Published in final edited form as:
*Int J Obes (Lond)*. 2015 March ; 39(3): 535–541. doi:10.1038/ijo.2014.152.

# ‘Fish out of water’: A cross-sectional study on the interaction between social and neighbourhood effects on weight management behaviours

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## Abstract

**Objective—**To analyse whether an individual’s neighbourhood influences the uptake of weight management strategies and if there is an interaction between individual socio-economic status (SES) and neighbourhood deprivation.

**Methodology—**Data were collected from the Yorkshire Health Study (2010-2012) for 27 806 individuals on the use of the following weight management strategies; ‘slimming clubs’, ‘healthy eating’, ‘increasing exercise’ and ‘controlling portion size’. A multi-level logistic regression was fit to analyse the use of these strategies, controlling for age, sex, body mass index, education, neighbourhood deprivation and neighbourhood population turnover (a proxy for neighbourhood social capital). A cross-level interaction term was included for education and neighbourhood deprivation. Lower Super Output Area was used as the geographical scale for the areal unit of analysis.

**Results—**Significant neighbourhood effects were observed for use of ‘slimming clubs’, ‘healthy eating’ and ‘increasing exercise’ as weight management strategies, independent of individual- and area-level covariates. A significant interaction between education and neighbourhood deprivation was observed across all strategies, suggesting that as an area becomes more deprived, individuals of the lowest education are more likely not to use any strategy compared to those of the highest education.

**Conclusions—**Neighbourhoods modify/amplify individual disadvantage and social inequalities, with individuals of low education disproportionally affected by deprivation. It is important to include neighbourhood-based explanations in the development of community based policy interventions to help tackle obesity.

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**Conflict of Interest:** None declared.

### MeSH Keywords

Weight reduction programs; poverty; SES; residence characteristics; obesity; interpersonal relations

## Introduction

The management of weight is an important component in maintaining both a healthy lifestyle and an optimal weight. The interest in personal weight management strategies has grown over the past 50 years and now represents a major component of health-related behaviour. This growth reflects the rise in levels of obesity both in the UK and in most parts of the world (1). A quarter of adults are currently classified as obese in the UK and this is estimated to double in size by 2050 (2). The health risks associated with obesity, such as the increased risk of type 2 diabetes, cardiovascular disease, stroke and osteoarthritis (3–5), as well as the related social and economic costs (2,6), makes tackling problematic obesity a pressing public health issue. Understanding the uptake of weight management strategies is therefore important to in order to address these concerns.

Much of the existing research on weight management has focussed on examining how the uptake of strategies vary by factors related to the individual; for example by age, sex (7–11) and socio-economic status (SES) (7,11–15). Whilst individual level factors are important, these alone do not account for the variation seen in patterns of weight management, hence the importance of examining the environment which individuals reside (16–19). Research has shown that there are significant environmental influences on physical activity (15,18,20–22), but otherwise there has been no investigation of the uptake of specific weight management strategies beyond this. An understanding of this may aid the development of community-based interventions to improve uptake of healthy strategies that can help tackle obesity.

The social environment has been shown to be important in affecting health-related behaviours (15,19,22–24), and it is this dimension of understanding that the paper chooses to focus upon. The social environment is defined here as the small geographical areas surrounding individuals that encapsulates the social relationships, interactions and community an individual belongs to (20). Within the social environment, our study tests the association of social capital in influencing uptake of weight management strategies, given its association to obesity (16,20,22,25). The level of deprivation in an area has been shown to be an important factor for understanding differences in obesity and health-related behaviours (12,18,19,21,26). However as Pickett and Pearl (23) identify, to test the existence of neighbourhood effects, any analysis should also look at individuals not typical of the characteristics of their neighbourhood; the so called ‘fish out of water’. Just considering deprivation alone will ignore that a neighbourhood will consist of different social groups as areas are not completely socially exclusive. Exploring how individual- and area-level SES interact is important to understanding the role of neighbourhood and how it is affected by an individual’s social position. We apply this approach since it has been shown to be useful in non-obesity related studies (27–31).

