Fast Food and Childhood Obesity

Evidence from Great Britain

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Abstract

We study whether proximity to fast food restaurants affects childhood obesity. We use the UK Millennium Cohort Study - a nationally representative, longitudinal study - linked with highly granular geocoded food outlet data to measure the availability of fast foods around children's homes and schools from ages 7 to 14. We find, for certain children, in particular those with maternal education below degree level and those with lower self-regulation, that living near fast food restaurants is associated with increased Body Mass Index.

I. Introduction

In recent decades, we have witnessed a surge in childhood obesity. In the UK, there is evidence that younger generations are at much higher risk of obesity, with the probability of being overweight 2-3 times higher for children born after the 1980s than before (Johnson et al., 2015). Similar trends have been observed in the US since the 1980s (Flegal and Troiano, 2000). Increasingly, the burden falls disproportionately on those from low-income backgrounds (White et al., 2016), a reversal in trends from previous generations spanning the 1940s through the 1970s, when lower socioeconomic position tended to be associated with lower weights in the UK (Bann et al., 2018).

Meanwhile, the fast food retail industry in the UK has seen a major expansion in recent decades. Fast food restaurants – including chip shops, burger bars and pizzerias – account for more than a quarter (26%) of all eateries in England (BBC, 2018, Cummins et al., 2005, Fraser et al., 2012c)[1] – similar to the US (Walker et al., 2010). Global fast food industry market size estimates show a similar upward trend (IBISWorld, 2021, Eurostat, 2021). Alongside growth in the fast food industry, the prevalence of obesity among children born over the past two decades has been rising in the UK. These parallel trends are shown in Figure 1, which is based on nationally representative data from the Millennium Cohort Study (MCS). The Figure shows the growth in fast food restaurants around participants' residences and schools between 2008 and 2015, alongside an increasing trend in their standardized BMI. There is also evidence that socioeconomic inequalities in takeaway food outlet density have increased over time (Maguire et al., 2015), as have inequalities in childhood obesity (Bann et al., 2018).

[1] In 2018, the BBC Shared Data Unit reported a 34% increase in fast food outlets from 2010 to 2018 in the UK, and an increase in the average number of fast food outlets per 100,000 people from 47 in 2010 to 61 by 2018 (BBC, 2018) Figures from Public Health England (PHE) reveal England's poorest areas have 5 times more fast food outlets than the most affluent (PHE, 2018).

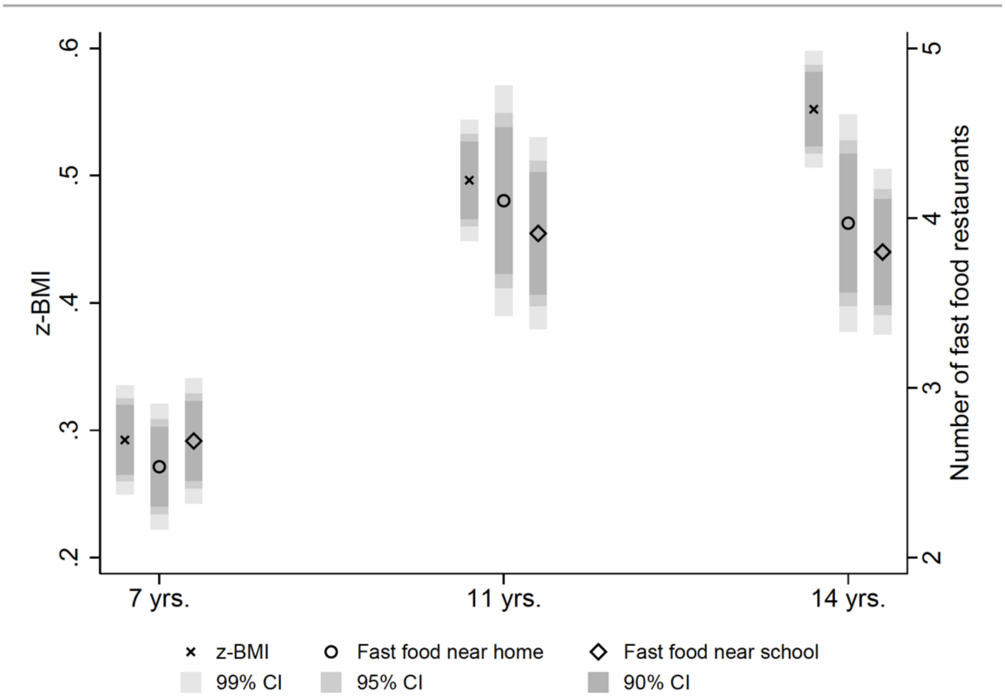

Figure 1. Trends in Fast Food restaurants and z-BMI during childhood.

Notes: The circles (diamonds) indicate the average number of fast food restaurant around MCS individuals' residences (schools) at ages 7, 11 and 14. The figure plots the number of fast food restaurants within 1,600 metres network-based buffers as defined in section II. The X indicate the average BMI standardized scores. We standardized individuals' BMI by age and sex using the 1990 UK Growth Reference (Cole et al., 1995). Grey bars show confidence intervals at 99, 95 and 90 per cent significance levels using MCS survey design and longitudinal weights.

These parallel trends in obesity and fast food availability by socioeconomic status may of course be entirely unrelated. Associations between them may reflect socioeconomic deprivation, for instance, rather than the presence of fast food restaurants, so associations based on cross-sectional data – which constitute the vast majority of the empirical evidence to date (Cobb et al., 2015, Feng et al., 2010, Fraser et al., 2012b, Harrison et al., 2011, Maguire et al., 2015, Mason et al., 2018, Snowdon, 2018, Walker et al., 2010, Williams et al., 2013) – must be interpreted cautiously. To our knowledge there are just a few papers that attempt to estimate causal relationships, and these are mostly confined to specific regions in the US (Alviola et al., 2014, Anderson and Matsa, 2011, Asirvatham et al., 2019, Currie et al., 2010, Davis and Carpenter, 2009, Dunn, 2010, Dunn et al., 2012, Powell, 2009, Qian et al., 2017). The majority of the evidence focuses on the availability of fast food restaurants around schools, and far less on children's homes. The general finding from these papers is that the impact of fast food restaurants is significant but relatively small, suggesting fast food restaurants play some, albeit limited, role in the evolution of childhood obesity.

In this literature, there remains little evidence on the behavioural mechanisms that may be driving a relationship between fast food availability and childhood obesity. Changes in the food environment may, for instance, induce positive or negative changes in other health-related behaviours (physical activity or dietary quality) and/or may result in a range of other dietary substitutions to compensate for increased fast food. Understanding the mechanisms at play is of course vital for appropriate policy response. Identifying children most at risk is equally important for policy targeting, and a key outstanding question is whether certain individuals are more or less vulnerable to increased fast food availability. Whilst there is some evidence that those from more disadvantaged backgrounds are at higher risk (Bann et al., 2018), we know far less on the extent to which personal characteristics such as the ability to self-regulate – a known correlate of other risky behaviours, such as drug abuse, binge drinking and eating disorders (Garland, 2018, Racine, 2018, Weiss et al., 2015) and a major determinant of other life outcomes such as labour market success (Pearce et al., 2016, Cunha and Heckman, 2007, Heckman et al., 2006, Kautz, 2014) - play a role in this context (Cawley, 2015). The paucity of good quality measures of health behaviours and personal characteristics/skills in administrative data has precluded exploration of this question.

In this paper, we first use a rich longitudinal data set linked with highly granular geographical data with the exact location of commercial and public facilities across Great Britain (the Ordnance Survey Point of Interest Dataset, hereon PoI), to study how school and residence proximity to fast food restaurants relates to the BMI of children. Second, we consider possible transmission mechanisms, including changes in diet and exercise. Finally, we explore heterogeneity in effects – by standard dimensions including sex and socioeconomic characteristics, along with the more novel domain of emotional regulation.

We use individual fixed effects (FE) to account for omitted individual variables, exploiting changes in fast food restaurants near MCS respondents' homes and schools over time. We create even more precise road network-based buffers than in the previous literature (Bivoltsis et al., 2018) and choose three levels of proximity: 400 meters, 800 meters and 1,600 meters, as all roughly within reasonable walking distance (Wilkins et al., 2019b). The detailed longitudinal data in the MCS together with the granular and rich geographical information in the PoI data, allows us to control for proximity to other food environments, as well as time-varying individual and time-varying area characteristics.

We find that an increase in the supply of fast food restaurants around individuals' homes results in increased BMI. A one standard deviation increase in the number of fast food restaurants within 1,600 metres home-buffer, i.e., around a 20-minute walking distance, increases BMI by 1.0% above the sample mean. We show that the effect size decrease as distance increases – the further away from homes a fast food restaurant is located, the lower the effect on obesity – consistent with increased transportation costs faced by consumers. We find a similar pattern near individuals' schools – within the 1,600 metres buffer, a one standard deviation increase in fast food restaurants increases BMI by 0.1 points, a 0.5% increase over the sample mean, and a similar effect of 0.6% is found for the 800 metres buffer. However, for schools, we find that it is closer proximity – within 400-800 metres – that is driving the detrimental effect on children's BMI. Results are similar when we look at other anthropometric measures such as body fat, weight, BMI standardized scores, overweight and obesity.

While the effect on the overall sample is fairly low and consistent with what other studies have found, our data allow us to provide novel evidence of the heterogeneous effect of fast food restaurants at the individual level, which is an important advance on previous studies that use school-level administrative data. We find that the effects of one standard deviation increase in the 1,600 meters home-buffer are almost doubled among the low educated, rising to 1.7%. Around the 1,600 meters school-buffer, it rises to 2%, which is 3.7 times larger. This evidence suggests that access to fast food could play a role in exacerbating socioeconomic disparities in childhood obesity in the UK. Additionally, we evaluate heterogeneity by children's emotional development owing to its important role in a wide range of lifetime outcomes (Kautz, 2014). We explore the impact of fast food restaurants among individuals with higher levels of emotional dysregulation, which has been shown to predict excess weight gain and obesity among adolescents (Kelly, 2016, Limbers and Summers, 2021, Graziano et al., 2010). Using the emotional dysregulation sub-scale of the Child Social Behaviours Questionnaire at age 7 (Sylva et al., 2004, Hogan et al., 1992) and fast food exposure around the 1,600 meters home-buffer, we document a differential positive effect on BMI for participants with lower emotional regulation of 1.8% with respect to the sample mean. We find similar results, for the 1,600 meters school-buffer, although less precisely estimated.

Whilst we cannot rule out completely that our results are in part driven by unobserved changes in demand for fast food, as opposed to changes in the supply of fast food, we provide several pieces of evidence to suggest this is not the case. First, we show that our results are robust to controlling for a large number of individual time-varying variables, such as the availability of other food outlets and socioeconomic characteristics known to be linked with childhood obesity. They are also robust to controlling for area-level time-varying economic conditions that may affect trends in the fast food markets. Second, we show that our results are not due to residential sorting, omitted variable bias, or measurement error. In addition, our results are robust to the inclusion of additional individual time-varying markers of childhood obesity (i.e., breakfast consumption, physical activity, and mode of transport from home to school), as well as to changes in the definition of fast food restaurants. In addition, we perform a falsification tests and document that the increase in the availability of stores that we argue should not be associated with BMI, e.g., construction services or employment agencies, does not affect respondents' obesity. Together, this evidence suggests that selection on unobservables is unlikely to be an issue and allays concerns around selection of fast food outlets on the basis of demographic characteristics.

We explore two potential mechanisms that may explain how the availability of fast food restaurants increase BMI: individual's diet and physical activity. First, using respondent's consumption of fruits, breakfast, and sweetened drinks to proxy changes in dietary quality, we find null effects of fast food availability on these measurements. Further, we evaluate whether fast food restaurant availability impacts on the take-up of meals provided by schools, which meet quality nutrition standards, again finding no impact. Second, we find that an increase in the availability of fast food restaurants does not induce compensatory behaviours in physical activity.

We contribute to the literature on fast food access and childhood obesity in several ways. First, in a different context and using a nationally representative sample, we reinforce findings from previous research based mainly in the US that documents that fast food availability near schools significantly affect child and adolescent obesity (Alviola et al., 2014, Asirvatham et al., 2019, Currie et al., 2010, Davis and Carpenter, 2009). We also confirm the findings of Qian et al. (2017) by showing that children's exposure to fast food near home contributes to higher BMI standardized scores. Our paper provides among the very first evidence for Great Britain, adding to evidence based mainly on the US, and specifically California (Currie et al., 2010, Dunn, 2010) and Arkansas (Alviola et al., 2014, Asirvatham et al., 2019, Qian et al., 2017, Zeng et al., 2019). Moreover, in using a nationally representative longitudinal sample of children born across Great Britain at the turn of the millennium, we are able to estimate individual fixed effects and evaluate changes in BMI and other anthropometric measures over time. With the exception of Asirvatham et al. (2019) and Qian et al. (2017) - which use student-level longitudinal data in Arkansas - much of the previous literature has been based analysis on school-level cross-sectional administrative data.

Second, our study is one of the first to probe the extent to which the small estimated effect of fast food availability on BMI may reflect compensatory behaviours, by evaluating the extent to which health behaviours including diet and exercise are impacted upon. In showing that such behaviours are unlikely to be at play, we provide evidence for policy to suggest that targeting fast food availability is likely to play only a limited role in efforts to reduce childhood obesity, and a much broader approach is called for.

Third, our novel findings that the impact of fast food restaurants is higher for those with lower levels of emotional regulation is consistent with the work of Allcott et al (2019), who suggest that demand factors are more important in driving nutritional inequalities than any supply-side factors. One such factor determining the demand for healthy behaviours, including drug intake and food consumption, is the ability to regulate emotions. In providing evidence that this is a relevant factor in determining the weight inequalities we observe, our paper provides new insights into the ongoing discussion around geographical nutritional disparities in the 'food deserts' literature (Allcott et al., 2019, Bitler and Haider, 2011).

Fourth, our measure of access to fast food restaurants, which uses road-based network buffers, is a major improvement on the more commonly used measure of radial distance or arbitrarily defined geographic regions (Alviola et al., 2014, Qian et al., 2017, Zeng et al., 2019). In using the transport network to take into account the geographical characteristics around schools and residences (Wilkins et al., 2017, Wilkins et al., 2019b), we can create local food environments for each individual, which are considerably more accurate and prevent one from falling into the ecological fallacy – i.e., when inference about individuals is deduced from inference from arbitrarily defined geographic units (e.g., ZIP codes) (Chen et al., 2013).

A fifth contribution is that, unlike previous studies which consider proximity of fast food restaurants to either schools or homes, our study considers both. In this way we can provide a more complete picture of the obesogenic environment facing young people and can compare effects across both types of exposure. Studies that focus on the impact of fast food restaurants near schools on childhood obesity find positive and relatively small effects (Alviola et al., 2014, Asirvatham et al., 2019, Currie et al., 2010, Davis and Carpenter, 2009, Zeng et al., 2019), which are similar to the positive effects found for fast food restaurants near homes (Qian et al., 2017).

Finally, we contribute to the literature by providing evidence on body fat alongside measured BMI, which together present a much better measure of adiposity (Nuttall, 2015), and we believe this is the first study addressing this question to do so.

The paper is organised as follows. In section II, we describe data and present summary statistics. Section III present our methodology and identification strategy. We present our results in section IV and conclude in section V.

II. Data and Summary Statistics

Our analysis uses rich longitudinal data from a nationally representative birth cohort, the Millennium Cohort Study (MCS), combined with highly granular geographical data from the Ordnance Survey Points of Interest (PoI) and Ordnance Survey Integrated Transport Network (ITN). We combine these data to create measures of the number of fast food and other retail food establishments within 400, 800, and 1600 metres network buffer zones around each respondent's home and school postcodes.

A. MCS

The MCS is a longitudinal study following the lives of a nationally representative sample of 19,244 families with children born between 2000 and early 2002 in the UK (Joshi and Fitzsimons, 2016). Starting when children were 9 months old, and subsequently, at ages 3, 5, 7, 11, 14 and 17[2], the MCS collects extensive information on respondents and their families, including parental education; employment and income; housing; family structure; ethnicity; physical and mental health, and health behaviours; cognitive and physical development, among many other characteristics.

