Health & Place 87 (2024) 103237

Contents lists available at ScienceDirect

Health and Place

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

Changes in the number and outcome of takeaway food outlet planning applications in response to adoption of management zones around schools in England: A time series analysis

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ARTICLE INFO

Keywords:
Takeaway management zones around schools
Exclusion zones
Planning outcomes
Natural experiment
Interrupted time series analysis

ABSTRACT

Physical exposure to takeaway food outlets ("takeaways") is associated with poor diet and excess weight, which are leading causes of excess morbidity and mortality. At the end of 2017, 35 local authorities (LAs) in England had adopted takeaway management zones (or "exclusion zones"), which is an urban planning intervention designed to reduce physical exposure to takeaways around schools. In this nationwide, natural experimental study, we used interrupted time series analyses to estimate the impact of this intervention on changes in the total number of takeaway planning applications received by LAs and the percentage rejected, at both first decision and after any appeal, within management zones, per quarter of calendar year. Changes in these proximal process measures would precede downstream retail and health impacts. We observed an overall decrease in the number of applications received by intervention LAs at 12 months post-intervention (6.3 fewer, 95% CI -0.1, -12.5), and an increase in the percentage of applications that were rejected at first (additional 18.8%, 95% CI 3.7, 33.9) and final (additional 19.6%, 95% CI 4.7, 34.6) decision, the latter taking into account any appeal outcomes. This effect size for the number of planning applications was maintained at 24 months, although it was not statistically significant. We also identified three distinct sub-types of management zone regulations (full, town centre exempt, and time management zones). The changes observed in rejections were most prominent for full management zones (where the regulations are applied irrespective of overlap with town centres), where the percentage of applications rejected was increased by an additional 46.1% at 24 months. Our findings suggest that takeaway management zone policies may have the potential to curb the proliferation of new takeaways near schools and subsequently impact on population health.

1. Introduction

Takeaway food outlets ('takeaways') are highly prevalent in many contexts across the world. There are approximately 60,000 takeaways in England, and they are more prevalent in deprived areas (Maguire et al., 2015; Public Health England, 2018), which may amplify health inequalities. Takeaways are also clustered around schools (Smith et al., 2013; Trapp et al., 2023), which may impact negatively on children's health. In 2022, the market size (i.e. turnover) of the takeaway industry in the UK was £21.4 billion, an increase from £19.6 billion in 2021

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https://doi.org/10.1016/j.healthplace.2024.103237
Received 2 June 2023; Received in revised form 11 March 2024; Accepted 21 March 2024
Available online 1 April 2024

(Statista, 2023). Frequent consumption of takeaway food, which is generally energy dense, nutrient poor and served in large portions (Jaworowska et al., 2014; Monsivais and Drewnowski, 2007; Robinson et al., 2018) has been linked to obesity and weight gain over time (Duffey et al., 2007; Penney et al., 2017; Pereira et al., 2005). Physical access ("exposure") to takeaways, which sell hot food intended for consumption off the premises, has also been associated with poor diet and excess weight (Burgoine et al., 2014; Townshend and Lake, 2017; Jiang et al., 2023).

In English local authorities (LAs), urban planners have the ability to influence population exposure to takeaways if there are concerns about health (Lake et al., 2017). Planning permission must be obtained from a LA for a new takeaway premises, or to change the use of an existing premises to open a new takeaway. This permission can be denied or have conditions attached, such as restrictions on opening hours. The most common type of health-focused planning regulation, adopted by 35 of 325 LAs in England up to 2018, were takeaway management zones (sometimes referred to by LAs as "exclusion zones") around schools (see Box 1) (Keeble et al., 2019a, 2019b). Precise specifications of takeaway management zones include variations in their distance (e.g. 200–400m, 10 min walking distance), shape (i.e. circular or based on the street network) and geographical anchor point (e.g. school site boundary, school site centre or entrance points), which together determine size; and educational establishment to which they are applied (e.g. primary and/or secondary schools). These management zones either prohibit the opening of new takeaway premises (full management zones) or restrict hours of operation of new outlets (time management zones) (Smith et al., 2013). In some cases, town centres (see Box 1) are excluded from these regulations where they overlap with management zones (town centre exempt zones).

The intended effect of takeaway management zones is to improve health by preventing any further increase in the number of takeaways near to a school, thereby reducing future population-level takeaway exposure (Keeble et al., 2019b). Restricting the opening of new outlets is assumed to occur as a result of either reducing the number of takeaway planning applications received by LAs and/or reducing the percentage of these applications that are successful at first or final decision (see Box 1). These process measures of effectiveness will precede downstream retail and health impacts. Two previously published evaluations of takeaway management zones around schools in the UK were either unable to detect less proximal downstream retail impacts, or were unable to directly attribute any such impacts to management zones around schools (Brown et al., 2021, 2022). Proximal planning-related outcomes are immediately amenable to policy impact and are measurable using routine, secondary data, but have not been studied. Moreover, previous LA-specific evaluations of this intervention may have been confounded by local events, which necessitates broader geographic coverage of future evaluation. Such gaps in scientific knowledge have been reported as a barrier to policy adoption and effective implementation (Keeble et al., 2021; O'Malley et al., 2021). Perhaps as a result, and despite endorsement for takeaway management zones in national policy and planning guidance (Greater London Authority, 2012; Local Government Association, 2016; Public Health England, 2014, 2020), uptake of takeaway management zones across LAs in England has been relatively limited.

In this study, we used routine data to study the number and outcome of planning applications for new takeaways, before and after the adoption of takeaway management zones around schools, across all 35 LAs that have adopted management zones in England (2009–2017). We conducted a natural experimental evaluation of this intervention using controlled and uncontrolled interrupted time series analyses, and stratified our results by intervention sub-type.

2. Methods

We used interrupted time series analyses (with controls where possible) to estimate changes from four years pre-to two years post-adoption of takeaway management zones around schools ("the intervention") on three outcomes: total number of takeaway applications submitted; percentage of takeaway applications rejected at first decision; and percentage of takeaway applications rejected at final decision.