The aim of this study is to test for the existence of neighbourhood effects on influencing the uptake of different weight management strategies and extending this analysis to examine whether neighbourhoods modify or imprint upon individual social factors.

## Methodology

### Data

Data were obtained on 27 806 individuals who were recruited for the first wave of the Yorkshire Health Study (formerly the South Yorkshire Cohort Study) (2010-2012) (32,33). Whilst the cohort was introduced to collect information on the health needs of individuals in the South Yorkshire region of England, its focus on weight and weight management makes it particularly relevant to this study, addressing prior data availability issues that have limited previous research.

The following dependent variables were defined. Individuals in the cohort self-reported whether they used any of the following strategies to manage their weight; ‘increasing exercise’, ‘eating healthy’, ‘controlling portion size’ and ‘using slimming clubs’ (for example, this included membership of ‘Weight Watchers’ or ‘Slimming World’). A variable indicating if individuals were engaged in any of these activities was also created.

The highest attained level of education was chosen to measure SES. Five hierarchical levels were defined, following the 2011 UK Census categorisation (alongside the international equivalent). These were: “no qualifications”, “level 1” (individual has either less than 5 GCSEs/CSEs/O-levels or has achieved NVQ level 1; equivalent to less than expected secondary level of education), “level 2” (individual has either more than 5 GCSEs/CSEs/O-levels, one A/AS-level or has achieved NVQ level 2; expected level of secondary education), “level 3” (individual has either two or more A-levels, four or more AS-levels or has achieved NVQ level 3; post-secondary school educated) and “level 4+” (individual has at least a degree and/or a NVQ level 4 or above; university level educated). Level of education is a good measure of SES, since an investment in human capital allows individuals to access better employment opportunities and thus acquire economic and social resources (34). It also represents an ability to interact with and understand the literature surrounding health-promoting resources and behaviours. The measure has been used for similar purposes in previous research (12). It allows the disaggregation of individuals by deprivation level and it does not match up to deprivation exclusively (e.g. 9.5% of individuals of the highest education level resided in the most deprived quintile).

Lower Super Output Area (LSOAs) was chosen as the geographical scale for the area-based analysis (35). LSOAs are administrative zones assembled from postcodes to create a small-level geography for analysing and disseminating data. Zones have similar population sizes (approximately 1600) and were designed to exhibit social homogeneity (36). The small size of LSOAs is valuable for assessing the role of neighbourhoods. However, they are also suitably large to contain a useful number of individuals in each LSOA (a mean of 34 individuals from the cohort per LSOA) improving the stability of estimates (37). There is also a range of social and demographic information available at the scale to control for area level factors.

The ‘Indices of Deprivation 2010’ (38) measure was used as the measure of neighbourhood-based deprivation. The Indices of Deprivation provides a multi-dimensional measure of socio-economic disadvantage and has been shown elsewhere to capture the effect of the socio-economic environment on obesity (17,26). The Indices of Deprivation was defined at LSOA level.

Population turnover (the net change of the population for all ages as a rate per 1000) using modelled 2012 statistics from the ONS (Office for National Statistics, UK) for LSOAs was included to measure residential stability. In areas with a high rate of population turnover, residents are denied the ability to build strong social bonds, and this limits social capital and inter-personal support that is present in an area (39). Population turnover has been used as a measure of social capital in previous studies that explore the relationship between social capital and health (40).

Age, gender and body mass index (BMI) were identified as important confounders. These have previously been shown to be associated with the use of weight management strategies, as well as with the proposed explanatory variables (7,8,13). Each variable was self-reported.

### Analysis

Given the hierarchical structure to the data, with individuals nested within neighbourhoods, a multi-level logistic regression model was used for the analysis. A multi-level approach allows the modelling of effects at both the individual and neighbourhood levels and allows the estimation of variability at the neighbourhood level, after adjustment for individual level effects (37). The standard deviation of this effect was reported, along with a likelihood ratio test against a null hypothesis of no variation at the neighbourhood level. This approach has been used previously in similar studies (19,41,42).

