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# Childhood obesity, is fast food exposure a factor?

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ABSTRACT

Access to fast food has often been blamed for the rise in obesity which in turn has motivated policies to curb the spread of fast food. However, robust evidence in this area is scarce, particularly using data outside of the US. It is difficult to estimate a causal effect of fast food given spatial sorting and ever-present exposure. We investigate whether the residential access to fast food increased BMI of adolescents at a time when fast food restaurants started to open in the UK. The time period presents the study with large spatial and temporal differences in exposure as well as plausibly exogenous variation. We merge data on the location and timing of the first openings of all fast food outlets in the UK from 1968–1986, with data on objectively measured BMI from the 1970 British Cohort Survey. The relationship between adolescent BMI and the distance from the respondents' homes and time since opening, is studied using OLS and Instrumental Variables regression. We find that fast food exposure had no effect on BMI. Extensive robustness checks do not change our conclusion.

## 1. Introduction

The increasing prevalence of childhood and adolescent obesity is a major public health problem. Today, one in three British and American children are overweight or obese, and obesity in early life is likely to persist into adulthood (Reilly, 2006; Ogden et al., 2014; Guo et al., 2002). It has been suggested that there is a positive relationship between the proximity to fast food and childhood obesity (Chou et al., 2004; Davis and Carpenter, 2009) as fast foods are energy dense, have a high glycemic index and are served in large portion sizes with soft drinks (Ebbeling et al., 2002). Many countries, including the UK, have implemented policies to restrict access to fast food (Keeble et al., 2019). However, the overall evidence of the role of fast food access on childhood and adolescent obesity is mixed (Jia et al., 2021). The difficulty is studying the causal effect of fast food when it is ever present since there is no exogenously induced variation in its supply. Currie et al. (2010) propose that future research should study "… fast food restaurant entry in a society where fast food is scarce.". If we can study an era when fast food is being introduced and some locations do not have exposure to it - or get it later - then by a (good as) random draw on geographical location, we can observe the effect of fast food proximity independent of the choice of residential location. Following this logic, our paper exploits the inception of fast food entry in Great Britain.

We estimate the effect of the proximity from home and the duration of exposure to all fast food outlets, as they are first introduced, on BMI in 1986. Global obesity rates started to rise in the 1980s led by the US and the UK (Chinn and Rona, 2001). The timing also coincides with the rapid expansion in the number of fast food establishments (Chou et al., 2004. The increased supply of cheap, accessible, convenient and energy-dense foods, is often blamed for the rising obesity prevalence (Swinburn et al., 2004). We have collected data on all fast food outlets in the UK, from inception to 1986. The fast food data is combined with the 16 year follow-up of the 1970 British Cohort Survey (BCS). We focus on the BMI of adolescents as they are more likely to visit fast food restaurants frequently (Paeratakul et al., 2003). Our key finding is that fast food exposure had no effect on BMI and extensive robustness checks do not change our conclusions.

Our departure from the previous literature is that we measure fast food exposure not only in terms of distance (from the child's home), but also in terms of duration (how long the outlet was there when they were growing up). Hence, we generate a fast food intensity measure which is a function of both distances and duration of all nearby outlets. Given the

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ubiquitous presence of fast food today, studies on its relationship with childhood obesity focus exclusively on spatial access. Analysing variations in BMI when fast food restaurants started to penetrate a previously untapped market, provides our study with a dramatic variation in the proximity and duration of fast food access.

Secondly, we provide the first robust evidence on the relationship between access to fast food and obesity in a Western country outside of the US by analysing nationwide data for the UK and exploiting various sources of potentially random exposure. This is of importance as many European countries have high childhood obesity rates but a different patterning of the built environment and demographic characteristics compared to the US (Walker et al., 2010). Aside from Johar et al. (2017) analysing the effect of the introduction fast food in China, studies which do not use data for the US are descriptive.

Pieroni and Salmasi (2014) show that areas with a higher density of restaurants and lower prices of takeaway have a higher proportion of obese inhabitants. Burgoine et al. (2014) find that those who are most exposed to outlets offering takeaway in the commuting, home and work environment are estimated to have a 1.21 higher BMI. Contrasting evidence is reported by Davillas and Jones (2020) who do not find that fast food outlet density have an impact on BMI or waist circumference of adults using nationally representative data for the UK. On the other hand, a relative measure of fast food exposure as a percentage of all available food outlets reveals a positive association with BMI and body fat in adults in London, UK (Burgoine et al., 2018). However, using the same data but an absolute measure of fast food exposure results in a weak relationship (Mason et al., 2018. Hobbs et al. (2019b) do not find a consistent positive relationship between a variety of measures of fast-food availability and obesity analysing cross-sectional data from Yorkshire, UK, with self-reported anthropometric information. Using similar data but including additional survey waves, Hobbs et al. (2019a) take into consideration that outlets tend to cluster together and do not find that differential access to various types of restaurants, including fast food, affects BMI. Few studies focus exclusively on children in the home environment. Using cross-sectional data on children in Leeds, UK, Griffiths et al. (2014) find no evidence of an association between the number of food outlets (supermarkets, takeaway and retail) and childhood obesity in the home or school neighbourhoods, including the commuting environment. A review on fast food near schools in the UK by Turbutt et al. (2019) shows a lack of reliable evidence regarding the food environment surrounding schools and obesity amongst pupils.

All of these studies are observational and do not address the endogeneity problem stemming from the potential correlation between the location of fast food restaurants and unobserved determinants of BMI. In addition to directly investigating and ruling out that geographical characteristics or reverse causality drive our findings, we also rely on plausibly exogenous variation in the access to fast food and conduct an Instrumental Variable (IV) analysis. Instrumenting the proximity to a fast food outlet with the distance to its distribution centre, following the identification strategy applied in the literature studying the effects of Wal-Mart in the US (Holmes, 2011; Courtemanche and Carden, 2011), confirms our OLS results.

IV regression has been used in many studies from the US. Chen et al. (2013) use the amount of zoned non-residential land as an IV for fast food location and find a small but positive effect on adult obesity. Most studies instrument the access to fast food with the distance to the nearest major highway. Dunn (2010) finds a positive relationship between fast food proximity and BMI in women and in minority populations within counties of medium population densities. Anderson and Matsa (2011) do not find a positive relationship between restaurant consumption and obesity for white and rural Americans after employing a similar identification strategy. The authors suggest that the extra calories consumed from fast food are being offset by eating less energy dense food at home.

Studies using IV to identify the effect of fast food access on childhood obesity focus on the school environment. Alviola et al. (2014) instrument the distance from a school in Arkansas to the closest fast food outlet with the proximity to the closest major highway. Analysing school-level cross-sectional data, they observe that the addition of a fast food outlet within 1 mile increases obesity levels by 1.23 % points. Employing a similar identification strategy, Asirvatham et al. (2019) analyse student-level panel data. Their IV estimation shows that the surrounding restaurants only marginally affect students' BMI but no effects are found after relying on plausibly exogenous re-assignment of students across schools.

