DISCUSSION PAPER SERIES

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ABSTRACT

Does Using Planning Policy to Restrict Fast Food Outlets Reduce Inequalities in Childhood Overweight and Obesity?

Half of local governments in England use planning policy to promote a healthier environment. In 2015, Gateshead Council in the North-East of England was the first local authority to ban planning permission for any new fast-food outlet. We explore if this policy is associated with changes in inequalities in childhood overweight and obesity at age 10/11 by area level deprivation. Data on childhood overweight and obesity came from the National Child Measurement Programme for 2011-2020. Data on food outlets were obtained from Food Standard Agency Food Hygiene Rating Scheme for 2012-2020. Data on area level deprivation is from the Office of National Statistics. We employed a difference-in-difference approach, to compare changes in childhood overweight and obesity rates between Gateshead and five other local authorities in the North-East of England which did not use planning policy to restrict fast-food outlets. The analysis was at the Middle Super Output Area Level (MSOA). Our results showed the prevalence of overweight and obesity in the second and third most deprived quintiles of MSOAs reduced by 4.798% and 4.106%, respectively, compared with the control groups. We did not find statistically significant changes in other deprivation quintiles when comparing the control and treatment groups. Using planning policy to limit new fast-food outlets may have played a small part in reducing health inequalities in childhood weight in Gateshead when comparing with other local authorities in the North-East of England. Planning in conjunction with other policies may be a cost-effective approach to tackling inequalities in childhood weight.

JEL Classification:	I18, J13, I14
Keywords:	food environment, childhood weight, England, difference in difference

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1. Introduction

In spite of recent commitments by the UK government to reduce childhood overweight and obesity, childhood obesity rates remain stubbornly high (Department of Health & Social Care, 2020). In 2006/07, 31.7% of children in year 6 were living with overweight or obesity which rose to 35.2% in 2019/20 and further increased to 40.9% in 2020/21 (National Health Service, 2021). This rise has been partially exacerbated by the Covid-19 pandemic (Patterson et al., 2021).

There is robust evidence showing that childhood obesity can have adverse impacts on health in the short term (childhood) and long term (adulthood). Childhood obesity in childhood is associated with increased risk for anxiety and depression, low self-esteem, lower reported quality of life, increased risk of bullying and facing stigma, and increased risk of obesity in adulthood (Meixner et al., 2020; Morrison et al., 2015; Simmonds et al., 2015). Childhood obesity is strongly associated with increased risk of type II diabetes, cardiovascular diseases, as well as mental disorders in adulthood (Hannon et al., 2005; Weihrauch-Blüher et al., 2019; Reilly et al., 2003; Puder & Munsch, 2010). The estimated costs to the NHS on treating overweight and obesity related diseases was £6.1 million in 2015 and is forecast to reach £9.7 billion by 2050 (Public Health England, 2017).

The causes of childhood obesity are complex and multifaceted. However, a general consensus is that environmental factors, which can affect children's energy balance, play an important role in the prevalence of childhood obesity (Anderson & Butcher, 2006; Sahoo et al., 2015). There is evidence showing that the out-of-home food environment has impacts on childhood energy intakes (Poti & Popkin, 2011; Powell & Nguyen, 2013; Patterson et al., 2012). In particular, fast-food consumption and location of fast-food outlets are strongly associated with a higher energy intake and a higher prevalence of childhood obesity (Patterson et al., 2012; Bowman et al., 2004; Fraser et al., 2012; Fraser & Edwards, 2010). There is a large evidence base which shows that deprivation is a key determinant of prevalence of childhood obesity and inequalities in childhood obesity (Kinra et al., 2000; Ells et al., 2015; El-Sayed et al., 2012; Conrad & Capewell, 2012). The density of fast-food outlets in England has been rising. Data form the Food Standards Agency (n.d.) shows that the average number of fast-food outlets across English local authorities (local governments) increased from 142 to 170 between 2019 to end of 2021. This is particularly the case for areas of higher deprivation, which research

from 2018, found have five times as many fast-food outlets compared to more affluent areas (Wise, 2018). This may be a contributing factor to inequalities in childhood weight.

Since April 2013, local authorities in England have a statutory duty for some areas of public health including improving population health (UK Parliament, 2014). Because of the clear and consistent evidence based demonstrating a relationship between childhood obesity and the food environment (Patterson et al., 2012; Poti & Popkin, 2011), national public health guidance was developed to encourage and support local authorities to use the planning system to promote a healthy weight environment (Office for Health Improvement & Disparities, 2022a). Approximately 50% of local authorities have employed supplementary planning documents restricting planning permission for new takeaways to promote a healthier food environment (Keeble et al., 2019). There are three different types of supplementary planning documents used by local authorities: 1) school exclusion zone (restricting planning permission for new fast-food outlets usually within 400 metres of a school); 2) limiting the density of fast-food outlets (planning permission for new fast-food outlets will be rejected if a certain threshold number of fast-food outlets has been reached); and 3) restricting new fast-food outlets based upon local childhood obesity rates (restricting planning permission for new fast-food outlets in areas where more than a certain threshold percentage of children are living with obesity) (Brown et al., 2022). Supplementary planning guidance may be an important policy tool to reducing childhood inequalities in weight; however, there is currently no evidence on the effectiveness of planning policy on health outcomes.