Box 1
Definitions of key terms.

Takeaway management zones (around schools)	Areas (in this case around schools) in which regulations are applied to proposed new takeaways. Sometimes referred to by LAs as "exclusion zones". Precise specifications (e.g. size, shape) vary by local authority. We identified three main sub-types: Town centre exempt zones exclude town centres where they overlap with management zones; Time management zones restrict hours of operation for new outlets; Full management zones are not limited by time or by town centres.
Use class	Classifications defined by government in national legislation, relating to the uses of buildings or other land.
Takeaway food outlet	'Takeaways', as they are referred to here, are food outlets selling 'hot food for consumption off the premises'. Until September 2020, they were use class A5 (now class *Sui Generis*) within the urban planning system in England.
New takeaways	According to planning guidelines, new takeaways are those opening in new premises in new buildings, as well as those opening in premises in existing buildings where the previous retail use was not a takeaway (i.e. change of use).
Planning portal	A searchable database of new planning applications received and decisions made. Available on local authority websites.
Planning Inspectorate (PINS)	An executive body of government with responsibility for deciding planning appeal outcomes.
First and final planning decisions	When planning applications are submitted, 'first' planning decisions are made by local authorities. 'Final' decisions include the outcomes of first decisions that were not appealed, and the results of any subsequent appeals determined by PINS.
Town centres	Designated by local authorities, these are locations in which retail, commercial, leisure and cultural uses are concentrated. Includes city centres and local high streets.

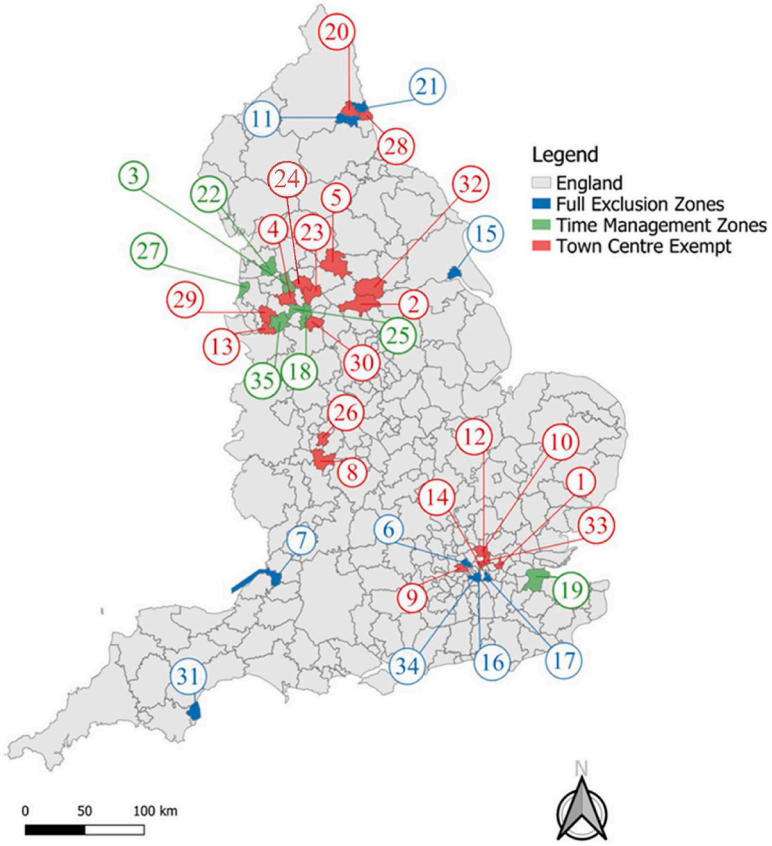
2.1. Intervention and candidate control LAs

Our intervention LAs were all those in England that had adopted takeaway management zones around schools prior to December 31, 2017 (n = 35; Fig. 1). We used this date as our cut-off for inclusion in the analyses to allow for a two year post-intervention follow-up period that would not be impacted by temporary amendments to the planning system in response to the COVID-19 pandemic, which came into force in 2020 (Moore et al., 2024). We identified our sample via freedom of information (FOI) requests, sent to all 325 LAs in England in June 2021. The response rate to these requests was 100% (325/325 LAs). For the 35 intervention LAs, we followed this up in November 2021 with a second FOI request, to establish zone specifications and to confirm the adoption date. The response rate to these requests was 71% (25/35 LAs). Where no response was received this information was found in the public domain. We identified three different sub-types of management zone: 19 LAs operated "town centre exempt zones"; nine LAs operated "full management zones"; and seven LAs operated "time management zones" (see Box 1).

For each intervention LA, a candidate control LA that might serve as a control was identified using the 2018 Chartered Institute of Public Finance and Accountancy (CIPFA) Nearest Neighbour Model (Chartered Institute Of Public Finance And Accountancy, 2018). CIPFA scores are a composite of 27 indices relating to LA demographic and socioeconomic characteristics. The candidate control for each intervention LA was the most statistically similar LA that had no takeaway management zone regulation, provided it was not an immediate geographical neighbour (to avoid the potential for spill-over effects contaminating the results) or subject to boundary change during the period studied (see Supplementary material A). All candidate control LAs had nearest neighbour scores that indicated less than 1% difference from their intervention LA (Rudolf et al., 2019).

