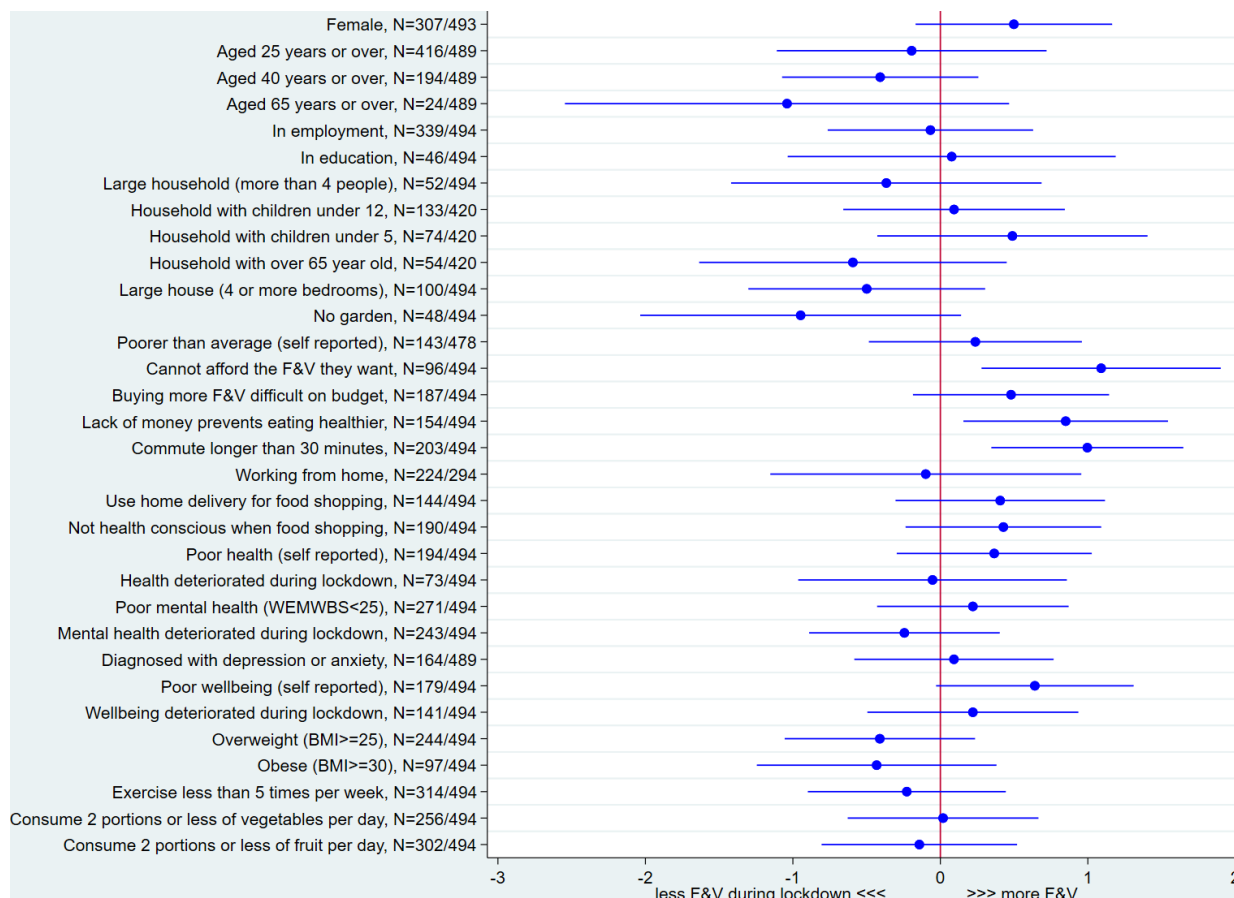


Figure 3 Heterogeneity in change (during lockdown vs after/before) in fruit and vegetable (F&V) consumption (portions/day). BMI, body mass index; SWEMWBS, Warwick-Edinburgh Mental Wellbeing Scale.

emotional eating, associated factors included boredom, feeling low, stress and economic uncertainty.

People found comfort in takeaways, calorie dense food and snacking. Some lost the motivation ‘*can’t be bothered*’ to dedicate efforts around appearance, cooking, preparing fresh meals or following a healthy lifestyle.