In 2015, Gateshead, a local authority in the North East of England, implemented all three types of the planning policy, which is equivalent to a blanket-ban on obtaining planning permission for change of use or building of a new premise for use as a fast-food outlet. The ambition of the policy is to reduce the year-6 obesity rate from 23% in 2015 to less than 10% by 2025 (Gateshead Council, 2015). According to the most recent Gateshead Authority Monitoring Report 2020-21 (Gateshead Council, 2021), the number of hot food takeaways has reduced from 198 in 2015 to 162 in 2020 and further sharply reduced to 97 in 2021. Our previous research showed that this policy led to statistically significant reduction in the density and proportion of fast-food outlets in Gateshead compared to other neighbouring local authorities which did not have similar planning policy in place (Brown et al., 2022).

The aim of this paper is to explore if a reduction in fast-food outlets is associated with any change in childhood overweight and obesity rates in Gateshead compared to other similar local

authorities in the North East of England. Gateshead is one of the most 15% deprived local authorities in England (Gateshead Council, n.d.). Gateshead had an employment rate of 73.6% in 2019 which was lower than the national average of 75.8%. Life expectancy in Gateshead was 77.8 for men and 81.8 for women between 2017-2019, which was lower than the national averages of 79.8 and 83.4 respectively (Gateshead Council, 2022a). In 2017, 36% of year 6 children (aged 10 to 11 years) were living with overweight or obesity in Gateshead compared with 34.3% in England (Cheetham & Rushmer, 2017). Gateshead has been disproportionally adversely affected by austerity cuts from 2010. Between 2015 and 2020, local authorities in England received on average a 14% reduction in funding for public health from the central government (Local Government Association, 2018). Gateshead, however, had experienced cuts in spending of more than 40% between 2010 and 2017 (Butler, 2018). Recently, Gateshead council had a £15 million shortfall in early 2022 with an estimation of further £55 million shortfall over the next three financial years (Gateshead Council, 2022b; Holland, 2022).

2. Data and Methods

Data sources

All datasets used in this study are administrative datasets that are publicly available. We downloaded data on childhood overweight and obesity between 2011-2020 from https://fingertips.phe.org.uk/. This data was collected by National Child Measurement Programme (NCMP). NCMP is a statutory programme delivered annually by NHS Primary Care Trusts before 2013 and local authorities after 2013. They are responsible for measuring the height and weight of all school children in reception and year 6 across England (Office for Health Improvement & Disparities, 2022b). Children are classified as overweight if their BMI is on or above the 85th centile of the British 1990 growth reference according to age and sex (Dinsdale et al., 2011).

Data on food outlets were available between 2012-2020 and can be freely downloaded from the Food Standard Agency Food Rating Scheme (FSA FHRS) at https://data.food.gov.uk/catalog/datasets/38dd8d6a-5ab1-4f50-b753-ab33288e3200. The FSA FHRS records information (including business name, type of food outlets, location, and hygiene rating) on all food outlets in the UK and is updated regularly. All food outlets in the UK must be inspected by the local environmental health officers and obtain a hygiene rating before they can operate. There is evidence that the FSA FHRS dataset shows a broad coverage

of food outlets and a high spatial accuracy of the food environment in the North East of England (Kirkman et al., 2020).

We also used data on population size between 2012-2020 (Office for National Statistics, 2021) and Index of Multiple Deprivation (IMD) 2019 (Office for National Statistics, 2019). IMD is an overall measure of seven distinct domains of deprivation including income deprivation, employment derivation, health deprivation and disability, education, skills and training deprivation, crime, barriers to housing and services, and living environment deprivation.