We focus our analysis on body mass index (BMI), but also present evidence for percentage of body fat and other anthropometric variables because together they provide

[2] The MCS 17 survey was not available at the time of conducting the analysis.

a more accurate picture of adiposity (Nuttall, 2015).[3] Since age 3, respondents' weight and height have been measured in the home by trained interviewers, and the percentage of body fat has also been measured at ages 7, 11 and 14. BMI is calculated by dividing weight in kilograms by squared height in metres. Height was measured using Leicester height stadiometers[4] and recorded to the nearest completed millimetre. Weight and body fat measurements were taken using Tanita BF-522W scales, which calculate weight to the nearest 0.1kg, and body fat percentage to the nearest 0.1%. The percentage of body fat was calculated measuring the amount of resistance encountered by a weak electrical current as it travels through the body (Chaplin Grey et al., 2010).

B. Ordnance Survey Point of Interest (PoI)

The PoI data contains geocoded information on over 4 million commercial and public facilities across Great Britain, and is available annually from 2005 - 2013, and quarterly from September 2014 (OS, 2015). Each facility is geocoded by the data collector and assigned to one of around 600 classes, which in turn are further classified into larger categories and groups, resulting in an extremely rich and granular data set.[5] We obtained PoI data using an educational licence and used ArcGIS 10.4 to create areas around respondents' residences and schools.

PoI has a high level of correspondence with street level audits, which are regarded as the gold standard for spatial data (Wilkins et al., 2017). It is a validated[6] dataset with high spatial and count accuracy, especially post-2010[7], and has been used regularly in UK

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[3] In Online Appendix A we show results for BMI standardized scores, percentage of body fat, weight, overweight and obese. We standardized respondent's BMI by age and sex using the 1990 UK Growth Reference (Cole et al., 1995).

[4] A Leicester height stadiometer is a foldable device with a sliding head plate, a base plate and four connecting rods marked with a measuring scale.

[5] In Online Appendix B we show the PoI categories used in this study.

[6] Using detailed data for the county of Cambridgeshire, UK, Burgoine and Harrison (2013) validated the PoI data, concluding that PoI is a viable alternative to measure obesogenic environments.

[7] Due to a change of supplier in late 2010, which resulted in improved data collection and classification methods, there is some difference in raw category counts in pre- and post-2010 PoI data. For example, Cummins et al. (2005) used the Yellow Pages to identify every listing for

Retail Food Environment (RFE) research (Skidmore et al., 2010, Harrison et al., 2011, Jennings et al., 2011, Fraser et al., 2012a, Cetateanu and Jones, 2014, Burgoine et al., 2017). We extract data on food outlets from this database, following previous work, to characterize obesogenic environments (Cetateanu and Jones, 2014, Jennings et al., 2011, PHE, 2016, PHE, 2017, Skidmore et al., 2010). We describe this in detail in section D.

C. Ordnance Survey Integrated Transport Network (ITN)

The ITN dataset is a snapshot of the entire road network of Great Britain, which contains road-routing information, including one-way streets, banned turns, and access restrictions. ITN data are available from 1997 onwards, on an annual or biannual basis.[8] We use the ITN dataset around each respondent's home and school locations to construct areas that consider how the road network restricts individual's travel, i.e., road network-based buffers. These highly local irregular buffers, as opposed to areas defined by administrative boundaries, which have been extensively used in the fast food literature, better characterize the respondent's neighbourhood considering that individuals often cross administrative boundaries for food (Charreire et al., 2010). Specifically, we use the postcode centroid of the address at interview at each sweep, and the postcode centroid of the school they were attending at each sweep.[9] Whilst the majority of previous research studying the impact of food environments on obesity used Euclidean distance to construct buffers (Wilkins et al., 2017), road network-based buffers are considered to be more accurate because they better characterize the influence of the built environment on individuals (Bivoltsis et al., 2018, Charreire et al., 2010).

McDonald's, finding 942 in January 2005. In the September 2005 PoI dataset, there are 850 McDonald's outlets.

[8] ITN data are available from Edina Digimap on a non-regular basis -i.e. 1 - 3 times per year- from February 2007.

[9] Postcodes are the smallest geographical administrative area in the UK. There are around 1.8 million postcodes, and they could contain between 1-300 addresses with an average of 15 addresses per postcode. Since schools generally comprise a single unit postcode, school locations are generally located more accurately than homes.

D. Classification of fast food and other outlets

We use PoI data from Septembers of 2008, 2012 and 2015, along with ITN data from October 2008, June 2012, and June 2015. These years overlap with the age 7, 11 and 14 sweeps of the MCS. To characterize obesogenic environments across time and locations we count the number of fast food restaurants and other food outlets within road network-based buffers around respondents' schools and residences.

We use GIS to construct 400, 800, and 1600 metres road network-based buffers. Although there is still little theoretical or empirical consensus on the appropriate size of neighbourhoods (Boone-Heinonen and Gordon-Larsen, 2012), buffer sizes of 400, 800, and 1600 metres are the most prevalent in RFE research (Wilkins et al., 2019b), since they equate to an average person's 5-minute, 10-minute, and 20-minute walking distance.

One particularly challenging issue in the economic, epidemiological, and geographical literature is the classification of food outlets. The systematic review of Wilkins et al. (2019b) found that nearly half of the studies they analysed did not provide a clear definition of how they constructed their food outlets categories. In the absence of any standardised food classification schemas (Block et al., 2018), some research, all US-based, has categorised fast-food outlets based on the biggest/most popular national chains (e.g. Alviola et al., 2014, Currie et al., 2010, Davis and Carpenter, 2009, Dunn, 2010, Dunn et al., 2012, Qian et al., 2017, Zeng et al., 2019). UK work tends to use PoI categories such as 'Fast food and takeaway outlets' and 'Fast food and delivery services' (Cetateanu and Jones, 2014), but other classifications based only on popularity and geographic presence have also been used (Robinson et al., 2018). Others use country specific industry codes – for example Ohri-Vachaspati et al. (2011) create food outlets categories reclassifying the North American Industry Classification System. In addition, although it is widely agreed that some foods are less healthy than others, classifying food retailers according to their 'healthfulness' is not a straightforward procedure (Pinho et al., 2019). For example, even though supermarkets are usually considered to be a source of healthy foods (Woodruff et al., 2018), they also offer a wide range of sugar-saturated beverages and snack foods. Correspondingly, many major fast food restaurants also offer healthier choices (Mahendra et al., 2017).

For the purpose of this study, relying only on the 'Fast food and takeaway outlets' and 'Fast food and delivery services' categories of the PoI data to evaluate changes over time is challenging because some major fast food chains were not appropriately included in these categories before 2010.[10] To avoids any possible inconsistencies in the classification of fast food restaurants between data collected before and after 2010, our definition of fast food restaurants combine both classification schemes used in the previous literate: biggest/most popular fast food chains and food categories in PoI data that were consistently recorded over time. We first included the major fast food restaurants in the UK (based on Robinson et al., 2018, Wilkins et al., 2019a): McDonalds, KFC, Burger King, Wimpy, Subway, Pizza Hut, and Dominos' Pizza.[11] These are identified straightforwardly using the name of the outlet recorded in the PoI data. We also included fish and chips shops, a common take-away food in the UK, identified using the available category in the PoI data, and kebab and chicken outlets, identified by looking at restaurants that have been classified as food outlets and that contain the words 'Kebab' and/or 'Chicken' in its commercial name. The decision to include fish and chips, and kebab and chicken outlets is largely driven by a combination of context and content: as salient fast food types across the UK, they provide highly calorific and processed meals (Jaworowska et al., 2014). Fish and chips shops and chicken outlets have been classified

[10] For instance, when we consider the following list of fast food chains: McDonalds, KFC, Burger King, Wimpy, Subway, Pizza Hut, and Dominos' Pizza, we find that 25.9% (n=619) of fast food chains around 1600 metres from respondent's residence at age 7 were not included in categories 'Fast food and takeaway outlets' or 'Fast food and delivery services'.

[11] Wilkins et al., (2019a) evaluated three definitions of fast food outlets: Narrow, Moderate and Broad. In their Narrow definition, they included, in addition to these major chains, the following outlets: Dixie Chicken, Chicken Cottage, Papa John's, Southern Fried Chicken (SFC), Five Guys, Harry Ramsdens, and Little Chef. Their Moderate definition adds outlets serving burgers, kebabs, fried chicken, fish and chips, pizza, Indian and Chinese outlets. Their Broad definition further adds takeaway cafes, retail bakeries and chain coffee shops (e.g., Starbucks). Our definition is closer to the Moderate definition in Wilkins et al., (2019a). It is found to be provide major agreements in statistical significance of finding in the cross-sectional association with BMI than the Narrow definition of fast food outlets. We show in Section B.3 and Tables A14 and A15 in Online Appendix that our results are not driven by changes in the definition of fast food outlets.

as unhealthy outlets previously in the literature (Cetateanu and Jones, 2014, Wilkins et al., 2019a). In 2006, the UK's Food Standards Agency (FSA) found that 18.5% of doner kebabs constitute a "significant" threat to public health (FSA, 2006), while in 2009, another study, which sampled 494 kebabs in the UK and classified its nutritional content using the FSA traffic light system for pre-packed food, found that 97%, 98% and 96% of kebabs would be 'red' for its fat, saturates fat, and salt content, respectively (LACORS, 2009).[12]

We also measure the availability of other food outlets, using the other food facilities available in the PoI data, as the availability of both healthy and unhealthy food has been found to be associated with dietary habits and BMI in cross-sectional analyses (Burgoine et al., 2014, Fraser et al., 2012b, Hobbs et al., 2019). Moreover, controlling for other food facilities around individuals' schools and residences is likely a good proxy for neighbourhood characteristics that are correlated with factors that both contribute to obesity and to the presence of fast food restaurants (Currie et al., 2010). Our definition of other food facilities includes: restaurants, butchers, confectioners, delicatessens, fishmongers, green and new age goods, grocers, farm shops and pick your own, organic and health foods, gourmet and kosher foods, convenience stores and independent supermarkets, and supermarket chains, other take away outlets. Together, our definitions of fast food and other food outlets include of all food outlets around respondents' residences and schools.

III. Methodology

Our objective is to estimate the causal effect of fast food restaurant availability on individuals' BMI. We provide results for additional anthropometric variables – body fat, weight, BMI standardized scores, overweight and obese – in Table A4 of Online Appendix A. We estimate two empirical models:

$$Y_{it} = \beta^k F_{it}^{\mathrm{k}} + \boldsymbol{X}_{it}^{'}\rho^k + \boldsymbol{Z}_{at}^{'}\delta^k + \alpha_i^k + \eta_t^k + \varepsilon_{it}^k \quad (1)$$

[12] The authors found that "the average kebab provides men (women) with 66% (89%) of their Guideline Daily Amount (GDA) of fat, 98% (148%) of their GDA for saturated fats and 98% (98%) of the GDA for salt".

where Y_{it} is the BMI of individual i at ages t=7, 11 and 14. In model (1), F_{it}^{k} is the number of fast food restaurants within distance k of respondent i's location at age t. We estimate the models separately for home and school locations, and we run three separate specifications for each – for k=400, 800, and 1600 metres. α_i^k is an individual fixed effect and η_t^k is a year of survey fixed effect. $\boldsymbol{X}_{it}^{'}$ includes a range of socioeconomic characteristics of individuals' families, including six dummies indicating the maternal highest educational level at the time of interview[13], the number of parents in the household, family income at time of interview, the number of people in the household excluding the individual, the number of rooms in the household, two dummies indicating household tenure and individual's age and age squared. $\boldsymbol{Z}_{at}^{'}$ includes the local authority district[14] unemployment rate and population estimates per 100,000 people to control for time-varying economic conditions that can potentially affect the circumstances of fast food industry and can be associated childhood weight. ε_{it}^{k} is a disturbance error assumed to be independent and identically distributed. Our key parameter of interest in (1) is β^k.

In order to study how the effect differs as the buffer expands, the second equation we estimate is

$$Y_{it} = \gamma_1 F_{it}^{400} + \gamma_2 F_{it}^{800} + \gamma_3 F_{it}^{1600} + \boldsymbol{X}_{it}^{'}\rho + \boldsymbol{Z}_{at}^{'}\delta + \alpha_i + \eta_t + \varepsilon_{it} \qquad (2)$$

In (2), F_{it}^{400}, F_{it}^{800}, and F_{it}^{1600} denote the number of fast food restaurants within a 400 metres buffer of the individual i's location at age t, between 400 and 800 metres, and

[13] The education level categories correspond to none, National Vocational Qualification (NVQ) levels from 1 to 5, and overseas qualification only. NVQ levels rank an individual's qualification by difficulty. For example, NVQ 1-3 levels include different levels of High School certificates and qualifications; NVQ 4 level includes bachelor's degrees, graduate certificates, and other higher education diplomas; and NVQ 5 level includes master's degrees, Postgraduate certificates/diplomas and Doctorate degrees.

[14] Local authority districts are sub-national areas used for purposes of local governments in the UK. There are 379 local authority districts in the UK, with a population average in 2016 of around 173,000 people ranging from 2,300 to 1,128,000 people.

between 800 and 1600 metres, respectively. Our key parameters of interest are γ_1, γ_2, and γ_3.

To allow for the possibility that the availability of food outlets other than fast foods may affect individual weight, the $\boldsymbol{X}_{it}^{'}$ vector also includes the number of other food outlets as described previously.[15] In addition, the inclusion of other food outlets around individuals' residences and schools helps mitigate the influence of local neighbourhood characteristics that are unobserved but that may be correlated both with the availability of fast food and with unobserved factors that contribute to childhood obesity. We cluster standard errors at the individual level, and estimates are weighted to account for attrition, using inverse probability weights, and survey design (Solon et al., 2015).

The effect of fast food availability on individual's BMI is identified by changes in the number of fast food restaurants over time. The identification assumption is that, conditional on individual fixed effects, year of survey dummies, and time-varying controls, no time-varying unobserved variables are systematically correlated both with changes in BMI and changes in the number of fast food restaurants, which we probe more extensively in the latter part of section IV.

IV. Results

We first provide summary statistics pertaining to the sample, then present our main results and an analysis of the plausibility of our identification strategy. We also explore heterogeneity in effects, showing estimates for different subsamples, and discuss potential mechanisms that may be at play. Finally, we present a series of robustness checks and falsification tests for our main specification.

A. Summary Statistics

We base our analysis on MCS respondents who were interviewed at ages 7, 11 and 14, including only those with valid measurements of BMI and body fat percentage through

[15] In Online Appendix B we describe the other food outlets used in our main specification.

this period (92% of MCS respondents). We exclude children living in Northern Ireland, for whom PoI data is not available. Our analytical sample includes 8,253 individuals. Table 1 presents the mean and standard deviation of child obesity across time in the sample.[16] We estimate that around 18% of 7 year old individuals were overweight with an average BMI of 16.4, and with 20.7% of body fat. Four years later, the percentage of individuals overweight and the percent of body fat increased to 25.7% and 22.0%, respectively. From ages 11 to 14, the percent of body fat and overweight remained stable despite the slightly increase in BMI from 19.1 to 21.4.

Tables A1 and A2 in the Online Appendix A present the average number of fast food restaurants and other food outlets around individuals' residences and schools across time. Several interesting facts emerge. First, we observe an increase over time in the number of fast food restaurants around individuals' homes and schools: at age 7, children in our sample had an average of 2.5 fast food restaurants within 1600 metres of home, while 7 years later the number had increased by around 60%, to 4. This trend is also observed in relation to individuals' schools, where fast food restaurants within 1600 metres increased by over 40% during this period, from 2.7 to 3.8. Second, we note that the increase in the number of fast food restaurants around individuals' home and schools is higher between ages 7 and 11, than between ages 11 and 14. Third, not only is the number of fast food restaurants increasing during this period, but so too are other food facilities. On average, at age 7 there were around 20.1 (21.5) other food facilities within 1600 metres of individuals' homes (schools). By age 14, these numbers had increased by 46.3% (40.9%).

Table 2 shows descriptive statistics for the overall analytical sample, and by distance from home (or school) to fast food restaurants. It shows that around 67.8% (71.8%) of individuals have lived (attended school) within 1600 metres, or 1 mile, of fast food restaurants during the analytic period. It also shows that with a few exceptions – as one would expect given large range of covarietes – child and family characteristics do not vary significantly by proximity to fast food restaurants.

[16] We use the International Obesity Task Force (IOTF) cutoffs (Cole et al., 2000).

