Title: Out-of-home food environment and the COVID-19 pandemic: An interrupted time-series analysis in England 2019 to 2021

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Abstract

In response to the COVID-19 pandemic, the UK government introduced three waves of national lockdowns and other measures to limit the spread of the virus between 2020-2021. A key component of these national lockdowns required the out-of-home food sector such as restaurants and pubs, to operate only as takeaways. The aim of this study was to investigate the impact of COVID-19 on the out-of-home food environment in England. Using monthly data collected at the local authority level between March 2019 to December 2021, we employed an interrupted time-series approach to analyse the trends of eight different types of food outlets: 1) fast-food/sandwich shop; 2) pub/night club/bar; 3) restaurant/café/canteen; 4) supermarket; 5) mobile caterer; 6) other catering premise, 7) fast-food chains, and 8) non-chained hot food outlets. Our findings suggest that the COVID-19 pandemic had heterogeneously impacted on different types of food outlets. After the easing of restrictions only restaurants, mobile caterers, pubs and supermarkets grew whereas fast-food outlets and mobile caters did not. However, when looking at chained and non-chained fast-food outlets, non-chained food outlets were more responsive to government policy during the pandemic such as the *Eat Out To Help Out* scheme. Whereas after restrictions eased, chained outlets grew at a faster rate compared to their non-chained counterparts, but all fast-food outlets had lower growth than before the pandemic. It is important to understand how the food environment is evolving and changing especially in relation to shocks such as the COVID-19 pandemic. The food environment has a direct and indirect impact on the economy and population health. Thus, it is of great value to understand how it is changing and when and where there is a role for Government intervention.

Keywords: COVID-19; food environment; UK; health

1. Introduction

The SARS-CoV-2 (COVID-19) pandemic significantly changed how food businesses operated. Before widespread vaccination, containment was the main strategy used to limit the spread of the virus. The introduction of virus containment measures from March 2020, lead to an 89% global reduction in restaurant traffic (Aaron Allen & Associates, 2020). In the UK at the start of the first national lockdown in March 2020, no food business was permitted to serve customers on their premises (The UK Government, 2020a). However, food businesses such as restaurants and pubs, were able to act as takeaways between March 2020 to March 2022 without requiring planning permission for a change of building use (Moore et al, 2022). Previously, food businesses were required to get planning permission from their local authorities before they could provide takeaway services. In support of the pandemic lockdowns, the UK Government introduced a furlough scheme to cover the majority of employee wages for those businesses unable to operate as usual (Clark, 2021). The proportion of wages covered by the Government changed as the COVID-19 pandemic progressed, with the scheme ending in September 2021. The restaurant sector was highly dependent on this scheme with 9% (approximately 159,400) of all employees furloughed at some point during the pandemic.

The general population were also restricted as to how often they could leave their homes and who they could interact with outside their household (Public Health England, 2020). These restrictions on movement, coupled with fear of the virus, changed how people engaged with the out-of-home food sector. Evidence from Food Standards Scotland (2021) showed that the average number of visits to an out-of-home food outlet dropped from 4.2 times per week in 2019 to 2.6 times per week in 2020. Conversely, the market value of takeaways increased by 31% and number of new customers using delivery services increased by 54% between 2019 and 2020. There is also evidence suggesting a significant rise in online food sales and the use of online food delivery platforms such as Deliveroo particularly during the first national lockdown in England (Panzone et al., 2021; The Guardian, 2021)

Another important factor at play was the Government white paper on Planning for the Future which was released in August 2020 (The UK Government, 2020b). Part of the changes proposed for the planning system, included reduced restrictions on where restaurants and pubs could open but greater restrictions on where takeaways could open nationally. This change in planning class for takeaways has been motivated by evidence finding an association between increased consumption of fast-food and obesity (Fraser, et al., 2012; Bahadoran, et al., 2015). Since the responsibility for public health has moved to local authorities in 2012 (The UK Government, 2012), more local authorities have taken an active role in managing and supporting the out-of-home food environment. For example, approximately 50% of local authorities have supplementary planning guidance in place restricting new takeaways within their jurisdiction (Keeble, et al., 2019). Public Health England (now Office of Health Improvement and Disparities and UK Health Security Agency) developed a toolkit to support local authorities to monitor the out-of-home food environment, develop guidance (such as for planning), and work with local food businesses to provide healthier food options (Public Health England, 2017).

Given the current complexity in the out-of-home food sector due to Brexit (Financial Times, 2022; The New York Times, 2021), rising prices (The Lancet Public Health, 2022), the changes in the planning policy (The UK Government, 2020b), as well as the COVID-19 pandemic, it is important to understand how the out-of-home food environment has changed from pre-pandemic. To date, there have been no published national level studies analysed the how trends in the out-of-home food sector have changed since the start of the COVID-19 pandemic.

The aim of our research was to explore how the size and types of outlets in the out-of-home food environment has changed in England during the course of the COVID-19 pandemic. This study provides important evidence for the development of food, public health, and planning policy going forward both locally and nationally. The COVID-19 pandemic provided a shock to the food environment and it is important to understand the impact of this and what it means for the future of the type and numbers of outlets and how this may affect health. We took a two-stage approach, firstly we looked at the changes between 2019 and 2021 in the six standardised food business types routinely collected in England. These are: 1) fast-food/sandwich shop; 2) pub/night club/bar; 3) restaurant/café/canteen; 4) supermarket; 5) mobile caterer; and 6) other catering premise. Secondly, we compared the changes in the number of the chain (multiple outlets nationwide) fast-food takeaway outlets against the non-chained independent takeaways.

2. Methods

2.1 Data

We used publicly available data from the Food Standards Agency's Food Hygiene Rating Scheme (FSA FHRS). All data can be accessed at the following link: https://ratings.food.gov.uk/open-data/en-gb. The FSA FHRS is the national monitoring programme of the hygiene of all food businesses to ensure that they are complying with food hygiene law in the UK. In each local authority, environmental health officers are required to inspect all food outlets within their local authority and upload the food hygiene rating within 28 days of an inspection (Food Standards Agency, N.A.). As part of the FHRS, they are also required to capture food business type inclusive of manufacturers, distributors, retailers, takeaways, restaurants, pubs, schools, hospitals, community centres, supermarkets, and mobile caters. For our research, we were interested in those businesses whose practices included out-of-home food provision. Therefore, from the FHRS we selected data on six type of food outlets: 1) fast-food/sandwich shop; 2) pub/night club/bar; 3) restaurant/café/canteen; 4) supermarket; 5) mobile caterer; and 6) other catering premise. Existing evidence has shown that the FSA FHRS dataset is more comprehensive in its coverage than other comparable commercial datasets (Kirkman et al., 2021) for the North East of England.

We restricted our data analysis to only local authorities (LA) in England between March 2019-December 2021 (34 months). The FSA FHRS dataset includes information on food businesses in 311 English local authorities. Two local authorities: Three Rivers, and East Staffordshire classified *'mobile caterers'* as *'other catering premises'* before August 2019 and May 2020 respectively but changed their classification to *'mobile caterers'* after this period. Another local authority Lichfield classified *'other catering premises'* as *`restaurants'* after May 2020 but not before. Therefore, we excluded these local authorities with inconsistent food outlet classification from the analysis of *'mobile caterers', 'other catering premises',* and *'restaurants'*.