Change in working arrangements negatively affected participants’ food choices. Working from home changed eating habits. Some participants reported adding fruit to their packed lunch prelockdown, with fewer snacks and more dietary structure:

Abundance of resources and successful change

A number of participants highlighted several resources that helped them increase their F&V consumptions. These included social support, better access, improved knowledge and more time. Social support involved a reliance on close members to help with the food shop and having family members to help with the cooking.

Regular access to healthier options such as F&V boxes, local farm shops and growing fresh produce helped people to increase their consumption.

The change in mode of shopping where some chose to walk to shops or access their local market positively influenced participants’ purchases as well as more time to prioritise their well-being.

Many participants reported a clear and strong motivation to become healthier, acquire better habits and lifestyle. Some wanted to build a healthier and stronger immune system in the light of the COVID-19 pandemic while others wanted to protect their mental health. Although some food outlets were closed but this seemed to have a positive effect on participants’ habits. The challenges in ‘usual’ shopping modes seemed to serve as enablers to healthier shopping habits.

F&V consumption after lockdown

Two emerging themes were associated with decreased F&V consumption: lockdown behavioural spill over and external and internal distress. Increased F&V consumptions were associated with having improved access and increased health consciousness.

Lockdown behavioural spill over and distress

Some of the contributors of behavioural change during national lockdown such as lack of motivation and deporation in mental health seemed to spill into the post lockdown period.

Others found it difficult to release themselves from lockdown habits despite attempts to become healthier while some questioned the back to normal climate. Lack of financial means, time constraints and access issues were external

Table 2 Multivariable analysis

Variable	Females			Males		
	(1)	(2)	(3)	(1)	(2)	(3)
Time saved commuting	0.045	0.040	0.040	-0.013	-0.007	-0.005
SE	0.020	0.020	0.020	0.019	0.020	0.019
P value	0.026	0.048	0.049	0.475	0.737	0.798
95% CI	(0.005 to 0.084)	(0.000 to 0.080)	(0.000 to 0.079)	(-0.051 to 0.024)	(-0.045 to 0.032)	(-0.042 to 0.032)
Time at home	0.006	0.008	0.008	-0.008	-0.002	-0.006
SE	0.010	0.010	0.010	0.009	0.010	0.010
P value	0.560	0.432	0.427	0.396	0.850	0.561
95% CI	(-0.013 to 0.025)	(-0.012 to 0.028)	(-0.012 to 0.028)	(-0.027 to 0.011)	(-0.021 to 0.017)	(-0.025 to 0.014)
Age 65+	0.256			-3.638		
SE	1.556			1.870		
P value	0.870			0.054		
95% CI	(-2.821 to 3.332)			(-7.335 to 0.059)		
Age		0.013	0.011		-0.036	-0.045
SE		0.023	0.023		0.025	0.024
P value		0.573	0.650		0.152	0.066
95% CI		(-0.033 to 0.059)	(-0.035 to 0.056)		(-0.084 to 0.013)	(-0.092 to 0.003)
With obesity	-0.760			0.146		
SE	0.670			0.731		
P value	0.258			0.842		
95% CI	(-2.084 to 0.565)			(-1.299 to 1.592)		
BMI		-0.045	-0.044		0.055	0.037
SE		0.031	0.031		0.067	0.066
P value		0.149	0.159		0.418	0.574
95% CI		(-0.107 to 0.016)	(-0.105 to 0.017)		(-0.078 to 0.187)	(-0.093 to 0.167)
'Cannot afford to buy fruit and veg'	0.210	-0.327		0.764	1.007	
SE	0.778	0.825		0.895	1.025	
P value	0.788	0.692		0.395	0.328	
95% CI	(-1.329 to 1.748)	(-1.959 to 1.304)		(-1.007 to 2.534)	(-1.020 to 3.033)	
'Difficult to buy more fruit and veg on my budget'	0.204	0.202		-0.525	-0.536	
SE	0.744	0.784		0.714	0.773	
P value	0.785	0.797		0.464	0.489	
95% CI	(-1.268 to 1.676)	(-1.347 to 1.751)		(-1.936 to 0.887)	(-2.064 to 0.991)	
'Lack of money prevents me from eating healthily'	0.643	0.895		0.717	0.700	
SE	0.787	0.829		0.846	0.943	
P value	0.415	0.282		0.398	0.459	
95% CI	(-0.912 to 2.198)	(-0.744 to 2.534)		(-0.955 to 2.389)	(-1.165 to 2.565)	
No garden			-0.977			-1.916
SE			0.881			1.209
P value			0.269			0.115
95% CI			(-2.719 to 0.765)			(-4.306 to 0.474)