Figure 1. Middle layer super output area boundaries in Gateshead
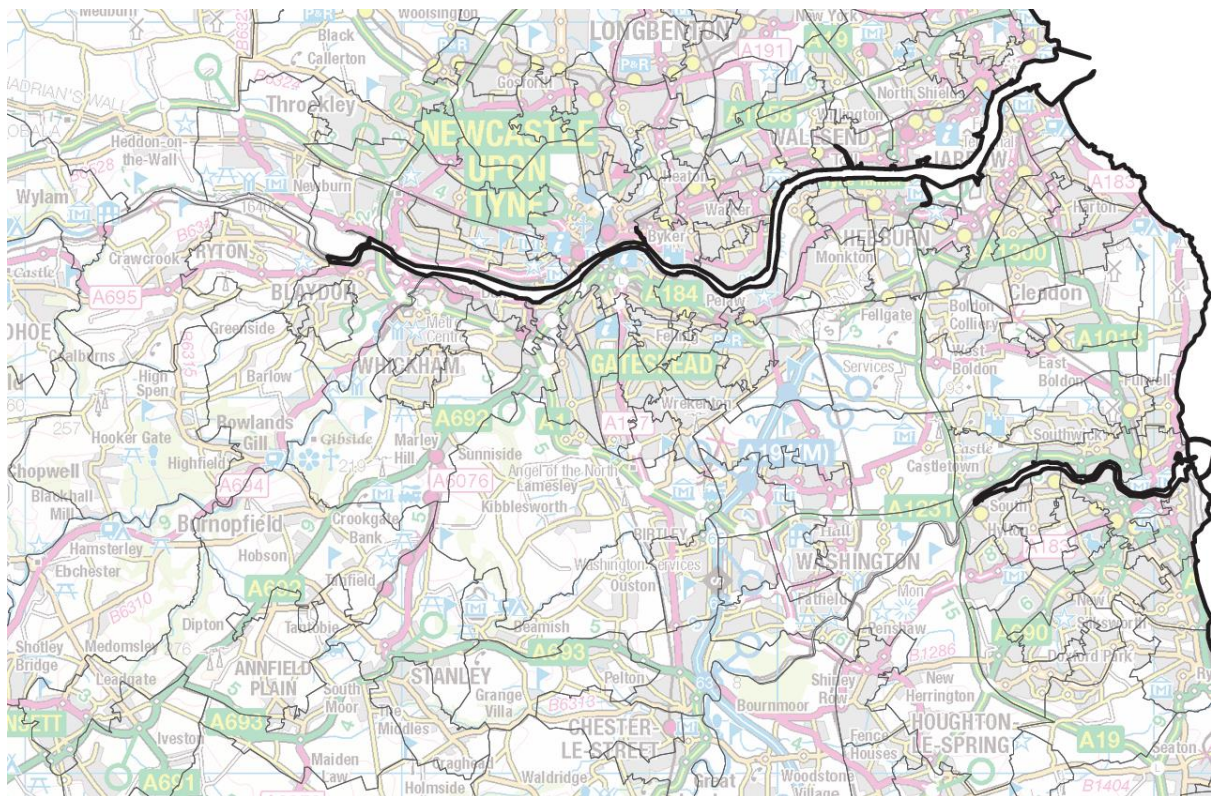
Geography

We undertook all analysis at the middle layer super output area (MSOA) level because the NCMP data is not publicly available at a smaller geography. A MSOA is a geographical area with an average population of 7200 people (National Health Service, n.d.). Figure 1 depicts MSOA boundaries in Gateshead and Gateshead's neighbouring local authorities. As the MSOA boundaries are determined by population size, MSOAs area varies so that rural MSOAs are typically bigger than urban MSOAs.

Local authorities in the North East of England

MSOAs in Gateshead were the treatment groups. To identify an appropriate group of control units, we restricted the selection of control groups to the MSOAs located in the North East of England belonging to local authorities that had not adopted any type of the planning policy over the study period. There were five local authorities which met the criteria: 1) Stockton on Tees, 2) Durham, 3) Northumberland, 4) Darlington, and 5) Hartlepool. These areas were all within the most 20% deprived local authorities in England (Ministry of Housing, Communities & Local Government, 2021). We excluded MSOAs in the six local authorities in the North East that also implemented planning guidance to restrict planning permission for fast-food over the study period. These six local authorities are 1) Newcastle upon Tyne, 2) South Tyneside, 3) North Tyneside, 4) Sunderland, 5) Middlesbrough, and 6) Redcar and Cleveland.

Outcome variable: Prevalence of year 6 overweight and obesity

The main outcome of interest was the prevalence of overweight and obesity for children in year 6 (aged 10-11). We used the annual data from the NCMP between 2011 and 2020. Table 1 displays the average prevalence of year 6 overweight and obesity across MSOAs in Gateshead and the other five local authorities respectively. Gateshead's MSOAs had a higher prevalence of year 6 overweight and obesity in all years.

Density of fast-food outlets

We calculated the density of fast-food outlets by MSOA and year between 2012 and 2020. The density of fast-food outlets is defined as the number of fast-food outlets per 100,000 residents. A higher density of fast-food outlets indicates that the year-6 children have a higher exposure to unhealthy food. This measure has been widely used in previous studies (Brown et al., 2022; Public Health England, 2018). To count the number of fast-food outlets within each MSOA, we extracted the postcode and location information of all fast-food outlets from the FSA FHRS dataset. The population in each MSOA was provided by the Office for National Statistics (2021). As shown in Table 1, density of fast-food outlets in Gateshead was higher than the other five local authorities in all years.