Before conducting analysis as part of data preparation, we identified missingness in the dataset. During the COVID-19 pandemic, environmental health officers who normally inspect food businesses were seconded to other posts within the local authority. No face-to-face inspections on premises were being undertaken (Food Standards Agency, 2021). Thus, although normally data is uploaded within 28 days this did not happen during some months so we dropped months where no new data was entered. Most of the missing months were in 2021. To account for data missingness, we used a simple linear interpolation method (Bayen et al., 2015). Research using

the data pre-COVID (Brown et al. 2021: Brown et al. 2022) showed linear trends in the growth in all types of food outlets in the North East of England. Therefore, we assumed that the food environment (i.e., number of food outlets) is changing at a relatively constant rate between any two observations.

2.2 Outcome variables

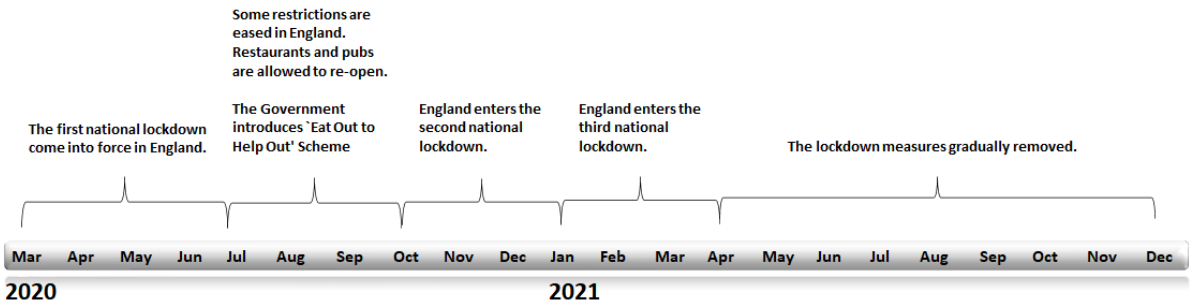
The primary outcome variable is the monthly count for each of the 6 types of food outlets for each LA 1) fast-food/sandwich shop; 2) pub/night club/bar; 3) restaurant/café/canteen; 4) supermarket; 5) mobile caterer; and 6) other catering premise. Our secondary outcome variable is a binary variable which equals one if a takeaway business is a chain and is equal to zero if a takeaway business is independent. To classify fast-food chains we used the following keywords to identify these businesses: McDonalds, KFC, Burger King, Dixy Chicken, Krispy Kreme, Taco Bell, Domino's Pizza, Papa Johns, Pizza Hut, Pizza Express, Nando's, Subway, Five Guys, Greggs, Chicken Cottage, Pret a Manger, Costa, Starbucks, and Caffe Nero. For non-chained hot-food outlets, we selected keywords that are related to the following seven cuisines/types of food outlets: fish and chips, chicken, pizza, Chinese, Thai, Indian, coffee and tea, kebab and general takeaways. The full list of keywords that we used for this process can be found in Appendix A.

2.3 The COVID-19 pandemic lockdown timeline in England

Figure 2 shows the timeline of the UK Government COVID-19 pandemic lockdowns and associated restrictions. To mitigate the impacts of lockdowns, food businesses were temporarily allowed to provide takeaway services without requiring permission from their local planning authority between March 2020 and March 2022 (Moore et al., 2022). Based upon the different pandemic restrictions in place, we defined six distinct time periods in our sample: 1) the pre-intervention period, March 2019-Febuary 2020; 2) the first intervention period (the first national lockdown), March 2020-June 2020; 3) the second intervention period, *Eat Out to Help Out* Scheme[1], July 2020-September 2020; 4) the third intervention period (second national lockdown), October 2020-December 2020; 5) the fourth intervention period (third national lockdown), January 2021-March 2021; and 6) the fifth intervention period is the easing of restrictions following the third national lockdown, April 2021-December 2021.

Figure 2. Timeline of COVID-19 lockdowns and measures in England

[1] This was a government policy measure to help food businesses reopening following the first national COVID lockdown. As part of the scheme, the Government covered up to 50% of the cost of food and non-alcoholic drinks eaten-in at participating outlets. It applied all-day Monday to Wednesday from 3 to 31 August 2020. The discount is capped at a maximum of £10 per head. For more information see: https://commonslibrary.parliament.uk/research-briefings/cbp-8978/#:~:text=The%20Eat%20Out%20to%20Help,encouraging%20consumers%20to%20eat%20out.



Statistical Analysis

To statistically examine the impact of lockdown policy on the food environment, we used a panel interrupted time series analysis (PITSA) approach (Linden, 2017; 2021; 2022). The PITSA is commonly used to evaluate the effect of an intervention or a series of interventions on an outcome variable across a number of cross-sectional units. The PITSA allows to control for pre-existing trends. There is evidence showing that all types of food outlets have an increasing trend in the past decade (d'Angelo, 2020; Brown et al., 2022). The PITSA is capable of examining the treatment effects of multiple interventions that occur within a specific time frame. In our setting, we have identified five interventions as shown in Figure 2, which gives us six segments. Therefore, we are able to compare the changes in the food environment before and after each intervention and estimate the effects of multiple intervention periods using the PITSA.

Specifically, we estimated the following model:

$$\begin{aligned} Y_{ti} = \beta_0 + \beta_1 First_{ti} + \beta_2 Second_{ti} + \beta_3 Third_{ti} + \beta_4 Fourth_{ti} + \beta_5 Fifth_{ti} + \beta_6 T_{ti} \\ + \beta_7 T1_{ti} First_{ti} + \beta_8 T2_{ti} Second_{ti} + \beta_9 T3_{ti} Third_{ti} \\ + \beta_{10} T4_{ti} Fourth_{ti} + \beta_{11} T5_{ti} Fifth_{ti} + \varepsilon_{ti} \end{aligned} \quad (1)$$

Where, Y_{ti} represents the count of one of the six types of food outlets (1) fast-food/sandwich shop; 2) pub/night club/bar; 3) restaurant/café/canteen; 4) supermarket; 5) mobile caterer; and 6) other catering premise) in a local authority, i, in month, t. So equation (1) is estimated 6 times for each of the six different types of outlets. $First$ is a dummy variable indicating the first intervention period. T is the number of months since the start of our analysis. $T1$ is the number of months since the first intervention (the value of pre-first-intervention period is set to 0). Accordingly, $Second$ to $Fifth$ indicate the second to the fifth intervention periods, and $T2$ to $T5$ represent the number of months since the corresponding intervention. We also included five interaction terms, T1*First to T5*Fifth, for the five intervention periods. ε is the clustered error term at the local authority level.

β_0 is the intercept that estimates the starting number of a type of food outlets. β_1 to β_{11} are the parameters of coefficients to be estimated. β_1 to β_5 estimate the immediate effect of the five interventions on the number of food outlets. β_6 estimates the trend of the outcome variable until the first intervention (i.e., the first national lockdown).

β_7 to β_{11} estimate the change in the trend (growth rate) of the outcome variable after each of the five interventions. β_7 estimates the change in the trend of the outcome variable after the first intervention. β_8 to β_{11} estimate the difference between the current intervention trend and the previous intervention trend rather than the difference to the preintervention trend (Linden, 2017; 2022).

3. Results

Table 1 summarises the average number of food outlets across the local authorities by type of food outlets every 3 months over the study period. We found that all types of food outlets, except for pubs, had an increasing trend over the whole study period. The number of pubs remained constant over time.