B. Benchmark estimates: The impact of fast food restaurants on individuals' BMI

We start our analysis by estimating equations (1) and (2) separately for individuals' homes and schools. Table 3 presents our preferred within-individual estimates that capture whether changes in individuals' BMI are affected by changes in the number of fast food restaurants around individuals' homes and schools. We show cross-sectional estimates for BMI and other anthropometric measures in Table A3 of Online Appendix A. Columns 1 and 5 show the results around homes and schools for a specification that includes only year of survey and individual fixed effects. Overall, the results show that the impact of an additional fast food restaurant within 1,600 metres from respondents' homes on BMI is positive and significant. We also find an increased number of fast food restaurants around individuals' schools increases BMI, mainly driven by the 800 metre buffer. The positive association between the number of fast food restaurants around homes and schools on BMI is robust to the inclusion of the number of other food outlets (columns 2 and 6), time-varying individual controls (columns 3 and 7), and local authority district controls (columns 4 and 8). We find similar results when we use as outcomes the percentage of body fat, weight in kilograms and BMI standardized scores (Table A4 in Online Appendix A).

Looking more closely at the estimates, and first at those pertaining to proximity of fast foods in relation to homes (columns 1-4 in Panel A of Table 3), we find that an additional fast food restaurant within 1600 metres, from ages 7 to 14, increases respondents' BMI by 0.036 points, which represents a 0.2% (=0.04/18.95 $\times$100) increase over the sample mean of 18.95. The estimates are a little larger when we focus on fast food restaurants within 800 metres, with an increase of 0.3% (=(0.06/18.95) $\times$100) with respect the sample mean. We find that the size of the estimates decrease as the buffer radius increases, consistent with higher transportation and psychological costs faced by individuals (Currie et al., 2010). Results around individuals' schools (columns 5-8 in Panel A of Table 3) show a similar pattern but are slightly larger, with an additional fast food restaurant within 1600 (800) metres increasing BMI by 0.5% (0.6%) over the sample mean.

Estimates from equation (2) in Panel B show that the impact around individuals' residences is likely driven by the increase in fast food restaurants between 800-1600 metres (column 4). Although point estimates within 400 meters and between 400-800 metres are relatively larger than 800-1600 metres, they are less precisely estimated. Interestingly, we see that findings around individuals' school are mainly driven by increases in fast food restaurants between 400-800 metres (column 8). This evidence suggests that close proximity of fast food restaurants to schools seems to be more detrimental than to homes.

In terms of the magnitude of the associations, our main specification that shows an additional fast food restaurant – respectively – within 400, 800, and 1600 metres of individuals' homes increase BMI by 0.10, 0.06, 0.04 points, translates into a gain of 344, 157, and 86 grams during the period under consideration. Expressed in standardized BMI scores, these estimates are 0.029, 0.018, and 0.008, respectively (see column 3 in Table A4 of Online Appendix A), with the last two statistically significant at the 5% and 10% level. To compare these to existing estimates, Qian et al. (2017), using a similar student fixed effect model but over a sample of movers in Arkansas, found that the effect of an additional fast food restaurant within 1,600 metres of the child's residence on BMI standardized scores was 0.0019. In contrast, Asirvatham et al. (2019) find null effects in a similar specification. Previous studies, that focus on obesity rates using school-level data in Arkansas and instrumental variable methods, find that an additional fast food restaurant within 1,600 metres increases the obesity rate by 1.23% (Alviola et al., 2014) and 1.22% (Qian et al., 2017). As a comparison, in the same 1,600 metres buffer around schools, we find an increase of 0.2 percentage points in obesity, a 3.4% with respect to a sample rate of 5.8.[17]

Cross-sectional estimates in Table A3 of Online Appendix A show a positive and significant association between fast food restaurants around home and schools and

[17] Note that comparing point estimates between studies is challenging since we are not using the same methods in the identification strategy; however, we find the comparison useful to evaluate the magnitude of our point estimates.

individuals' BMI (columns 1 and 7). We find similar positive and significant association for other anthropometric measures such as percentage of body fat, weight, BMI standardized scores, and two binary variables indicating whether the individual is overweight and obese. Overall, we find that cross-sectional estimates are higher than fixed effect estimates across different specifications, indicating the importance of adjusting for fixed unobserved confounders. In section E, we provide evidence in favour of our identification strategy.

C. Heterogeneity

Whilst the overall effect is fairly low, and consistent with other studies, a key question is whether this masks heterogeneity among different subgroups. We evaluate if the effect of fast food restaurants on BMI varies by sex and socioeconomic status, as well as by levels of emotional regulation. The latter has been shown to be associated with a host of risky behaviours and obesity among adolescents (Kelly, 2016, Limbers and Summers, 2021, Graziano et al., 2010), along with major domains of life including in employment and education (Kautz, 2014). To test this, we estimate equation (1) and interact our fast food restaurants and other food outlet variables with these characteristics. Columns 1-4 of Table 4 show estimates for the 1600 metres buffer around individual's home, and columns 5-7 present corresponding estimates around schools.

Sex: Previous research has documented sex-specific attitudes towards dietary behaviours, and differences in risk attitudes and behaviours have been observed between men and women (Eckel and Grossman, 2002). We do not find any differences in effects between male and females for fast food restaurants around homes (columns 1 in Table 4), but smaller (although less precisely estimated) effects for males than females around schools.

Socioeconomic status: Previous research in the UK and elsewhere portrays a very clear pattern of disparity in adolescent obesity by socioeconomic status (Bann et al., 2018), and so an important question, which has not been addressed by previous studies, is the extent to which the availability of fast food restaurants might exacerbate these inequalities. To shed light on this, we use a binary variable indicating maternal education level – specifically, whether the individual's mother has a degree or higher (47.7%) or not. We show that the impact of fast food restaurants on BMI is significant and almost twice as high among individuals whose mothers have lower education levels (columns 2 and 4 in Table 4), indicating that fast food exposure could exacerbate nutritional inequalities.

Self-regulation: We explore to what extent one's inability to regulate emotional responses, i.e., emotional dysregulation, could play a role in determining the impact of fast food restaurants on BMI. Emotional dysregulation involves, among other things, a lower capability to control impulsive behaviours and has been associated with adolescent obesity (Kelly, 2016, Limbers and Summers, 2021) and a range of risky behaviours such as substance use (Weiss et al., 2015, Garland, 2018), and mental illness including self-harm (Crowell, 2018) and eating disorders (Racine, 2018). Additionally, eating behaviours such as emotional eating, i.e., overeating in response to negative emotions, has been considered a marker of emotional dysregulation, and indeed one that could help in clinically screening early obesity diagnoses (Micanti et al., 2017).

To study this, we use the emotional dysregulation sub-scale of the Child Social Behaviours Questionnaire at age 7 (Sylva et al., 2004, Hogan et al., 1992). We first validate our measure of emotional dysregulation by analysing whether high levels of emotional dysregulation at age 7 predict fast food consumption at age 14, risk behaviours (smoking and drinking) at 14, patience at 14, and risk taking at 11. Fast food consumption is a binary variable that measures whether the individual eats fast food one or more days per week. We characterise smoking and drinking behaviours with a binary variable indicating if the individual has ever smoked or drank alcohol. We use the question 'How patient is the respondent?' to measure patience at age 14, a score ranging from 0 to 10, where 10 indicates that the highest level of patience. Risk taking at age 11 is measured using the risk taking score of the CANTAB Cambridge Gambling Task, where higher values indicate of greater risk taking (Atkinson, 2015). Table A16 in Online Appendix A shows OLS estimates for outcomes at age 11 and 14 as a function of respondents' emotional dysregulation at age 7, controlling for individual and local area variables at age 7. Results reveal a consistent pattern, whereby children with high emotional dysregulation at age 7 are more likely to eat fast food, more likely to have ever tried smoking, ever tried alcohol, more impatient, and more willing to take risk.

Having shown that the measure of emotional dysregulation predicts impatience, risk taking and risky behaviours during childhood, we next analyse whether the effect of fast food restaurants availability on BMI varies by emotional dysregulation. Results indicate that the effect is almost double for those with higher levels of emotional dysregulation, suggesting that proximity to fast foods is more detrimental for those with a lower ability to self-regulate. When we stratify the sample by low/high maternal education and low/high emotional regulation, we estimate that with respect to the BMI sample mean, the impact of a one standard deviation increase in fast food exposure is 1.7% (95% CI: 0.6, 2.9) larger for more at-risk participants (low maternal education and low emotional regulation) than less vulnerable participants (high maternal education and high emotional regulation).[18]

D. Possible transmission mechanisms

We have estimated the overall effect of fast food availability to be fairly low, but significantly larger among participants whose mothers have lower education levels and who themselves have lower levels of emotional regulation. A key question for policy is whether this reflects compensatory behaviours, which is what we next explore. In particular, we analyse whether there is any evidence of individuals changing their diets and/or levels of physical activity, in response to increased proximity to fast foods.

Diet: We investigate two dimensions of diet – consumption of particular foods and take-up of school meals, which meet national nutritional standards. We first focus on three specific behaviours that may have been affected by changes in the availability of

[18] Estimates for the stratified sample are available upon request.

unhealthy food: *consumption of fruit*, *sweetened drinks*[19] and *skipping breakfast*.[20] *Consumption of fruit* is a binary variable indicating whether the individual eats fruits at all.[21] *Consumption* of *sweetened drinks* is a binary variable defined as whether the individual drinks *sweetened drinks* at all. *Skipping breakfast* is a binary variable indicating whether the individual skips breakfast at least once a week. We additionally create a score variable to proxy *unhealthy diet habits* defined as the sum of the three previous binary variables, with higher scores indicating poorer quality diets.

To estimate the effect of fast food restaurants on proxies of unhealthy dietary habits, we estimate equation (1) using the 1600 metres buffer around homes and schools. Results in Table 5 provide no evidence that an increase in the availability of fast food restaurants around individuals' homes has an impact on unhealthy dietary habits.[22] Whilst these results are interesting, they should be interpreted carefully for at least three reasons. First, our framework allows us only to evaluate changes in the presence or absence of some unhealthy behaviours, however, we cannot evaluate changes at the intensive margin. Second, we evaluate mid-term changes over a period of 7 years and therefore do not

[19] In the MCS sweep 4, age 7, parents were asked 'When the individuals drinks between meals, what does he/she drinks?'. For age 7, we defined *Consumption* of *sweetened drinks* as a binary variable indicating whether individual reported drinking 'Artificially sweetened drinks (diet cola, sugar-free squash)'. However, in the MCS sweep 5 and 6, ages 11 and 14, individuals were asked 'How often, if at all, do you drink sugary drinks like regular cola or squash?'. For ages 11 and 14, we defined *Consumption* of *sweetened drinks* as a binary variable indicating whether individual reported one or more days a week. Given the change in the question between surveys we are only able to proxy whether the children drink or not *sweetened drinks*, but not the frequency of consumption.

[20] We use the question 'How often do you eat breakfast over a week?' to define those children who skip breakfast at least one day per week.

[21] In the MCS sweeps 4 and 5, ages 7 and 11, we use the question 'On a typical day, how many portions of fresh, frozen, tinned, or dried fruit does the individual eat?', and we define *Consumption of fruits* as those who reported one or more portions; however, in the MCS sweep 6, age 14, we use the question 'How often do you eat at least 2 portions of fruit per day? A portion of fruit could be a whole piece of fruit, like an apple or banana or 80g of fruit (like in a fruit salad) but does not include fruit juices', and we define *Consumption of fruits* as those who reported 'Some days, but not all days' or 'Every day'. Given the change in the question between surveys we are only able to proxy whether the children eat or not fruits, but not the frequency of fruit consumption.

[22] We also estimate impacts after stratifying the sample by low/high maternal education, and low/high emotional regulation, and find no impacts on markers of healthy diet for these sub-groups (estimates are available upon request).

capture more frequent changes in behaviours. Third, we only observe some markers of dietary quality which provide an incomplete characterization of changes in food consumption.

We next study whether the availability of fast food restaurants around homes and schools impacts on whether or not participants receive school meals. Access to free school means in the UK is determined by parental eligibility for certain benefits, and non-eligible families can choose to avail of school meals by paying for them. We estimate that 16% of children in our sample at age 7 received free school meals, and a further 39% paid for school meals. Given that school meals in the UK have to meet high quality nutritional standards (Evans and Harper, 2009), our hypothesis is that the availability of unhealthy food options such as fast food restaurants could induce parental compensatory behaviours to increase the take-up of school meals. However, the null results in column 5 of Table 5 indicate that changes in the availability of fast food restaurants are not associated with changes in take-up of school meals.

Physical Activity: Changes in individuals' physical activity due to changes in the availability of fast food restaurants could be indicative of individual compensatory behaviours. If higher fast food availability induced an increase in the consumption of fast food, then individuals may respond by increasing their levels of physical activity – mitigating the overall impact on their BMI. To evaluate whether the fast food restaurants is associated with individual's physical activity, we estimate equation (1) using as an outcome the weekly frequency of physical activity. Using the reported categories, we define three binary variables that indicate whether the individual exercised 1 or more, 3 or more, and 5 or more days per week. We additionally create a continuous variable that imputes the mid-point of the intervals associated to each category (i.e., zero days, 1.5 days, 3.5 days, and 6 days). The null results reported in the Table 6 show that we do not find evidence that changes in food environments induce children to change their physical activity.

E. Identification strategy

E.1. Plausibility of our identification strategy

Our empirical specification identifies the impact of fast food restaurants on BMI under the assumption that, conditional on individual- and year of survey fixed effects, and controlling for local authority district and individual characteristics, the within-individual variation in fast food outlets over time is independent of any other determinant of BMI.

Residential sorting, i.e., the fact that location of individuals' residences and of fast food restaurants over time is likely non-random, is one main reason why this assumption may not hold. There are two reasons why the number of fast food restaurants near the individuals' homes (or schools) might change. First, through individuals moving residence (or school) to or from areas with more or fewer fast food restaurants, and second, due to openings and closures of restaurants across time. We provide evidence that both potential sources of bias are not confounding our main results. In addition, we also provide evidence that our results are not be driven by measurement error.

Regarding the first threat to our identification strategy, whilst it is very unlikely that families are making their residential (or school) decisions on the basis of fast food availability, we nonetheless explore this empirically. First, we estimate equation (1) but interact both food outlet variables with a binary variable indicating whether families did not change residence during the period. We do not find differential significant effect on the impact of fast food restaurants on BMI between those families who changed residence and those who stayed in the same place (see Table A5 in Online Appendix). This provides suggestive evidence that our results are not driven by changes in exposure to fast food restaurants among those families who changed residence during this period. Second, to formally test whether the number of fast food restaurants at age t= 7, 11 and 14 is correlated with the probability of individuals changing residence between t-1and t, we estimate the following model:

$$D_{it} = \tau^k + \theta^k F_{it}^{\mathrm{k}} + \nu_i^k + \mu_t^k + \epsilon_{it}^k \quad (3)$$

where D_{it} is a binary variable indicating if individual changed residence between t-1 and t, considering changes of residences between ages 5-7, 7-11 and 11-14 years. τ^k is a constant term, ν_i^k is an individual fixed effect, and μ_t^k is a year of the survey dummy variable. The superscript k indicates buffers of 400, 800, and 1,600 metres around residences and schools. Results shown in Table A6 of Online Appendix A show a null association between the number of fast food restaurants in t and the probability of changing residence between t-1 and t.

$$D_{it} = \alpha^k + \eta^k F_{it-1}^{\mathrm{k}} + \nu_i^k + \mu_t^k + \epsilon_{it}^k \tag{4}$$

We also estimate equation (4) and evaluate whether the number of fast food restaurants at ages 7 and 11 is correlated with changes of residence between ages 7-11 and 11-14. The results reported in Table A7 of Online Appendix A show null effects. We interpret this evidence as indicating that families within our sample are not deciding where to move based on fast food availability.

Third, as a robustness check, we re-estimate equations (1) and (2) but controlling for D_{it} to assess whether the impact of fast food restaurants on BMI at t is affected. If D_{it} captures time-varying family unobservables correlated with the decision to change residence, our finding that estimates remain stable after controlling for D_{it} – shown in Table A8 of Online Appendix A – provide evidence that residential sorting is not driving our results.

