

1 **Abstract**

2 **Objectives:** We investigated whether a higher number of fast food outlets in an individual's
3 home neighbourhood was associated with increased prevalence of type 2 diabetes and related
4 risk factors, including obesity.

5 **Design:** Cross-sectional study.

6 **Setting:** Three UK-based diabetes screening studies (one general population, two high-risk
7 populations) conducted between 2004 and 2011. The primary outcome was screen-detected
8 type 2 diabetes. Secondary outcomes were risk factors for type 2 diabetes.

9 **Subjects:** 10,461 participants (mean age: 59 years; 53% male; 21% non-White ethnicity).

10 **Results:** There was a higher number of neighbourhood (500m radius from home postcode)
11 fast food outlets among non-White ethnic groups ($P < 0.001$) and socially deprived areas
12 ($P < 0.001$). After adjustment (social deprivation, urban/rural, ethnicity, age, sex), more fast
13 food outlets was associated with significantly increased odds ratios (ORs) for diabetes (OR
14 [95% CI] = 1.02 [1.00, 1.04]) and obesity (1.02 [1.00, 1.03]). This suggests that for every
15 additional two outlets per neighbourhood, we would expect one additional diabetes case,
16 assuming a causal relationship between the fast food outlets and diabetes.

17 **Conclusions:** These results suggest that increased exposure to fast food outlets is associated
18 with increased risk of type 2 diabetes and obesity, which has implications for diabetes
19 prevention at a public health level and for those granting planning permission to new fast
20 food outlets.

1 **Introduction**

2 Type 2 diabetes mellitus is a growing epidemic with estimates suggesting that worldwide
3 prevalence will increase from 366 million in 2011 to 552 million in 2030.¹ Prevalence is
4 closely associated with increasing obesity rates,² and is linked to environmental changes
5 which have led to more sedentary lifestyles and poor quality dietary intake.³ Therefore, while
6 interventions aimed at individuals changing behaviours can be successful,⁴ population level
7 environmental changes are also needed if we are to curb the obesity epidemic and
8 consequently the heavy burden of obesity-related disease, such as type 2 diabetes.⁵

9 Consumption of fast food is a factor commonly linked with the obesity epidemic, and there is
10 some scientific evidence from adult populations to support this claim. Regular fast food
11 consumption has been linked to low adherence to dietary recommendations.⁶ Greater energy
12 density, high fat content, high levels of trans fatty acids, high sodium content, and larger
13 portion sizes of fast food may all potentially contribute to overall poor diet quality.⁶⁻⁹ There is
14 however limited evidence in adults at the population level to suggest that the number of fast
15 food outlets in an area is associated with obesity levels, with some,¹⁰ but not all,^{11,12} studies
16 finding that more outlets were associated with increased obesity levels, possibly due to
17 methodological weaknesses in some studies such as self-reported height and weight.

18 The existing research outlined above suggests that fast food might be a reasonable target for
19 public health interventions aimed at reducing obesity and related conditions, including type 2
20 diabetes. There are however key gaps in the literature; namely, a lack of data exploring the
21 association between fast food and type 2 diabetes as well as a lack of data from Europe, and
22 in high risk minority ethnic groups, such as South Asians.¹⁰⁻¹³ These analyses of over 10,000
23 individuals from a multi-ethnic UK population are the first step towards addressing these
24 gaps. We aimed to investigate the relationship between the number of fast food outlets in an
25 individual's neighbourhood and screen-detected type 2 diabetes and associated risk factors.

27 **Experimental Methods**

28 *Study population*

29 These analyses used data from three studies (ADDITION-Leicester,¹⁴ Let's Prevent
30 Diabetes¹⁵ and Walking Away from Diabetes¹⁶), which were conducted by the same research

group in Leicestershire, UK and used identical standard operating procedures. This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human participants were approved by the [name of ethics committee removed for blinding]. Written informed consent was obtained from all participants.