2.2. Mapping of takeaway management zones

Using a geographic information system (PostGIS), we mapped bespoke management zones around all schools subject to the intervention in each of our intervention LAs according to published criteria in



Local authority	Adoption date	Local authority	Adoption date	Local authority	Adoption date
1. Barking and Dagenham	21/07/2010	13. Halton	01/03/2012	25. Salford	01/01/2014
2. Barnsley	01/03/2012	14. Islington	01/06/2013	26. Sandwell	01/03/2012
3. Blackburn with Darwen	01/04/2016	15. Kingston upon Hull	01/11/2017	27. Sefton	07/09/2017
4. Bolton	01/09/2013	16. Lambeth	01/09/2015	28. South Tyneside	29/11/2017
5. Bradford	01/11/2014	17. Lewisham	26/11/2014	29. St Helens	22/06/2011
6. Brent	01/11/2016	18. Manchester	01/03/2017	30. Stockport	01/03/2011
7. Bristol	01/07/2014	19. Medway	01/07/2014	31. Torbay	06/04/2017
8. Bromsgrove	25/01/2017	20. Newcastle upon Tyne	01/10/2016	32. Wakefield	18/01/2017
9. Ealing	01/12/2013	21. North Tyneside	20/07/2017	33. Waltham Forest	24/03/2009
10. Enfield	01/11/2014	22. Preston	02/07/2015	34. Wandsworth	01/03/2015
11. Gateshead	02/06/2015	23. Rochdale	01/04/2015	35. Warrington	01/04/2014
12. Hackney	01/07/2015	24. Rossendale	01/06/2011		

Fig. 1. Local authorities (n = 35) that had adopted takeaway management zones (by sub-type) around schools as of December 31, 2017.

guidance documents or as derived from FOI requests. We also replicated these management zones to identical specifications within each candidate control LA. We used school location data from Edubase, which is a comprehensive and longitudinal national database of schools in England (Chalkley et al., 2020). Our management zones were dynamic and captured the opening of new schools, and the closure of existing schools over the six year study period for each LA. To derive management zones anchored to the school centre or boundary, we used polygon data on school sites from Ordnance Survey (OS) Mastermap Sites (Ordnance Survey, 2022) and Topography layers (Ordnance Survey, 2018). For those based on access points, these data were also available in OS Mastermap Sites layer. Town centre boundaries were manually digitized according to interactive and static maps made available on LA websites.

2.3. Takeaway planning application data

To identify planning application data for new takeaways (see Box 1) in order to calculate our outcomes, we used the following key words to search individual intervention and candidate control LA planning portals: 'A5', and 'takeaway', 'take-away' and 'fast food', which were search terms deemed indicative of likely A5 use. We restricted each search to six-year study periods specific to each intervention LA (four years pre- and two years post-intervention), using the same search dates for its candidate control.

We collated the following information for each application: unique identifier; date submitted; proposed address or geographic coordinates (where these were provided in lieu of a proposed address); application decision and date; appeal status; and appeal decision and date. In some instances appeals data were not accessible through LA planning portals, and were therefore requested directly from the Planning Inspectorate (PINS, see Box 1). Appeal data from PINS were not available prior to 2010, which affected the entire four year pre-intervention period for 3 LAs (2 intervention and 1 candidate control), 2 years for 2 LAs (1 intervention and 1 candidate control) and 1 year for 2 LAs (1 intervention and 1 candidate control). As this data represented a small proportion of our total sample, we chose to retain these LAs within analyses (Supplementary material B).

Proposed takeaway locations were geocoded from full address data using the Google Geocoding API. We overlaid these points on intervention and candidate control LAs to determine which applications would have fallen within management zones and therefore been subject to the intervention, considering whether management zones were active at the time of application.

2.4. Outcomes

We report three primary outcomes.

1. Total number (count) of takeaway planning applications submitted within management zones per quarter of calendar year (based upon application date).
2. Percentage (%) of takeaway planning applications rejected within management zones per quarter of calendar year at first decision, based on first decision date (see Box 1).
3. Percentage (%) of takeaway planning applications rejected within management zones per quarter of calendar year at final decision (see Box 1).

Due to the limited number of applications per LA, data were aggregated across all LAs (separately across intervention and control LAs) and into a quarterly time series. Therefore, time was uniformly translated into indicative 90-day quarters of calendar year around the intervention date (t). The resultant time series can therefore be understood to reflect 24 observations around t (i.e. t_{-16}, t_{-15}, t_{-14}, …,t, …,t_{+6}, t_{+7}, t_{+8}) i.e. 16 quarters pre- and 8 quarters post-intervention. At each time point, outcomes were either the sum of the number of applications or the percentage of applications rejected, calculated separately for all management zones and by regulation sub-type.

2.5. Statistical analyses

We used a combination of controlled and uncontrolled interrupted time series (ITS) analyses. Where pre-intervention trends between intervention and candidate control LAs for each outcome were parallel we used controlled ITS (n = 3 analyses). Where trends were not parallel, we reverted to an uncontrolled analysis (n = 9 analyses). As elsewhere (Grepin et al., 2022; Yau et al., 2022), we assessed parallel trends using a Wald test, see Supplementary material C.

Uncontrolled ITS permits estimation of an intervention effect as the difference between the modelled linear trend based on observed post-intervention data, and a counterfactual linear trend extrapolated (i.e. projected forwards) into the post-intervention period based on pre-intervention data (Bernal et al., 2017). In a controlled ITS, the intervention effect is the difference in the differences between post-intervention observed and counterfactual trends for intervention and control LAs. See Supplementary material D for full ITS model specifications.

We report results at twelve (t_{+4}) and twenty-four months (t_{+8}) post-intervention. We also report results for all LAs together (n = 35), and for LAs stratified by regulation sub-type: town centre exempt zones (n = 19), full management zones (n = 9), time management zones (n = 7). For completeness, raw ITS model coefficients (including level change at the point of intervention and post-intervention trend change) are also reported in Supplementary material E.

Prior to model fitting, a preliminary regression model was fitted in order to test for autocorrelation of residuals using Durbin-Watson (Turner et al., 2021) and Ljung-Box tests (Thayer et al., 2021), and seasonality using a Webel and Ollech test (Ollech and Webel, 2023). Neither autocorrelation nor seasonality were identified. We used a Poisson model where the outcome was total number of applications, and a binomial logistic model for other outcomes. All final models were checked for over-dispersion and retested for autocorrelation and partial autocorrelation (Supplementary material F). All analyses were conducted in R using *emmeans*, *EPI* and *margins* functions. Outcomes were modelled as independent, and a two-sided α level of 0.05 was used to test for statistical significance throughout, adopting Wald-based confidence intervals.