Our study measures access to fast food at home as children spend more time at home than in school and a large proportion of school-aged children in our data were entitled to free school meals (von Hinke Kessler Scholder (2013). Thus, our paper is related to the growing literature studying the impact of fast food exposure outside of the school environment. Dunn et al. (2012) exploit changes to fast food exposure on the route between home and school. The authors do not find an association between changes in fast food exposure given by children's transition to different schools, and BMI, using longitudinal data. No effects are found of the proximity to restaurants, including fast food outlets, on weight gain of college students randomly assigned to different dormitories (Kapinos et al., 2014). Zhao et al. (2014) estimate the effects of "Moving to Opportunity", a public policy programme which randomly allocated housing vouchers for people to move out of poor areas. Changes in the availability of fast food were not significant in explaining BMI. In contrast, using a similar identification strategy Han et al. (2020) report positive effects of fast food proximity on childhood obesity for low-income households in New York City.

In addition to analysing the relationship between a change in the exposure to fast food and BMI, we utilise variation stemming from a sharp supply shock from the largest fast food company. Robustness checks which restrict the analysis to exposure to this particular fast food chain provide us with greater confidence in the near random exposure and confirm our null findings. Thus, our paper adds to the scarce evidence base on the impact of unprecedented changes to fast food supply which includes Sturm and Hattori (2015) reporting that the Los Angeles Fast Food Ban did not succeed in reducing obesity rates.

## 2. Fast food in Great Britain 1968–1986

We define fast food outlets as restaurants which are open at any time of the day specialising in easily prepared processed foods that are served quickly, often using counter service. Following Dunn (2010) and Alviola et al. (2014), we focus on the biggest franchised "limited service" restaurants offering takeaway. Four fast food franchises consisting of 952 addresses in the UK met this criterion: Burger King (11), KFC (82), McDonald's (230) and Wimpy (646). Our investigations suggest that KFC, Burger King and McDonald's, did not close any restaurants during the time of our analysis. The start of Wimpy closures occurred mainly after the time period of our study. Appendix A.1.1 describes the methodology used to obtain the locations of the outlets along with an in-depth description of the data. We treat fish and chip shops as a constant background factor as they have a long history in the UK and its consumption was essentially constant during the time period of our study, see Fig. A.3 in the Appendix. Fish and chip shops were not considered due to the nature of their operations: "sales are concentrated at particular times of day, early lunchtime and evening, often very late evening and do not normally operate outside those times." They also engage in batch production as opposed to continuous production and do not usually employ seating (Sault et al., 2002). Moreover, teenagers consume typical fast food meals such as burgers more frequently than fish and chips (see Table A.9 in the Appendix). Fig. 1 illustrates the expansion of the four companies throughout time. As observed in Fig. 1, KFC was the first fast food chain in the UK in 1968. The Figure also confirms the large market share of Wimpy and shows that Burger King was not a major contender during the time of our study. We observe a big jump in the openings of Wimpy outlets in 1977. The number of Wimpy restaurants decreased afterwards at the same time as

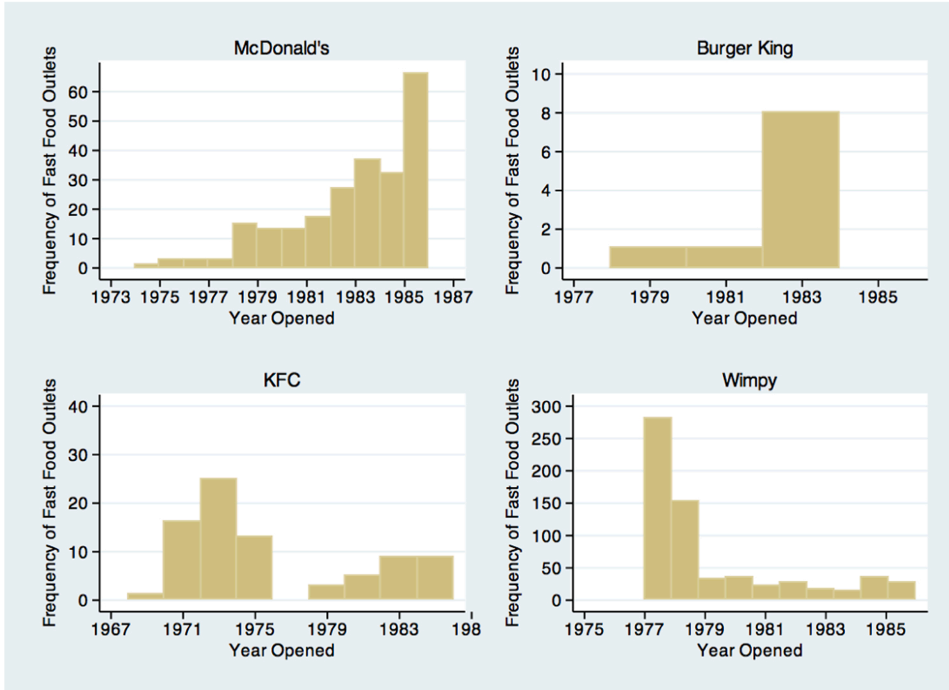



**Fig. 1.** Opening of Fast Food Outlets by Company.

McDonald's establishments started to increase.

Wimpy started off as a subsection in J. Lyon's restaurants in 1954. These restaurants were usually located in high-end locations. From the 1960s and onwards, Wimpy became separate fast food restaurants. The company greatly increased its number of outlets and started to offer takeaway meals in 1977 (Tassiopoulus, 2008, pp. 92). The sudden supply shock was a result of the company's national site plan of opening up a restaurant in every British town with a population greater than 30, 000 and in smaller towns with a high influx of tourists. Other determinants of fast food locations were the location of; pedestrian crossings, traffic lights, traffic counts, competitors, other stores and general spending power of the area (Voss et al., 1985, p. 255).

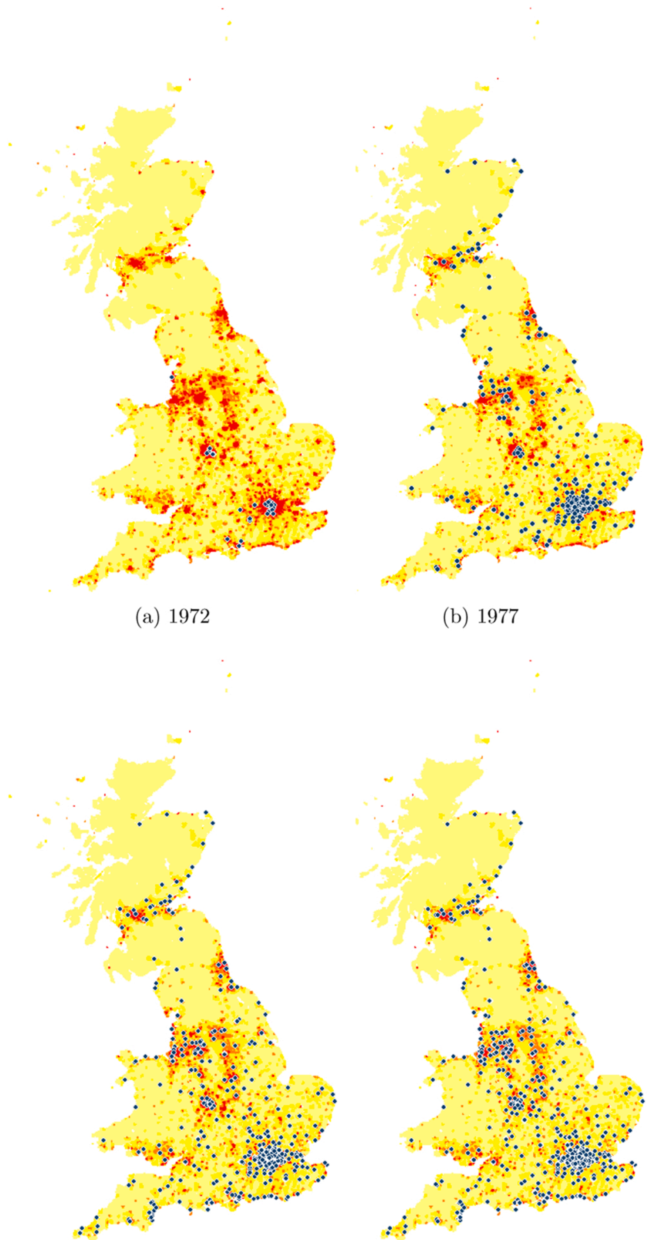
McDonald's concentrated their early expansion in Greater London as the firm's only distributor was based in outer London. Like other successful retail firms, opening decisions were made centrally and sequentially. McDonald's started from one location and expanded gradually to other large cities and towns. The franchise focused on already established shopping locations. McDonald's became the dominant provider of fast food shortly after the time period of our study (Toivanen and Waterson, 2011).