Table 1. Average number of food outlets by type across the local authorities over time

Date	Fast-Food (1)	Other Catering (2)	Mobile Caterers (3)	Rest-aurants (4)	Pubs (5)	Super-markets (6)	Chains (7)	Non-Chained (8)
Mar 19	142.2	145.5	58.1	320.5	144.6	35.4	37.4	234.5
Jun 19	143.3	146.2	59.1	321.5	144.3	36.0	38.0	235.8
Sep 19	145.4	149.0	60.8	324.7	144.5	36.4	38.5	239.1
Dec 19	146.6	149.6	61.3	326.7	143.9	36.5	38.9	241.0
Mar 20	147.5	149.7	61.0	326.5	143.9	36.7	39.3	241.7
Jun 20	149.3	154.5	61.7	327.7	144.0	36.9	39.4	244.1
Sep 20	153.2	165.9	63.9	331.0	144.0	37.0	39.5	249.2
Dec 20	159.5	187.6	66.8	337.4	144.8	37.5	39.8	259.1
Mar 21	164.3	203.7	68.6	342.2	144.8	37.8	40.0	265.7
Jun 21	167.6	212.5	71.7	347.3	145.2	38.1	40.2	271.3
Sep 21	169.2	214.7	72.6	350.6	145.1	38.3	40.4	273.9
Dec 21	170.2	213.8	72.8	353.4	144.9	38.6	40.8	275.1

Note: To preserve space, this table only presents the average number of food outlets at a 3-month interval. However, the monthly data is available and was used in the analysis.
Chains and non-chained are abbreviations for fast-food chains and non-chained hot food outlets respectively.

Table 2 presents the results of our interrupted time series analysis for the number of food outlets categorised by FSA FHRS Individual plots illustrating the temporal change for each type of outlet can be seen in Appendix Figures A1-A6. β_0 shows the estimated average number of each type of food outlet across the local authorities in March 2019 the start of our study. β_6 shows that, before March 2020, the first national lockdown, the number of all types of food outlets, except for pubs, had statistically significantly increased.

β_1-β_5 show changes in the count of food outlets. The lockdowns and associated COVID-19 restrictions had immediate impacts on the number of food outlets. After England entered the first national lockdown in March 2020 (β_1), the number of all types of food outlets statistically significantly decreased. The number of restaurants declined by 2.43, the number of other caters decreased by 2.57 and there were smaller declines in fast-food of 1.04 and mobile food outlets 1.60 and the smallest decline in supermarkets 0.22. There was not a significant decline in the number of pubs. However, the number of all types of food outlets except for pubs and supermarkets had statistically significantly increased immediately following the *Eat Out to Help Out* Scheme (β_2) ranging from 4.29 for other catering to 1.50 for restaurants, 1.75 for fast-food, and 0.87 for mobile caters. After the second national lockdown (β_3) there was a significant increase for all types of food outlets with the largest rise again for other catering (4.86) and an increase of 1.27 for fast-food, 1.54 for restaurants, a smaller increase for pubs (0.56), mobile caterers (0.64) and supermarkets (0.27). The third national lockdown (β_4) had

no significant change on the number of all types of food outlets. After the UK government announced the gradual easing of the final national lockdown (β_5), the number of mobile caterers (1.58), restaurants (1.03), pubs (0.43), and supermarkets(0.13) increased but the number of fast-food outlets and other catering premises did not have statistically significant change.

β_7-β_{11} show the changes in trends for growth of different types of outlets. Compared with the pre-lockdown period (β_7), there were no significant changes in the growth of fast-food outlets, mobile caterers, and pubs during the first lockdown. The growth rate of restaurants (-0.38) and supermarkets (-0.08) had statistically significantly decreased, but the growth rate of other catering premises (0.95) had statistically significantly increased compared with the pre-lockdown period. Compared with the first national lockdown period (β_8), growth in fast-food (0.54), other catering (2.06), mobile caters (0.49), and restaurants (0.59) increased. There was no change in trend for pubs and supermarkets.. During the second national lockdown (β_9), there was a further increase in the growth rate of fast-food outlets (0.80), other catering premises (3.15), and restaurants (0.97). There was no change in trends for the other three types of food outlets. During the third national lockdown (β_{10}) there was a significant decrease in the growth of all types of out-of-home food outlets, 0.36 for fast-food, -1.40 for other catering, -0.31 for mobile caters, -0.40 for restaurants, -0.17 for pubs, and -0.06 for supermarkets. With the gradual easing of the final national lockdown (β_{11}), we found no significant changes in the growth of mobile caterers, restaurants, and pubs compared to the previous period. However, there was a significant increase in the growth of supermarkets (0.06) and decrease in the growth of fast-food outlets (-0.98) and other catering premises (4.56) compared with the third national lockdown period.

Comparing the magnitude of coefficients between different types of food outlets, we found that pubs and supermarkets were the least sensitive to the lockdowns and COVID-19 restrictions. Other types of food outlets were more sensitive to external changes over this period. Overall, other catering had the largest growth over the lockdown period which reversed after restrictions eased.

Table 2. Interrupted time series analysis of the number of food outlets by the FSA FHRS business type

	Fast-Food (1)	**Other Catering (2)**	**Mobile Caterers (3)**	**Rest-aurants (4)**	**Pubs (5)**	**Super-markets (6)**
β_0 (Constant)	141.90**	144.87**	58.05***	319.65**	144.36**	35.52***
	(6.85)	(6.42)	(2.35)	(15.84)	(5.69)	(1.67)
β_1 (First)	-1.04***	-2.57***	-1.60***	-2.43***	-0.22	-0.21**
	(0.35)	(0.47)	(0.23)	(0.68)	(0.25)	(0.09)
β_2 (Second)	1.75***	4.29***	0.87***	1.50***	-0.04	0.04
	(0.25)	(0.79)	(0.21)	(0.38)	(0.18)	(0.05)
β_3 (Third)	1.27***	4.86***	0.64***	1.54***	0.56***	0.27***
	(0.26)	(0.67)	(0.15)	(0.57)	(0.15)	(0.06)
β_4 (Fourth)	-0.17	-1.54***	-0.06	-0.21	0.07	0.14***
	(0.15)	(0.43)	(0.10)	(0.30)	(0.08)	(0.04)
β_5 (Fifth)	0.37	0.98	1.58***	1.03**	0.43***	0.13**
	(0.32)	(0.86)	(0.20)	(0.44)	(0.13)	(0.07)
β_6 (T)	0.55***	0.54***	0.36***	0.75***	-0.02	0.12***
	(0.12)	(0.20)	(0.06)	(0.19)	(0.05)	(0.03)

β_7 (T1*First)	0.00	0.95***	-0.13	-0.38*	0.06	-0.08**
	(0.13)	(0.25)	(0.09)	(0.20)	(0.10)	(0.03)
β_8 (T2*Second)	0.54***	2.06***	0.49***	0.59***	-0.02	-0.00
	(0.12)	(0.59)	(0.13)	(0.15)	(0.09)	(0.02)
β_9 (T3*Third)	0.80***	3.15***	0.08	0.97***	0.08	0.04
	(0.17)	(0.58)	(0.12)	(0.32)	(0.09)	(0.03)
β_{10} (T4*Fourth)	-0.36***	-1.40***	-0.31***	-0.40*	-0.17***	-0.06**
	(0.11)	(0.32)	(0.07)	(0.22)	(0.06)	(0.03)
β_{11} (T5*Fifth)	-0.98***	-4.56***	-0.14	-0.39	0.04	0.06**
	(0.16)	(0.50)	(0.09)	(0.25)	(0.06)	(0.03)
# of local authorities	311	308	309	310	311	311
# of observations	10,574	10,472	10,506	10,540	10,574	10,574

Note: Standard errors in parentheses are clustered at the local authority level. *p < 0.10, **p < 0.05, ***p < 0.01.