2.6. Sensitivity analyses

To test whether any observed changes were specific to the time the intervention occurred, we conducted two sensitivity analyses (both forms of temporal falsification) (Craig et al., 2017). First, we moved the intervention date to a year prior to adoption (t_{-4}). Second, we moved the intervention date to two years prior (t_{-8}), and curtailed the time series to the pre-intervention period only (t_{-16}, …,t_{-1}). If any observed changes were robust to the date of the intervention, we would expect to observe no changes at other times.

3. Results

Intervention LAs were predominantly urban, with 66% classified as "urban with major conurbation", 31% as "urban with city and town", and 3% as "urban with minor conurbation" (Bibby and Brindley, 2013). These LAs were largely (63% of LAs) within the most deprived fifth of LAs in England (Department For Communities And Local Government, 2019). Across a total active takeaway management zone area of 979, 541 km^2 (20% of total land of the intervention LAs), 578 takeaway planning applications were submitted over the six study years, with 457 of these in the pre-intervention period, at a rate of 28.6 per quarter. In the post-intervention period, 121 were submitted at a rate of 15.1 per quarter (Table 1). Overall in the pre-intervention period, 45.6% of

Table 1
Descriptive statistics for total takeaway management zone coverage, overall by regulation sub-type.

	Management zones (n = 35 LAs)	Full management zones (n = 9 LAs)	Town centre exempt (n = 19 LAs)	Time management zones (n = 7 LAs)
Total land area covered, km^2 (%)	979,541 (20)	532,023 (15)	240,869 (27)	206,648 (12)
Median (IQR) land area covered per LA, %	17 (10–36)	27 (13–78)	15 (12–35)	12 (7–18)
Pre-intervention				
Applications, n	457	193	153	111
Mean applications per quarter, n	28.6	12.1	9.6	6.9
Rejected at first decision, %	45.6	32.7	52.6	45.1
Rejected at final decision, %	42.6	30	49.4	43.6
Post-intervention				
Applications, n	121	50	36	35
Mean applications per quarter, n	15.1	4.5	6.2	4.4
Rejected at first decision, %	57.2	66.5	56.8	42.8
Rejected at final decision, %	55.3	60.6	56.8	42.8

submitted applications were rejected at first decision. This rose to 57.2% in the post-intervention period.

3.1. Change in total number of applications

Compared to the counterfactual of no intervention, the intervention was associated with a significant decrease in an already declining number of takeaway planning applications submitted within management zones across all LAs (n = 35) at 12 months, but not at 24 months post-adoption (Fig. 2A). Specifically, in an uncontrolled ITS analysis (Table 2), the intervention was associated overall with 6.3 (95% CI -0.01, -12.5) fewer applications submitted at 12 months, and 7.1 fewer at 24 months (95% CI -15.0, 0.8). The intervention was not associated with a significant change in number of applications at 12 or 24 months in those adopting full management zones (n = 9, Fig. 2B), town centre exempt zones (n = 19, Fig. 2C), or time management zones (n = 7, Fig. 2D).

3.2. Change in percentage of applications rejected (at first decision)

The intervention was associated with a significant increase in the percentage of takeaway planning applications that were rejected at first decision within management zones across all intervention LAs at 12 months, but not 24 months post-adoption (Fig. 3A). Specifically, in an uncontrolled analysis (Table 3), the intervention was associated overall with an additional 18.8% (95% CI 3.7, 33.9) of takeaway applications being rejected at 12 months, and an additional 16.2% (95% CI –7.0, 39.4) at 24 months. The intervention was also associated with a significant increase in the percentage of applications rejected across those adopting full management zones at 12 and 24 months (Fig. 3B). Parallel

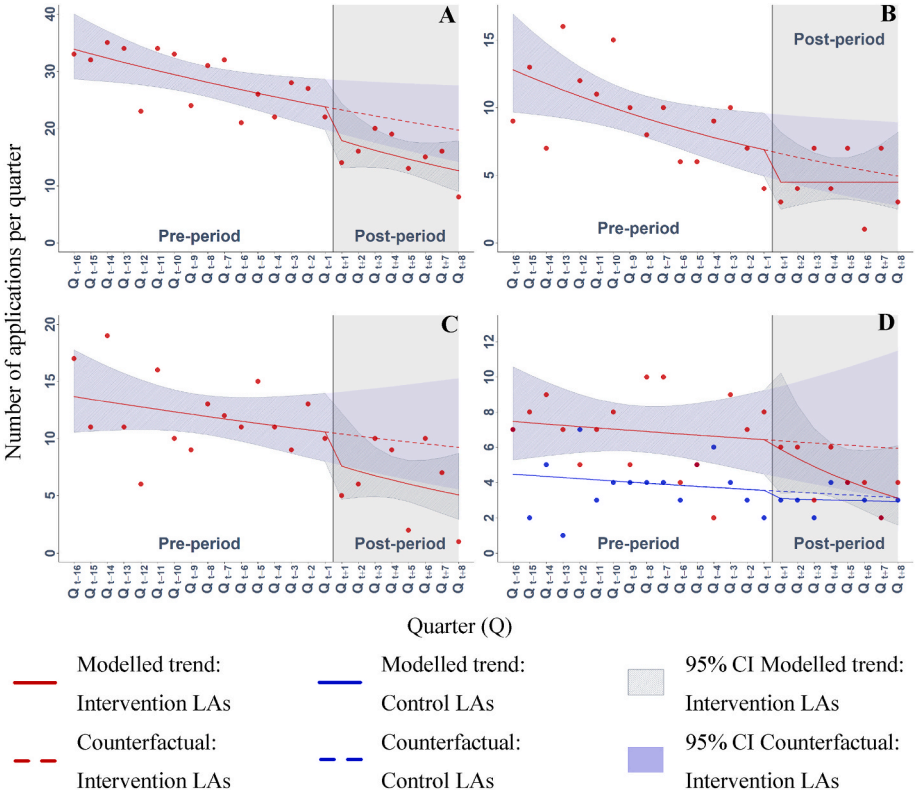


Fig. 2. Visualisation of the difference in the total number of applications submitted within takeaway management zones around schools, overall (A) and by regulation sub-type; full management zones (B); town centre exempt zones (C); and time management zones (D). Modelled using uncontrolled (A–C) and controlled (D) interrupted time series analyses (all Poisson models). Points are observed data. The vertical line represents when planning measures were adopted (*t*), thus defining pre- and post-intervention periods.