The studies have been described in detail elsewhere.¹⁴⁻¹⁶ Briefly, they involved screening individuals for type 2 diabetes and then conducting randomised controlled trials for those found either to have type 2 diabetes (ADDITION-Leicester) or to be at high risk of developing it (Let's Prevent Diabetes and Walking Away from Diabetes). The data used for these analyses are based only on the cross-sectional screening stage of each study.

ADDITION-Leicester (2004-2009) was a population based screening programme for people aged 40-75 years (White European) or 25-75 years (other ethnic groups). Let's Prevent Diabetes (2009-2011) screened individuals at high risk of type 2 diabetes on a risk score, aged 40-75 years (White European) or 25-75 years (other ethnic groups). Walking Away from Diabetes (2010) also screened individuals at high risk of type 2 diabetes on a risk score, but adults aged 18-75 years were eligible. The studies recruited from primary care (response rate = 22% in all three studies¹⁷) and had similar exclusion criteria, which included a previous diagnosis of type 2 diabetes. All participants screened in these studies were potentially eligible for inclusion in these analyses. Subjects were excluded if they had a missing or invalid postcode (zip code), as it was not possible to define neighbourhood for these individuals. If subjects participated in more than one study then the most recent record was kept.

Variables

The biochemical, anthropometric and demographic variables used in these analyses were measured during the screening visit.¹⁴⁻¹⁶ The primary outcome variable was type 2 diabetes diagnosed using the World Health Organisation 2011 guidelines as fasting glucose ≥ 7.0 mmol/l, 2 hour glucose ≥ 11.1 mmol/l or HbA1c $\geq 6.5\%$ (48 mmol/mol).¹⁸ Since people with known diabetes were excluded from screening, these individuals are those with undiagnosed type 2 diabetes, rather than all type 2 diabetes cases. Fasting blood samples for glucose and HbA1c were obtained following a minimum of eight hours fast. An oral glucose tolerance test was then performed where participants consumed a standard measure of glucose and had another blood test two hours later. Fasting glucose, 2 hour glucose and

HbA1c were also considered separately as secondary outcomes, as were several other variables. The presence of impaired glucose regulation, a high risk state for type 2 diabetes, was diagnosed as fasting glucose between 6.1 and 6.9mmol/l, 2 hour glucose between 7.8 and 11.0mmol/l, or HbA1c between 6.0 and 6.4% (42 and 46mmol/mol). Body mass index was calculated from height and weight which were measured by trained staff. Obesity was defined as body mass index $\geq 30\text{kg/m}^2$ for all participants, except South Asians for whom it was defined as $\geq 27.5\text{kg/m}^2$.¹⁹ Total, LDL and HDL cholesterol were also measured in the fasting blood sample, as was fasting insulin in Walking Away from Diabetes (n=654) and for a random subset of ADDITION-Leicester participants (n=905). These outcomes were chosen as they may mediate the association between fast food consumption and type 2 diabetes, as well as being risk factors for other conditions.

The primary explanatory variable in these analyses is the absolute number of fast food outlets in the participant's neighbourhood. Neighbourhood was defined as the Euclidean distance within 500m of the participant's home (identified through their postcode, which in the UK contains 15 individual addresses on average). There is no standard definition of neighbourhood, therefore we chose to use a definition of 500m as this distance is commonly used in physical activity studies, such as neighbourhood walkability studies,²⁰⁻²² and additionally considered the effect of this through sensitivity analyses. The locations of fast food outlets were extracted from an online business listing (Thompson's directory) in January 2014 using the following search terms: 'fast food', 'fish and chips', and 'take away' to fit with the standard definition of fast food (i.e. hot food cooked on site that can be produced quickly and taken away). This means that the majority of outlets labelled as 'fast food outlets' were self-defined when the outlets signed up for the business directory. Adding additional search terms, such as 'pizza', did not alter the number of outlets that were identified. The following confounding variables were also considered. Age, sex and ethnicity were all self-reported by the participant. Ethnicity was self-reported based on the British Census categories, but was grouped as White European (White British, White Irish, other White background), South Asian (Indian, Pakistani, Bangladeshi, other Asian background) and Other (Black Caribbean, Black African, other Black background, White and Asian, White and Black Caribbean, White and Black African, other mixed background, Chinese, other Chinese background, other background), due to a small number of participants in some ethnic groups. Index of Multiple Deprivation 2007 scores were used as a measure of social deprivation (http://data.gov.uk/dataset/index_of_multiple_deprivation_imd_2007). These