Fig. 2 illuminates the geographical and time dimensions of the entry process, from the first outlets established between 1968 and 1972, to 1986 - when the BCS cohort were aged 16. The locations of fast food outlets are depicted on heat maps. Yellow, orange and red areas indicate low, medium and high population densities, respectively. We observe that restaurants opened up in areas with high population density. One notices a dramatic increase in the access to fast food all over Great Britain. Only 1.63 % of all available outlets in 1986, were open by 1972, and this share increases rapidly to 36.8 % by 1977 and 68.41 % in 1982. This highlights the quick expansion of Wimpy outlets in 1977/1978 followed by the proliferation of McDonald's restaurants in the 1980s. These key dates justify the emphasis on the time period prior to 1986 as it provides the study with considerable variation in the access to fast food, both spatially and temporally. According to Voss et al. (1985), p. 255, there was less abundant supply of cheap sites in European cities compared to American cities. Therefore, in conjunction with the discussed determinants of early fast food location, it is unlikely that any unobserved obesogenic household characteristics determine the location of fast food outlets up to 1986 to the same extent as they do today.

## 3. Data

We use individual panel data from the BCS which surveyed all children born in England, Scotland and Wales, in the week between the 5th and 11th of April 1970. Given the nature of birth cohorts consisting of a sample born in a particular period, the respondents are geographically distributed as the UK population. The cohort has been followed up 10 times and we focus on the 1986 survey due to available information on respondents' postal codes and objectively measured weights and heights. The 1986 follow-up sample was traced mainly through local governments responsible for education, i.e. Local Education Authorities (LEAs) in England and Wales and regional councils in Scotland, using registers from secondary and special educational establishments (Goodman and Butler, 1986). Geographical information on postal codes was used to calculate the distance from BCS respondents' homes to the location of all fast food outlets in 1986. From 16,135 children surveyed at birth, 11,622 children in the 1986 sweep also had available information on postcodes. The main outcome variable of interest, BMI, defined as an individual's weight in kilograms divided by one's height in metres squared ($kg/m^2$), is derived from the respondents' weights and heights measured by the school nurse or a community medical officer at age 16.

The selection criteria for our analytical sample consists of respondents with available information on BMI and postcode in 1986 and the household not changing LEA (henceforth, also denoting Scottish regional councils) between age 10 and 16 which enables us to measure the impact of fast food exposure over time. From the 11,622 teenagers, 53 % (6143) had complete medical examination forms. The sample of 16 year olds fell to 5498 after removing adolescents with incomplete anthropometric information. From the 14,940 children of the 1980 sweep, 66 % (9831) remained in their respective LEAs.



(a) 1972 (b) 1977

(c) 1982 (d) 1986

**Fig. 2.** Fast Food Outlets in Great Britain 1968–1986. These figures graph the location of fast food outlets in 1972, 1977, 1982 and 1986. The blue dots illustrate the location of fast food outlets on heat maps representing the population density per ward according to the 1981 UK Census. Red areas denote the highest tertile of population per ward and yellow areas define the lowest population density per ward.

## 4. Methods

Shorter distances to fast food outlets can increase the demand for fast food due to lower travel costs (and opportunity cost) and supplier-induced demand (Jekanowski et al., 2001). Since fast foods can be addictive, it is likely that the introduction of fast food generates its own demand through taste formation, i.e. that past consumption has a reinforcing effect on the marginal utility of present and future consumption (Stigler and Becker, 1977). If a preference for fast food induces taste formation, its introduction might cause weight gain over time. The temporal variation in fast food access in our data permits the analysis of the relationship between the duration of fast food exposure and BMI. We write the basic relationship between fast food exposure and BMI for individual $i$ as:

$$BMI_i = \alpha_0 + \gamma Distance_i + \delta Duration_i + \theta(Distance_i * Duration_i) + \beta X_i + \mu_i \quad (1)$$

The outcome variable, $BMI_i$, is BMI for individual $i$ at age 16. The explanatory parameters of interest are; *Distance*, or its reciprocal, measuring the distance (or alternative functional forms) from respondent $i$'s residence to the closest fast food restaurant in 1986. We vary the functional form to allow for the possibility of a non-linear relationship. *Duration* measures the association between BMI and the time since opening of the given outlet. The $\theta$ coefficient measures the interaction between distance and duration.

We use $X$ to denote a vector of observable individual characteristics. We include covariates for; maternal BMI, gender, ethnicity, social class, birth weight and cigarette smoking. Moreover, a dummy variable of household microwave ownership is included to control for the consumption of other processed food as previous literature suggests that the introduction of microwaves is likely to have affected obesity rates (Finkelstein and Strombotne, 2010). Covariates for residing in London, in an inner urban area and for land of residence (England, Scotland or Wales) are added to control for the adolescents' spatial environment. See Appendix A.2.1 for a list and explanation of the included variables. $\mu$ is the error term clustered on LEA. There are 120 LEAs in the 1986 BCS constituting the smallest administrative geographical boundary identified at the time of the survey.

Next we construct *Intensity* of fast food exposure by taking the sum of the durations per fast food outlet $j$ since the time of the establishment of the closest 20 restaurants, divided by their respective distances to one's home.

$$Intensity = \sum_{\forall j: d \leq 5} \frac{Duration_j}{Distance_j} \quad (2)$$

We estimate Equation (2), as set out below, as an alternative to Equation (1), where our parameter of interest is the coefficient, $\psi$, on *Intensity*.

$$BMI_i = \alpha + \psi Intensity_i + \beta X_i + \mu_i \quad (3)$$

Previous literature highlights multiple threats to identification when estimating the effect of fast food exposure on BMI using OLS. It has been suggested that the location of fast food establishments is correlated with the location of other constituents of an obesogenic environment (Swinburn et al., 2011). Fast food companies might locate themselves near households with lower concerns with dietary health. Reverse causality could constitute another problem if this subgroup choose to reside where fast food restaurants proliferate. On the other hand, restaurants might target consumers with a high opportunity cost of domestic food preparation which might bias our estimates of fast food proximity on BMI downwards (Anderson and Matsa, 2011; Dunn, 2010).