Table 2
Estimated difference in total number of planning applications submitted within takeaway management zones around schools at 12 and 24 months (compared to the counterfactual), overall and by regulation sub-type.

		12 months post-intervention		24 months post-intervention	
	ITS type	Difference in applications, n	95% CI	Difference in applications, n	95% CI
Management zones (n = 35 LAs)	Uncontrolled	−6.3	(-0.1, -12.5)	−7.1	(-15.0, 0.8)
Full management zones (n = 9 LAs)	Uncontrolled	−1.3	(-4.4, 1.7)	−0.4	(-4.4, 3.5)
Town centre exempt zones (n = 19 LAs)	Uncontrolled	−3.5	(-7.7, 0.8)	−4.1	(-9.5, 1.3)
Time management zones (n = 7 LAs)	Controlled	−1.4	(-4.9, 2.1)	−2.6	(-7.1, 1.8)

ITS = interrupted time series; Uncontrolled ITS = permits estimation of an intervention effect as the difference between the modelled trend based on observed post-intervention data, and a counterfactual trend extrapolated (i.e. projected forwards) into the post-intervention period from based on the pre-intervention trend data; Controlled ITS = permits estimation of an intervention effect as the difference in the differences between post-intervention observed and the counterfactual trends for intervention and control LAs; LA = local authority.

pre-intervention trends allowed a controlled analysis (Table 3), with the effect of the intervention being an additional 38.6% (95% CI 13.7, 63.5) of takeaway applications being rejected at first decision at 12 months, and an additional 46.1% (95% CI 12.3, 79.9) at 24 months. The intervention was not associated with a change in the percentage of rejected applications for those adopting town centre exempt zones (Fig. 3C) or time management zones (Fig. 3D).

3.3. Change in percentage of applications rejected (at final decision)

The intervention was associated with a significant increase in the percentage of takeaway planning applications that were rejected at final decision within management zones across all LAs at 12 months, but not 24 months post-adoption (Fig. 4A). Specifically, in an uncontrolled analysis (Table 4), the intervention was associated overall with an additional 19.6% (95% CI 4.7, 34.6) of takeaway applications being rejected at 12 months, and an additional 13.8% (95% CI -9.2, 36.7) at 24 months. The intervention was associated with an increase in the percentage of rejected applications across those adopting full management zones at 12 (additional 29.9% rejected, 95% CI 3.9, 55.9) but not 24 months (Table 4). The intervention was not associated with the percentage of rejected applications for those adopting town centre exempt zones or time management zones (Table 4).

3.4. Sensitivity analyses

Changing the date of intervention to a year or two years prior to adoption resulted in no intervention effects being observed (Supplementary material G). This provides evidence that observed changes were specific to the actual time of intervention.

4. Discussion

In this first nationwide study of the impacts of takeaway management zones around schools (sometimes referred to by LAs as “exclusion zones”), across all intervention LAs we observed a decrease in the number of applications received at 12 months post-adoption, and an increase in the percentage of those applications that were rejected at first and final decision at this time point. The effect size for the number of applications was maintained, although it was not statistically significant at 24 months. In analyses stratified by the type of management zone adopted, the changes observed in rejections were most prominent in full management zones (where the regulations are applied irrespective of overlap with town centres), where an additional 38.6% and 46.1% of applications were rejected at first decision at 12 and 24 months respectively, and an additional 19.6% were rejected even after appeal at 12 months. Estimates of intervention effects in all other stratified analyses did not meet statistical significance.

Our results suggest that takeaway management zones around schools have been effective in two ways: reducing the total number of planning applications submitted and increasing the percentage of these applications that are rejected at 12 months post-intervention. Although the number of planning applications submitted was already declining in the pre-intervention period (which itself may have been a pre-adoption effect, see limitations), adoption was associated with an acceleration of this trend. Consequently we would expect that there will have been a reduction in the number of new takeaways being opened in this period, and a reduction in the total number of takeaways present and population exposure to takeaways, compared to a scenario where no intervention was adopted. We also found weak evidence to suggest the association between intervention and percentage of rejected applications was sustained at 24 months post-adoption, while the association with number of applications was greater at this time point. These modelled trends were not significant owing to a tendency for confidence intervals to widen in the late post-intervention period. We hypothesise that prospective takeaway operators became more aware of the policy, perhaps as a result of informal pre-application inquiries, making them less likely to apply. A reduction in the number of such inquiries was previously reported anecdotally in one intervention LA (Keeble et al., 2021).

In stratified analyses, relative to matched control LAs, adoption of full management zones was associated with a significant increase in the proportion of takeaway applications rejected at 12 months, and an even greater proportion of rejections at 24 months. Such was the strength of these associations, it is possible that these impacts on the proportion of rejections were driving the effects of management zones observed overall; however our aim was not to test this. Estimates of intervention effects in all other stratified analyses did not meet statistical significance. It is possible that regulations need to apply at all hours, and within town centres where customer demand is likely to be strongest, to successfully curb new takeaway outlets. Exempting town centres from management zones appears to significantly weaken the potential for this regulation to have a measurable impact, and restrictions on opening hours may not be serving as a sufficient deterrent. However, it also seems likely that to some extent we can attribute a lack of significance in many sub-group analyses to the wide confidence intervals associated with reduced statistical power.