The second threat to our identification strategy is the presence of omitted time-varying characteristics at the individual level correlated with both BMI and the number of fast food restaurants. This bias could appear if opening and closures of fast food restaurants respond to changes in families' preferences or tastes, which should lead to a correlation between trends in families' characteristics and the number of fast food restaurants. To formally test this, we use the abundant information in the MCS, and ask whether conditional on individual fixed effects and area level controls, the availability of fast food restaurants is correlated with time-varying individual-level characteristics. We estimate this placebo analysis as follows. First, we use the following variables individually: the presence of two parents or carers in the household, OECD equivalised weekly family income, whether the highest educational level of individual's mother is degree or above level[23], number of siblings in the household, individual's general health reported by their parent[24], and Strengths & Difficulties Questionnaire (SDQ) total difficulties score.[25] Second, we estimate the best linear prediction of BMI using all controls in equation (1) but excluding fast food restaurants and other food outlets. We then regress the predicted value from this regression on fast food restaurants, controlling for individual fixed effects, area level controls and other food outlets. Results in columns 1-6 in Table A9 of Online Appendix A provide evidence that a large group of time-varying variables are generally not correlated with the availability of fast food restaurants around individuals' residences and schools.[26] Although we of course cannot rule out that other individual time-varying unobservables variables may be driving our results, results in column 7 of Table A9 showing that the number of fast food restaurants is not significantly associated with BMI predictor, and the evidence in columns 2-3 and 6-7 of Table 3 showing that estimates remain stable when individual and area controls are included, suggesting that selection on unobservables is unlikely.

Another potential source of bias is measurement error in the number of fast food restaurants around residences and schools. There are two reasons why this is unlikely to be driving our results. First, attenuation bias due to classical measurement error in fixed effects regressions should bias downwards our point estimates, providing a conservative estimate of the effect of fast food restaurants. Second, by focusing on major fast food chains together with fish and chips, kebab, and chicken outlets, instead of using the aggregate PoI categories, we circumvent any issues around potential misclassification

[23] We classify individuals in the high educational group when their mothers had achieved National Vocational Qualification levels 4 or 5 at the age 5 survey, while other individuals are classified in the low education group when their mothers had achieved National Vocational Qualification levels 1-3 or none.
[24] The individual's general health is reported by respondent's parent and ranges from 1 to 5, where 1 is excellent and 5 is poor health.
[25] The SDQ total difficulties score is created as the sum of the following sub-scales: conduct problems (5 items), hyperactivity/inattention (5 items), peer relationship problems (5 items), and prosocial behaviour (5 items).
[26] Only two of thirty-six coefficients are significant at 10% level.

due to changes in PoI classifications over time. In the next section, we also provide evidence that are results are not driven by different definitions of fast food restaurants.

E.2. Robustness and falsification exercises

In this section we present three robustness checks and two falsification exercises. We first show that the availability of fast food restaurants is correlated with individual's fast food consumption. We then show that our main results are robust to including additional time-varying individual controls that predicts BMI (breakfast consumption, physical activity, and mode of transport from home to school). Then, we show that our results are robust to changes in definitions to fast food restaurants. In addition, we show that our main specification is robust to a falsification exercise that re-estimate equation (1) but replace fast food restaurants with facilities that should not have an impact on BMI.

Robustness exercise

We first analyse whether individuals' fast food consumption is correlated with the availability of fast food restaurants. Whilst there is no information in the MCS about respondents' fast food consumption at ages 7 and 11, at age 14 parents were asked 'how often does the child eat fast food?'. The four possible answers for this question are 'one or more days a week', 'less often but at least one a month', 'less than once a month', and 'never'. Using this variable, we estimate an ordered logit model to see whether the availability of fast food restaurants around individual's homes is cross-sectionally correlated with fast food consumption. Results in Table A10 of Online Appendix A show Odd Ratios estimates indicating a positive and highly significant association between the number of fast food restaurants withing 1600 metres around home (and schools) and eating fast food one or more days per week.

Second, we show that our main results are robust to several checks. First, we include additional time-varying individual controls in equation (1) that, although endogenous, are expected to predict BMI. First, we include the frequency of breakfast consumption, with lower frequencies having been shown to be associated with an increased risk of obesity (Kelly et al., 2016, Alsharairi and Somerset, 2016, Yaguchi-Tanaka and Tabuchi, 2020).

We also control for the frequency of physical activity, given negative links between physical activity and obesity (Dhar and Robinson, 2016, Griffiths et al., 2016, Riddoch et al., 2009). Finally, we control for six categories of modes of transport between school and home (public transport, local authority bus, vehicle, bicycle, walking and other). Results in Table A11 of Online Appendix A show that the impact of fast food restaurants around 1600 metres from home and schools on BMI is robust to the inclusion of these individual time-varying controls. We find similar results for the 800- and 400-meters buffer presented in Tables A12 and A13.

We next check whether our key results are robust to other fast food definitions used in the literature. We modify our definition of fast food restaurants by adding the following outlets to our list of fast food chains: Dixie Chicken, Chicken Cottage, Papa John's, Southern Fried Chicken (SFC), Five Guys, Harry Ramsdens and Little Chef. By including these additional fast food chains, our definition should resemble more closely the 'Moderate' classification created by Wilkins et al. (2019a). Results in Tables A14 and A15 in Online Appendix show that the magnitude and significance of estimated parameters remain stable to changes in the definition of food and fast food restaurants.

Falsification exercise

Finally, we estimate a placebo exercise by running our preferred specification but replacing our fast food variable with the number of facilities in other PoI categories that arguably should not be associated with individuals' obesity. Specifically, we use the categories 'IT, marketing and media services', 'Employment and career agencies', 'Consultancies', and 'Construction services.'[27] Figures A1 and A2 of Online Appendix A show the results of this exercise for equation (1), and Figures A3 and A4 for equation (2). Across all specifications, we do not find evidence that commercial facilities near individuals' residences or schools are associated with either individuals' BMI or body fat percentage, providing further evidence on the reliability of our main findings.

[27] In Table B2 of Online Appendix B we show a description of the facilities consider in each of these four categories.

V. Conclusion

Using data from a rich longitudinal study in Great Britain, combined with detailed nationwide geo-coded data on the location of fast food outlets, we show that increased exposure to fast food restaurants near homes and schools increases BMI during childhood. While we find consistent and statistically significant detrimental effects of exposure to fast food restaurants, point estimates are relatively small. Whilst the results are similar to what previous studies have found (Alviola et al., 2014, Currie et al., 2010, Qian et al., 2017, Asirvatham et al., 2019), we provide novel evidence on heterogenous effects using the richness of the MCS survey data.

We find that a one standard deviation increase in fast food restaurants within 1,600 metres of individual residences increases BMI by 1.0% with respect to the sample mean, and by 0.5% within the 1,600 metres school-buffer. Our results also suggest that closer proximity of fast food restaurants – within the 800 meters – is detrimental for schools, whereas for homes, larger distances of up to 1,600 metres are more relevant. We find similar results for other anthropometric measures including body fat, BMI standardized scores, weight, and derived measures of overweight and obesity. Our results also indicate that access to fast food restaurants surrounding schools increases weight, where a marginal increase in fast food restaurants within 800 metres increases BMI and the incidence of overweight by 0.4% and 4.0% respectively with respect the sample mean.

Regarding heterogenous effects, our findings suggest that the detrimental effects of the availability of fast food restaurants on BMI are almost twice as high among participants whose mothers have relatively low levels of education. These results are consistent with educational inequalities within the household amplifying health inequalities at early ages (Deaton, 2003, Marmot, 2010) and with cross-sectional evidence in the UK, which shows that access to fast food restaurants accentuates socioeconomic inequalities in adults (Burgoine et al., 2016). The inter-relationship between nutrition knowledge and maternal education is one potential explanation for the larger estimated effect of fast food exposure among those with poorer socioeconomic conditions (Parmenter et al., 2000).

We additionally hypothesize that the total effects could be in part explained by underlying individual characteristics, such as emotional regulation, which has been shown to predict excess weight and obesity in adolescents (Kelly, 2016, Limbers and Summers, 2021), and to be associated with risky behaviours such as drug abuse, binge drinking, and eating disorders (Garland, 2018, Micanti et al., 2017, Racine, 2018, Weiss et al., 2015). By focussing on the ability of children to self-regulate their emotions, we can identify groups that are potentially more responsive to exposure to unhealthy food. Our results are consistent with this hypothesis, indicating that the positive effect of fast food on BMI is almost double among participants with lower levels of emotional regulation. Further, the larger effects among those with both low socioeconomic status and low emotional regulation suggests that tackling individual demand-drivers for unhealthy food, including non-cognitive characteristics such as self-regulation, may be more important than targeting the fast food environment, which our results suggest is not likely to be a panacea when it comes to reducing inequalities. Finally, we investigate whether the low estimated impacts reflect compensatory behaviours – increased physical activity and substitution to healthier foods at home – but find no evidence of this.

The extent to which our results have a causal interpretation relies on the plausibility of our identification strategy. One concern is that selection into more or less deprived areas across time could bias our results; however, we provide suggestive evidence that our results are not driven by changes of residence during the analysed period. Another concern is potential unobservable time-varying factors correlated with access to fast food restaurants and individuals' BMI. To mitigate this concern, we control for several time-varying indicators; moreover, we also control for other food facilities and area-level characteristics, which are plausibly correlated with unobserved time-varying local economic conditions and infrastructure. Additionally, we present evidence that our results are robust to different specifications and provide several falsification tests in favour of our empirical specification. This evidence together alleviates concerns about identification, and though we cannot completely rule out self-selection and omitted variable bias, this paper provides novel evidence on this important question for a nationally representative sample of young people across Great Britain.

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Tables and Figures

Table 1. Descriptive statistics: Individual's anthropometric measurements and fast food restaurants

	7 years		11 years		14 years		Full sample	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Weight in kilograms	25.2	4.7	41.1	9.7	58	13	41.4	16.6
Height in centimetres	123.5	5.5	146.2	7.2	164.2	8.1	144.6	18.1
Body Mass Index	16.4	2.2	19.1	3.5	21.4	4.1	19.0	4.0
Percentage of Body Fat	20.7	5.2	22	7.8	21.7	9.2	21.5	7.6
Child is obese	4.7	21.1	5.8	23.3	7.3	26.1	5.9	23.6
Child is overweight	18	38.4	25.7	43.7	26.1	43.9	23.3	42.3
Fast food restaurants around homes								
1600 metres	2.5	3.3	4.1	6.0	4.0	5.7	3.5	5.2
800 metres	0.6	1.1	1.0	2.0	1.0	1.9	0.9	1.7
400 metres	0.2	0.5	0.2	0.7	0.2	0.7	0.2	0.6
Fast food restaurants around schools								
1600 metres	2.7	3.3	3.9	5.4	3.8	4.9	3.5	4.6
800 metres	0.7	1.2	1.1	1.9	0.8	1.5	0.9	1.6
400 metres	0.2	0.5	0.2	0.6	0.1	0.5	0.2	0.5
Observations	8,253		8,253		8,253		24,759	

Note: The 'Overweight' & 'Obese' categories are defined using the International Obesity Task Force (IOTF) cutoffs (Cole et al., 2000)

Table 2. Descriptive statistics by availability of fast food restaurants (%)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
			Home			School	
	All	<1600 mts.	<800 mts.	<400 mts.	<1600 mts.	<800 mts.	<400 mts.
Individuals' Demographics							
Child is male	52.0	51.8	51.7	53.4	51.8	51.9	52.0
Mother is White	84.4	79.7	75.4	72.9	80.5	78.6	78.8
Mother is Mixed	3.3	3.9	3.8	3.6	3.7	3.3	3.9
Mother is Indian	2.3	2.8	3.4	3.1	2.8	2.8	2.9
Mother is Pakistani and Bangladeshi	4.6	6.1	8.6	11.5	6.0	7.0	7.8
Mother is Black or Black British	4.0	5.4	6.8	6.7	5.2	6.2	4.9
Mother is from another Ethnic group	1.4	2.0	1.9	2.3	1.9	2.1	1.7
Mother highest NVQ level is 1 [a,b]	8.1	8.7	9.4	10.9	8.7	9.5	11.9
Mother highest NVQ level is 2 [a]	28.4	28.5	29.0	27.3	29.0	27.1	27.1
Mother highest NVQ level is 3 [a]	14.7	14.4	13.5	13.0	14.6	14.9	15.2
Mother highest NVQ level is 4 [a]	28.1	25.5	23.4	23.4	25.3	24.0	24.2
Mother highest NVQ level is 5 [a]	5.2	5.2	5.1	4.8	5.2	4.9	4.5
Mother has overseas qualification only [a]	3.2	3.5	3.5	3.4	3.6	4.1	3.3
Mother does not have any of these qualification [a]	12.1	14.3	16.0	17.2	13.7	15.5	13.7
Number of Parents/Carers in household							
Two parents/carers [a,b]	77.9	76.1	74.7	73.0	76.3	75.3	76.1
One parent/carer [a]	22.1	23.9	25.3	27.0	23.7	24.7	23.9
OECD equivalised weekly family income [a]	387.4	365.0	342.2	319.6	370.2	357.4	355.1
Number of people in household (not including individual) [a]	3.5	3.5	3.6	3.6	3.5	3.6	3.6
Numbers of rooms in the household [a]	6.0	5.8	5.7	5.6	5.9	5.8	5.9
Housing Tenure							
Own - mortgage/loan [a,b]	55.6	52.8	50.2	45.9	53.8	51.8	53.7
Own outright [a]	5.5	5.1	5.1	5.1	5.1	5.2	5.8
Rent or other [a]	38.9	42.1	44.7	49.0	41.0	43.0	40.5
Local authority level variables							
Unemployment rate [a]	8.0	8.4	8.7	8.8	8.3	8.5	8.6
Population estimates [a]	2.3	2.5	2.6	2.7	2.4	2.4	2.4
Observations	8,253	5,603	3,054	1,060	5,929	3,624	1,385

Note: This table shows descriptive statistics at age 7 by the presence of fast food restaurants within 400, 800, 1600 metres buffers. Columns 2 & 5; 3 & 6; and 4 & 7 include individuals with one or more fast food restaurants within 1600, 800, 400 metres buffers, respectively. [a] Indicates time-varying variables included as controls in equations (1) and (2). [b] Indicates the baseline category excluded in the empirical specifications. Descriptive statistics of the variables *Fast food restaurants* and *Other food outlets* are in the Online Appendix A.

Table 3. The impact of fast food restaurants on BMI

	Home				School			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A. Fast food restaurant within								
Equation 1, k = 400m	0.114*	0.103	0.100	0.0980	-0.00605	0.0341	0.0318	0.0296
	(0.0594)	(0.0794)	(0.0777)	(0.0775)	(0.0342)	(0.0432)	(0.0428)	(0.0426)
Equation 1, k = 800m	0.0574***	0.0607**	0.0591**	0.0554**	0.0291**	0.0750***	0.0741***	0.0742***
	(0.0200)	(0.0257)	(0.0255)	(0.0255)	(0.0143)	(0.0236)	(0.0229)	(0.0229)
Equation 1, k = 1600m	0.0290***	0.0389***	0.0390***	0.0355***	0.00219	0.0220**	0.0218**	0.0225**
	(0.00880)	(0.0127)	(0.0126)	(0.0126)	(0.00883)	(0.0107)	(0.0106)	(0.0106)
Panel B. Equation 2								
Fast food restaurant								
within 400m	0.0921	0.108	0.104	0.102	-0.0165	0.0446	0.0424	0.0404
	(0.0601)	(0.0791)	(0.0774)	(0.0773)	(0.0342)	(0.0432)	(0.0428)	(0.0426)
between 400m and 800m	0.0292	0.0476	0.0472	0.0432	0.0444***	0.0819***	0.0813***	0.0818***
	(0.0272)	(0.0309)	(0.0306)	(0.0306)	(0.0158)	(0.0251)	(0.0244)	(0.0244)
between 800m and 1600m	0.0243**	0.0312**	0.0317**	0.0283**	-0.00834	0.00599	0.00598	0.00683
	(0.0110)	(0.0141)	(0.0142)	(0.0142)	(0.0111)	(0.0121)	(0.0121)	(0.0120)
Other food outlets	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Individual controls	No	No	Yes	Yes	No	No	Yes	Yes
Area level controls	No	No	No	Yes	No	No	No	Yes
Individual FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year of survey FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	24759	24759	24759	24759	24759	24759	24759	24759
Number of individuals	8253	8253	8253	8253	8253	8253	8253	8253
Mean of dependent variable	18.95	18.95	18.95	18.95	18.95	18.95	18.95	18.95

Notes: Columns 1-4 show estimates around respondents' residences and columns 5-8 around schools. In Panel A, each cell reports a different regression, and rows show results for three different equations – one for each respective buffer indicated in equation (1): β^{400}, β^{800} , and β^{1600}. In Panel B, rows show estimates of equation (2): γ_1, γ_2, and γ_3. Other estimates in equations (1) and (2) are omitted due to space limitations but available upon request. ***, **, and * denote statistically significant at 1%, 5% and 10%. Robust standard errors in parenthesis are clustered at the individual level.