Table 1. Characteristics of MSOAs in Gateshead and the other five local authorities in the North East

Gateshead MSOAs:	2011 (1)	2012 (2)	2013 (3)	2014 (4)	2015 (5)	2016 (6)	2017 (7)	2018 (8)	2019 (9)	2020 (10)

	2011 (1)	2012 (2)	2013 (3)	2014 (4)	2015 (5)	2016 (6)	2017 (7)	2018 (8)	2019 (9)	2020 (10)
Year-6 Overweight and Obesity (%)	22.9	22.8	22.4	21.5	20.6	21.3	23.1	23.6	24.0	23.9
Density of Fast-food Outlets	-	113.1	115.2	114.4	112.6	108.0	114.4	115.2	115.1	116.9
IMD 2019 Decile	-	-	-	-	-	-	-	-	3.7	-
No. of MSOAs	27	27	27	27	27	27	27	27	27	27
Other MSOAs:	**2011 (1)**	**2012 (2)**	**2013 (3)**	**2014 (4)**	**2015 (5)**	**2016 (6)**	**2017 (7)**	**2018 (8)**	**2019 (9)**	**2020 (10)**
Year-6 Overweight and Obesity (%)	19.9	20.4	20.5	20.5	20.4	20.8	21.4	21.7	21.7	21.6
Density of Fast-food Outlets	-	91.9	93.8	97.6	98.2	102.6	103.1	103.5	103.7	106.8
IMD 2019 Decile	-	-	-	-	-	-	-	-	4.4	-
No. of MSOAs	156	156	156	156	156	156	156	156	156	156

Note: This table shows the mean of prevalence of year 6 overweight and obesity, density of fast-food outlets and IMD scores across the MSOAs in Gateshead and the other five local authorities (1. Stockton on Tees, 2. Durham, 3. Northumberland, 4. Darlington, and 5. Hartlepool) over the study period.

Relative deprivation

To measure the relative deprivation for each MSOA, we used a population weighted IMD score following the method described in the English indices of deprivation 2019 research report (Ministry of Housing, Communities & Local Government, 2019). A higher IMD score indicates a higher level of deprivation. Then, we ranked the IMD scores and identified the IMD deciles. As shown in Table 1, the average IMD decile for MSOAs in Gateshead was 3.7, which means they were the most 37% deprived MSOAs in England. Whereas MSOAs in the other five local authorities were, on average, the most 44% deprived MSOAs in England. Because we expected that the impact of planning policy may be more pronounced in the more deprived areas, we identified MSOA deprivation quintiles within Gateshead. The first IMD quintile includes the most deprived MSOAs and the fifth IMD quintile includes the least deprived MSOAs in Gateshead.

Identification of control groups

The decision to planning policy restricting new fast-food outlets was not coincidence given that Gateshead had a higher density of fast-food outlets and a higher level of deprivation compared to the other five local authorities in the North East as shown in Table 1. Furthermore, there is significant heterogeneity in the distribution of fast-food outlets between the MSOAs in

Gateshead and the other five local authorities as shown in Figure 2. In both groups, MSOAs with a higher level of deprivation tend to have a higher density of fast-food outlets. However, the first IMD quintile of MSOAs in Gateshead had a lower density of fast-food outlets than the second and third IMD quintiles. The MSOAs in Gateshead also had a relatively higher variation in the density of fast-food outlets over time. These dynamics make it difficult to identify an appropriate control group.