Our results appear to highlight a tension between local priorities and national policy, played out through the PINS appeal decision-making process (Ministry Of Housing Communities And Local Government, 2012). PINS are an executive body of government with responsibility for deciding planning appeal outcomes on a case-by-case basis. If prospective takeaway operators feel that first denial of planning permission was in contravention of a local development plan or other local planning guidance (Department for Levelling Up (2023)), they have the right to lodge an appeal with PINS. PINS inspectors will then decide the outcome, considering evidence from LA and appellant representations, national policy and local regulations including takeaway management zones (O’Malley et al., 2021). In our study, the effect of full management zones in increasing the proportion of applications rejected at 12 months by LAs was halved after taking into account appeal outcomes made by PINS; albeit it was still significantly higher than would have been expected in the absence of intervention. At 24 months, the effect of full

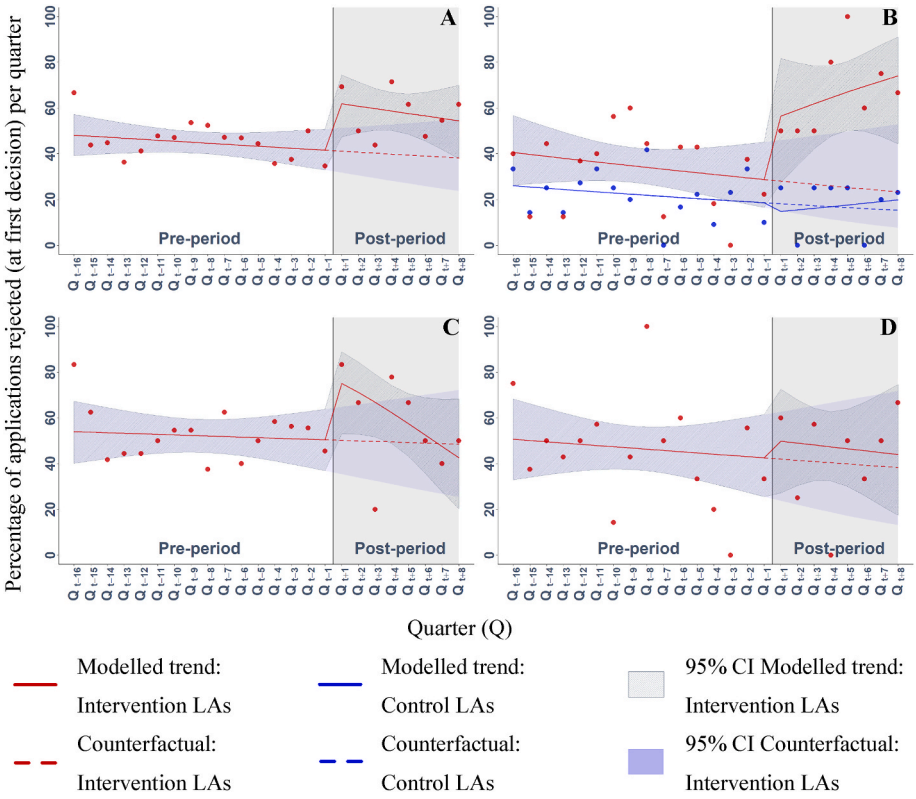


Fig. 3. Visualisation of the difference in the percentage of applications rejected (at first decision) within takeaway management zones around schools, overall (A) and by regulation sub-type; full management zones (B); town centre exempt zones (C); and time management zones (D). Modelled using uncontrolled (A, C-D) and controlled (B) interrupted time series analyses (all binomial logistic models). Points are observed data. The vertical line represents when planning measures were adopted (*t*), thus defining pre- and post-intervention periods.

Table 3
Estimated difference in the percentage of applications rejected (at first decision) within takeaway management zones around schools at 12 and 24 months (compared to the counterfactual), overall and by regulation sub-type.

		12 months post-intervention		24 months post-intervention	
	ITS type	Difference in applications rejected, %	95% CI	Difference in applications rejected, %	95% CI
Management zones (n = 35 LAs)	Uncontrolled	18.8	(3.7, 33.9)	16.2	(-7.0, 39.4)
Full management zones (n = 9 LAs)	Controlled	38.6	(13.7, 63.5)	46.1	(12.3, 79.9)
Town centre exempt zones (n = 19 LAs)	Uncontrolled	12.8	(-10.5, 36.2)	−5.9	(-42.2, 30.4)
Time management zones (n = 7 LAs)	Uncontrolled	6.9	(-23.4, 37.2)	5.7	(-40.7, 52.1)

ITS = interrupted time series; Uncontrolled ITS = permits estimation of an intervention effect as the difference between the modelled trend based on observed post-intervention data, and a counterfactual trend extrapolated (i.e. projected forwards) into the post-intervention period from based on the pre-intervention trend data; Controlled ITS = permits estimation of an intervention effect as the difference in the differences between post-intervention observed and the counterfactual trends for intervention and control LAs; LA = local authority.

management zones taking into account appeal outcomes made by PINS was further diminished and was no longer statistically significant. Thus, it appears the ability of local authorities to implement their own planning regulations, which were adopted in line with local priorities, can be substantially limited by PINS. However, it is not mandatory for inspectors to have been trained in public health. Moreover, as documented in recent research, PINS inspectors have shown a "general lack of engagement" with health in some decision-making (O'Malley et al., 2021). For example, it was previously observed from their written decision-making that inspectors have sometimes failed to cite or afford significant weight to key evidence linking takeaways to unhealthy eating (O'Malley et al., 2021). This apparent discrepancy in the prioritisation of health between LAs adopting this intervention and PINS may to some extent explain the differences we observed at first and final decisions.