Table 4. Heterogeneity in the effect of fast food restaurants on BMI

	Home				School			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Fast food restaurant								
within 1600m	0.0325*	-0.00844	0.0142	-0.0726	0.0433***	-0.0249**	0.0161	-0.0131
	(0.0178)	(0.0157)	(0.0205)	(0.0505)	(0.0162)	(0.0108)	(0.0126)	(0.0416)
within 1600m X Male	0.00233				-0.0403*			
	(0.0244)				(0.0212)			
within 1600m X Low education		0.0618***				0.0841***		
		(0.0228)				(0.0196)		
within 1600m X High emotional dysregulation			0.0488*				0.0185	
			(0.0265)				(0.0219)	
within 1600m X Emotional dysregulation score				0.0640**				0.0222
				(0.0275)				(0.0259)
Other food outlets	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Area level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year of survey FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	24,759	24,759	24,258	24,258	24,759	24,759	24,258	24,258
Number of individuals	8,253	8,253	8,086	8,086	8,253	8,253	8,086	8,086
Mean of dependent variable	18.95	18.95	18.95	18.95	18.95	18.95	18.95	18.95

Notes: This table show OLS results for a modified equation (1) that interact the fast food restaurants and other food outlets variables with the variables shown in the rows. Male is a dummy variable that take value 1 if respondent is male and 0 if is girl. Low educational level is a dummy variable equals to one if respondent's highest maternal education (measured when respondent was 5 years old) is below degree level and 0 if is degree level or higher. High emotional dysregulation is a dummy variable equals 1 if the emotional dysregulation sub-scale of the Child Social Behaviours Questionnaire at age 7 is above the sample median and 0 otherwise. The Emotional dysregulation score is the score of the dysregulation sub-scale of the Child Social Behaviours Questionnaire at age 7. Each column reports a different regression. Other estimates in equation (1) are omitted due to space limitations but available upon request. ***, **, and * denote statistically significant at 1%, 5% and 10%. Robust standard errors in parenthesis are clustered at the individual level.

Table 5. Effect of fast food restaurants on individual's diet and take-up of school meals.

	(1)	(2)	(3)	(4)	(5)
	Do not eat fruits	Drink sweetened drinks	Skip breakfast at least one time per week	Unhealthy diet score	Meal is provided by school
Panel A. Fast food restaurants within 1600m from homes	-0.151	0.393	0.190	0.00447	-0.213
	(0.134)	(0.322)	(0.246)	(0.00426)	(0.268)
Panel B. Fast food restaurants within 1600m from schools	-0.0397	0.076	-0.053	0.00002	-0.197
	(0.0979)	(0.234)	(0.173)	(0.00291)	(0.213)
Other Food Outlets	Yes	Yes	Yes	Yes	Yes
Individual controls	Yes	Yes	Yes	Yes	Yes
Area level economic controls	Yes	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes	Yes
Observations	24,680	24,566	24,689	24,698	24,105
Number of individuals	8,253	8,253	8,253	8,253	8,249
Mean of the dependent variable	6.22	47.74	20.66	0.744	54.56

Notes: This table show OLS results for equation (1) but replacing BMI by diet variables. Outcome variables are defined as follow. 'Do not eat fruits' is a dummy variable equals to 1 if individuals do not report eating fruit and 0 otherwise. In the MCS sweeps 4 and 5, ages 7 and 11, we use the question 'On a typical day, how many portions of fresh, frozen, tinned, or dried fruit does the individual eat?', and we define *Consumption of fruits* as those who reported one or more portions; however, in the MCS sweep 6, age 14, we use the question 'How often do you eat at least 2 portions of fruit per day? A portion of fruit could be a whole piece of fruit, like an apple or banana or 80g of fruit (like in a fruit salad) but does not include fruit juices', and we define *Consumption of fruits* as those who reported 'Some days, but not all days' or 'Every day'. Given the change in the question between surveys we are only able to proxy whether the children eat or not fruits, but not the frequency of fruit consumption. 'Drink sweetened drinks' is a dummy variable equals to 1 if respondent drink sweetened drinks and 0 otherwise. In the MCS sweep 4, age 7, parents were asked 'When the individuals drinks between meals, what does he/she drinks?'. For age 7, we defined *Consumption* of *sweetened drinks* as a binary variable indicating whether individual reported drinking 'Artificially sweetened drinks (diet cola, sugar-free squash)'. However, in the MCS sweep 5 and 6, ages 11 and 14, individuals were asked 'How often, if at all, do you drink sugary drinks like regular cola or squash?'. For ages 11 and 14, we defined *Consumption* of *sweetened drinks* as a binary variable indicating whether individual reported one or more days a week. Given the change in the question between surveys we are only able to proxy whether the children drink or not *sweetened drinks*, but not the frequency of consumption. We use the question 'How often do you eat breakfast over a week?' to define those children who skip breakfast at least one day per week. *Unhealthy diet* score is defined as the sum of the three previous dummy variables, with higher scores indicating poorer quality diets. 'Meal is provided by school' is a dummy variable equals to 1 if the individual's meal was provided by the school and 0 otherwise. Each cell reports a different regression. Panel A show estimates around homes and Panel B around school. Other estimates in equation (1) are omitted due to space limitations but available upon request. ***, **, and * denote statistically significant at 1%, 5% and 10%. Robust standard errors in parenthesis are clustered at the individual level.

Table 6. Effect of fast food restaurants on individuals' physical activity.

	(1) Physical Activity (continuous)	(2) 1 day or more	(3) 3 days or more	(4) 5 days or more
Panel A. Fast food restaurants within 1600m from homes	0.00408	0.161	-0.138	0.177
	(0.00995)	(0.288)	(0.241)	(0.202)
Panel B. Fast food restaurants within 1600m from schools	0.00954	0.208	0.101	0.176
	(0.00766)	(0.192)	(0.202)	(0.151)
Other Food Outlets	Yes	Yes	Yes	Yes
Individual controls	Yes	Yes	Yes	Yes
Area level economic controls	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes
Observations	24,703	24,703	24,703	24,703
Number of individuals	8,253	8,253	8,253	8,253
Mean of the dependent variable	2.467	80.28	42.22	16.74

Notes: This table show OLS results for equation (1) but replacing BMI by physical activity variables. The outcome variables in Columns 2, 3, and 4 are three binary variables that indicate whether the individual exercised 1 or more, 3 or more, and 5 or more days per week. The outcome variable in Column 1 is a continuous variable that imputes the mid-point of the intervals associated to each category (i.e., zero days, 1.5 days, 3.5 days, and 6 days). Each cell reports a different regression. Panel A show estimates around homes and Panel B around school. Other estimates in equation (1) are omitted due to space limitations but available upon request. ***, **, and * denote statistically significant at 1%, 5% and 10%. Robust standard errors in parenthesis are clustered at the individual level.

ONLINE APPENDIX

Appendix A

Table A1. Availability of fast food restaurants and other food outlets around individual's home and across time

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	1600 metres			800 metres			400 metres		
	7 years	11 years	14 years	7 years	11 years	14 years	7 years	11 years	14 years
Fast Food Restaurants									
Fast Food	2.54	4.10	3.97	0.63	1.04	1.00	0.15	0.25	0.23
McDonalds	0.12	0.18	0.16	0.02	0.03	0.03	0.00	0.00	0.00
KFC	0.11	0.14	0.14	0.02	0.02	0.02	0.00	0.00	0.00
Burger King	0.03	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Wimpy	0.02	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Subway	0.07	0.20	0.24	0.01	0.04	0.05	0.00	0.01	0.01
Pizza Hut	0.09	0.16	0.11	0.01	0.03	0.02	0.00	0.01	0.00
Domino's Pizza	0.08	0.25	0.16	0.01	0.05	0.03	0.00	0.01	0.01
Kebab & Chicken	0.65	1.31	1.31	0.16	0.32	0.33	0.03	0.08	0.07
Fish and chip shops	1.36	1.80	1.80	0.40	0.54	0.53	0.11	0.14	0.14
Others Food Facilities									
Other Food Outlets	20.07	29.75	29.43	5.20	7.80	7.47	1.29	1.89	1.80
Restaurants	4.18	5.98	6.23	0.96	1.43	1.43	0.21	0.31	0.30
Bakeries	0.95	1.27	1.27	0.24	0.34	0.32	0.06	0.08	0.07
Butchers	1.10	1.28	1.19	0.30	0.35	0.29	0.08	0.09	0.08
Confectioners	0.21	0.44	0.42	0.05	0.11	0.10	0.01	0.02	0.03
Delicatessens	0.28	0.57	0.59	0.06	0.14	0.15	0.01	0.03	0.03
Fishmongers	0.10	0.19	0.16	0.02	0.05	0.04	0.00	0.01	0.01
Green and new age goods	0.01	0.04	0.03	0.00	0.01	0.01	0.00	0.00	0.00
Grocers; farm shops and pick your own	0.89	1.75	1.50	0.25	0.45	0.37	0.06	0.11	0.09
Organic; health; gourmet and kosher foods	0.38	0.32	0.38	0.09	0.06	0.08	0.02	0.01	0.01
Conv. stores and independent supermarkets	5.38	9.43	9.21	1.52	2.60	2.49	0.42	0.68	0.65
Supermarket chains	1.56	1.55	1.40	0.37	0.42	0.36	0.09	0.11	0.09
Other takeaway outlets	5.02	6.92	7.04	1.33	1.84	1.82	0.32	0.44	0.43
Observations	8253	8253	8253	8253	8253	8253	8253	8253	8253

Note: This table shows descriptive statistics of variables used to create our 'fast food restaurants' and 'other food facilities' we use in the regression analysis.

Table A2. Availability of fast food restaurants and other food outlets around individual's school and across time

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	1600 metres			800 metres			400 metres		
	7 years	11 years	14 years	7 years	11 years	14 years	7 years	11 years	14 years
Fast Food Restaurants									
Fast Food	2.69	3.91	3.80	0.75	1.08	0.84	0.20	0.20	0.15
McDonalds	0.14	0.17	0.15	0.02	0.04	0.02	0.00	0.01	0.01
KFC	0.11	0.12	0.11	0.02	0.03	0.02	0.00	0.00	0.00
Burger King	0.03	0.05	0.05	0.00	0.02	0.01	0.00	0.01	0.00
Wimpy	0.02	0.03	0.02	0.00	0.02	0.01	0.00	0.00	0.00
Subway	0.08	0.23	0.28	0.01	0.07	0.07	0.00	0.01	0.01
Pizza Hut	0.10	0.14	0.10	0.02	0.03	0.02	0.00	0.01	0.00
Domino's Pizza	0.09	0.30	0.17	0.02	0.07	0.03	0.01	0.01	0.01
Kebab & Chicken	0.64	1.10	1.10	0.17	0.29	0.22	0.03	0.05	0.04
Fish and chip shops	1.48	1.79	1.82	0.49	0.53	0.44	0.15	0.11	0.07
Others Food Facilities									
Other Food Outlets	21.53	29.83	30.30	6.04	7.95	6.80	1.60	1.40	1.29
Restaurants	4.73	6.45	6.86	1.13	1.70	1.37	0.26	0.22	0.24
Bakeries	1.02	1.43	1.44	0.31	0.38	0.34	0.08	0.05	0.06
Butchers	1.16	1.24	1.17	0.38	0.33	0.26	0.11	0.06	0.04
Confectioners	0.23	0.45	0.49	0.06	0.12	0.12	0.01	0.02	0.03
Delicatessens	0.33	0.62	0.62	0.09	0.16	0.14	0.02	0.03	0.03
Fishmongers	0.10	0.20	0.14	0.03	0.04	0.02	0.00	0.00	0.00
Green and new age goods	0.02	0.04	0.03	0.00	0.01	0.01	0.00	0.00	0.00
Grocers; farm shops and pick your own	0.95	1.50	1.29	0.27	0.33	0.26	0.07	0.06	0.05
Organic; health; gourmet and kosher foods	0.43	0.42	0.43	0.12	0.11	0.09	0.03	0.02	0.02
Conv. stores and independent supermarkets	5.63	8.80	8.86	1.68	2.39	2.04	0.50	0.51	0.43
Supermarket chains	1.64	1.69	1.61	0.45	0.46	0.39	0.12	0.09	0.07
Other takeaway outlets	5.28	6.99	7.34	1.51	1.92	1.75	0.39	0.33	0.32
Observations	8253	8253	8253	8253	8253	8253	8253	8253	8253

Note: This table shows descriptive statistics of variables used to create our 'fast food restaurants' and 'other food facilities' we use in the regression analysis.

Table A3. The impact of fast food restaurants on respondents' anthropometric measurements, cross-sectional estimates.

	Home						School					
	BMI	Body fat (%)	Weight (Kg.)	z-BMI	Overweight	Obese	BMI	Body fat (%)	Weight (Kg.)	z-BMI	Overweight	Obese
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel A. Fast food restaurants within												
Equation 1, k = 400m	0.142**	0.326**	0.228	0.0462*	1.726*	0.586	0.150**	0.196	0.347**	0.0547***	2.131**	1.173**
	(0.0654)	(0.141)	(0.170)	(0.0245)	(0.962)	(0.457)	(0.0626)	(0.125)	(0.175)	(0.0200)	(0.843)	(0.553)
Equation 1, k = 800m	0.0895***	0.168**	0.208**	0.0324***	0.779**	0.277	0.113***	0.203***	0.224**	0.0348***	0.944***	0.693***
	(0.0331)	(0.0651)	(0.0910)	(0.0116)	(0.376)	(0.213)	(0.0260)	(0.0515)	(0.0869)	(0.00884)	(0.332)	(0.180)
Equation 1, k = 1600m	0.0568***	0.106***	0.137***	0.0187***	0.428**	0.303***	0.0339**	0.0779***	0.0335	0.00958**	0.252	0.284***
	(0.0181)	(0.0368)	(0.0496)	(0.00631)	(0.188)	(0.109)	(0.0131)	(0.0288)	(0.0346)	(0.00445)	(0.178)	(0.0906)
Panel B. Equation 2 Fast food restaurants												
within 400m	0.131**	0.304**	0.202	0.0440*	1.647*	0.461	0.149**	0.192	0.345*	0.0546***	2.102**	1.129**
	(0.0649)	(0.141)	(0.170)	(0.0243)	(0.969)	(0.452)	(0.0622)	(0.124)	(0.176)	(0.0200)	(0.839)	(0.545)
between 400m and 800m	0.0631*	0.104	0.170*	0.0255**	0.451	0.0648	0.107***	0.202***	0.213**	0.0321***	0.730**	0.531***
	(0.0340)	(0.0751)	(0.102)	(0.0116)	(0.415)	(0.219)	(0.0287)	(0.0579)	(0.0953)	(0.00960)	(0.339)	(0.196)
between 800m and 1600m	0.0500**	0.0920**	0.125**	0.0153**	0.339	0.346***	0.00894	0.0397	-0.0295	0.00137	0.0353	0.175
	(0.0210)	(0.0427)	(0.0613)	(0.00729)	(0.223)	(0.127)	(0.0148)	(0.0331)	(0.0391)	(0.00501)	(0.199)	(0.110)
Other food outlets	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Area level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year of survey FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	24,759	24,466	24,759	24,759	24,759	24,748	24,759	24,466	24,759	24,759	24,759	24,748
Mean of dependent variable	18.95	21.56	41.36	23.05	5.784	0.433	18.95	21.56	41.36	23.05	5.784	0.433

Notes: This table show OLS estimates for cross-sectional models. Columns 1-6 show estimates around respondents' residences and columns 7-12 around schools. In Panel A, each cell reports a different regression, and rows show results for three different equations – one for each respective buffer in equation (1): β^{400}, β^{800} , and β^{1600}. In Panel B, rows show estimates of equation (2): γ_1, γ_2, and γ_3. Other estimates in equations (1) and (2) are omitted due to space restrictions but available upon request. ***, **, and * denote statistically significant at 1%, 5% and 10%. Robust standard errors in parenthesis are clustered at the individual level.