scores are a publicly available postcode measure, which are calculated using a variety of indicators including income, employment, education and living environment. A higher score indicates higher deprivation. An urban/rural indicator was obtained from the Office for National Statistics. This groups morphologies as urban (>10,000 residents); town and fringe; or villages, hamlets and isolated dwellings. For these analyses, the two latter categories were grouped as 'rural'. Physical activity was measured using the short version of the International Physical Activity Questionnaire (IPAQ), and published standards were used to clean the data and produce estimates of the number of metabolic equivalents (METs) per day for total activity.²³

Statistical analysis

The main purpose of these analyses was to investigate whether the number of neighbourhood fast food outlets was associated with screen-detected type 2 diabetes and other metabolic risk factors. Descriptive characteristics by study and for the overall population are presented. Continuous variables are summarised as mean (standard deviation [SD]) and categorical variables as number (percentage). The mean (SD) number of fast food outlets was summarised overall and within subgroups of patient characteristics. ANOVA was used to test for a difference in the number of outlets within subgroups. Generalised estimating equation models were fitted separately for each primary (type 2 diabetes) and intermediate (impaired glucose regulation, obesity, body mass index, waist circumference, fasting glucose, 2 hour glucose, HbA1c, total cholesterol, LDL cholesterol, HDL cholesterol, fasting insulin) outcome. For each of these outcomes, an unadjusted and adjusted model was fitted. Adjusted models included the following confounders: social deprivation (continuous), urban/rural indicator (continuous), ethnicity (White European, South Asian, Other), age (continuous) and sex (Male, Female). The generalised estimating equation models had the number of fast food outlets as the explanatory variable, a term to allow for clustering within postcodes, exchangeable correlation structures and robust standard errors. The distribution and link function were binomial and logit for binary outcome variables, and Gaussian and identity for continuous outcome variables. Physical activity (total METs) was also considered as a confounder, but this did not change the results and so it was not included in the presented models, because this variable was only available for 82% of the sample and including it substantially reduced the sample size unnecessarily. Sensitivity analyses were repeated for

the adjusted analyses using different distances for the definition of neighbourhood, and using the density (number of outlets per 200 residents, where neighbourhood population size was obtained from 2011 Census data) of neighbourhood fast food outlets in a 500m radius as the explanatory variable instead of the absolute number of outlets. Interaction terms between the number of fast food outlets and ethnicity, urban/rural indicator, and social deprivation score were fitted in turn. All analyses were performed in Stata v13 and P-values are two-sided. A p-value of less than 0.05 was considered statistically significant for main effects and less than 0.1 for interactions. Missing data were not imputed.

Results

ADDITION-Leicester screened 6,749 participants, of whom 300 were excluded because they had a missing postcode and 6 because they had an invalid one, leaving 6,443 eligible participants. Let's Prevent Diabetes screened 3,450 participants, of whom 18 had an invalid postcode, thus 3,432 participants were eligible. Walking Away from Diabetes screened 833 participants, of whom 3 had an invalid postcode, thus 830 participants were eligible. There were 244 people who participated in more than one of the studies, so these analyses included a total of 10,461 participants, whose characteristics are shown in Table 1.

In summary, the participants were aged 59.0 (SD 10.4) years old on average and 53% were male. ADDITION-Leicester participants tended to be slightly younger and were more likely to be female compared with the other two studies. This is because ADDITION-Leicester was a general population screening study, whereas the other two studies screened high risk individuals. There were a mean of 2.1 (SD 3.7; range = 0 to 36) fast food outlets in participants' neighbourhoods (Table 2). The number of neighbourhood fast food outlets was significantly higher for South Asians than White Europeans ($P < 0.001$), in urban areas compared with rural areas ($P < 0.001$), and near those with high compared with low social deprivation ($P < 0.001$).