3.1 Fast-food chains versus non-chained hot-food outlets

Table 3 details the results for interrupted time series analysis for the number of fast-food chains and non-chained fast-food outlets. Respective plots can be found in Appendix Figure A7 and A8. Appendix Figure A9 compares the growth rate of fast-food chains and non-chained hot-food outlets since the beginning of our study. On average, each local authority had an estimated mean of 37 fast-food chains and 234 non-chained hot-food outlets in March 2019. During the pre-intervention period (β_6), both fast-food chains and non-chained hot-food outlets grew by 0.17 and 0.79 per month.

Table 3. The number of fast-food chains and non-chained hot-food outlets

	Fast-Food Chains	**Non-Chained**
	(1)	**(2)**
β_0 (Constant)	37.40***	233.80***
	(1.89)	(9.41)
β_1 (First)	-0.17**	-2.02***
	(0.07)	(0.38)
β_2 (Second)	0.06*	2.15***
	(0.04)	(0.26)
β_3 (Third)	0.26***	2.50***
	(0.04)	(0.34)
β_4 (Fourth)	0.22***	-0.73***
	(0.03)	(0.19)
β_5 (Fifth)	0.12**	1.31***
	(0.05)	(0.35)
β_6 (T)	0.17***	0.79***
	(0.02)	(0.15)
β_7 (T1*First)	-0.15***	-0.04
	(0.02)	(0.15)
β_8 (T2*Second)	0.00	0.77***
	(0.02)	(0.15)
β_9 (T3*Third)	-0.01	1.40***

	(0.03)	(0.19)
β_{10} (T4*Fourth)	-0.05***	-0.80***
	(0.02)	(0.14)
β_{11} (T5*Fifth)	0.13***	-1.27***
	(0.02)	(0.20)
# of local authorities	311	311
# of observations	10,574	10,574

Note: Standard errors in parentheses are clustered at the local authority level. *p < 0.10, **p < 0.05, ***p < 0.01.

β_1-β_5 show the immediate impact of interventions on the number of chained and non-chained food outlets. After England entered the first national lockdown in March 2020 (β_1), the number of chained and non-chained food outlets decreased by 0.17 and 2.02. Following the *Eat Out to Help Out* Scheme (β_2), the number of non-chained hot food outlets had a statistically significantly increase of 2.15. However fast-food chains were less sensitive to the *Eat Out to Help Out* Scheme. After the second national lockdown (β_3), chained and non-chained food outlets had significant increases of 0.26 and 2.50 respectively. The third national lockdown (β_4) led to an increase in the fast-food chains (0.22) but a decrease in the non-chained hot food outlets (-0.73). After the UK government announced the gradual easing of the final national lockdown (β_5), there was an increase in both chained (0.12) and non-chained food outlets (1.31).

β_7-β_{11} show the changes in the growth rate of chained and non-chained food outlets. Compared with the pre-lockdown period (β_7), the growth rate of fast-food chains significantly decreased by 0.15 but the growth of non-chained hot food outlets had no significant change. Compared with the first national lockdown period (β_8), we found no significant change in the growth of fast-food chains but a significant increase in the non-chained hot food outlets (0.77). During the second national lockdown (β_9), the growth of fast-food chains kept the same but the non-chained hot food outlets had a further increase of 1.40. During the third national lockdown (β_{10}), the growth of both chained and non-chained food outlets experienced significant decreases of 0.05 and 0.80. With the gradual easing of the final national lockdown (β_{11}), although both chain and non-food chains continue to grow, the growth of fast-food chains started to rebound (0.13) but the rate of growth of non-chained hot food outlets decreased by -1.27 compared with the growth in the previous intervention period.

4. Discussion

Using national data at the local authority level, our study provided the first statistically robust analysis of how the food environment has been changing in England since the start of the COVID-19 pandemic. Our results showed that during the lockdowns associated with containing the COVID-19 pandemic there was a decrease in the growth in all types of food outlets. In between lockdowns with government programmes such as the *Eat Out to Help Out* scheme, there was an increase in growth in all types of food outlets except supermarkets and pubs. After the easing of all restrictions, there was an increase in growth for mobile caterers, restaurants, pubs, and supermarkets but not fast-food outlets and other catering. When comparing chained and non-chained hot-food outlets, non-chained food outlets were more responsive to government policy such as the *Eat Out to Help Out* scheme. After the easing of restrictions, both chained and non-chained food outlets continued to grow, but the former experienced a significantly higher rate of growth and the latter experienced a significantly lower rate of growth compared to the lockdown periods. Differences in growth and growth

rates between the different types of food outlets during the pandemic may stem from how people used them with some being more sensitive to changes in policy restricting movement.

These findings have implications on how to manage the food environment going forward. Evidence from both the US and UK exploring changes in the food environment over time has uniformly tended to show an increase in all types of food outlets (James, et al., 2017; d'Angelo, et al., 2020). The COVID-19 pandemic led to a sudden unexpected change how people engaged with their food environment (Moore et al., 2022). Particularly at the start of the pandemic, there was an increase in people eating less food from the out-of-home sector and more food prepared at home purchased from supermarkets (The Obesity Health Alliance, 2020). As a result, the supermarket sector in the UK had an estimated £4 billion growth in sales during the first national lockdown period (Panzone et al., 2021). As COVID-19 restrictions ended, expenditure at out-of-home food businesses returned to pre-pandemic levels (Office for National Statistics, 2022a). However, our findings suggest that not all types of outlets have benefitted from this increased expenditure. Only supermarkets (β_{11} in Table 2) and chained fast-food outlets (β_{11} in Table 3) had significant growth following the ease of COVID-19 restrictions.

The situation following the end of restrictions is more challenging because of the cost-of-living crisis and Brexit. Particularly, the rise in the cost of food was one of the largest upward contributors of inflation between June and July 2022 (Office for National Statistics, 2022b). This may lead to longer term changes in how people engage with the out-of-home food sector and wider health inequality as many families will likely suffer from increased food insecurity (The Lancet Public Health, 2022). With rising energy bills and post-Brexit immigration rules implemented on 1st Jan 2021, many food outlets were closed because of the high operating costs and staff shortage (BBC, 2022; Financial Times, 2022; The New York Times, 2021). This may have negatively impacted on local food variety and availability, which may then have implications for dietary intake from the out-of-home food sector and its impact on health.

Our findings have policy implications at both the local, national, and international level. For local authorities to successfully manage their food environment it is important to be able to monitor how the food environment is changing over time and how shocks to the system such as the COVID-19 pandemic and the associated containment measures and impact on the supply chain affect the rate of growth of different types of food outlets. This can help them prioritise what types of policies they should focus on (e.g., restriction of new food outlets or working with existing food outlets to reformulate their menu to provide healthier options, or even creating incentives for certain types of food businesses to locate in the area).

At the national level, these findings can be used to monitor the food environment and develop national policy to feed into the Government's ambition to reduce obesity in adults and children by half in 2030 (Department of Health & Social Care, 2020). The success of the *Eat Out to Help Out* scheme has shown that central government-led interventions are significantly more impactful than the voluntary favoured scheme of the past (Theis and White, 2021).