4.1. Comparison with previous findings

To the best of our knowledge, previously published research into the effects of takeaway management zones, specifically as a tool to address takeaway proliferation, has been limited to two UK studies undertaken in two neighbouring LAs in the North East of England (Brown et al., 2021, 2022). In one study in Newcastle, no intervention effect on total number of fast-food outlets was observed for management zones, which in this case were exempting town centres (Brown et al., 2021). In a second study in Gateshead, where ("full") management zones including town centres were adopted, a reduction in the number of takeaways was reported (Brown et al., 2022). Broadly, these results are consistent with our finding of a non-significant impact when takeaway management zones excluded town centres. However, it should also be noted that the Gateshead study was unable to discern the impacts of school-centred zones specifically among a suite of other planning interventions adopted simultaneously. Our findings are specific to the impacts of takeaway

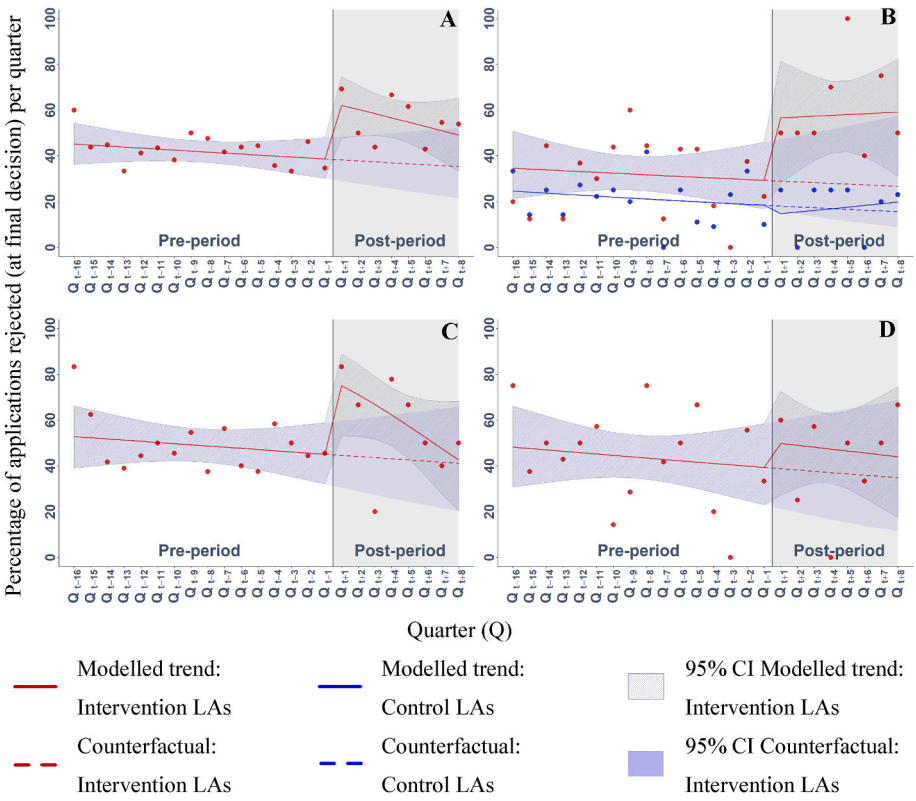


Fig. 4. Visualisation of the difference in the percentage of applications rejected (at final decision) within takeaway management zones around schools, overall (A) and by regulation sub-type; full management zones (B); town centre exempt zones (C); and time management zones (D). Modelled using uncontrolled (A, C-D) and controlled (B) interrupted time series analyses (all binomial logistic models). Points are observed data. The vertical line represents when planning measures were adopted (*t*), thus defining pre- and post-intervention periods.

Table 4
Estimated difference in the percentage of applications rejected (at final decision) within takeaway management zones around schools at 12 and 24 months (compared to the counterfactual), overall and by regulation sub-type.

		12 months post-intervention		24 months post-intervention	
	ITS type	Difference in applications rejected, %	95% CI	Difference in applications rejected, %	95% CI
Management zones (n = 35 LAs)	Uncontrolled	19.6	(4.7, 34.6)	13.8	(-9.2, 36.7)
Full management zones (n = 9 LAs)	Controlled	29.9	(3.9, 55.9)	28.1	(-10.0, 66.2)
Town centre exempt zones (n = 19 LAs)	Uncontrolled	19.2	(-3.9, 42.3)	1.5	(-34.3, 37.3)
Time management zones (n = 7 LAs)	Uncontrolled	10.3	(-19.5, 40.0)	9.2	(-36.5, 54.8)

ITS = interrupted time series; Uncontrolled ITS = permits estimation of an intervention effect as the difference between the modelled trend based on observed post-intervention data, and a counterfactual trend extrapolated (i.e. projected forwards) into the post-intervention period from based on the pre-intervention trend data; Controlled ITS = permits estimation of an intervention effect as the difference in the differences between post-intervention observed and the counterfactual trends for intervention and control LAs; LA = local authority.

management zones around schools as the most common form of takeaway-focused planning intervention in England (Keeble et al., 2019b). The broad geographic coverage of our analysis also minimizes the risk of confounding from local events such as market saturation, which may have also affected the two previous studies. Lastly, these previous studies addressed the effect of planning interventions on the total number of takeaway food outlets, and not more proximal process outcomes.

We are not aware of the adoption of takeaway management zones around schools in any other non-UK setting. Our results are therefore internationally relevant as they provide evidence for the potential effectiveness of such zones in similar sociodemographic and urban planning contexts worldwide, such as in the US and Australia. Importantly, these are contexts in which impacts of other urban planning interventions to address takeaway retail have either been evaluated and impacts not observed, or have not been evaluated, rendering their adoption and implementation open to challenge (Nixon et al., 2015). For example, a study in South Los Angeles found that a different type of city-wide 'zoning' (urban planning) intervention, which targeted large fast-food outlets only, was too weak to affect meaningful retail change (Sturm and Cohen, 2009; Sturm and Hattori, 2015).