Table 3 shows the model estimates for the association between the number of fast food outlets and each outcome. In unadjusted analyses, the number of fast food outlets was positively associated with screen-detected type 2 diabetes (odds ratio [OR] 1.05; 95% confidence interval [CI]: 1.04, 1.07; $P < 0.001$), 2 hour glucose (b 0.02; 95% CI: 0.00, 0.03; $P = 0.01$), HbA1c (b 0.01; 95% CI: 0.00, 0.01; $P < 0.001$) and fasting insulin (b 0.13; 95% CI:

0.04, 0.22; $P < 0.01$). After adjustment for social deprivation score, urban/rural indicator, ethnicity, age and sex, the positive association with type 2 diabetes was attenuated but remained significant (OR 1.02; 95% CI: 1.00, 1.04; $P = 0.02$), while the associations with each of 2 hour glucose, HbA1c and fasting insulin were no longer significant. Conversely, the positive associations with obesity, body mass index and fasting glucose strengthened and became significant ($P < 0.01$ for both obesity and body mass index) or borderline significant ($P = 0.06$ for fasting glucose). There was no significant interaction on type 2 diabetes between outlets and ethnicity ($P = 0.21$), outlets and urban/rural location ($P = 0.98$) or outlets and social deprivation score ($P = 0.93$).

Sensitivity analyses for different definitions of neighbourhood showed similar results (Web Table 1). Interestingly, when neighbourhood was defined to cover a smaller region (100m or 250m), the relationship between the number of fast food outlets and type 2 diabetes was weak but there were significant positive associations with adiposity measures. Conversely, for areas of neighbourhood covering larger regions (500m, 750m or 1000m), the number of fast food outlets was positively associated with type 2 diabetes, obesity and fasting glucose; these associations were small but significant. Sensitivity analyses using the density, instead of the absolute number, of fast food outlets demonstrated a similar pattern of results to the main analyses, although there were some differences in terms of which results were significant (Web Table 2).

Discussion

In a multi-ethnic region of the UK, individuals had on average two fast food outlets within 500m of their home. This number differed substantially by key demographics, including ethnicity; people of non-White ethnicity had more than twice the number of fast food outlets in their neighbourhood compared with White Europeans. We found that the number of fast food outlets in a person's neighbourhood was associated with an increased risk of screen-detected type 2 diabetes and obesity, after adjustment for confounders. Associations with other intermediate outcomes were weak and generally non-significant after adjustment for confounders. The exceptions were body mass index and fasting glucose which displayed weak positive associations with the number of fast food outlets.

1 This work has several notable strengths; namely, it is the first study, to our knowledge, to
2 look at the association between the number of neighbourhood fast food outlets and type 2
3 diabetes, it included a large sample size from a multi-ethnic population, gold-standard
4 measures were used to obtain the outcomes, results were found to be reasonably robust in
5 sensitivity analyses, and due to the detailed data that were collected we were able to look at
6 potential moderators of the relationships identified. Nonetheless, these results should be
7 interpreted with consideration of the study's limitations. First, these are cross-sectional
8 analyses, as with much of the literature on this topic, thus it is not possible for us to infer a
9 causal effect. Although plausible causal mechanisms exist as discussed below, it is possible
10 that demand precedes supply and that there are more fast food outlets in the neighbourhood
11 as that is the type of food that the residents want. Second, the number of the fast food outlets
12 was measured in 2014, whilst other variables were measured earlier, and only a sample of
13 fast food outlets was included in these analyses, due to time and cost constraints. The
14 associations demonstrated are therefore likely to be attenuated and the relationship between
15 fast food outlets and obesity-related outcomes might in fact be stronger than observed.