Internationally, these findings are relevant to governments from other high-income countries which are also grappling with a 'bruised' hospitality sector where trends may be similar for the out-of-home food sector. In the UK, as is the case in many other high-income countries, takeaways tend to cluster in areas of high deprivation; contributing to health inequalities (Green, et al., 2021; Hobbs, et al., 2019; Public Health England, 2016). Thus, it is also important to consider trends in out-of-home food consumption and what this may mean for the contribution of this sector to rising obesity rates globally.

It is also worth noting how the various interventions impacted upon different businesses during the pandemic and what learning can be applied to future policies that may target an

improvement in the healthiness of our out-of-home food environments. We showed heterogeneity in the response by different types of food businesses towards opening and closing outlets to the various policy interventions by the UK government. There may have been various factors behind this such as the accessibility to furlough funding depending upon business type (e.g. it may have been administratively more challenging for small food businesses to apply for and access furlough funding) (Office for National Statistics, 2022c). Therefore, it is important for policy makers to consider these differences when developing future food policy.

4.1 Strengths and Limitations

Our study has several strengths. Our dataset is at local authority level and covers all food outlets in England over the pre-pandemic, pandemic, and post-pandemic periods. We have used a comprehensive and validated data source and applied robust statistical estimates. There are some limitations. For example, our dataset contains a number of missing observations, which may lead to a bias our estimations. In addition, changes in how food outlets were inspected during the pandemic, which included the use of remote rather than in person inspections (Food Standards Agency, 2021). Plus, additional responsibilities related to the pandemic for environmental health teams which have reduced their capacity to enter data to the FSA system in a timely manner (Moore et al., 2022). This may mean that we have underestimated the subsequent growth and decline in out-of-home food outlets.

5. Conclusion

The COVID-19 pandemic was a significant shock to the out-of-home food environment in the UK. In order to understand what lasting impact this may have had we explored trends in growth for 6 different types of food outlets: 1) fast-food/sandwich shop; 2) pub/night club/bar; 3) restaurant/café/canteen; 4) supermarket; 5) mobile caterer; and 6) other catering premise during and after COVID-19 pandemic restrictions. During the restriction of movement as a result of the lockdowns, there was a decrease in the number of all types of out-of-home food outlets. The *Eat out to Help Out* scheme had the Government's desired effect of stimulating growth in the out-of-home catering sector. However, following the end of COVID-19 restrictions, with the population of England adjusting to a new normal, only supermarkets experienced significant growth. Our results also highlight the greater adaptability of non-chained hot-food outlets during the pandemic compared with chained fast-food outlets. However, the growth of fast-food chains started to rebound when COVID-19 restrictions were lifted which was not seen for non-chained hot-food outlets. Policy makers should take into account the differential impact of government interventions on various types of food businesses evidenced from our results when developing future policies to ensure equal opportunities for economic growth and the potential impact on population health.

Appendix A

List of Keywords that were used to identify fast-food chains and non-chained hot-food outlets:

Fast-Food Chains: mcdonalds, kfc, k.f.c, burger king, pret a manger, dixy chicken, krispy kreme, taco bell, dominos pizza, papa johns, pizza hut, pizza express, nandos, subway, five guys, greggs, chicken cottage, costa, starbucks, caffè nero

Fish and Chips: fish, cod, fish and chips, fryer, chippy, plaice, fry, haddock

Chicken: chicken, peri, wings, chickie, rooster, dixy

Pizza: pizza, pizzeria

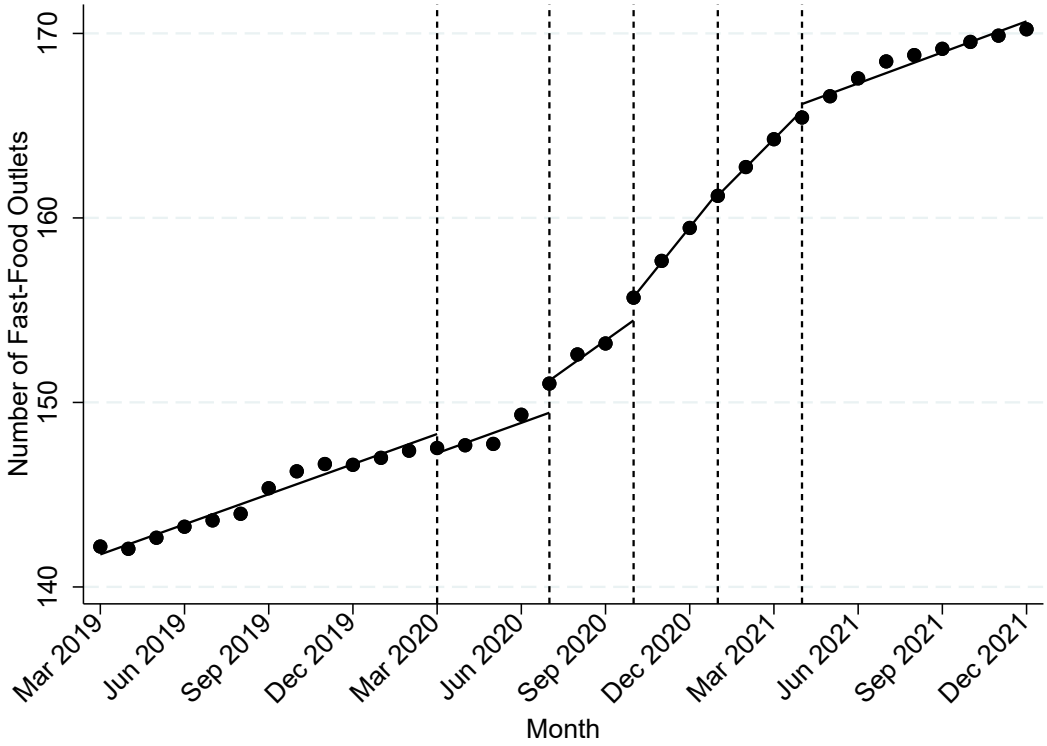
Chinese & Thai: Chinese, east, orient, wok, china, oriental, dragon, hong kong, thai, Cheung, Singapore, chop suey, peking, shanghai, cantonese, lotus, noodle, bamboo, bangkok

Indian: india, dengal, balti, Bombay, tandoori, curry, masala, madras, tikka, spice, raj, halal'