Table shows the coefficient estimates of linear Ordinary Least Squares (OLS) regressions of the dependent variable 'Consumption of fruit and vegetables (portions/day)' on the independent variables listed in the first column. All models include time saved commuting and time at home. Model (1) controls for dummies for 'age over 65 years', 'living with obesity' and three dummy variables for low food budget; model (2) replaces the first two dummy variables for age in years and BMI; and model (3) also replaces the budget dummies for a dummy variables indicating that the household has 'no garden'. The first three columns are for female, the second set of three columns for male respondents. Table entries show (unstandardised) coefficients, 95% CIs for these coefficients, standard errors and P values. BMI, body mass index.

factors associated with reduced F&V consumptions. Participants reported financial barriers and inability to regularly afford F&V. In addition, participants found it difficult to

frequently access shops for fresh produce. Comfort eating, poor mental health and lack of motivation were internal factors that were associated with reduced consumptions

Improved access and increased health consciousness

Participants reported changes in shopping habits, such as more frequent visits to the supermarkets and buying more fresh produce. Others reported that the continued use of online shopping or deliveries helped them to plan and eat healthier. Improved access to facilities for exercise, both indoors and outdoors, helped to increase activity which in turn drove desire to be healthier. Participants became more conscious of their health and wanted to increase fruit and veg consumption in order to improve immunity, lose weight or start leading healthier lifestyle.

Weight changes

Participants were asked to describe changes to their weight during and after the national lockdown. Participants were divided into three main categories (overall weight gain, weight control and weight loss followed by weight gain) based on changes to their weight during the two time points.

Weight loss followed by weight gain

Eight participants experienced weight loss during lockdown and weight gain after lockdown finished. This was as a result of having less time to exercise after lockdown finished as well as having less time to look after health when period of lockdown finished.

Overall weight gain

137 participants experienced some degree of weight gain, either during lockdown, after lockdown finished or during both. The most common theme was increase in alcohol, snacking and unhealthy food, secondary to mental health problems or boredom. Some experienced overall reduction in activity.

Weight control

185 participants described overall weight loss during lockdown or post lockdown. The facilitators for the positive changes were improved diet with portion control and overall healthier foods. Participants described increase in motivation after lockdown ended. Increase in physical activity also played a role. Change in eating habits with less take away and eating in restaurants. Stress induced loss of appetite was one of the reasons for weight loss.

DISCUSSION

Our study found that F&V consumption of residents of the West Midlands during lockdown was not significantly lower than outside of lockdown. This study suggests that consumption may have been slightly higher during lockdown based on contemporary reports of portions consumed during the lockdown (T0: May) and after the lockdown (T1: September). We also asked at T1 whether people had increased or reduced their F&V consumption since T0 and the answer was a non-significant decrease.

We hypothesised that lockdown would have negative effect on diet including F&V consumption, as a proxy for healthy diets more generally, which has been evidenced

in other published articles, many of which have used cross-sectional designs.^{15 30} When asked to self-report changes, our study participants expressed the opinion that their F&V consumption had declined (quantitatively non-significantly, but explicitly in the qualitative data). However, we did not find support for the hypothesis in our contemporaneous quantitative data on portions consumed at two time points. Another longitudinal study using five British cohort studies has similar findings to our study, in that F&V intake was broadly similar pre and during lockdown.³¹ This raises implications for design and interpretation of studies on this topic, suggesting that studies asking participants to self-report increases or decreases in F&V consumption may give inaccurate results.

We explored whether there were certain population subgroups whose F&V consumption was more adversely or less adversely affected by lockdown. We found that (1) some measures of financial constraints and (2) having a long commute (outside of lockdown) are associated with higher consumption of F&Vs during lockdown, than afterwards. There is weaker evidence that women and participants reporting low levels of well-being may have experienced higher increases in F&V consumption during lockdown, whereas older people may have experience lower consumption during lockdown than afterwards. A multivariable analysis revealed that the patterns for women can largely be explained by time saved commuting during lockdown (compared with afterwards), while no other variable investigated was significantly associated with change in F&V consumption. For men, being older was (weakly) associated with lower consumption of F&Vs during lockdown than afterwards, but no other variables were significantly associated.