4.2. Strengths and limitations

We quantified post-intervention change in proximal application-related planning outcomes, which are immediately amenable to policy impact and are on the causal pathway from intervention to health impacts (Lake et al., 2017; Keeble et al., 2019b). We used routine secondary data from LA planning portals, which record planning applications received, including date and address details. Further, we were able to systematically search for applications for planning use class A5 and indicative A5 outlets, which removed the need for researcher classification by outlet type. To our knowledge, such use of planning application data in research is unprecedented. That said, the validity of

this data source is also unknown.

It is possible that our results were subject to confounding from exogenous events that occurred simultaneously alongside the intervention. This is particularly the case for uncontrolled analyses, which constituted the majority of our analytical models. However, we took a number of precautions to minimize this risk as far as possible. First, we synchronised time in aggregated analyses, so that the intervention time point (t) was unique to each of 35 different LAs, adopting between 2009 and 2017. This reduces the likelihood of confounding, particularly by national-level interventions, which would need to have occurred systematically across time points over these eight years. Second, where possible we used matched LA controls in the presence of pre-intervention parallel trends, verified through testing. Controls allowed us to discern changes that affect both intervention and control LAs, which were not attributable to the intervention. Third, as aforementioned the broad geographic coverage of our analysis across 35 LAs, minimizes risk of confounding from local events. Fourth, we conducted sensitivity analyses, which demonstrated that "moving" the intervention in time resulted in no effect being observed. Fifth, we tested for and confirmed the absence of seasonality and autocorrelation within our data, reducing susceptibility to temporal bias.

We used dynamic takeaway management zones, which accounted for new schools opening and existing schools closing post-adoption, which would affect zone coverage and therefore the geographic extent of the intervention. This is a strength of our work, as these changes would not be captured in static maps made available by LAs at date of adoption. However, our management zones were based on routine data and therefore may not match those implemented by LAs. For example, where zones were anchored to school entrance points, we are aware that LAs often use local knowledge to identify the main or primary access point (s). We relied on school entrance point data contained within an Ordnance Survey product for this purpose (Ordnance Survey, 2022), although visual checks on our derived zones versus those published by several LAs suggested a high degree of fidelity. Moreover, these checks indicated that any mismatch would likely result in an overestimation of the extent of management zones, and therefore an underestimation of any observed intervention effects.

Our data precluded us from analysing the effect of the intervention within each LA in our sample. Although we stratified by management zone sub-type, other contextual factors might have moderated the intervention's impact in individual LAs. In line with previous UK findings (Keeble et al., 2019a), our intervention LAs were predominantly urban and relatively more deprived. Therefore, while the results of our large, nationwide evaluation are likely to be generalizable to other similar UK local authorities, generalisability to rural LAs for example, of which there were none in our sample, remains unknown. In data preparation we observed a high degree of heterogeneity in LA implementation that could have impacted our aggregated results. For example, we are aware that some LAs were citing draft regulations when refusing planning permission to takeaways, up to 24 months prior to formal adoption. This may have suppressed the number of applications and inflated the number of rejections in the pre-intervention period, and from visual inspection of the data there is also some evidence of this. Although this is also an effect of the policy, in our analyses this would only serve to under-estimate any observed impacts at the point of formal adoption. Lastly, appeals data were unavailable for four intervention and three candidate control LAs. While imperfect, because these data were all missing from pre-intervention periods, this would have resulted in an underestimation of any intervention effect.

4.3. Implications for policy and future research

Historically, a lack of scientific evidence has been reported by planners and public health practitioners as a barrier to policy adoption and effective implementation (Keeble et al., 2021; O'Malley et al., 2021). For example, an absence of evidence for takeaway management zone effectiveness was acknowledged as a material consideration by planning inspectors during the 2019 London Plan review (The Planning Inspectorate, 2019). LAs are hesitant to waste their limited resources on interventions that have not been proven effective (Keeble et al., 2021), which may explain limited uptake in England despite endorsement for takeaway management zones in national policy and planning guidance (Greater London Authority, 2012; Local Government Association, 2016; Public Health England, 2014, 2020). Our findings suggest that takeaway management zone policies may have the potential to curb the proliferation of new takeaways near schools and subsequently impact on population health. Moreover, such management zones are implementable by local authorities using existing powers and are therefore readily scalable nationwide, which could also support further adoption.

However, the extent to which our observed changes in two planning process outcomes serve to affect the overall number of new takeaways remains unknown and will be the focus of our future work. Related, changes in overall population exposure to takeaways, and the downstream health and economic impacts of the intervention have also not been quantified. Moreover, it is possible that the intervention has displaced takeaways to other areas including the immediate periphery of management zones. This potential for unintended impacts warrants further study.

5. Conclusions

Despite nearly a decade of adoption, the impacts of takeaway management zones (sometimes referred to by LAs as "exclusion zones") around schools on planning applications for new takeaways were unknown. To our knowledge this is the first nationwide study of the adoption of these zones. These takeaway management zones were associated with an overall decrease in the number of planning applications received by LAs, and an increase in the percentage of those applications that were rejected at first and final decision (the latter taking into account any appeal outcomes) at 12 months post-intervention. Adoption of full management zones, where regulations are applied regardless of overlap with town centres, was associated with a significantly increased percentage of applications being rejected at 12 and 24 months. Our findings suggest that takeaway management zone policies may have the potential to curb the proliferation of new takeaways near schools and subsequently impact on population health.

Funding and acknowledgements

This study is funded by the National Institute for Health Research (NIHR) Public Health Research Programme (Project number: NIHR130597). The views expressed are those of the author(s) and not necessarily those of the NIHR or the Department of Health and Social Care. JR, AW, YH, MK, BL, AS, SJS, MW, JA and TB were supported by the Medical Research Council (grant number MC_UU_00006/7). OM is supported by a UKRI Future Leaders Fellowship (MR/T041226/1)). For the purpose of open access, the author has applied a Creative Commons Attribution (CC BY) licence to any Author Accepted Manuscript version arising.

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Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.healthplace.2024.103237.

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