16 The results of this study add to the limited evidence that currently exists regarding fast food
17 outlets, obesity and type 2 diabetes in adults. The majority of previous studies conducted
18 have taken place in the United States,²⁴ thus we provide novel data from a large multi-ethnic
19 population within the UK, which increases the generalisability of our findings. Previous
20 studies have demonstrated that increased exposure to fast food outlets is inversely associated
21 with healthy lifestyle score, adherence to dietary recommendations and overall diet quality,
22 which are risk factors for type 2 diabetes.^{6,7} In comparison, a major strength of this study was
23 that it looked directly at the relationship between fast food outlets and type 2 diabetes.

24 However, we did not differentiate between different types of fast food outlet, and so this is an
25 area for potential future work. This would allow variations and nuances in the relationship
26 between fast food location/distance and incidence of type 2 diabetes to be identified, related
27 to the nutritional level of the fast food outlet. Moreover, future work or similar work in other
28 countries could also include convenience stores, as they tend to be a common source of junk
29 food and sugared drinks.

30 The results support data from the CARDIA study which found that increased fast food
31 consumption was associated with clinically relevant changes in cardiovascular disease and
32 type 2 diabetes risk factors including increased weight.⁸ They also support the results of
33 Smith *et al* who found that regular fast food consumption was associated with increased

1 abdominal obesity,⁶ and of Maddock *et al* who found that as the square miles per fast food
2 restaurant decreased (i.e. the density of restaurants increased), obesity prevalence measured at
3 the state-level increased.¹⁰ The observed association between the number of fast food outlets
4 with obesity and type 2 diabetes does not come as a surprise; fast food is high in total fat,
5 trans fatty acids and sodium, portion sizes have increased 2 to 5 fold over the last 50 years,⁹
6 and a single fast food meal provides approximately 5860kj (1,400kcal).²⁵ The energy density,
7 defined as the energy content per unit weight of foods, meals or diets,²⁶ of fast food may also
8 be important, since individuals consume a relatively constant weight of food, therefore
9 consumption of high energy density foods may lead to a passive increase in energy intake.²⁵
10 Experiments have also shown energy dense diets challenge the innate ability to maintain
11 energy homeostasis.²⁶ Furthermore, fast food outlets often provide sugar rich drinks.
12 Carbonated drinks appear to bypass the satiety mechanisms and the energy provided by them
13 is not compensated for during meals.⁹ It is also plausible that the observed associations are
14 due to confounding. It has been shown that unhealthy behaviours (i.e. smoking, excessive
15 alcohol use, poor diet and low levels of physical activity) cluster together.²⁷ In particular,
16 poor diet and low physical activity tend to occur together, thus the observed association
17 between fast food outlets and obesity-related outcomes in this study might also reflect known
18 associations between obesity and lack of physical activity. However, this is unlikely since
19 adjusting for physical activity did not alter the findings.

20 Other key findings of our study included observing very few significant associations between
21 the number of neighbourhood fast food outlets and diabetes risk factors. This contrasts with
22 the CARDIA study which observed increases in HOMA-IR, waist circumference and
23 triglycerides, and reduced HDL cholesterol with increased fast food consumption.⁸ These
24 different findings may be because we measured the availability of fast food, and the
25 CARDIA study measured consumption.⁸ Our data also demonstrated a greater number of fast
26 food outlets in non-White than White neighbourhoods as reported in studies conducted in the
27 United States.^{7,24} This is particularly relevant in the UK South Asian population who are
28 known to be at increased risk of developing type 2 diabetes compared with White European
29 counterparts,²² and suggests that environmental differences between ethnic groups might be
30 contributing towards this problem.²⁸ Finally, we found that the association between the
31 number of fast food outlets and the various outcomes that we considered was somewhat
32 dependent on the definition of neighbourhood that was used. We chose to define
33 neighbourhood as the Euclidean distance within 500m of the participant's home, since there

1 is a standard definition of neighbourhood is not available but this is commonly used in the
2 physical activity literature.²⁰⁻²² Sensitivity analyses using different distances in the definition
3 suggested that when neighbourhood was defined to cover a small region there were positive
4 associations with adiposity measures, whereas for larger regions there were positive
5 associations with type 2 diabetes, obesity and fasting glucose. This might be a chance
6 finding, or it could reflect that some definitions are more prone to confounding than others.