Figure 2. Density of fast-food outlets by IMD quintile
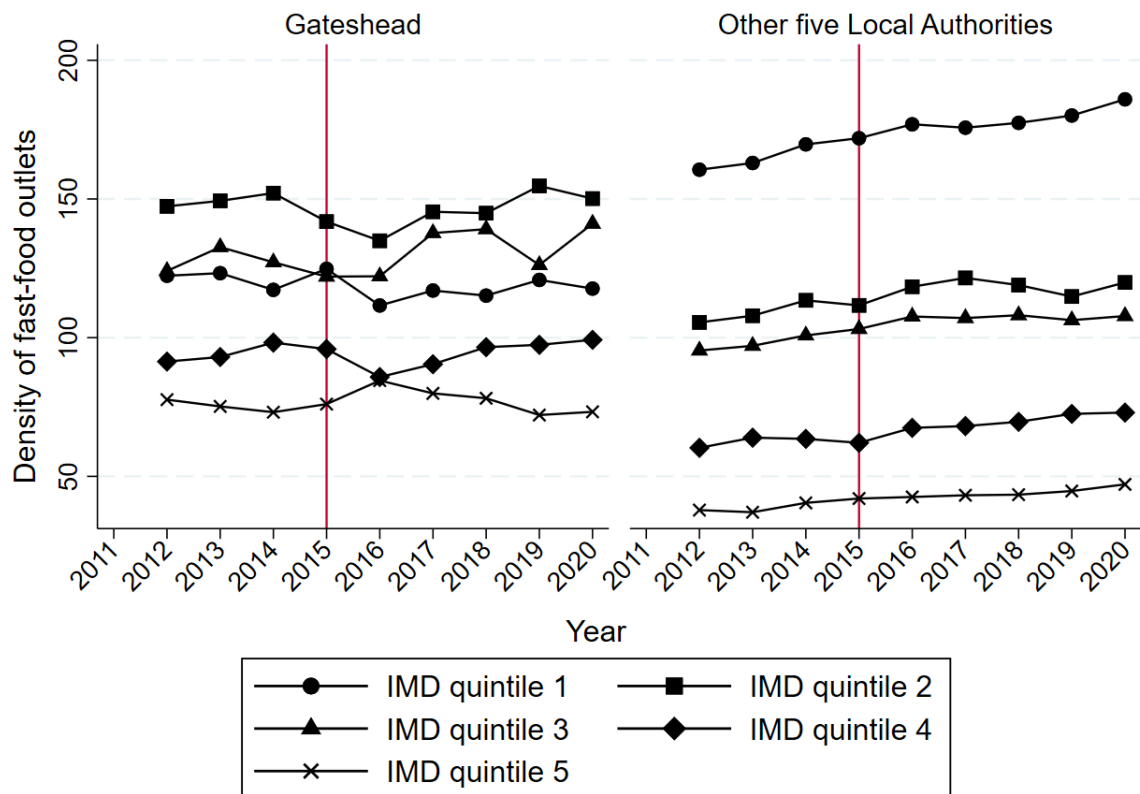
Note: IMD quintile 1 refers to the most 25% deprived MSOAs in Gateshead or the other five local authorities. IMD quintile 5 refers to the least 25% deprived MSOAs in Gateshead or the other five local authorities.

To overcome this challenge, we employed propensity score matching (PSM) approach (Rosenbaum & Rubin 1983). A one-to-one matching without replacement was performed. Specifically, using a logit regression model we employed the density of fast-food outlets and IMD scores as predictors to estimate the propensity scores for MSOAs. There are 27 MSOAs in Gateshead, and therefore 27 MSOAs from the other five local authorities with the nearest propensity scores were identified as the control groups.

Table 2 compares the characteristics of MSOAs in the treatment and control groups before and after the matching. As shown, before the matching, the control groups have a lower IMD score with a higher standard deviation and a lower density of fast-food outlets with a higher standard deviation compared to the treatment groups. After the matching, the differences between the control and treatment groups become smaller as shown in column (5) and (6). Results from the t-tests show that there are no statistically significant differences in IMD scores and density of fast-food outlets between the matched control and treatment MSOAs. This suggests that we might have identified an appropriate group of MSOAs as the control groups.

Table 2. Characteristics of MSOAs in the treatment and control groups before and after propensity score matching

	Treatment: All & Matched		Control: All		Control: Matched		t-tests	
	Mean	SD	Mean	SD	Mean	SD	Diff.	P-value
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
IMD 2019 scores	28.25	12.07	26.29	13.60	28.67	13.34	0.42	0.90
Density of fast-food outlets	113.82	77.13	95.39	94.45	107.86	77.14	-5.97	0.78
No. of MSOAs	27		156		27			

Note: Results from the t-tests, columns (7) and (8), show the differences between the matched control and treatment MSOAs. None of the means in column (5) is statistically significantly different from the means in column (1).

Statistical analysis

This study employed a difference in differences (DID) model to quantitively examine the changes in the prevalence of overweight and obesity in children in year 6 in Gateshead compared to other similar local authorities by the relative deprivation quintile. The planning policy was adopted in 2015. Thus, the pre-treatment period is 2011-2015 and the post-treatment period is 2015-2020. We estimated the models using the matched sample from the propensity score matching model. Gateshead's MSOAs are the treatment groups. The control groups include the matched MSOAs from the other five other local authorities. Equation (1) shows the DID model. Analyses were conducted using STATA v.17 (StataCorp, 2021).

$$Weight_{it} = \beta Treat_i * Post_t + \alpha_i + \tau_t + \varepsilon_{it} \tag{1}$$

Where, the subscript i and t indicates a MSOA and observation year respectively; $Weight_{it}$ is the prevalence of year 6 overweight and obesity in MSOA i in year; $Treat_i$ is a dummy variable that is set to 1 if an MSOA i is within Gateshead, 0 otherwise; $Post_t$ is a dummy variable that is set to 1 for the post-intervention years and 0 for the pre-intervention years; α_i is the year fixed effects; τ_t is the MSOA fixed effects; ε_{it} is the error term; β is the parameter of coefficients

to be estimated. We expect β to be negative if the planning policy has had positive impacts on reducing the prevalence of childhood overweight.