Coffee and Tea: café, café, coffee, tea, bubble, cha

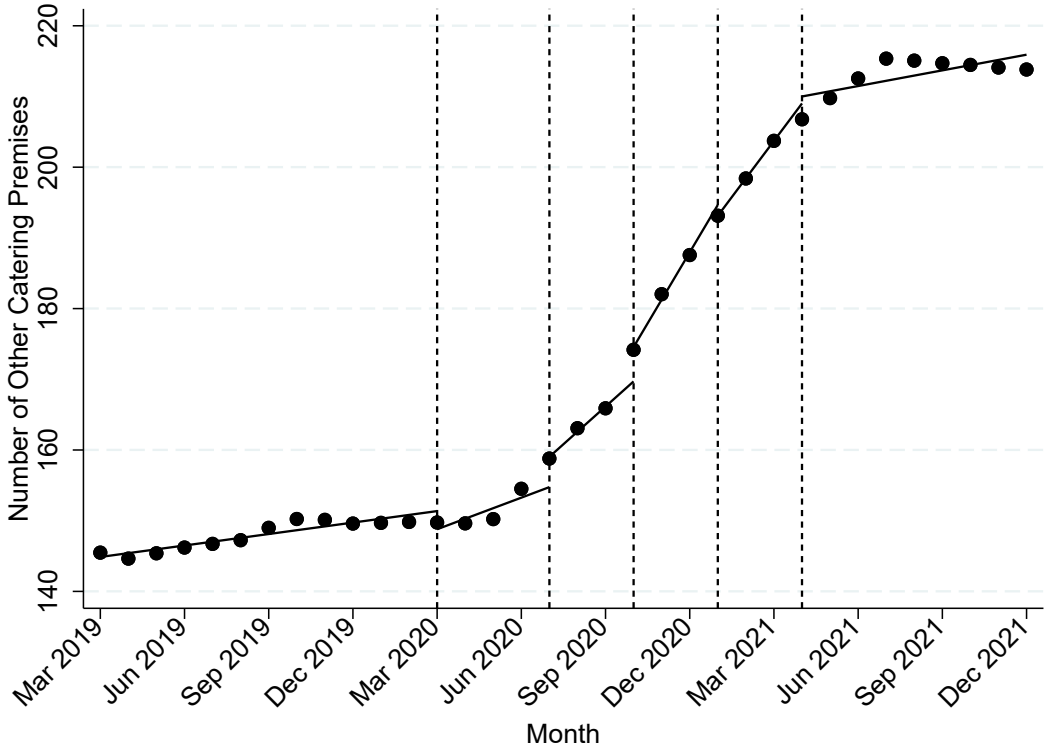
Kebab and general takeaways: kebab, grill, flame, takeaway, burger, charcoal, munchies, shawarma, persian, diner, taste, away, sandwich, kitchen

Figure A1. Average Number of Fast-Food Outlets across Local Authorities



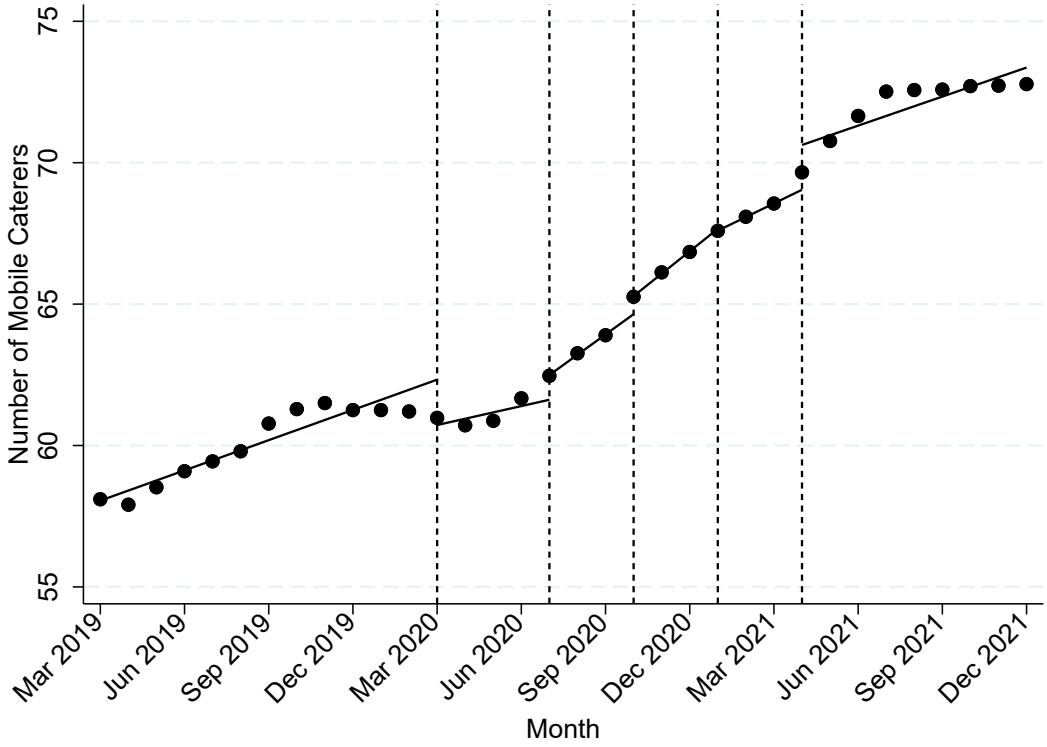
Note: Intervention months: Mar2020; Jul2020; Oct2020; Jan2021; Apr2021.

Figure A2. Average Number of Other Catering Premises across Local Authorities



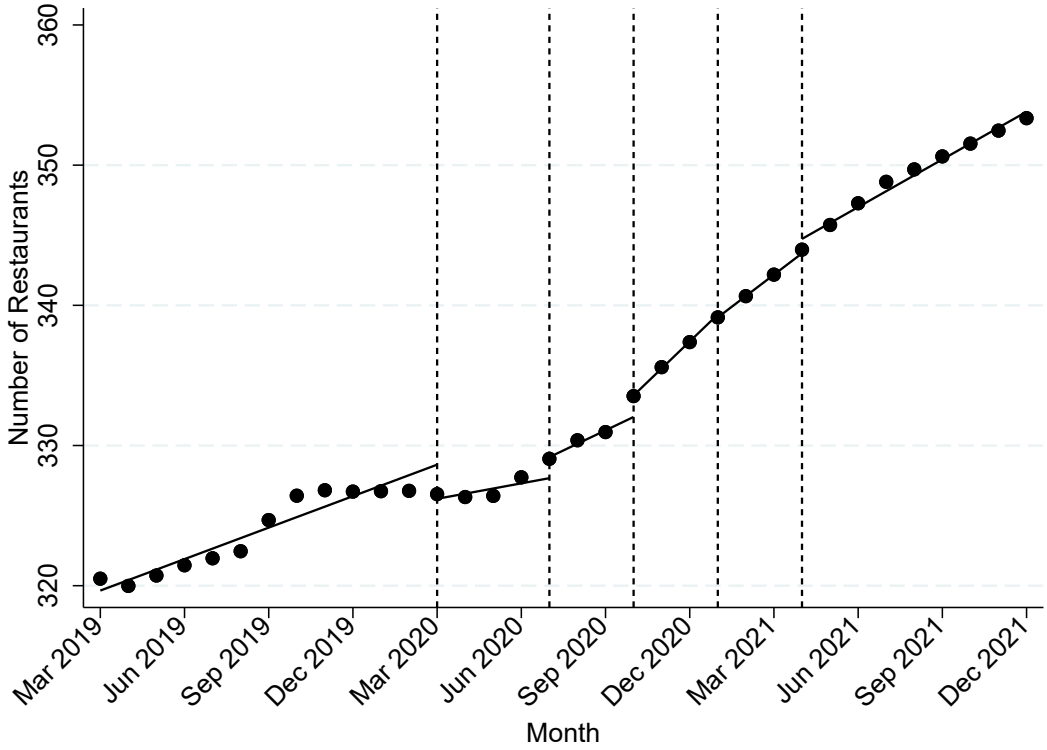
Note: Intervention months: Mar2020; Jul2020; Oct2020; Jan2021; Apr2021.