8 We estimated that for each additional fast food outlet, there was a 2% increase in the odds of
9 screen-detected type 2 diabetes. Assuming 7% undiagnosed type 2 diabetes prevalence in
10 neighbourhoods with no outlets (based on our data) and approximately 200 residents in a
11 500m radius, then we would expect approximately 14 people in a 500m radius to have
12 undiagnosed type 2 diabetes. Assuming that the number of fast food outlets is causally
13 associated with type 2 diabetes then our results suggest that for every additional two outlets
14 per approximately 200 residents or 500m radius, we would expect to see one more diabetes
15 case. We also note that in our data, type 2 diabetes prevalence is fairly steady at
16 approximately 8% when there were fewer than 4 outlets at which point it increases to
17 approximately 11% (data not shown). However, our data sampling method means that we
18 will not have captured all of the outlets and so we cannot suggest a suitable cap on the
19 number of outlets per 500m radius from these data. Clearly more work is needed before
20 guidance can be put in place but this study highlights that public health consideration needs
21 to be given when granting planning permission to new fast food outlets. Some local planning
22 authorities in England already have such measures in place, but the evidence base for the
23 restrictions that they impose is limited.³⁰ Furthermore, fast food outlets themselves could
24 potentially contribute towards reducing this problem by introducing healthier choices to their
25 menus. A recent survey found that, from 2010 to 2013, the proportion of main dishes with
26 healthy Nutrient Profile Index scores increased from 46% to 54% in five of the largest fast
27 food chains in the US.³¹ This suggests that steps are being taken by fast food outlets to
28 address the problem, but further action is required.

29 This research highlights areas where knowledge is currently lacking. First, it needs to be
30 ascertained whether there is a causal association between the number of fast food outlets and
31 obesity-related outcomes. While many of Bradford Hill's criteria for causation³² are satisfied,
32 e.g. consistency, plausibility, and biological gradient, unanswered questions remain around

1 temporality, which would require longitudinal studies. Second, the intervention effect of
2 reducing or limiting the number of fast food outlets in a neighbourhood should be explored.
3 Finally, precise measurement of the number of fast food outlets is required to provide
4 evidence for the upper limit of fast food outlets in relation to the health of the residents.

5 In conclusion, this study suggests that an increased number of fast food outlets in the
6 neighbourhood is associated with an increased risk of screen-detected type 2 diabetes and of
7 being classified as obese, suggesting that fast food outlets might be a reasonable target for
8 public health interventions. However, these analyses are from cross-sectional data and
9 conclusions should be interpreted with caution, with further research required, in particular to
10 establish causality.

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Table 1. Descriptive Characteristics of the Study Population.

Variable	ADDITION- Leicester (n = 6200)	Let's Prevent Diabetes (n = 3431)	Walking Away from Diabetes (n = 830)	All (n = 10461)
Age, years	56.19 (10.78)	63.17 (8.11)	63.11 (8.18)	59.03 (10.37)
Social deprivation score	19.74 (14.11)	17.32 (14.99)	20.22 (16.31)	18.99 (14.63)
Body mass index, kg/m ²	28.00 (5.03)	32.45 (5.70)	32.44 (5.62)	29.85 (5.75)
Waist circumference, cm	93.74 (13.21)	107.50 (39.9.)	101.80 (12.38)	98.99 (26.24)
Fasting glucose, mmol/l	5.19 (0.91)	5.33 (0.84)	5.32 (0.79)	5.25 (0.88)
2 hour glucose, mmol/l	6.01 (2.43)	6.62 (2.50)	6.49 (2.42)	6.25 (2.47)
HbA1c, %	5.70 (0.61)	5.94 (0.52)	5.92 (0.58)	5.79 (0.59)
Total cholesterol, mmol/l	5.54 (1.08)	5.09 (1.03)	5.09 (1.07)	5.35 (1.09)
LDL cholesterol, mmol/l	3.53 (0.93)	3.03 (0.89)	3.07 (0.90)	3.33 (0.94)
HDL cholesterol, mmol/l	1.37 (0.38)	1.39 (0.44)	1.39 (0.37)	1.38 (0.40)
Fasting insulin	10.04 (8.61)	-	10.65 (7.34)	10.30 (8.10)
Female	53.1	39.1	36.6	47.2
White European	74.0	86.7	88.4	79.4
South Asian	23.5	10.7	8.1	18.0
Other ethnicity ^a	2.6	2.6	3.5	2.7
Rural location	11.7	24.5	17.5	16.3
Screen-detected type 2 diabetes	6.2	10.9	9.4	8.0
Impaired glucose regulation	25.3	42.9	40.9	32.3
Obese	33.0	64.2	65.1	46.0