Results from the full sample without PSM are included in Appendix Table A1.

Sensitivity analysis

One of the key assumptions of DID model is the parallel trends between the treatment and control groups (Duflo et al. 2007). Following Brown et al. (2022), we estimated the dynamic effects of policy intervention using the model as shown in Equation (2).

$$Overweight_{it} = \beta_1\,Treated_i \times Pre_t^{-4} + \beta_2\,Treated_i \times Pre_t^{-3} + \beta_3\,Treated_i \times Pre_t^{-2} +$$
$$\beta_4\,Treated_i \times Post_t^{-1} + \beta_5\,Treated_i \times Post_t^{+1} + \beta_6\,Treated_i \times Post_t^{+2} + \beta_7\,Treated_i \times$$
$$Post_t^{+3} + \beta_8\,Treated_i \times Post_t^{+4} + \beta_9\,Treated_i \times Post_t^{+5} + \alpha_i + \tau_t + \varepsilon_{it} \qquad (2)$$

Where, Pre_t^{-4}, Pre_t^{-3}, ..., $Post_t^{+4}$, and $Post_t^{+5}$, are the year dummy variables for 2011, 2012, …, 2019, and 2020 respectively. The interaction term for the intervention year 2015, $treated_i * Pre_t^0$, is the base case, and therefore is omitted from the equation. We were interested in β_1, β_2, β_3, and β_4. If our setting did not violate the parallel trends assumption, β_1, β_2, β_3, and β_4 should not statistically significantly different from 0.

We also conducted an alternative parallel trends test using the Stata command `estat ptrends' (STATA, n.d.). We reported results from `estat ptrends' in Appendix Table A2 because they are consistent with the results from equation (2).

3. Results

Prevalence of year 6 overweight and obesity

Figure 2 shows the average prevalence of year 6 overweight and obesity across the matched MSOAs by IMD quintile over the study period. Compared to the control groups, Gateshead MSOAs tend to have more variations in the prevalence of year 6 overweight and obesity. In both treatment and control groups, the most deprived MSOAs (i.e., IMD quintile 1) have the highest prevalence of year 6 overweight and obesity, and the least deprived MSOAs (i.e., IMD quintile 5) have the lowest prevalence of year 6 overweight and obesity in all years. In

particular, the prevalence of year 6 overweight and obesity in the most deprived MSOAs appears to be increasing over time. However, the prevalence of year 6 overweight in the least deprived MSOAs were relatively constant over the sample years.