Figure A3. Average Number of Mobile Caterers across Local Authorities



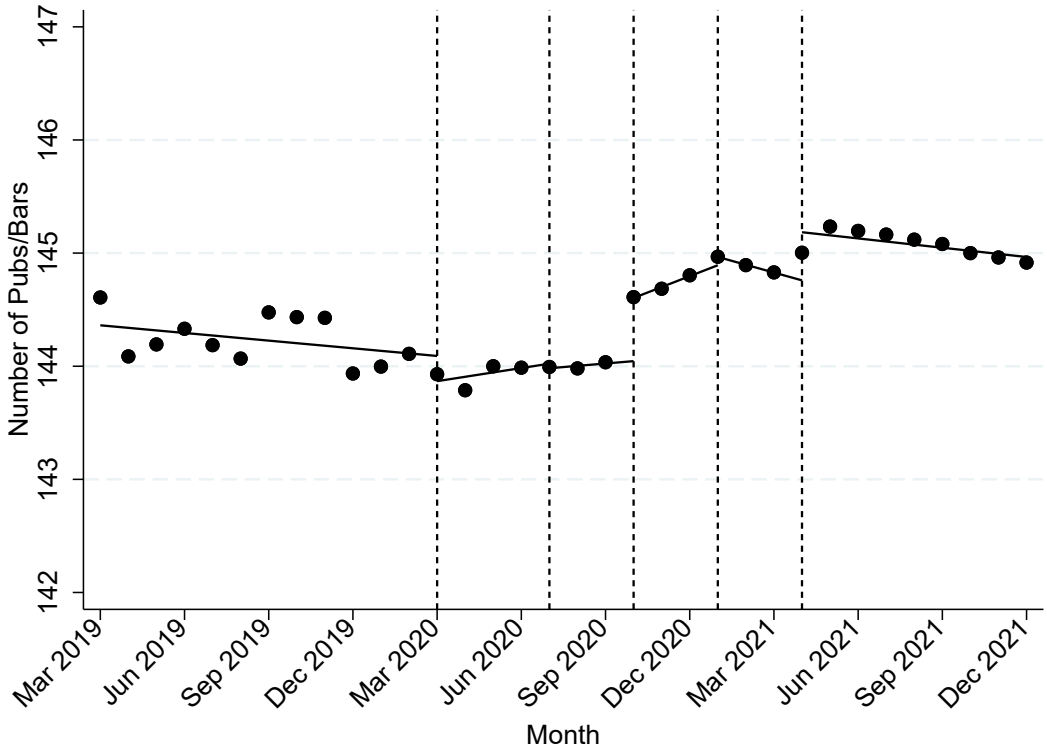
Note: Intervention months: Mar2020; Jul2020; Oct2020; Jan2021; Apr2021.

Figure A4. Average Number of Restaurants across Local Authorities



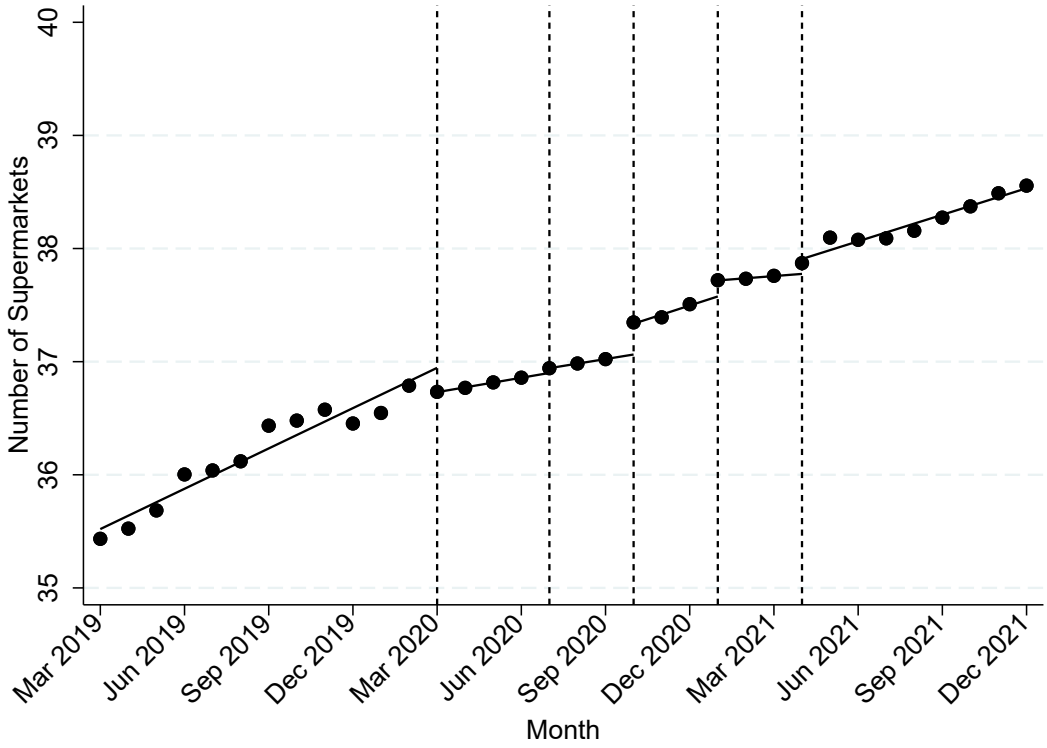
Note: Intervention months: Mar2020; Jul2020; Oct2020; Jan2021; Apr2021.

Figure A5. Average Number of Pubs across Local Authorities



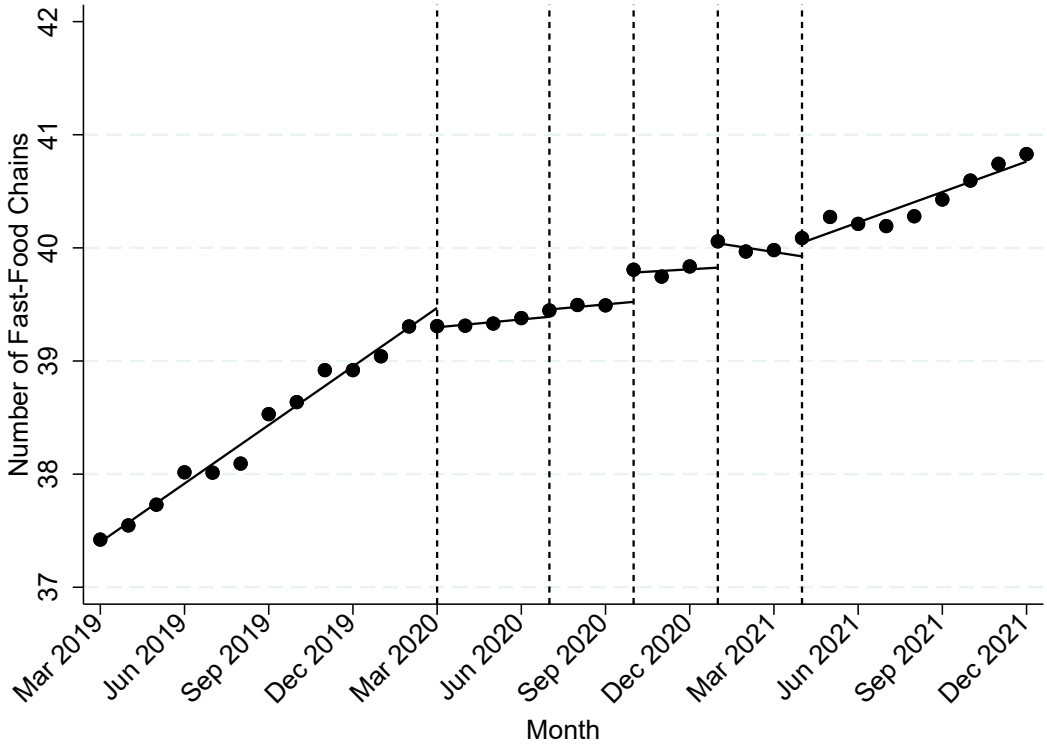
Note: Intervention months: Mar2020; Jul2020; Oct2020; Jan2021; Apr2021.