Table A4. The impact of fast food restaurants on respondents’ anthropometric measurements, fixed effects estimates.

	Home					School				
	Body fat (%)	Weight (Kg.)	z-BMI	Overweight	Obese	Body fat (%)	Weight (Kg.)	z-BMI	Overweight	Obese
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A. Equation 1										
Fast food restaurants within 400m	0.252	0.344	0.0288	1.608	-0.0125	-0.0375	-0.0700	0.0124	1.499**	0.846**
	(0.183)	(0.214)	(0.0289)	(1.293)	(0.552)	(0.104)	(0.130)	(0.0130)	(0.729)	(0.395)
Fast food restaurants within 800m	0.121*	0.157**	0.0175**	0.537	0.0150	0.112*	0.167**	0.0223***	0.955**	0.308
	(0.0675)	(0.0776)	(0.00891)	(0.364)	(0.233)	(0.0586)	(0.0718)	(0.00752)	(0.371)	(0.202)
Fast food restaurants within 1600m	0.0849**	0.0858**	0.00798*	0.251	0.0711	0.0180	0.0304	0.00432	0.184	0.226**
	(0.0343)	(0.0380)	(0.00425)	(0.189)	(0.130)	(0.0253)	(0.0315)	(0.00339)	(0.137)	(0.103)
Panel B. Equation 2										
Fast food restaurants within 400m	0.244	0.359*	0.0311	1.651	-0.0314	-0.0230	-0.0525	0.0153	1.590**	0.876**
	(0.183)	(0.217)	(0.0284)	(1.261)	(0.553)	(0.104)	(0.131)	(0.0129)	(0.721)	(0.396)
between 400m and 800m	0.0957	0.106	0.0138	0.277	-0.00726	0.140**	0.211***	0.0236***	0.821**	0.188
	(0.0810)	(0.0936)	(0.0105)	(0.493)	(0.246)	(0.0615)	(0.0744)	(0.00811)	(0.387)	(0.227)
between 800m and 1600m	0.0698*	0.0604	0.00467	0.144	0.0885	-0.0111	-0.0118	-0.000886	-0.0386	0.203*
	(0.0370)	(0.0427)	(0.00447)	(0.216)	(0.145)	(0.0285)	(0.0371)	(0.00373)	(0.165)	(0.108)
Other food outlets	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Area level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year of survey FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	24,466	24,759	24,748	24,759	24,759	24,466	24,759	24,748	24,759	24,759
Number of individuals	8,252	8,253	8,253	8,253	8,253	8,252	8,253	8,253	8,253	8,253
Mean of dependent variable	21.56	41.36	0.433	23.05	5.784	21.56	41.36	0.433	23.05	5.784

Notes: This table show OLS estimates for fixed-effect models. Columns 1-6 show estimates around respondents’ residences and columns 7-12 around schools. In Panel A, each cell reports a different regression, and rows show results for three different equations – one for each respective buffer in equation (1): β^{400}, β^{800} , and β^{1600}. In Panel B, rows show estimates of equation (2): γ_1, γ_2, and γ_3. Other estimates in equations (1) and (2) are omitted due to space restrictions but available upon request. ***, **, and * denote statistically significant at 1%, 5% and 10%. Robust standard errors in parenthesis are clustered at the individual level.

Table A5. Differential effects by change of residence

	Home			School		
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Equation 1						
Fast food restaurants within 400m	0.185			-0.0913		
	(0.121)			(0.0833)		
Fast food restaurants within 400m x Stay	-0.209			0.179*		
	(0.138)			(0.0951)		
Fast food restaurants within 800m		0.0853**			0.104**	
		(0.0389)			(0.0439)	
Fast food restaurants within 800m x Stay		-0.0605			-0.0467	
		(0.0506)			(0.0499)	
Fast food restaurants within 1600m			0.0363*			0.0270
			(0.0192)			(0.0195)
Fast food restaurants within 1600m x Stay			-0.000864			-0.00708
			(0.0247)			(0.0233)
Other food outlets	Yes	Yes	Yes	Yes	Yes	Yes
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes
Area level controls	Yes	Yes	Yes	Yes	Yes	Yes
Year of survey FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	24,759	24,759	24,759	24,759	24,759	24,759
Number of individuals	8253	8253	8253	8253	8253	8253
Mean of dependent variable	18.95	18.95	18.95	18.95	18.95	18.95

Notes: This table show OLS results for a modified equation (1) that interact the fast food restaurants and other food outlets variables with D_{it}, named Stay. D_{it} is a dummy variable that takes value 1 if respondents changed residence between t-1 and t, i.e. between ages 5-7, 7-11 and 11-14. ***, **, and * denote statistically significant at 1%, 5% and 10%. Robust standard errors in parenthesis are clustered at the individual level.

Table A6. Estimates of the probability of moving residence between t-1 and t as function of fast food restaurants in t.

	Home			School		
	(1)	(2)	(3)	(4)	(5)	(6)
Fast food restaurants within 1600m	-0.00136					
	(0.00196)					
Fast food restaurants within 800m		0.00416				
		(0.00467)				
Fast food restaurants within 400m			0.00419			
			(0.0101)			
Fast food restaurants within 1600m				0.000852		
				(0.00179)		
Fast food restaurants within 800m					- 0.000770	
					(0.00308)	
Fast food restaurants within 400m						-0.00670
						(0.00713)
Survey year = 5 (age 11)	0.0571***	0.0533***	0.0546***	0.0540***	0.0553***	0.0550***
	(0.00817)	(0.00794)	(0.00782)	(0.00765)	(0.00769)	(0.00776)
Survey year = 6 (age 14)	-0.00102	-0.00452	-0.00328	-0.00392	-0.00290	-0.00333
	(0.00790)	(0.00749)	(0.00727)	(0.00743)	(0.00721)	(0.00723)
Constant	0.185***	0.179***	0.181***	0.180***	0.182***	0.183***
	(0.00658)	(0.00519)	(0.00454)	(0.00683)	(0.00507)	(0.00453)
Other Food Outlets	No	No	No	No	No	No
Individual controls	No	No	No	No	No	No
Area level economic controls	No	No	No	No	No	No
Individual FE	Yes	Yes	Yes	Yes	Yes	Yes
Year of survey FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	24,759	24,759	24,759	24,759	24,759	24,759
Number of individuals	8,253	8,253	8,253	8,253	8,253	8,253

Notes: This table shows estimates for equation (3) $D_{it} = \tau^k + \theta^k F_{it}^{\mathrm{k}} + \nu_i^k + \mu_t^k + \epsilon_{it}^k$. The outcome is a binary variable indicating if respondents changed residence between ages t-1 and t, i.e., between ages 5-7, 7-11 and 11-14. The variable fast food restaurants in the buffer k (F_{it}^{k}) is measured at ages 7, 11 and 14. ***, **, and * denote statistically significant at 1%, 5% and 10%. Robust standard errors in parenthesis are clustered at the individual level.

Table A7. Estimates of the probability of moving residence between t-1 and t as function of fast food restaurants in t-1.

	Home			School		
	(1)	(2)	(3)	(4)	(5)	(6)
Fast food restaurants within 400m			-0.00325			
			(0.0186)			
Fast food restaurants within 800m		0.00180				
		(0.00690)				
Fast food restaurants within 1600m	0.00357					
	(0.00322)					
Fast food restaurants within 400m						0.000788
						(0.00894)
Fast food restaurants within 800m					0.00517	
					(0.00350)	
Fast food restaurants within 1600m				-0.00126		
				(0.00213)		
Survey year = 6 (age 14)	-0.0636***	-0.0587***	-0.0577***	-0.0565***	-0.0597***	-0.0580***
	(0.00854)	(0.00784)	(0.00765)	(0.00766)	(0.00759)	(0.00761)
Constant	0.228***	0.236***	0.237***	0.240***	0.233***	0.237***
	(0.00949)	(0.00608)	(0.00496)	(0.00733)	(0.00483)	(0.00398)
Other Food Outlets	No	No	No	No	No	No
Individual controls	No	No	No	No	No	No
Area level economic controls	No	No	No	No	No	No
Individual FE	Yes	Yes	Yes	Yes	Yes	Yes
Year of survey FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	16,506	16,506	16,506	16,506	16,506	16,506
Number of individuals	8,253	8,253	8,253	8,253	8,253	8,253

Notes: This table shows estimates for equation (4) $D_{it} = \alpha^k + \eta^k F_{it-1}^{\mathrm{k}} + \nu_i^k + \mu_t^k + \epsilon_{it}^k$. The outcome is a binary variable indicating if respondents changed residence between ages 7-11 and 11-14 years. The variable fast food restaurants (F_{it-1}^{k}) is measured at ages 7 and 11. ***, **, and * denote statistically significant at 1%, 5% and 10%. Robust standard errors in parenthesis are clustered at the individual level.

Table A8. Effect of fast food restaurants on BMI, controlling for changes in residence (D_{it})

	Home		School	
	(1)	(2)	(3)	(4)
Panel A. Fast food restaurants within				
Equation 1, k = 400m	0.108	0.0969	0.0242	0.0304
	(0.0758)	(0.0779)	(0.0432)	(0.0428)
Equation 1, k = 800m	0.0544**	0.0540**	0.0696***	0.0750***
	(0.0257)	(0.0254)	(0.0222)	(0.0231)
Equation 1, k = 1600m	0.0340***	0.0356***	0.0192*	0.0227**
	(0.0126)	(0.0126)	(0.00993)	(0.0106)
Panel B. Equation 2				
Fast food restaurants				
within 400m	0.110	0.101	0.0330	0.0412
	(0.0763)	(0.0777)	(0.0432)	(0.0428)
between 400m and 800m	0.0400	0.0418	0.0776***	0.0825***
	(0.0304)	(0.0305)	(0.0237)	(0.0246)
between 800m and 1600m	0.0266*	0.0288**	0.00387	0.00690
	(0.0141)	(0.0142)	(0.0113)	(0.0121)
Other food outlets	Yes	Yes	Yes	Yes
Individual controls	Yes	Yes	Yes	Yes
Area level controls	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes
Year of survey FE	Yes	Yes	Yes	Yes
Change of residence control	No	Yes	No	Yes
Observations	24,759	24,759	24,759	24,759
Individuals	8,253	8,253	8,253	8,253
Mean of dependent variable	18.95	18.95	18.95	18.95

Notes: Columns 2 and 4 show estimates of equations (1) and (2) controlling for changes in residence (D_{it}). Columns 1 and 3 show benchmark estimates for comparison purposes (similar to columns 4 and 8 in Table 3). In Panel A, each cell reports a different regression, and rows show results for three different equations – one for each respective buffer in equation (1): β^{400}, β^{800} , and β^{1600}. In Panel B, rows show estimates of equation (2): γ_1, γ_2, and γ_3. Other estimates are omitted due to space limitations but available upon request. ***, **, and * denote statistically significant at 1%, 5% and 10%. Robust standard errors in parenthesis are clustered at the individual level.

Table A9. Estimates of effect of fast food restaurants around individual's residence and schools on individuals and mother demographics

	Two parents/carers	OECD equivalised weekly family income	NVQ level 4 or 5	Siblings of individual in household	SDQ Total score	General level of health	Best Linear Prediction (BMI)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: Homes							
Fast food restaurants within 1600m	0.000234	-0.164	0.00111	0.00005	-0.00400	-0.00215	-0.000302
	(0.00239)	(0.674)	(0.00101)	(0.000707)	(0.0267)	(0.00520)	(0.00138)
Fast food restaurants within 800m	-0.00113	2.055	0.00252	-0.000722	-0.0595	-0.00560	0.00118
	(0.00568)	(1.442)	(0.00204)	(0.00132)	(0.0528)	(0.0110)	(0.00268)
Fast food restaurants within 400m	0.000439	2.298	0.00567	-0.00144	-0.00280	-0.0549	0.00275
	(0.00924)	(2.801)	(0.00468)	(0.00251)	(0.159)	(0.0342)	(0.00619)
Panel B: Schools							
Fast food restaurants within 1600m	0.00119	-1.074*	0.000319	-0.00002	-0.02740	-0.00007	0.000279
	(0.00147)	(0.626)	(0.000764)	(0.000268)	(0.0198)	(0.00385)	(0.000896)
Fast food restaurants within 800m	-0.00205	-1.330	-0.000310	-0.000192	0.0309	0.00279	0.000957
	(0.00483)	(1.399)	(0.00161)	(0.000395)	(0.0596)	(0.00929)	(0.00206)
Fast food restaurants within 400m	0.00484	0.882	0.00466	-0.00201	0.120	0.0330*	0.00192
	(0.00713)	(2.602)	(0.00333)	(0.00180)	(0.0925)	(0.0172)	(0.00386)
Observations	24,759	24,759	24,759	24,759	24,086	24,686	24,759
Individuals	8,253	8,253	8,253	8,253	8,249	8,253	8,253
Other Food Outlets	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual controls	No	No	No	No	No	No	No
Area level economic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year of Survey FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table show OLS estimates. Each cell shows a different regression that includes a constant, other food outlets, area level economic controls, year of survey fixed effect, and individual fixed effect. Outcomes are shown at the top of each column. 'Two parents/carers' is a dummy variable equals 1 if two parents or carers are present in the household and 0 otherwise; OECD equivalised weekly family income; 'NVQ level 4 or 5' is a dummy variable equals 1 if the highest educational level of the mother is degree or above level and 0 otherwise; the numbers of siblings of individual in household; the individual's general health is reported by respondent's parent and ranges from 1 to 5, where 1 is excellent and 5 is poor health; and the Strengths & Difficulties Questionnaire (SDQ) total difficulties score. ***, **, and * denote statistically significant at 1%, 5% and 10%. Robust standard errors in parenthesis are clustered at the individual level.

Table A10. Association between fast food restaurants and the fast food consumption, age 14 (Odd Ratios)

	Home		School	
	(1)	(2)	(3)	(4)
Fast food restaurants within 1600m	1.035***	1.033***		
	(0.00887)	(0.0123)		
Fast food restaurants within 1600m			1.026***	1.032***
			(0.00673)	(0.0112)
Observations	8,193	8,193	8,193	8,193
Other Food Outlets	No	Yes	No	Yes
Individual controls	No	Yes	No	Yes
Area level economic controls	No	Yes	No	Yes

Notes: This table show Odd Ratios. The outcome variable is a dummy variable that takes 1 if respondent eats fast food one or more days per week at age 14. ***, **, and * denote statistically significant at 1%, 5% and 10%. Robust standard errors are in parenthesis.

Table A11. Effect of fast food restaurants around 1600 metres on BMI, controlling for additional individual time varying characteristics.

	Home					School				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Fast food restaurants within 1600m	0.0355***	0.0358***	0.0351***	0.0358***	0.0353***	0.0225**	0.0222**	0.0220**	0.0220**	0.0226**
	(0.0126)	(0.0127)	(0.0127)	(0.0127)	(0.0127)	(0.0106)	(0.0105)	(0.0105)	(0.0106)	(0.0105)
Weekly physical activity										
Not at all		0.272***			0.257***		0.272***			0.257***
		(0.0809)			(0.0808)		(0.0812)			(0.0810)
1-2 days		0.378***			0.352***		0.381***			0.354***
		(0.0665)			(0.0665)		(0.0669)			(0.0668)
3-4 days		0.344***			0.326***		0.342***			0.323***
		(0.0627)			(0.0626)		(0.0622)			(0.0620)
Breakfast per week										
Never			0.347***		0.323***			0.347***		0.323***
			(0.121)		(0.120)			(0.120)		(0.119)
Every day			-0.372***		-0.353***			-0.376***		-0.356***
			(0.0679)		(0.0678)			(0.0679)		(0.0678)
Mode transport from school to home										
Public transport				0.0451	0.0397				0.0495	0.0435
				(0.108)	(0.108)				(0.109)	(0.109)
School or local authority bus, minibus				0.148*	0.125				0.139*	0.118
				(0.0799)	(0.0791)				(0.0802)	(0.0793)
Car or other vehicle				0.202***	0.198***				0.206***	0.202***
				(0.0530)	(0.0532)				(0.0529)	(0.0531)
Bicycle				0.0405	0.124				0.0198	0.106
				(0.126)	(0.125)				(0.131)	(0.128)
Other				-0.336**	-0.290*				-0.338**	-0.291*
				(0.153)	(0.153)				(0.151)	(0.151)
Other Food Outlets	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Area level economic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year of survey FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	24,759	24,703	24,680	24,682	24,615	24,759	24,703	24,680	24,682	24,615
Individuals	8,253	8,253	8,253	8,249	8,249	8,253	8,253	8,253	8,249	8,249
Mean of the dependent variable	18.95	18.94	18.94	18.94	18.94	18.95	18.94	18.94	18.94	18.94

Notes: This table show OLS estimates for our preferred individual fixed-effect specification including additional time-varying controls. Outcome is BMI and other estimates are omitted due to space restrictions but available upon request. ***, **, and * denote statistically significant at 1%, 5% and 10%. Robust standard errors in parenthesis are clustered at the individual level.