Figure 3. Prevalence of year 6 overweight and obesity by IMD quintile overtime
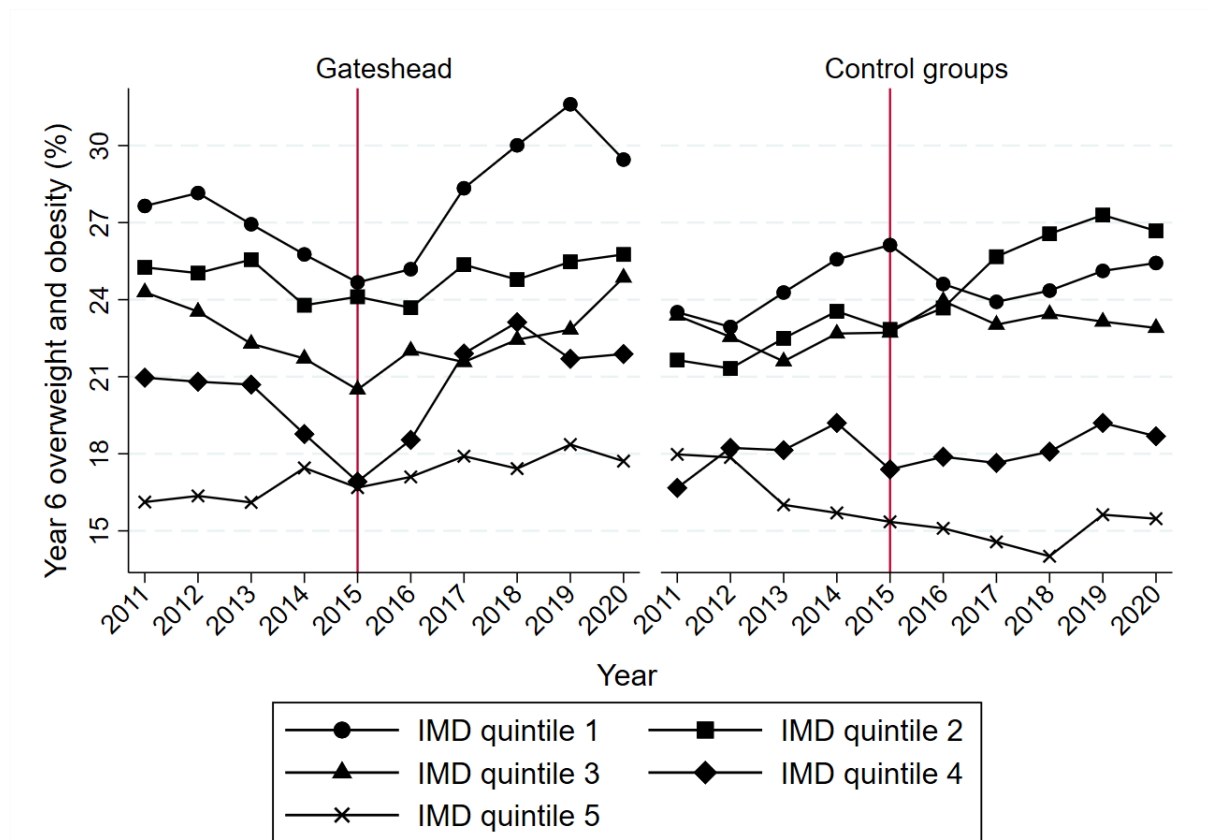
Note: IMD quintile 1 refers to the most 25% deprived MSOAs in Gateshead and the matched MSOAs from the control groups. IMD quintile 5 refers to the least 25% deprived MSOAs in Gateshead and the matched MSOAs from the control groups.

Evaluation of planning policy

Table 3 presents the PSM-DID results by IMD quintile. Our results show that, in the second most deprived quintile of MSOAs, the prevalence of year 6 overweight and obesity had a statistically significant reduction of 4.789% (p<0.01) in Gateshead following the adoption of the planning policy compared with the control groups. We also found a statistically significant reduction of 4.106% (p<0.01) in the third deprivation quintile of MSOAs. In other deprivation quintiles, there was no statistically significant changes in the prevalence of year 6 overweight and obesity in Gateshead compared to the control groups after the adoption of the planning

policy. These results are robust to the estimates without matching as shown in Appendix Table A1.

Table 3. The impact of planning policy on childhood overweight and obesity by IMD quintile

	Q1	Q2	Q3	Q4	Q5
Treat*Post	1.168	-4.789***	-4.106***	1.811	1.321
	(1.638)	(1.083)	(1.322)	(1.019)	(1.279)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
MSOA Fixed Effects	Yes	Yes	Yes	Yes	Yes
N	100	120	100	120	100

Note: Q1-5 refer to the IMD quintile 1-5 respectively. Standard errors in parentheses are clustered at the MSOA level. ** $p < 0.05$, *** $p < 0.01$

Sensitivity analysis

Table 4 presents results estimating the dynamic effects of planning policy and examining the parallel trends assumption. We found that all the pre-intervention interaction terms (i.e., $Treated * Pre^{-4}$ - $Treated * Pre^{-1}$) are statistically insignificant in the second and fifth deprivation quintiles, which means the parallel trends hold in these two quintiles before the policy intervention. However, this is not the case in the first, third, and fourth deprivation quintiles where some of the pre-intervention interaction terms are statistically significant suggesting violation of the parallel trends assumption. The alternative parallel trends test (estat ptrends) Appendix Table A2 shows consistent results.

Results from the second deprivation quintile also shows that the impacts of planning policy started to become statistically significant from 2019 and onwards. This implies that it may need at least four years after the policy implemented to see the statistically significant changes in the prevalence of year 6 overweight and obesity.

Table 4. The dynamic effects of planning policy on childhood overweight and obesity by IMD quintile

	Q1	Q2	Q3	Q4	Q5
Treated * Pre^{-4} (2011)	6.933	3.340	4.998**	5.978**	-1.909
	(3.797)	(2.019)	(2.173)	(2.491)	(2.614)
Treated * Pre^{-3} (2012)	7.523**	3.996	7.174***	4.040	-3.148
	(3.136)	(3.634)	(1.265)	(2.528)	(3.040)
Treated * Pre^{-2} (2013)	5.333*	1.581	5.810**	3.337	-2.632
	(2.723)	(2.100)	(2.410)	(2.288)	(2.399)