Figure A6. Average Number of Supermarkets across Local Authorities



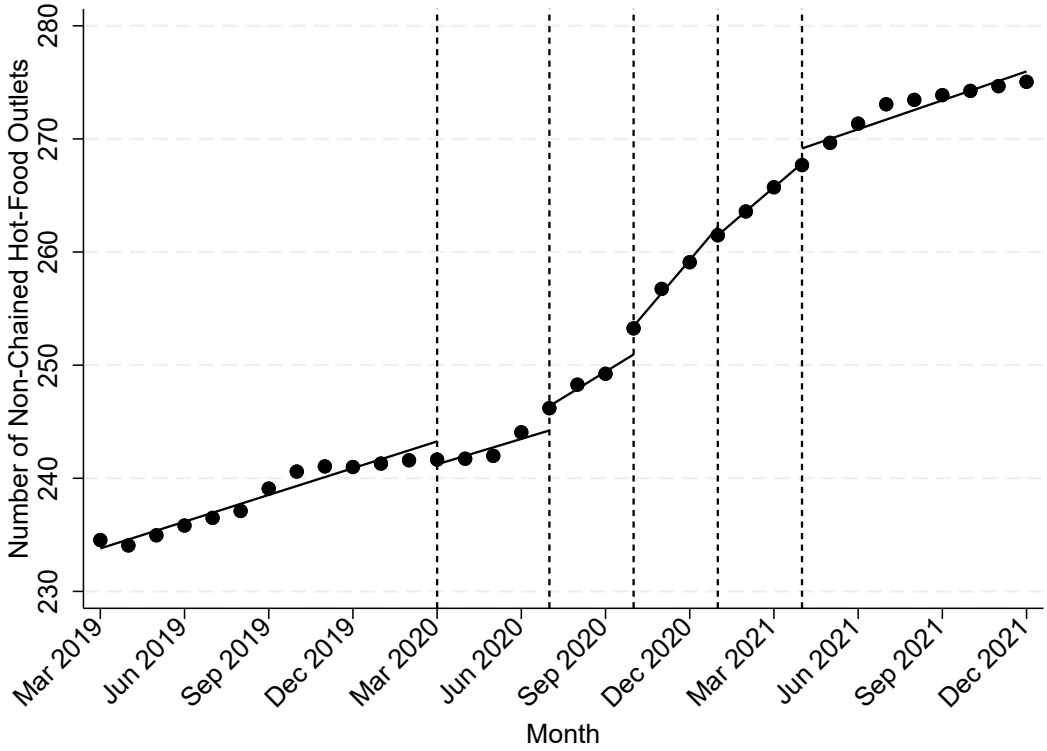
Note: Intervention months: Mar2020; Jul2020; Oct2020; Jan2021; Apr2021.

Figure A7. Average Number of Fast-Food Chains across Local Authorities



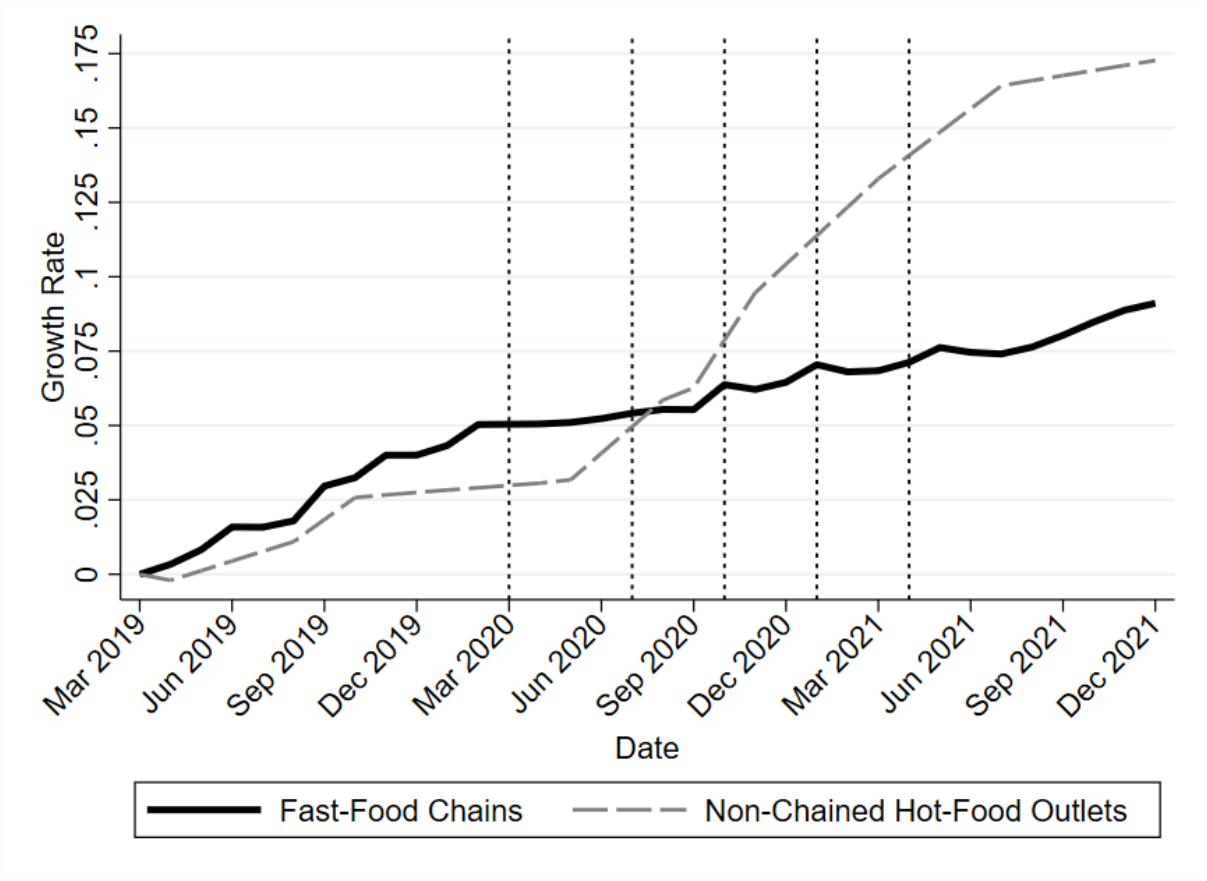
Note: Intervention months: Mar2020; Jul2020; Oct2020; Jan2021; Apr2021.

Figure A8. Average Number of Non-Chained Hot-Food Outlets across Local Authorities



Note: Intervention months: Mar2020; Jul2020; Oct2020; Jan2021; Apr2021.

Figure A9. Growth Rate of Chained and Non-Chained Food Outlets



Note: Intervention months: Mar2020; Jul2020; Oct2020; Jan2021; Apr2021.

Author Contributions

LG, NA, HB, and AA came up with the project idea and helped developed the study design. HX conducted the analysis and drafted the paper. All authors commented on the draft.

Coflict of Interest:

None to declare

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Ethical Approval: This study uses data on businesses which do not come under GDPR legislation therefore ethical approval was not required.

Data Availability:

All data used in this study is publicly available and can be accessed here: https://ratings.food.gov.uk/open-data/en-gb

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