Table A12. Effect of fast food restaurants around 800 metres on BMI, controlling for additional individual time varying characteristics.

	Home					School				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Fast food restaurants within 800m	0.0554**	0.0569**	0.0554**	0.0565**	0.0564**	0.0742***	0.0720***	0.0728***	0.0756***	0.0764***
	(0.0255)	(0.0254)	(0.0253)	(0.0256)	(0.0253)	(0.0229)	(0.0226)	(0.0226)	(0.0229)	(0.0226)
Weekly physical activity										
Not at all		0.275***			0.260***		0.274***			0.259***
		(0.0812)			(0.0811)		(0.0813)			(0.0811)
1-2 days		0.382***			0.355***		0.383***			0.357***
		(0.0669)			(0.0668)		(0.0669)			(0.0667)
3-4 days		0.344***			0.326***		0.343***			0.324***
		(0.0628)			(0.0627)		(0.0623)			(0.0621)
Breakfast per week										
Never			0.352***		0.329***			0.349***		0.325***
			(0.120)		(0.119)			(0.120)		(0.119)
Every day			-0.372***		-0.352***			-0.376***		-0.357***
			(0.0679)		(0.0678)			(0.0676)		(0.0676)
Mode transport from school to home										
Public transport				0.0439	0.0378				0.0535	0.0479
				(0.109)	(0.109)				(0.108)	(0.108)
School or local authority bus, minibus				0.143*	0.122				0.143*	0.122
				(0.0800)	(0.0792)				(0.0801)	(0.0792)
Car or other vehicle				0.202***	0.199***				0.209***	0.206***
				(0.0531)	(0.0533)				(0.0531)	(0.0533)
Bicycle				0.0293	0.115				0.0276	0.114
				(0.131)	(0.128)				(0.131)	(0.129)
Other				-0.344**	-0.298*				-0.337**	-0.291*
				(0.152)	(0.152)				(0.152)	(0.152)
Other Food Outlets	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Area level economic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year of survey FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	24,759	24,703	24,680	24,682	24,615	24,759	24,703	24,680	24,682	24,615
Individuals	8,253	8,253	8,253	8,249	8,249	8,253	8,253	8,253	8,249	8,249
Mean of the dependent variable	18.95	18.94	18.94	18.94	18.94	18.95	18.94	18.94	18.94	18.94

Notes: This table show OLS estimates for our preferred individual fixed-effect specification including additional time-varying controls. Outcome is BMI and other estimates are omitted due to space restrictions but available upon request. ***, **, and * denote statistically significant at 1%, 5% and 10%. Robust standard errors in parenthesis are clustered at the individual level.

Table A13. Effect of fast food restaurants around 800 metres on BMI, controlling for additional individual time varying characteristics.

	Home					School				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Fast food restaurants within 800m	0.0980	0.0924	0.0931	0.0914	0.0883	0.0296	0.0331	0.0377	0.0331	0.0406
	(0.0775)	(0.0761)	(0.0794)	(0.0771)	(0.0775)	(0.0426)	(0.0425)	(0.0429)	(0.0425)	(0.0426)
Weekly physical activity										
Not at all		0.273***			0.258***		0.270***			0.255***
		(0.0812)			(0.0810)		(0.0813)			(0.0812)
1-2 days		0.381***			0.355***		0.380***			0.353***
		(0.0670)			(0.0669)		(0.0669)			(0.0668)
3-4 days		0.343***			0.325***		0.343***			0.324***
		(0.0628)			(0.0627)		(0.0627)			(0.0625)
Breakfast per week										
Never			0.349***		0.325***			0.349***		0.325***
			(0.121)		(0.119)			(0.120)		(0.119)
Every day			-0.374***		-0.355***			-0.375***		-0.356***
			(0.0681)		(0.0680)			(0.0681)		(0.0680)
Mode transport from school to home										
Public transport				0.0452	0.0390				0.0489	0.0430
				(0.108)	(0.108)				(0.109)	(0.109)
School or local authority bus, minibus				0.141*	0.119				0.140*	0.119
				(0.0801)	(0.0793)				(0.0801)	(0.0793)
Car or other vehicle				0.203***	0.199***				0.206***	0.202***
				(0.0530)	(0.0532)				(0.0530)	(0.0532)
Bicycle				0.0286	0.115				0.0229	0.108
				(0.131)	(0.128)				(0.131)	(0.128)
Other				-0.345**	-0.299**				-0.335**	-0.288*
				(0.153)	(0.153)				(0.153)	(0.153)
Other Food Outlets	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Area level economic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year of survey FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	24,759	24,703	24,680	24,682	24,615	24,759	24,703	24,680	24,682	24,615
Individuals	8,253	8,253	8,253	8,249	8,249	8,253	8,253	8,253	8,249	8,249
Mean of the dependent variable	18.95	18.94	18.94	18.94	18.94	18.95	18.94	18.94	18.94	18.94

Notes: This table show OLS estimates for our preferred individual fixed-effect specification including additional time-varying controls. Outcome is BMI and other estimates are omitted due to space restrictions but available upon request. ***, **, and * denote statistically significant at 1%, 5% and 10%. Robust standard errors in parenthesis are clustered at the individual level.

Table A14. Robustness analysis: Effect of a modified fast food restaurant definition on BMI, equation (1)

	Home		School	
	(1)	(2)	(3)	(4)
Fast food restaurants (base definition)				
Equation 1, k = 400m	0.0980		0.0296	
	(0.0775)		(0.0426)	
Equation 1, k = 800m	0.0554**		0.0742***	
	(0.0255)		(0.0229)	
Equation 1, k = 1600m	0.0355***		0.0225**	
	(0.0126)		(0.0106)	
Fast food restaurants (modified definition)				
Equation 1, k = 400m		0.0861		0.0336
		(0.0758)		(0.0435)
Equation 1, k = 800m		0.0509**		0.0698***
		(0.0253)		(0.0221)
Equation 1, k = 1600m		0.0369***		0.0214**
		(0.0124)		(0.0106)
Other food outlets	Yes	Yes	Yes	Yes
Individual controls	Yes	Yes	Yes	Yes
Area level controls	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes
Year of survey FE	Yes	Yes	Yes	Yes
Observations	24,759	24,759	24,759	24,759
Number of individuals	8,253	8,253	8,253	8,253
Mean of dependent variable	18.95	18.95	18.95	18.95

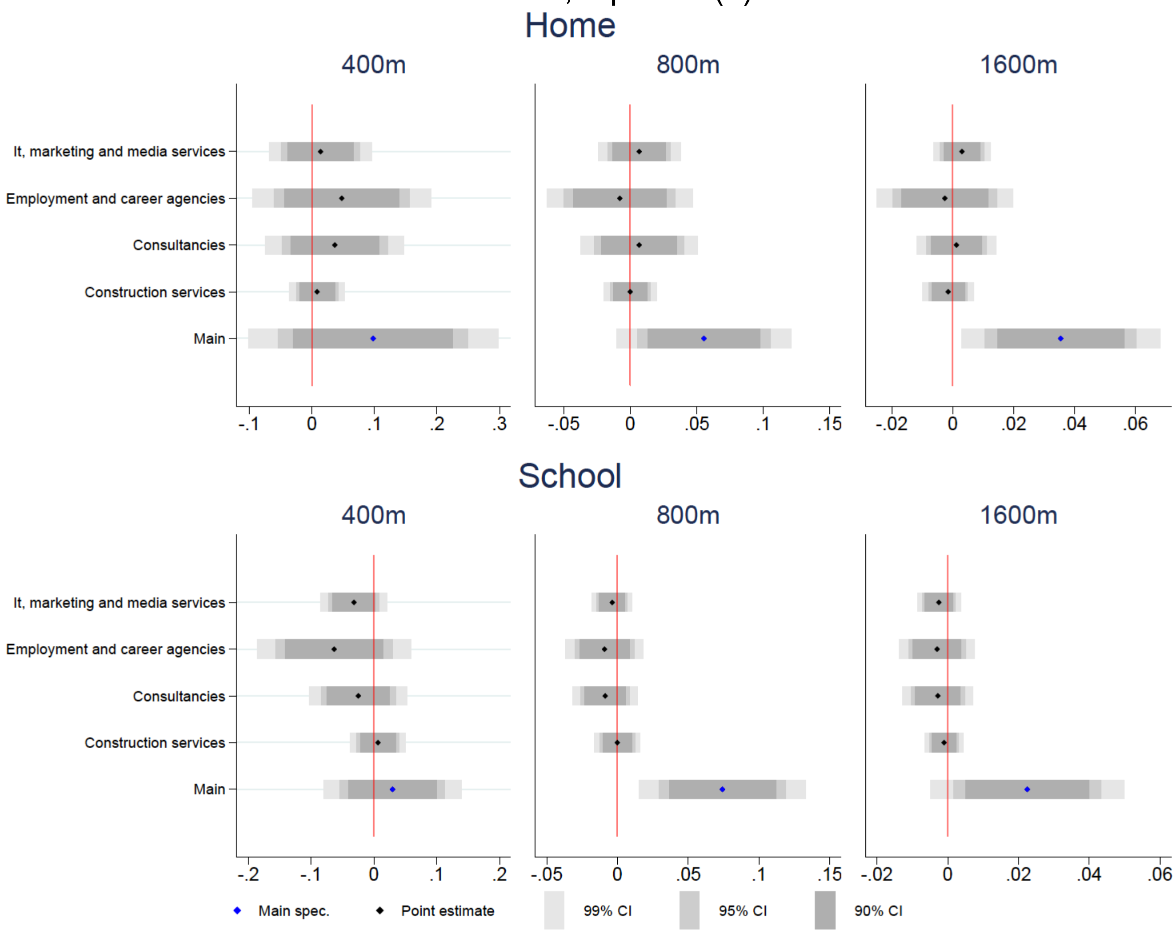
Notes: ***, **, and * denote statistically significant at 1%, 5% and 10%. Robust standard errors in parenthesis are clustered at the individual level.

Table A15. Robustness analysis: Effect of a modified fast food restaurant definition on BMI, equation (2)

	Home		School	
	(1)	(2)	(3)	(4)
Fast food restaurant (base definition)				
within 400m	0.102		0.0404	
	(0.0773)		(0.0426)	
between 400m and 800m	0.0432		0.0818***	
	(0.0306)		(0.0244)	
between 800m and 1600m	0.0283**		0.00683	
	(0.0142)		(0.0120)	
Fast food restaurant (modified definition)				
within 400m		0.0887		0.0428
		(0.0744)		(0.0435)
between 400m and 800m		0.0410		0.0757***
		(0.0314)		(0.0232)
between 800m and 1600m		0.0315**		0.00656
		(0.0140)		(0.0122)
Other food outlets	Yes	Yes	Yes	Yes
Individual controls	Yes	Yes	Yes	Yes
Area level controls	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes
Year of survey FE	Yes	Yes	Yes	Yes
Observations	24,759	24,759	24,759	24,759
Number of individuals	8,253	8,253	8,253	8,253
Mean of dependent variable	18.95	18.95	18.95	18.95

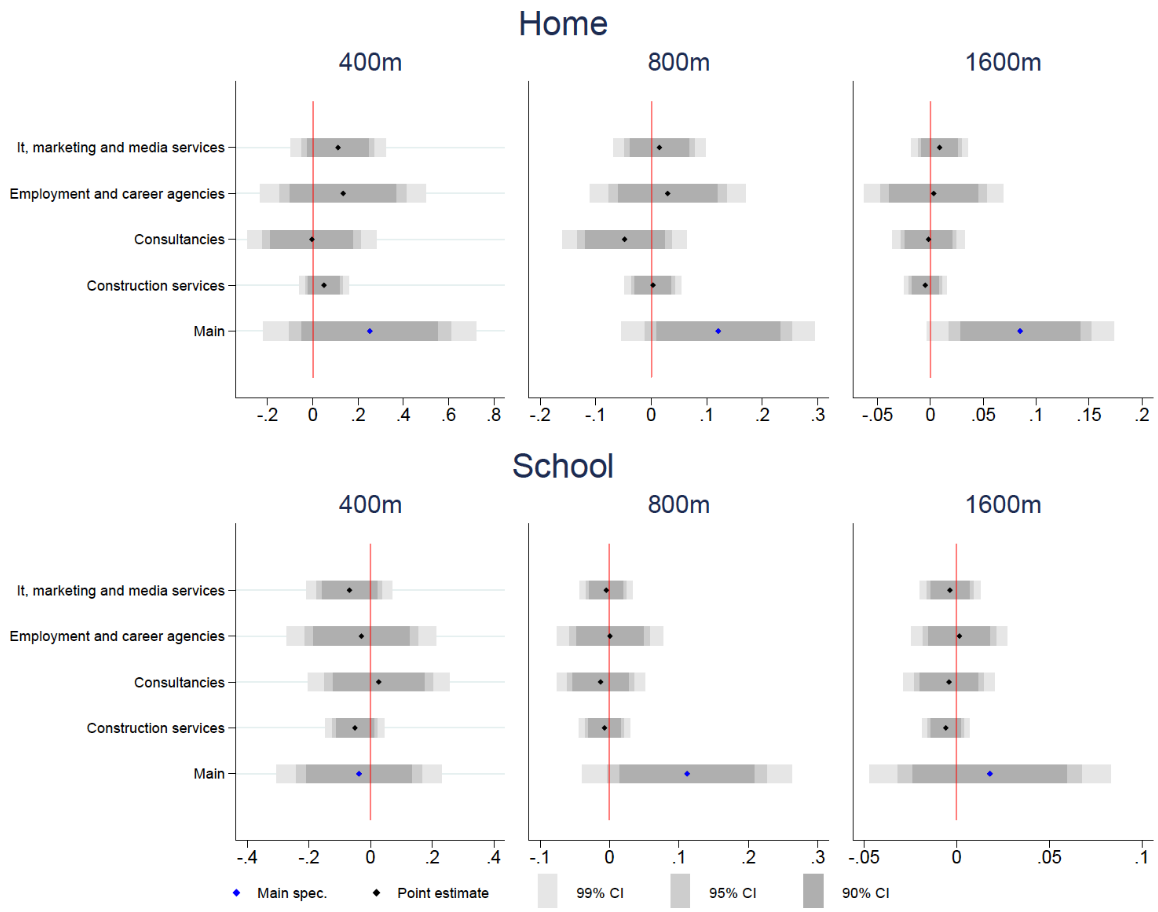
Notes: ***, **, and * denote statistically significant at 1%, 5% and 10%. Robust standard errors in parenthesis are clustered at the individual level.