Data are mean (standard deviation) or percentage.

Missing values: Social deprivation score 6; Body mass index/Obesity 208; Waist 205; Fasting glucose 33; 2 hour glucose 81; Total cholesterol 108; LDL cholesterol 467; HDL cholesterol 139; Fasting insulin 8902; Ethnicity 190; Urban/rural indicator 6; Type 2 diabetes 13; Impaired glucose regulation 13; Other variables 0.

^a The 'Other' ethnic group comprised 78% individuals of Black ethnicity, 18% individuals of mixed ethnicity, and 4% individuals who identified themselves as of another ethnic origin.

Table 2. Number of neighbourhood fast food restaurants by participant characteristics.

Variable	Category	Number of fast food outlets within 500m of home postcode		
		Mean	SD	P-value
All		2.06	3.73	
Age	<55 years	2.61	4.27	
	55-64 years	1.95	3.64	
	≥65 years	1.69	3.22	<0.001
Sex	Men	2.01	3.68	
	Women	2.12	3.78	0.107
Ethnicity	White European	1.53	3.17	
	South Asian	3.96	4.73	
	Other	4.57	5.33	<0.001
Urban/rural indicator	Urban	2.36	3.98	
	Rural	0.53	1.06	<0.001
Social deprivation	Low	0.91	1.89	
	High	3.53	4.83	<0.001

Abbreviations: SD, Standard Deviation.

Table 3. Association Between the Number of Neighbourhood Fast Food Outlets and Diabetes-Related Outcomes.

Outcome	Unadjusted		Adjusted ^a	
	OR	95% CI	OR	95% CI
Screen-detected type 2 diabetes	1.05	1.04, 1.07	1.02	1.00, 1.04
Impaired glucose regulation	1.00	0.99, 1.01	1.00	0.98, 1.01
Obese	1.03	1.01, 1.04	1.02	1.01, 1.03
	b	95% CI	b	95% CI
Body mass index, kg/m ²	0.02	-0.02, 0.05	0.04	0.00, 0.08
Waist circumference, cm	-0.04	-0.19, 0.11	0.10	-0.04, 0.25
Fasting glucose, mmol/l	0.01	-0.00, 0.01	0.01	-0.00, 0.01
2 hour glucose, mmol/l	0.02	0.00, 0.03	0.00	-0.01, 0.02
HbA1c, %	0.01	0.00, 0.01	0.00	-0.00, 0.01
Total cholesterol, mmol/l	-0.02	-0.02, -0.01	-0.01	-0.01, -0.00
LDL cholesterol, mmol/l	-0.01	-0.02, -0.01	-0.01	-0.01, -0.00
HDL cholesterol, mmol/l	-0.01	-0.01, -0.00	0.00	-0.00, 0.00
Fasting insulin ^b	0.13	0.04, 0.22	0.00	-0.11, 0.12

Abbreviations: b, Unstandardized regression coefficient; CI, Confidence Interval; OR, Odds Ratio.

^a Adjusted for social deprivation score, urban/rural indicator, ethnicity, age and sex.

^b Only available for 1559 participants (905 from ADDITION-Leicester and 654 from Walking Away from Diabetes).