Treated * Pre^{-1} (2014)	1.514	0.482	1.371	0.687	-0.085
	(1.772)	(2.213)	(1.540)	(1.901)	(1.772)
Treated * Post^{+1} (2016)	0.815	-1.202	-0.899	2.687**	0.445
	(1.286)	(0.882)	(3.265)	(1.211)	(1.367)
Treated * Post^{+2} (2017)	3.887	-1.232	-1.538	4.822**	0.362
	(3.586)	(1.487)	(2.510)	(1.750)	(3.208)
Treated * Post^{+3} (2018)	6.583	-0.879	-1.462	5.396*	0.735
	(4.392)	(1.873)	(2.401)	(2.655)	(2.454)
Treated * Post^{+4} (2019)	9.142*	-5.553***	0.940	3.949	-0.224
	(4.876)	(1.673)	(2.076)	(2.489)	(3.693)
Treated * Post^{+5} (2020)	6.715	-5.679**	1.785	6.245**	-2.488
	(4.871)	(2.506)	(2.558)	(2.088)	(4.695)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
MSOA Fixed Effects	Yes	Yes	Yes	Yes	Yes
N	100	120	100	120	100

Note: Q1-5 refer to the IMD quintile 1-5 respectively. Standard errors in parentheses are clustered at the MSOA level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4. Discussion

In this study, we provided the first empirical evidence on the effectiveness of planning policy on reducing the prevalence of year-6 overweight and obesity. Our main finding shows that the effectiveness of planning policy is strongly dependent on the area level deprivation. The prevalence of year-6 overweight and obesity had a statistically significantly decreased in the second and third most deprived quintiles of MSOAs. In the other deprivation quintiles, there were no significant changes in the prevalence of year-6 overweight and obesity after Gateshead adopted the planning guidance over the sample years.

Planning policy has direct impacts on the food environment which then has indirect impacts on weight. Evidence from Gateshead showed a 10% reduction in the density and proportion of fast-food outlets within 4 years of the policy intervention (Brown et al., 2022). There is evidence showing that the density of fast-food outlets is positively associated with the prevalence of childhood obesity (Fraser & Edwards, 2010; Cetateanu & Jones, 2014). The association between childhood overweight and obesity and deprivation has been well documented with evidence from the UK showing that children from more deprived areas are more likely to be overweight or obese (Kinra et al., 2000; Conrad & Capewell, 2012).

If planning policy can limit the density of fast-food outlets this can be a cost-effective mechanism to reduce inequalities in childhood weight. We found no significant changes in weight in Gateshead compared to the control groups in the least deprived MSOAs. Children living in the least deprived area on average have a healthier diet (Ziauddeen et al., 2018) and had a lower exposure to fast-food outlets throughout the study period. Therefore, the planning guidance is less likely to have significant impacts on the least deprived areas. Pre-intervention evidence suggested that MSOAs in the second and third most deprived deciles had the highest concentration of fast-food outlets which decreased after the adoption of the planning guidance which would suggest that this policy is working. If a lower density of fast-food outlets impacts childhood weight, then we would expect to a significant decrease in childhood overweight and obesity for children living in the second and third most deprived deciles compared to the control group. The decrease in childhood overweight and obesity is in these two deciles which would be most impacted by the policy. This is what we found, even though the parallel trend assumption was violated. The most deprived decile in Gateshead did not have the highest concentration of fast-food outlets which may partially explain the insignificant result for this decile.

We provided some evidence that promoting a healthier food environment by using planning tools may be a low-cost mechanism to reduce the prevalence of year-6 overweight and obesity. Importantly, this may be an effective mechanism to reduce inequalities in childhood overweight and obesity; a policy goal that has not been achieved to date with the long history of government policy to increase the prevalence of healthy weight children. However, it is important to keep in mind, that this policy may only be effective in areas with a high concentration of fast-food outlets. Local authorities should consider how the planning approach can be adjusted accordingly and applied within their local authorities in order to promote healthy weight in their communities.

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Appendix

Table A1. DID estimates without PSM on full sample by deprivation quintile

	Q1	**Q2**	**Q3**	**Q4**	**Q5**
Treat*Post	0.568	-2.542**	-3.362*	1.174	0.431
	(2.233)	(1.168)	(1.929)	(1.297)	(1.419)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
MSOA Fixed Effects	Yes	Yes	Yes	Yes	Yes
N	360	370	370	370	360

Note: Q1-5 refer to the IMD quintile 1-5 respectively. Standard errors in parentheses are clustered at the MSOA level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A2. STATA parallel-trends test (estat ptrends)

	F-statistic	P-value
	(1)	(2)
IMD Quintile 1	3.83	0.08
IMD Quintile 2	2.80	0.12
IMD Quintile 3	7.19	0.03
IMD Quintile 4	5.92	0.03
IMD Quintile 5	0.86	0.38