Figure A1. Placebo estimates for child's BMI, equation (1)



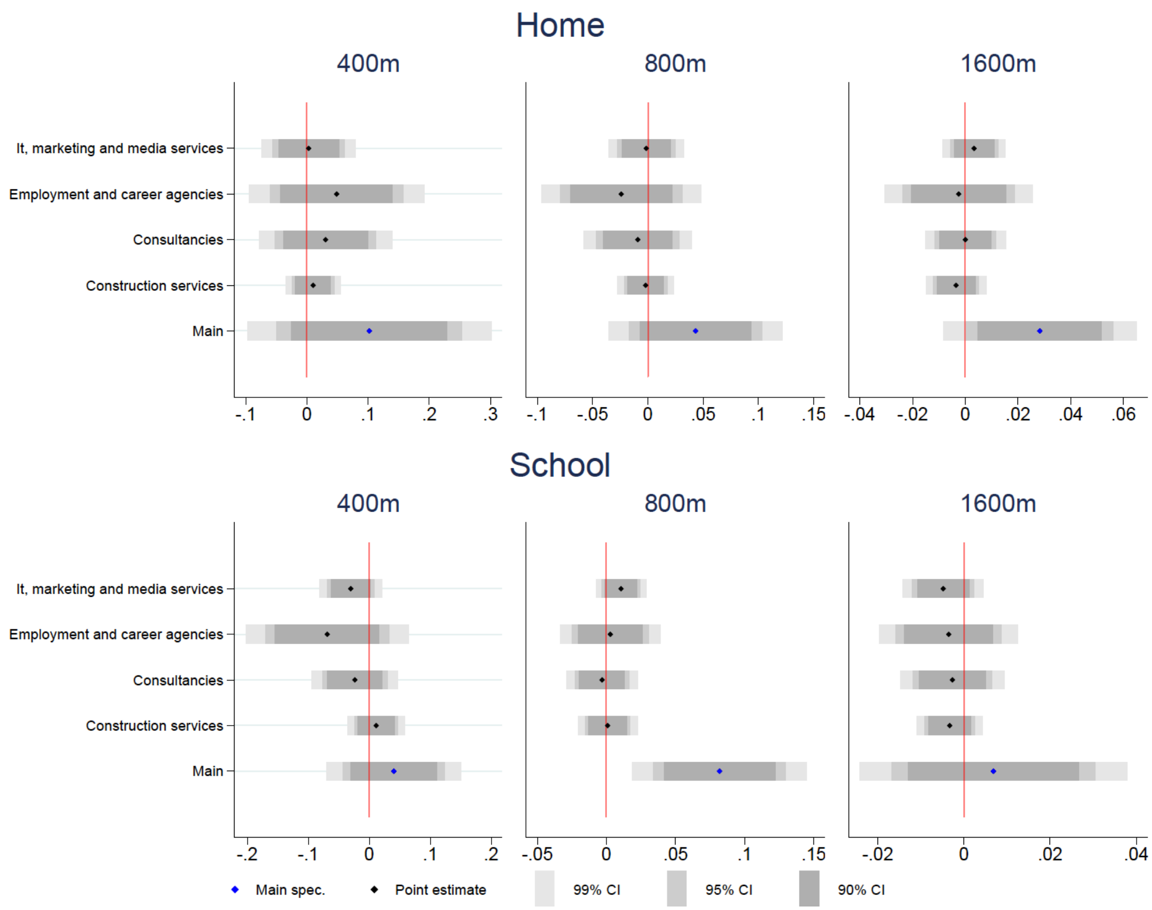
Notes: Each point estimate denotes a different regression using individuals' BMI as depended variable. This figure shows estimates for equation (1) using our preferred individual fixed effect specification. Our preferred specification is labelled as 'Main'. Other estimates shown in this figure replace the number of fast food restaurants by the numbers of other placebo PoI facilities within 400, 800, and 1600 metres from individual's residence and school. We plot estimates using placebo exposure to facilities in the following PoI categories: 'It, marketing and media services', 'Employment and career agencies', 'Consultancies', and 'Construction services'.

Figure A2. Placebo estimates for child's Body Fat percentage, equation (1)



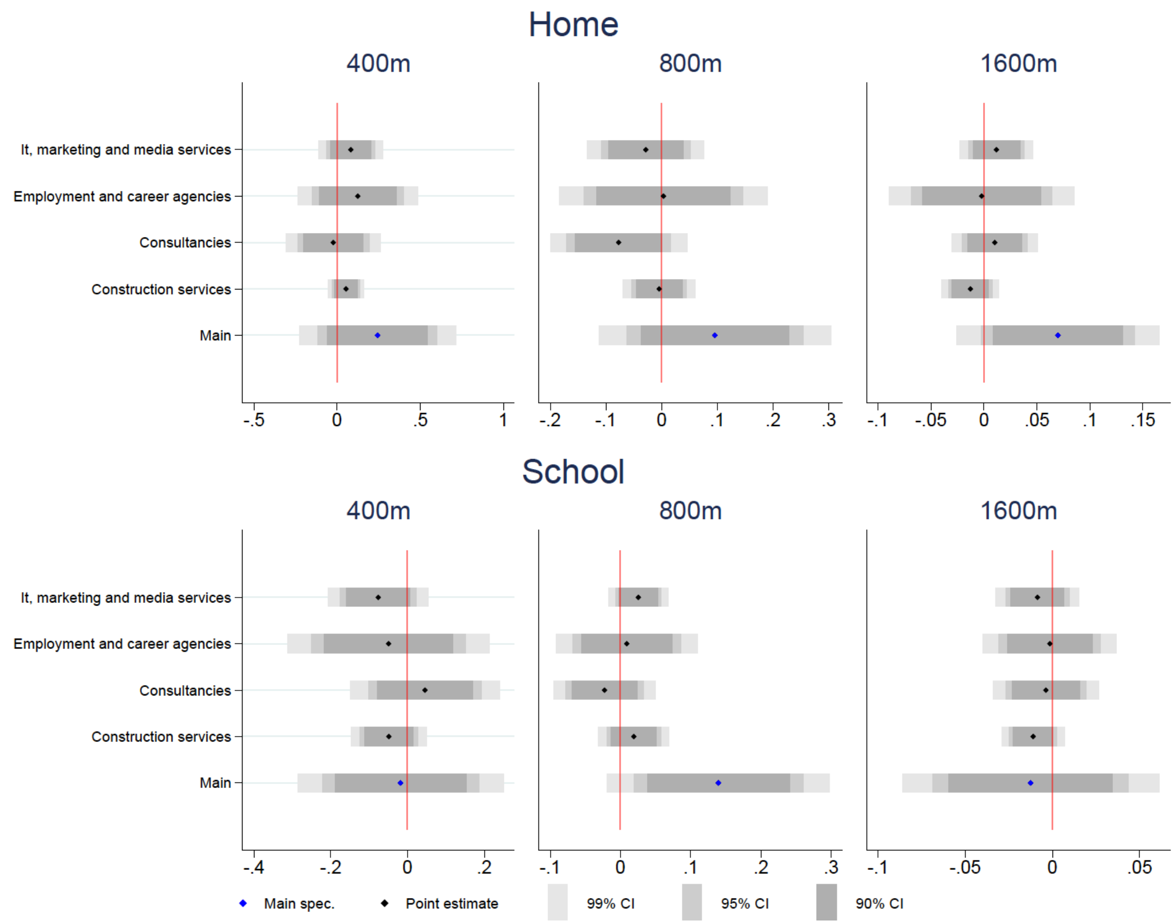
Notes: Each point estimate denotes a different regression using individuals' Body Fat percentage as depended variable. This figure shows estimates for equation (1) using our preferred individual fixed effect specification. Our preferred specification is labelled as 'Main'. Other estimates shown in this figure replace the number of fast food restaurants by the numbers of other placebo PoI facilities within 400, 800, and 1600 metres from individual's residence and school. We plot estimates using placebo exposure to facilities in the following PoI categories: 'It, marketing and media services', 'Employment and career agencies', 'Consultancies', and 'Construction services.

Figure A3. Placebo estimates for child's BMI, equation (2)



Notes: Each point estimate denotes a different regression using individuals' BMI as depended variable. This figure shows estimates for equation (2) using our preferred individual fixed effect specification. Our preferred specification is labelled as 'Main'. Other estimates shown in this figure, replace the number of fast food restaurants by the numbers of other placebo PoI facilities within 400 metres, between 400 and 800 metres, and between 800 and 1600 metres from individuals' residences and schools. We plot estimates using placebo exposure to facilities in the following PoI categories: 'It, marketing and media services', 'Employment and career agencies', 'Consultancies', and 'Construction services.

Figure A4. Placebo estimates for child's Body Fat percentage, equation 2



Notes: Each point estimate denotes a different regression using individuals' Body Fat percentage as depended variable. This figure shows estimates for equation (2) using our preferred individual fixed effect specification. Our preferred specification is labelled as 'Main'. Other estimates shown in this figure, replace the number of fast food restaurants by the numbers of other placebo PoI facilities within 400 metres, between 400 and 800 metres, and between 800 and 1600 metres from individuals' residences and schools. We plot estimates using placebo exposure to facilities in the following PoI categories: 'It, marketing and media services', 'Employment and career agencies', 'Consultancies', and 'Construction services.

Table A16. Association of Emotional Dysregulation at age 7 and outcomes at age 14 and 11

	Eat fast food one or more days per week (age 14)	Ever smoke (age 14)	Ever tried alcohol (age 14)	Individual's Patience (age 14)	Risk taking (age 11)
	(1)	(2)	(3)	(4)	(5)
Panel A.					
High emotional dysregulation	4.478***	5.004***	4.132***	-0.554***	0.0145***
	(1.194)	(1.411)	(1.402)	(0.0601)	(0.00434)
Panel B.					
Emotional dysregulation	3.935***	6.831***	5.264***	-0.726***	0.0171***
	(1.393)	(1.519)	(1.611)	(0.0754)	(0.00476)
Observations	8,029	7,643	7,710	8,001	7,719
Individual controls at age 7	Yes	Yes	Yes	Yes	Yes
Area level economic controls at age 7	Yes	Yes	Yes	Yes	Yes
Mean of the dependent variable	26.85	52.91	50.80	5.708	0.527

Notes: This table show OLS estimates. Each cell reports a different regression. Individual and area level controls at age 7 are the same we include in our main specification. The outcome in column 1 is a dummy variable that measures if the individual eats fast food one or more days per week. In columns 2 and 3, outcomes variables are dummy variables indicating if the individual has ever smoked and drank alcohol, respectively. Individual's Patience is a continuous variables created with the question ‘How patient is the respondent?’. It is a score ranging from 0 to 10, where 10 indicates that the highest level of patience. Risk taking at age 11 is measured using the risk taking score of the CANTAB Cambridge Gambling Task, where higher values indicate of greater risk taking (Atkinson, 2015). Dependent are shown in Panel A and B. High emotional dysregulation is a dummy variable equals 1 if the emotional dysregulation sub-scale of the Child Social Behaviours Questionnaire at age 7 is above the sample median and 0 otherwise. The Emotional dysregulation score is the score of the dysregulation sub-scale of the Child Social Behaviours Questionnaire at age 7.

Appendix B

Definitions of covariates, fast food restaurants and other food outlets.

Fast food restaurants

The main fast food restaurant variable used in this paper is defined as the number of the following fast food chains in the Points of Interest data.

- McDonalds: The outlet's name in the PoI data includes the string "McDonald's Restau*" OR "McDonalds" AND belongs to the PoI group "Accommodation, eating and drinking" and category "Eating and drinking".
- KFC: The outlet's name in the PoI data includes the string "KFC" OR "K F C*" OR "KFC*" AND belongs to the PoI group "Accommodation, eating and drinking" and category "Eating and drinking".
- Burger King: The outlet's name in the PoI data includes the string "Burger King*" AND belongs to the PoI group "Accommodation, eating and drinking" and category "Eating and drinking".
- Wimpy: The outlet's name in the PoI data includes the string "Wimpy*" AND belongs to the PoI group "Accommodation, eating and drinking" and category "Eating and drinking".
- Subway: The outlet's name variable in the PoI data includes the string "Subway*" AND belongs to the PoI group "Accommodation, eating and drinking" and category "Eating and drinking".
- Pizza Hut: The outlet's name in the PoI data includes the string "*Pizza Hut*" AND belongs to the PoI group "Accommodation, eating and drinking" and category "Eating and drinking".
- Dominos' Pizza: The outlet's name in the PoI data includes the string "Domino's Pizza*" AND belongs to the PoI group "Accommodation, eating and drinking" and category "Eating and drinking".
- Kebab and Chicken: The outlet's name in the PoI data includes the string ("*Chicken*" OR "*Keba*") AND belongs to the PoI group "Accommodation, eating and drinking" and category "Eating and drinking".
- Fish and chip shops: All outlets belonging to the class 1020020 "Fish and chip shops", of the PoI group "Accommodation, eating and drinking" and category "Eating and drinking".

Other food outlets

Using the Points of Interest classification scheme v3.1. The 'Other food outlets' variable (Table A1 and A2 in Online Appendix) is defined as the number of outlets in the following classes:

- From the PoI group 'Accommodation, eating and drinking' and category 'Eating and drinking'
    - 1020043: Restaurants

- 1020018: Takeaway outlets and 1020019: Food delivery services. These categories were grouped in a category named ‘Other takeaway outlets’

- From the PoI group ‘Retail’, and category ‘Food, drink and multi item retail’
  - 9470661: Bakeries
  - 9470662: Butchers
  - 9470663: Confectioners
  - 9470665: Delicatessens
  - 9470666: Fishmongers
  - 9470668: Green and new age goods
  - 9470669: Grocers; farm shops and pick your own
  - 9470672: Organic; health; gourmet and kosher foods
  - 9470699: Convenience stores and independent supermarkets
  - 9470819: Supermarket chains

Controls used in equations (1) and (2)

Individual level control

a) Maternal highest educational level: We use variable National Vocational Qualification (NVQ) variable created by CLS and available in the public data. Looks at academic and vocational qualifications gained by the MAIN respondent since last interview and compares them with the derived NVQ highest level from previous sweeps to ascertain the overall highest level attained across all sweeps. More details can be found in the documents “MCS: Guide to Derived Variables for waves 3, 4, 5 and 6”.
b) Number of Parents/Careers in household: We use variable HTYS created by CLS and available in the public data. Is a collapsed version of HTYP into a 1 or 2 parent family:
   1. *Two parents/carers*
   2. *One parent/carer*

   More details can be found in the documents “MCS: Guide to Derived Variables for waves 3, 4, 5 and 6”.
c) OECD equivalised weekly family income: We use variable OEDE, created by CLS and available in the public data. It divides total net income by number of household members according to their weight on the OECD equivalised income scale (equivalised household size) to give net disposable income. More details can be found in the documents “MCS: Guide to Derived Variables for waves 3, 4, 5 and 6”.
d) Number of people in household (not including individual): We use variable NUMH created by CLS and available in the public data. It uses the variable PRES from the household grid to count the number of people present in the

household (but does not include CMs) More details can be found in the documents “MCS: Guide to Derived Variables for waves 3, 4, 5 and 6”.

e) Numbers of rooms in the household: We use the question ROMA.
ROMA: How many rooms do you and your family have here excluding bathrooms, toilets, halls and garages?

Area level controls

a) Unemployment rate: We linked the unemployment rate of local authority districts using MCS respondent’s postcode of residence at each interview.
Source:
https://www.nomisweb.co.uk/query/construct/summary.asp?mode=construct&version=0&dataset=127
b) Population estimates per 100,000 people: We linked annual population estimates at local authority districts level using MCS respondent’s postcode of residence at each interview.
Source:
https://www.nomisweb.co.uk/query/construct/summary.asp?mode=construct&version=0&dataset=2002

Table B1. PoI categories used in falsification tests

Group description	Category description	Class description
Commercial services	Construction services	Metalworkers including blacksmiths
		Building contractors
		Construction completion services
		Construction plant
		Cutting, drilling and welding services
		Demolition services
		Diving services
		Electrical contractors
		Gardening, landscaping and tree surgery services
		Glaziers
		Painting and decorating services
		Plasterers
		Plumbing and heating services
		Pool and court construction
		Restoration and preservation services
		Road construction services
		Roofing and chimney services
		Fencing and drystone walling services
		Building and component suppliers
Commercial services	Consultancies	Architectural and building related consultants
		Business related consultants
		Computer consultants
		Construction service consultants
		Feng shui consultants, furnishers and shop fitters
		Food consultants
		Image consultants
		Interpretation and translation consultants
		Security consultants
		Telecommunications consultants
		Traffic management and transport related consultants

Table B1. PoI categories used in definition of Falsification tests (cont.)

Group description	Category description	Class description
Commercial services	Employment and career agencies	Careers offices and armed forces recruitment
		Domestic staff and home help
		Driver agencies
		Employment agencies
		Modelling and theatrical agencies
		Nursing agencies
Commercial services	It, advertising, marketing and media services	Advertising services
		Artists, illustrators and calligraphers
		Computer security
		Computer systems services
		Concert/exhibition organisers and services
		Database services
		Desktop publishing services
		Electronic and internet publishers
		Film and video services
		General computer services
		Internet services
		Literary services
		Mailing and other information services
		Marketing services
		Plate makers, print finishers and type setters
		Press and journalism services
		Printing and photocopying services
		Recording studios and record companies
		Telephone, telex and fax services
		Television and radio services