This motivates the application of IV analysis which leverages plausibly exogenous variation in the proximity to fast food. We follow the literature on the industrial organization of Wal-Mart (Holmes, 2011; Courtemanche and Carden, 2011) and instrument for the location of an outlet with distance to its distribution centre. The spread of fast food outlets in the early era in the UK was restricted to the proximity to distributors (Toivanen and Waterson, 2011). The location of a major distributor is likely to influence the location of a fast food outlet as it determines the distribution costs in terms of a driver's time, cost of transportation, inventory feedback and variable cost (Holmes, 2011). McDonald's opening decisions were made centrally and the company expanded slowly (Toivanen and Waterson, 2011). There were three McDonald's distribution centres prior to 1986 and all opened in 1977–1982 and were located in North London. Wimpy, on the other hand, had multiple distribution centres which have previously been supplying to J Lyon's restaurants. Therefore it is unlikely that the location of distribution centres were correlated with unobserved characteristics of households residing near fast food outlets after conditioning on observable covariates, particularly for residing in London.[2] See Appendix A.1.2 for more information on the distribution centre data.

Controlling for the same set of covariates as in Equation (1), we regress the distance from the BCS respondent's home to its closest fast food distributor in the first stage and estimate BMI using the instrumented distance to one's closest fast food outlet in the second stage.

$$DistFF_{ij} = \alpha_0 + \alpha_1 DistDistr_{ij} + \alpha_2 X_{ij} + \mu_{ij} \quad (4)$$

$$BMI_{ij} = \beta_0 + \beta_1 \widehat{DistFF}_{ij} + \beta_2 X_{ij} + \mu_{ij} \quad (5)$$

*DistDistr* is defined as a binary variable which takes value 1 if the respondent has at least one fast food distribution centre within 50 miles of one's home, and 0 otherwise.

## 5. Descriptive statistics

Table 1 presents the descriptive statistics for the full analytical sample (column 1), for respondents for whom basic demographic and birth weight information is available (column 2) as well as the sample with non-missing information for the full set of covariates in column 3. We focus on the sample with full available information. Mean BMI is 21.28 which corresponds to a healthy body weight. Around 8 % of our sample is considered to be obese and more than one fifth is overweight. The average distance from one's home to the closest outlet in 1986 is 4.57 miles with a mean duration since opening of 3.91 years. 17 % have access to a fast food restaurant within 1 mile and 71 % reside within 5 miles of an outlet. We note that the distribution of distance to a respondent's closest fast food outlet in 1986 is skewed. 90 % of respondents in the full sample have access to at least one fast food outlet within 10 miles and 99 % within approximately 23 miles, while the remaining 1 % reside between 23 and 107.8 miles of their closest fast food outlet, see Fig. A.4 in Appendix A.3. Our generated measure of fast food intensity, which takes account of the sum of the durations of exposure to a resident's closest 20 fast food outlets divided by their respective distances, indicates that the average intensity of fast food is 6.07.

Moreover, we note a limited ethnic diversity, the largest social class comprising of parents working in managerial and technical occupations, three quarters of respondents residing in non-urban areas, 11 % smoking at age 16 and 41 % of adolescents having a microwave at home. Although we note a slight increase in average distance to nearest fast food outlet, from 4.45 to 4.57 miles, in the largest sample compared to the sample excluding respondents with missing observations, and similarly a slight reduction in fast food intensity from 6.46 to 6.07, the composition of the sample characteristics are qualitatively similar across the sub-samples.[3] See Appendix A.2 for further information about the BCS data, spatial linkage and inclusion criteria.

Inspecting the relationship between the covariates and BMI at age 16 confirms the relevance of controlling for birth weight, smoking status, mother's BMI as well as household ownership of microwaves as these variables are statistically significant predictors of BMI, see Table A.10 in Appendix A.3.

**Table 1**
Descriptive statistics.

| | (1) | | (2) | | (3) | |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD |
| BMI | 21.28 | 3.23 | 21.27 | 3.23 | 21.26 | 3.23 |
| Obese | 0.09 | 0.28 | 0.09 | 0.28 | 0.08 | 0.28 |
| Overweight | 0.22 | 0.41 | 0.22 | 0.41 | 0.21 | 0.41 |
| Closest fast food $\leq$ 1 mile | 0.18 | 0.39 | 0.18 | 0.38 | 0.17 | 0.38 |
| Closest fast food $\leq$ 2 miles | 0.39 | 0.49 | 0.39 | 0.49 | 0.39 | 0.49 |
| Closest fast food $\leq$ 3 miles | 0.54 | 0.50 | 0.54 | 0.50 | 0.54 | 0.50 |
| Closest fast food $\leq$ 5 miles | 0.72 | 0.45 | 0.72 | 0.45 | 0.71 | 0.45 |
| Distance to closest fast food | 4.45 | 6.42 | 4.48 | 6.51 | 4.57 | 6.88 |
| Duration of closest fast food outlet | 3.92 | 4.49 | 3.91 | 4.48 | 3.91 | 4.47 |
| Fast food intensity | 6.46 | 13.88 | 6.32 | 13.55 | 6.07 | 13.20 |
| Girl | | | 0.52 | 0.50 | 0.52 | 0.50 |
| Ethnicity: European | | | 0.97 | 0.03 | 0.98 | 0.19 |
| Ethnicity: West Indian | | | 0.01 | 0.09 | 0.00 | 0.07 |
| Ethnicity: Asian | | | 0.01 | 0.11 | 0.01 | 0.10 |
| Ethnicity: Other | | | 0.00 | 0.07 | 0.00 | 0.07 |
| Social class: I Professional occupations | | | 0.05 | 0.04 | 0.05 | 0.05 |
| Social class: II Managerial and technical occupations | | | 0.26 | 0.44 | 0.27 | 0.44 |
| Social class: III.1 Skilled occupations (non manual) | | | 0.18 | 0.38 | 0.19 | 0.39 |
| Social class: III.2 Skilled occupations (manual) | | | 0.18 | 0.39 | 0.18 | 0.38 |
| Social class: IV Partly skilled occupations | | | 0.05 | 0.22 | 0.05 | 0.22 |
| Social class: Unskilled occupations | | | 0.01 | 0.10 | 0.01 | 0.11 |
| Social class: Student | | | 0.03 | 0.16 | 0.03 | 0.16 |
| Social class: Unclassifiable or missing information | | | 0.25 | 0.43 | 0.22 | 0.42 |
| Lives in England | | | 0.81 | 0.15 | 0.81 | 0.16 |
| Lives in Scotland | | | 0.07 | 0.25 | 0.07 | 0.26 |
| Lives in Wales | | | 0.12 | 0.33 | 0.12 | 0.33 |
| Lives in Urban area | | | 0.25 | 0.43 | 0.25 | 0.43 |
| Lives in London | | | 0.05 | 0.21 | 0.04 | 0.20 |
| Birth Weight (kg) | | | 3.32 | 0.52 | 3.32 | 0.52 |
| Mother's BMI in 1980 | | | | | 23.33 | 3.63 |
| Smoker | | | | | 0.11 | 0.31 |
| Household owns Microwave | | | | | 0.41 | 0.49 |
| Observations | 4536 | | 4353 | | 3585 | |

## 6. Results

We begin with estimating the association between BMI at age 16 and the continuous and categorical distances to one's closest fast food outlet in 1986. We report the regression results for each distance measure across specifications excluding controls, with basic socio-economic and geographical information and birth weight, and subsequently with the full set of controls in Table 2. From columns 1–3 in Table 2 we observe an insignificant coefficient hovering around 0 on the distance to one's closes fast food outlet. The inclusion of $Distance^2$ in columns 4–6 suggest that distance to fast food may have a positive (at a decreasing rate) relationship with BMI. However, the coefficient turns insignificant when the full set of covariates is included. Residing within 1 mile of a fast food outlet in 1986 is not associated with higher adolescent BMI. Likewise, including categorical distance measures of $\leq$ 1, 1–2, 2–3 and 3–5 miles, compared to living further away than 5 miles, does not indicate that residing closer to a fast food outlet raises BMI.