A previous longitudinal study of the UK population, using five British birth cohorts, found that younger cohorts were more likely to increase F&V consumption during lockdown than older cohorts, in line with our findings.³¹ We believe we are the first UK study to report a differential effect based on time saved commuting, which may be highly policy relevant, not just in the context of 'lockdowns' but for increasing F&V consumption in the population generally. Previous studies have reported particularly adverse effects of lockdown on diet for populations with overweight and obesity that we did not identify.^{30 32} The difference between their findings and ours may be due to the fact that these previous studies were mainly cross-sectional.

In terms of our secondary outcomes, first, well-being was lower in lockdown, measured by either life satisfaction or SWEMWBS. The changes during lockdown are also very large and broadly greater in size than the unhappiness associated with being unemployed or maritally separated, which are well-documented as the two strongest depressants of reported happiness in 'Western' society.^{33 34} The reported drop in overall life satisfaction is also in line with previous studies, for example, the UK Household Longitudinal Study found that psychological

distress increased 1 month into lockdown from 19.4% in 2017–2019 to 30.6% in April 2020³⁵ and the percentage of UK adults experiencing a significant mental health problem is estimated to have risen by approximately 50% based on nationally representative data collected before and during lockdown.³⁶ An additional study showed that aggregate well-being in the UK fell by 0.65 points on the same scale.³⁷ However, we found that self-reported health was higher in lockdown than after lockdown, which may have been driven by the trend towards increased F&V consumption and significant increase in physical activity during lockdown compared with after lockdown. Finally, self-reported weight was higher during lockdown than after lockdown but this was non-significant.

What were the barriers and facilitators to F&V consumption during lockdown? We found that access issues, and negative behaviour change reduced F&V consumption while abundance of resources and successful behaviour change which were associated with increased F&V consumption

The major strength of this study is that we have longitudinal data from the same participants allowing more objective analysis of dietary change than studies of retrospective habits at one point in time. A further strength of our study is the qualitative aspect. We could not identify any other qualitative or mixed methods study that has been published in the literature on this topic from anywhere in the world.

This study additionally has limitations. We recruited participants online, which means that the sample is not representative of the population of the West Midlands, although as described in our methods, our sample appears to be similar to a representative sample (the HSE) in terms of sociodemographics and patterns of F&V consumption. It is possible that selection bias affected our results. For example, people whose time was negatively affected by the lockdown, for example, essential workers with increased burden of work or parents with small children staying home from school, may have been less likely to respond to an online survey and may, therefore, be under-represented in our data. Furthermore, our data are self-reported. It has been shown that self-reported height and weight is unreliable and prone to biased, with the shortest and the heaviest people giving the most inaccurate self-reported measurements.³⁸ Other self-reported data (eg, the self-reports of dietary intake and physical activity) may also be inaccurate, with healthier behaviours reported due to social desirability bias. We were unable to take any steps to mitigate the extent of these biases, so it is possible that the rates of healthy behaviours were lower than we have reported, but it seems unlikely that this bias affected the reported change in healthy behaviours, which is our main interest in this paper.

CONCLUSIONS

There seems to be no evidence for a negative effect of lockdown on physical health, in terms of behavioural risk

factor for disease (F&V consumption, physical activity—both of which were maintained or increased during lockdown for our study sample) and in terms of self-reported weight and self-rated health. However, there is clear evidence that lockdown was detrimental to mental health.

We did not find evidence of significant inequalities in the effect of lockdown on F&V consumption between population subgroups explored—although there is some indication that women who usually have a long commute were particularly able to increase their F&V consumption during lockdown and perhaps that older men were more vulnerable to reduced F&V consumption during lockdown.

Concerns that lockdown negatively affected diet quality in the UK may be allayed to some extent by our findings, however an adverse effect on mental well-being is clearly apparent from our data.

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Contributors The idea for this study was conceived in a group meeting with all authors. TvR (guarantor) designed the survey with input from the other authors. TvR did the quantitative analysis of the data with help from LW, LA-K and PH did the qualitative analysis. OO drafted the manuscript with input from the other authors. All authors read and approved the final version.

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