A potential concern is that the limited sample size may not allow us

[2] Given that the distribution centres for the largest fast food company were established prior to the opening of fast food outlets and the rather short range of opening dates of McDonald's distribution centres, we are unable to instrument for the duration of fast food exposure.

[3] Moreover, we note that the sample of respondents who did not change LEA between 1980 and 1986 does not differ systematically from the full sample of respondents. Key descriptive statistics for the whole sample irrespective of moving status between 1980 and 1986 are displayed in Table A.8 in Appendix A.3. However, we note that the distance to closest fast food is somewhat higher in the full sample (average of 5.30 miles) and the substantially higher percentage - 60 %, of respondents with missing information on class somewhat alters the composition of social class.

**Table 2**
Relationship between fast food proximity and BMI.

| | (1) BMI | (2) BMI | (3) BMI | (4) BMI | (5) BMI | (6) BMI | (7) BMI | (8) BMI | (9) BMI | (10) BMI | (11) BMI | (12) BMI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Distance to closest fast food | 0.0046 | 0.0049 | -0.0004 | 0.0344** | 0.0392** | 0.0262 | | | | | | |
| | (0.010) | (0.010) | (0.009) | (0.016) | (0.016) | (0.017) | | | | | | |
| *Distance*$^2$ to closest fast food | | | | -0.0005** | -0.0005*** | -0.0004** | | | | | | |
| | | | | (0.000) | (0.000) | (0.000) | | | | | | |
| Closest fast food $\leq$ 1 mile | | | | | | | -0.0669 | -0.0957 | -0.1159 | -0.1922 | -0.2100 | -0.1739 |
| | | | | | | | (0.130) | (0.134) | (0.133) | (0.166) | (0.169) | (0.158) |
| Closest fast food 1–2 miles | | | | | | | | | | -0.2149 | -0.2125 | -0.1103 |
| | | | | | | | | | | (0.158) | (0.165) | (0.170) |
| Closest fast food 2–3 miles | | | | | | | | | | -0.0444 | 0.0086 | 0.1160 |
| | | | | | | | | | | (0.174) | (0.174) | (0.191) |
| Closest fast food 3–5 miles | | | | | | | | | | -0.2872* | -0.2648* | -0.2408 |
| | | | | | | | | | | (0.147) | (0.145) | (0.153) |
| Controls: Geography, socio-economic status and birth weight | | ✓ | ✓ | | ✓ | ✓ | | ✓ | ✓ | | ✓ | ✓ |
| Controls: Maternal BMI, smoker and microwave ownership | | | ✓ | | | ✓ | | | ✓ | | | ✓ |
| Observations | 4536 | 4353 | 3585 | 4536 | 4353 | 3585 | 4536 | 4353 | 3585 | 4536 | 4353 | 3585 |
| $R^2$ | 0.000 | 0.021 | 0.072 | 0.002 | 0.022 | 0.073 | 0.000 | 0.021 | 0.072 | 0.001 | 0.022 | 0.073 |

*Notes:* This table displays the OLS regression results for the association between BMI in 1986 and distance (in miles), *distance*$^2$ and various distance categories, from home to the closest fast food outlet in 1986. The omitted distance categories in columns 7–9 and 10–11 are distance $> 1$ and $> 5$ miles, respectively. The analysis is carried out for the pooled sample of BCS respondents at age 16 in 1986 for whom postal code information and anthropometric information was available in 1986 and who remained in the same LEA between age 10 and 16. The following control variables are included in the first set of controls denoted "Geography, socio-economic status and birth weight": gender, highest parental social class (1 Professional occupations, 2 Managerial and technical occupations, 3.1 Skilled occupations (non manual), 3.2 Skilled occupations (manual), 4 Partly skilled occupations, 5 Unskilled occupations, 6 Unclassifiable occupations or occupations with insufficient information, 7. Student, 8. Missing information), land of residence (England, Scotland, Wales), residing in London, residing in an urban area, ethnicity (European, West Indian, Asian, Other) and birth weight (kg). The following control variables are included in the set of controls denoted "Controls: Maternal BMI, smoker and microwave ownership": mother's BMI in 1980, adolescent's smoking status and household ownership of microwave. All standard errors are clustered on LEA and shown in parentheses. * $p < .10$, ** $p < .05$, *** $p < .01$.

to detect the true effect of fast food exposure on BMI given the small effect size found in previous papers. In an attempt to circumvent the potential issue of the lack of statistical power, we estimate the relationship between 1/Distance and 1/Distance$^2$, and BMI. Estimating the relationship using the inverse of distance, where a positive coefficient would suggest that closer proximity to fast food is associated with higher BMI, results in a small negative and insignificant coefficient across the specifications see Table A.11 in Appendix A.4.[4]

The lack of a positive association between fast food proximity and BMI may be explained by the, at most, small positive relationship between fast food proximity and frequency of takeaway consumption. A reduction of 1 mile to one's closest fast food outlet is associated with an increase of 0.013 takeaway meals per week (the average is approximately one takeaway meal per week), see Table A.12 in the Appendix. However, investigating the non-linear relationship using categorical distances does not suggest that living closer to fast food is related to eating more takeaway. Given that Viner and Cole (2006) find that the increase in BMI Z-score between 16 and 30 years of the BCS respondents was associated with eating takeaway meals twice or more per week and consuming two or more carbonated drinks per day, the potentially small association between fast food access and fast food consumption may explain the absence of weight gain in our study.

We also exploit variation in access to the first fast food outlet in a given boundary over time. We estimate BMI at age 16 on binary variables taking value 1 if the first fast food outlet opened between 1980 and 1986 within 1, 3 and 5 miles radius of one's home, in comparison to the lack of access within a given radius, controlling for BMI in 1980. The introduction of fast food access between age 10 and 16 is not related to an increase in BMI, see Table A.14 in the Appendix.

Next, we investigate the relationship between BMI and the duration of fast food exposure by regressing BMI on the number of years since the opening of the first fast food outlet within 1, 3 and 5 miles radius of the respondent's home. The estimates on duration are very close to zero and do not reach statistical significance for any given boundary, see Table 3. We have assumed that the longer a fast food outlet has been open near an individual's home, the higher the likelihood of weight gain. However, there is no consensus in the literature regarding the habit formation of foods consumed outside the home. Consumption could be higher for those who were newly introduced to fast food and then fade away over time. We test whether newer outlets have a positive association with BMI by regressing it on a dummy variable taking value 1 if the respondent lived within a radius of 1, 3 and 5 miles and 0 otherwise, of a fast food outlet in the last 1, 2 or 3 years, respectively. We do not find that access to newer outlets is positively related to BMI, see Table A.13 in the Appendix.

Interacting the inverse of distance (for ease of interpretation) and duration of exposure to one's closest fast food outlet in 1986 does not change our previous conclusions, see Table 4. In fact, the coefficient on *1/Distance* in the fully saturated model (see column 9) suggests that there is a negative relationship between residing closer to a fast food outlet and adolescent BMI.

Next, we present the regression results from Equation (3) where we estimate the aggregate influence of the proximity and duration of up to 20 closest outlets on BMI. As the importance of exposure might vary with the order of proximity to one's home, we also create a weighted *Intensity* measure where closer fast food outlets are allocated more weight. Additionally, we transform the intensity by taking the natural logarithm in order to reduce the positive skewness of the intensity distribution. Irrespective of how we modify the intensity measure, we fail to find support for a positive association with BMI, see Table 5.

Residing within 50 miles of a fast food distribution centre is a relevant predictor of fast food proximity, see the first stage results in Table A.15 in Appendix A.4. Using balancing tests to check the mean of

[4] Given the similarity across both sample compositions and coefficients in the main regression results, we present all robustness checks for specifications without covariates and the full set of covariates.

**Table 3**
Relationship between fast food exposure duration and BMI.

| | (1) BMI | (2) BMI | (3) BMI | (4) BMI | (5) BMI | (6) BMI | (7) BMI | (8) BMI | (9) BMI |
|---|---|---|---|---|---|---|---|---|---|
| Duration of first fast food outlet ≤ 1 mile | 0.005 | 0.005 | 0.004 | | | | | | |
| | (0.017) | (0.018) | (0.018) | | | | | | |
| Duration of first fast food outlet ≤ 3 miles | | | | 0.006 | 0.005 | 0.014 | | | |
| | | | | (0.012) | (0.012) | (0.013) | | | |
| Duration of first fast food outlet ≤ 5 miles | | | | | | | 0.003 | 0.003 | 0.008 |
| | | | | | | | (0.013) | (0.013) | (0.013) |
| Controls: Geography, socio-economic status and birth weight | | ✓ | ✓ | | ✓ | ✓ | | ✓ | ✓ |
| Controls: Maternal BMI, smoker and microwave ownership | | | ✓ | | | ✓ | | | ✓ |
| Observations | 4536 | 4353 | 3585 | 4536 | 4353 | 3585 | 4536 | 4353 | 3585 |
| $R^2$ | 0.000 | 0.022 | 0.072 | 0.000 | 0.022 | 0.072 | 0.000 | 0.022 | 0.072 |

*Notes:* This table displays the regression results for the association between BMI in 1986 and the duration since establishment from the first outlets established within 1, 3 and 5 miles from home in 1986. The analysis is carried out for the pooled sample of BCS respondents at age 16 in 1986 for whom postal code information and anthropometric information was available in 1986 and who remained in the same LEA between age 10 and 16. The following control variables are included in the first set of controls denoted “Geography, socio-economic status and birth weight”: gender, highest parental social class (1 Professional occupations, 2 Managerial and technical occupations, 3.1 Skilled occupations (non manual), 3.2 Skilled occupations (manual), 4 Partly skilled occupations, 5 Unskilled occupations, 6 Unclassifiable occupations or occupations with insufficient information, 7. Student, 8. Missing information), land of residence (England, Scotland, Wales), residing in London, residing in an urban area, ethnicity (European, West Indian, Asian, Other) and birth weight (kg). The following control variables are included in the set of controls denoted “Controls: Maternal BMI, smoker and microwave ownership”: mother’s BMI in 1980, adolescent’s smoking status and household ownership of microwave. All standard errors are clustered on LEA and shown in parentheses. * $p < .10$, ** $p < .05$, *** $p < .01$.

**Table 4**
Relationship between the interaction of distance and duration of fast food exposure, and BMI.

| | (1) BMI | (2) BMI | (3) BMI | (4) BMI | (5) BMI | (6) BMI | (7) BMI | (8) BMI | (9) BMI |
|---|---|---|---|---|---|---|---|---|---|
| Duration | 0.006 | 0.003 | 0.012 | 0.008 | 0.005 | 0.016 | 0.001 | -0.002 | 0.010 |
| | (0.010) | (0.010) | (0.011) | (0.011) | (0.011) | (0.012) | (0.012) | (0.013) | (0.013) |
| $1/Distance$ | | | | -0.026 | -0.027 | -0.055 | -0.131 | -0.134 | -0.139 * |
| | | | | (0.047) | (0.048) | (0.047) | (0.094) | (0.097) | (0.082) |
| Duration × $1/Distance$ | | | | | | | 0.014 | 0.014 | 0.011 |
| | | | | | | | (0.011) | (0.011) | (0.010) |
| Controls: Geography, socio-economic status and birth weight | | ✓ | ✓ | | ✓ | ✓ | | ✓ | ✓ |
| Controls: Maternal BMI, smoker and microwave ownership | | | ✓ | | | ✓ | | | ✓ |
| Observations | 4536 | 4353 | 3585 | 4536 | 4353 | 3585 | 4536 | 4353 | 3585 |
| $R^2$ | 0.000 | 0.022 | 0.072 | 0.000 | 0.022 | 0.072 | 0.000 | 0.022 | 0.072 |

*Notes:* This table displays the regression results for the association between BMI in 1986 and duration since establishment and the 1/Distance (in miles) from home to the closest fast food outlet in 1986, as well as the interaction between duration and 1/Distance. The analysis is carried out for the pooled sample of BCS respondents at age 16 in 1986 for whom postal code information and anthropometric information was available in 1986 and who remained in the same LEA between age 10 and 16. The following control variables are included in the first set of controls denoted “Geography, socio-economic status and birth weight”: gender, highest parental social class (1 Professional occupations, 2 Managerial and technical occupations, 3.1 Skilled occupations (non manual), 3.2 Skilled occupations (manual), 4 Partly skilled occupations, 5 Unskilled occupations, 6 Unclassifiable occupations or occupations with insufficient information, 7. Student, 8. Missing information), land of residence (England, Scotland, Wales), residing in London, residing in an urban area, ethnicity (European, West Indian, Asian, Other) and birth weight (kg). The following control variables are included in the set of controls denoted “Controls: Maternal BMI, smoker and microwave ownership”: mother’s BMI in 1980, adolescent’s smoking status and household ownership of microwave. All standard errors are clustered on LEA and shown in parentheses. * $p < .10$, ** $p < .05$, *** $p < .01$.

covariates across the analytical sample of respondents residing within 50 miles of a fast food distribution centre, compared to those who live further, shows that the IV is related to residing in an urban area and in England, and being of Non-European ethnicity. However, this is not surprising given that the fast food distribution centres are located near London, see Fig. A.5 in Appendix A.4. The validity of the IV is supported by the balanced covariates which may impact health behaviour but should ex-ante not be impacted by the proximity to a fast food distribution centre, such as the proportion of children with a parent in a skilled occupation, household ownership of a microwave and smoking status, see Table A.16 in Appendix A.4. Thus, conditional on controlling for available covariates, distance to a fast food distribution centre leverages plausible exogenous variation in the residential proximity to fast food in 1986. The two stage least squares results corroborate the lack of a negative relationship between BMI and distance to fast food observed in the OLS analysis, see Table 6. Moreover, the accompanying F-statistics in Table 6 show that the instrument is not weak after controlling for the full set of covariates.

## 7. Robustness analyses

We inspect whether our findings are driven by the respondents being at a less susceptible age for weight gain if exposed to fast food, compared to younger children. Postal code information is not available for children at age 10. Thus, we restrict the sample to children who did not move between the 1980 and 1986 survey waves and to outlets established by 1980 which comprises of 57.42 % of all the outlets in 1986. In our analytical sample, 10.8 %, 30.5 % and 40 % of BCS respondents had access to at least one fast food outlet within 1, 3 and 5 miles of their homes at age 10 in 1980. Regression results presented in Table A.31 in Appendix A.7 indicate a lack of a positive relationship between fast food exposure within 1, 3 or 5 miles, and BMI at age 10.

Our main analysis uses information on the distance to all fast food outlets. One might argue that restaurants far away are less likely to have an impact on the demand for fast food. Restricting the analytical sample to outlets within 5 miles does not change our conclusions, see Appendix A.5. We have also re-estimated our main specifications by changing the outcome variable to the probability of being overweight or obese. The results are qualitatively similar, see Appendix A.6. Additionally, we

**Table 5**
Relationship between Fast Food Intensity and BMI.

| | (1) BMI | (2) BMI | (3) BMI | (4) BMI | (5) BMI | (6) BMI | (7) BMI | (8) BMI | (9) BMI |
|---|---|---|---|---|---|---|---|---|---|
| Intensity of fast food | 0.002 | 0.004 | 0.002 | | | | | | |
| | (0.004) | (0.005) | (0.006) | | | | | | |
| Weighted Intensity of fast food | | | | 0.001 | 0.001 | 0.001 | | | |
| | | | | (0.002) | (0.003) | (0.003) | | | |
| Ln(intensity) of fast food | | | | | | | -0.017 | -0.044 | -0.070 |
| | | | | | | | (0.062) | (0.075) | (0.076) |
| Controls: Geography, socio-economic status and birth weight | | ✓ | ✓ | | ✓ | ✓ | | ✓ | ✓ |
| Controls: Maternal BMI, smoker and microwave ownership | | | ✓ | | | ✓ | | | ✓ |
| Observations | 4536 | 4353 | 3585 | 4536 | 4353 | 3585 | 2407 | 2309 | 1894 |
| $R^2$ | 0.000 | 0.022 | 0.072 | 0.000 | 0.022 | 0.072 | 0.000 | 0.028 | 0.080 |

*Notes:* This table displays the regression results for the association between BMI in 1986 and the intensity (as well as a weighted intensity measure where closer fast food outlets are allocated more weight and the natural logarithm of intensity) taking into account the proximity and durations of up to 20 closest fast food outlets to home in 1986. The analysis is carried out for the pooled sample of BCS respondents at age 16 in 1986 for whom postal code information and anthropometric information was available in 1986 and who remained in the same LEA between age 10 and 16 and. The following control variables are included in the first set of controls denoted "Geography, socio-economic status and birth weight": gender, highest parental social class (1 Professional occupations, 2 Managerial and technical occupations, 3.1 Skilled occupations (non manual), 3.2 Skilled occupations (manual), 4 Partly skilled occupations, 5 Unskilled occupations, 6 Unclassifiable occupations or occupations with insufficient information, 7. Student, 8. Missing information), land of residence (England, Scotland, Wales), residing in London, residing in an urban area, ethnicity (European, West Indian, Asian, Other) and birth weight (kg). The following control variables are included in the set of controls denoted "Controls: Maternal BMI, smoker and microwave ownership": mother's BMI in 1980, adolescent's smoking status and household ownership of microwave. All standard errors are clustered on LEA and shown in parentheses. * $p < .10$, ** $p < .05$, *** $p < .01$.

**Table 6**
Effect of distance to closest fast food on BMI: Two Stage Least Squares.

| | (1) BMI | (2) BMI | (3) BMI | (4) BMI | (5) BMI | (6) BMI | (7) BMI | (8) BMI | (9) BMI |
|---|---|---|---|---|---|---|---|---|---|
| Distance to closest fast food | 0.069 | 0.148 * | 0.097 | | | | | | |
| | (0.049) | (0.081) | (0.066) | | | | | | |
| Closest fast food $\leq$ 1 mile | | | | -1.053 | -3.602 | -2.059 | | | |
| | | | | (0.798) | (2.470) | (1.608) | | | |
| Closest fast food $\leq$ 2 miles | | | | | | | -0.686 | -1.600 * | -0.978 |
| | | | | | | | (0.505) | (0.968) | (0.711) |
| Controls: Geography, socio-economic status and birth weight | | ✓ | ✓ | | ✓ | ✓ | | ✓ | ✓ |
| Controls: Maternal BMI, smoker and microwave ownership | | | ✓ | | | ✓ | | | ✓ |
| F-statistic | 53.13 | 30.66 | 32.96 | 22.01 | 7.95 | 11.43 | 41.39 | 16.92 | 20.64 |
| Prob> F) | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| Observations | 4536 | 4353 | 3585 | 4536 | 4353 | 3585 | 4536 | 4353 | 3585 |
| $R^2$ | . | . | 0.032 | . | . | 0.026 | . | . | 0.056 |

*Notes:* This table displays the TSLS regression results for the effect of the instrumented distance (in miles) and distance categories to the closest fast food outlet in 1986 on BMI in 1986. The omitted distance categories in columns 4–6 and 7–9 are distance > 1 and > 2 miles, respectively. The instrument is residing within 50 miles of a fast food distribution centre. The analysis is carried out for the pooled sample of BCS respondents at age 16 in 1986 for whom postal code information and anthropometric information was available in 1986 and who remained in the same LEA between age 10 and 16. The following control variables are included in the first set of controls denoted "Geography, socio-economic status and birth weight": gender, highest parental social class (1 Professional occupations, 2 Managerial and technical occupations, 3.1 Skilled occupations (non manual), 3.2 Skilled occupations (manual), 4 Partly skilled occupations, 5 Unskilled occupations, 6 Unclassifiable occupations or occupations with insufficient information, 7. Student, 8. Missing information), land of residence (England, Scotland, Wales), residing in London, residing in an urban area, ethnicity (European, West Indian, Asian, Other) and birth weight (kg). The following control variables are included in the set of controls denoted "Controls: Maternal BMI, smoker and microwave ownership": mother's BMI in 1980, adolescent's smoking status and household ownership of microwave. All standard errors are clustered on LEA and shown in parentheses. * $p < .10$, ** $p < .05$, *** $p < .01$. 01. $R^2$ for columns (1), (3) and (5) is negative, meaning the model sum of squares is negative. STATA's ivregress command suppresses the printing of a negative $R^2$ which is why the values are not reported in the table.

investigate whether fast food exposure in one's school area affects BMI. Only 10.9 % of the BCS respondents buy school lunch outside of school. While, the BCS does not provide information on school location, we note that a lower average distance to fast food per LEA does not increase the likelihood of buying lunch outside of school or BMI, see Table A.32 in Appendix A.7.

We do not find a relationship between past BMI and future fast food availability, see Table A.33 in Appendix A.7. Thus, fast food outlets were not targeting households with a particular preference for maintaining a less or more healthy body weight and reverse causality is not of concern. Next, we reduce the scope for non-random fast food exposure by estimating the impact of proximity to Wimpy outlets only. As observed in Fig. 1, there was a dramatic increase of Wimpy restaurants in 1977 and 1978. The fast expansion (see Fig. A.6 in the Appendix) is due to the company being overtaken by United Biscuits and the management's aim to compete with the arrival of McDonald's. The rapid growth did not allow for a strategic targeting of certain households. We do not observe that living closer to a Wimpy restaurant has a positive association with adolescent BMI using various distance measures, see Table A.34 in Appendix A.7.

Lastly, we check the robustness of our main results by investigating whether there are area-level determinants which may explain our findings. For example, several papers report that more deprived areas have a higher density of fast food outlets compared to less deprived areas in the UK (Wise, 2018). We use the 1981 UK Census to analyse the relationship between area-level deprivation and the density of fast food outlets. Deprivation is measured using the Townsend index - a composite score of standardised deprivation proxies of an area (Townsend et al., 1987). The following four area characteristics are computed, standardised and aggregated per ward; percentage of unemployed individuals over age 16, percentage of households that are overcrowded (more than or equal to 1.5 persons per room), percentage of households that do not own their home, and the percentage of households without access to a car. We estimate a negative binomial regression due to most wards not having any fast food outlets. The outcome variable is the count of fast food outlets per ward with an offset of the log of population/10,000 per ward. Wards in the 4th and 5th quintiles of deprivation are not more likely to have more fast food outlets than the least deprived wards after controlling for the proportion of youth, immigrants and retirees, see Table 7.[5]

**Table 7**
Predictors of Fast Food Density.

| Dependent Variable: Fast Food Outlets/10 000 individuals/Ward | (1) | (2) |
|---|---|---|
| Quintile of Deprivation II | 0.659*** | 0.431** |
| | (0.194) | (0.198) |
| Quintile of Deprivation III | 0.667*** | 0.388** |
| | (0.174) | (0.176) |
| Quintile of Deprivation IV | 0.579*** | 0.186 |
| | (0.175) | (0.178) |
| Quintile of Deprivation V | 0.631*** | 0.142 |
| | (0.194) | (0.190) |
| Land Area (km$^2$) | -0.055*** | -0.047*** |
| | (0.010) | (0.009) |
| Proportion of Youth | 8.920*** | 17.346*** |
| | (2.543) | (2.205) |
| Proportion of Immigrants | 5.089*** | 4.455*** |
| | (0.639) | (0.660) |
| Proportion of Retirees | | 17.125*** |
| | | (1.326) |
| Constant | 1.089 | 0.853 |
| | (0.126) | (0.134) |
| Observations | 8578 | 8578 |
| Pseudo $R^2$ | 0.0797 | 0.1068 |

*Notes:* Data source: 1981 UK Census. Dependent variable is the count of fast food outlets with log of population/10 000 per ward as offset. Standard errors are clustered on electoral wards. * $p < .10$, ** $p < .05$, *** $p < .01$.

## 8. Conclusion

This paper studied the relationship between exposure to fast food and adolescent BMI using the BCS and historical data relating to the inception of fast food in Great Britain. The data on the timing of establishment and location of all fast food outlets prior to 1986 allowed us to investigate whether fast food proximity, duration since opening, as well as a generated intensity measure taking into account the proximity and durations of multiple outlets, affects BMI. We do not find any evidence of a positive association between numerous measures of exposure in the home environment and adolescent BMI. This study has filled a gap in the existing literature which has mostly focused on the distance to ever-present fast food restaurants using American data.

Our results are robust to instrumenting for the distance to one's closest fast food outlet with the distance to a fast food distribution centre. Additionally, one company, Wimpy, suddenly increased its number of fast food outlets which did not allow for a strategic timing and citing of their outlets. Restricting the analysis to Wimpy outlets confirms the zero results. The lack of a relationship is supported by previous research, see; Anderson and Matsa (2011); Fraser et al. (2012); Lee (2012); Dunn et al. (2012) and Asirvatham et al. (2019).

There are several potential explanations for our null findings. Firstly, the effect may be highly context specific, see Dunn (2010); Anderson and Matsa (2011); Dunn et al. (2012); Grier and Davis (2013). Adolescents may have less control over food choices in their home environment compared to their school environment. Our findings might differ from studies using American data where fast food is eaten more frequently than in the UK (Fraser et al., 2012). In fact, our analysis does not find support of fast food proximity having a meaningful impact on the frequency of takeaway consumption. Alternatively, the time period of our study may not translate to large effects on obesity as only a small proportion of our sample was exposed to fast food very near their home, particularly at younger ages. Specifically, the lack of weight gain during our study period may be explained by fast food being a novelty or not being comparably cheap relative to other foods as they are today which may cause different consumption patterns (Wiggins et al., 2015). Moreover, it is uncertain how well diets and caloric expenditure during the 1980′s compare to current levels and how this may interact with access to different size and scope of fast food establishments. Additionally, the population studied might not have a large propensity to gain weight if exposed to fast food given that positive effects have been found for specific sub-groups such as ethnic minority urban youth (Currie et al., 2010; Grier and Davis, 2013) and youth living in the poorest and one of the least healthy American states (Alviola et al., 2014). Our reduced sample size does not permit a heterogeneity analysis.

We contribute to the existing literature, often based on data for smaller geographical areas, by using nationwide data. Our results are based on the sample of BCS respondents who did not relocate in the last 6 years and for whom anthropometric and postcode information is available. However, it should be noted that this population could differ from the overall nationally representative sample. Various types of food outlets have been shown to cluster together (Hobbs et al., 2019a). Therefore, a limitation is that we are unable model the direct effects of community determinants of body weight, such as the commercial food environment or access to exercise inducing spaces, due to limited area-level information in the BCS and the lack of supplementary historical data. Furthermore, our small sample size and rich set of controls does not allow us to control for local area fixed effects.

Keeping these caveats in mind, there is no evidence of that the introduction of fast food induced any behavioural change which resulted in weight gain amongst adolescents in the UK in the 1980s. Our overall findings are supported by there being a decrease in total calories purchased since this time period (Griffith et al., 2016). Thus, we suggest that it is unlikely that the access to fast food caused the start of the British obesity epidemic. Half of local government areas in England have enacted policies to curb takeaway food outlets which for example restrict new outlets from opening in designated exclusion zones around places used by children (Keeble et al., 2019). However, despite such policies being common, there is a scarcity of literature evaluating these effects besides Sturm and Hattori (2015) which showed that zoning interventions do not deliver the expected results (Keeble et al., 2019). Thus, our paper supplements the evidence base regarding the lack of a relationship between a changing access to fast food and childhood and adolescent obesity which suggests that complementary interventions need to be considered.

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[5] Given that some area level characteristics are related to the availability of fast food outlets in 1981, we also generate area-level socio-economic covariates using the BCS data. Controlling for the percentage of non-European populations and a slightly modified Townsend index at the LEA level, where we use fathers' unemployment status as a proxy for the unemployed individuals over age 16, does not change our conclusions. Results are available upon requests.

## CRediT authorship contribution statement

**Wiktoria Tafesse:** Methodology, Formal analysis, Software, Validation, Investigation, Resources, Data curation, Visualisation, writing. **Peter Dolton:** Conceptualization, Methodology, Formal analysis, Investigation, Resources, Data curation, writing, Supervision, writing.

## Declaration of Interest statement

None.

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## Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.ehb.2022.101153.

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