To explore the differential effect of area level deprivation on weight management behaviour for people with different levels of education, a cross-level interaction term was included in the model as fixed effect parameter. The differential effects were visualised using interaction plots (i.e. plots of the mean predicted probability of the outcome versus deprivation, for each level of education). The other confounders were included as fixed effects to control for and estimate their relationships.

## Results

In the sample, 70% of individuals managed their weight through at least one of the strategies measured. The most popular strategy was ‘healthy eating’ (48.4%). ‘Controlling portion size’ and ‘increasing exercise’ were also commonly employed (43% and 42.3% respectively). 18.4% of the sample reported using ‘slimming clubs’. The demographic characteristics of the study population are presented in Table 1.

The first model used a binary dependent variable for whether an individual reported that they were managing their weight using any strategy (Table 2). The unconditional model was fit where only the intercept that was allowed to vary randomly by area (no parameters


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included). The standard deviation of the area level random effect was 0.172 and this was significantly different than the null hypothesis ($p<0.001$).

Different groups of parameters were then introduced into the model (Table 2) including individual-level covariates (Model A), area-level covariates (Model B) and the cross-level interaction term (Model C). A significant unobserved area level random effect was observed in Model A suggesting that an individual's neighbourhood still has an effect on weight management behaviour, independent of individual level characteristics. However, this significant effect disappears in subsequent models, having been accounted for by the deprivation variable.

The individual level predictors behaved in a way that has been reported in previous research. Weight management usage is more common in the young, in females, in those of high BMI and in people with higher levels of education (7,8,13). Both the area-level fixed effects covariates were significant suggesting the important influence of neighbourhood characteristics. Areas that were less deprived and had greater residential stability had more individuals managing their weight.

Model C also displayed a significant interaction between deprivation and individuals of high levels of education (compared to the reference group of no qualifications). As an area becomes more deprived, there is an interaction between an individual's education level and an area's level of deprivation that sees individuals of the highest education level become more likely to be managing their weight than compared to those of the lowest education level, additional to the fixed effects of deprivation and individual education. This relationship is depicted in Figure 1, which shows the predicted probabilities of an individual managing their weight across the different values of deprivation for each education level based upon Model C. As an area becomes more deprived, the gap between the top and bottom widens, showing uneven effects.

A series of models were then fit using the different weight management strategies as individual outcome variables to explore differences in behaviours (Table 3). As the analysis begins to discriminate by weight management strategy, the role of neighbourhoods also varies. A significant and independent effect was found in explaining the use of 'slimming clubs', 'increasing exercise' and 'healthy eating', being strongest for 'slimming clubs'. An insignificant result was observed for 'controlling portion size'.

There were some changes for the individual- and area-level covariates. Age was inconsistent suggesting that some strategies may be more effective to target at the elderly. Population turnover has become insignificant across each model, suggesting that social capital may be less useful an explanation when discriminating between healthy behaviours. There were variations by education level, with all outcomes bar 'slimming clubs' (which appears more universal socially in uptake) showing a social gradient. A social gradient exists where individuals of higher education also have better health characteristics (i.e. managing their weight). The differing strengths of the associations reported demonstrate a varying extent of social disparities by strategy. Sex, BMI and deprivation presented significant results in the




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same direction estimated previously for each outcome variable (although sex had a larger effect for explaining uptake of ‘slimming clubs’ than compared to the other outcomes).

The interaction term remained significant across each dependent variable, with the effect largest for ‘slimming clubs’. Plotting the predicted probabilities (Figure 2) showed consistent divergence between the levels of education as the level of deprivation increased. The divergence is a result of the lower education levels being greater affected by the level of deprivation than compared to those of high level of education.

## Discussion

### Key Results

This study has demonstrated the importance of neighbourhood effects in independently influencing the uptake of weight management strategies. Significant variation between areas was observed for the uptake of ‘slimming clubs’, ‘healthy eating’ and ‘increasing exercise’ weight management strategies. These effects persisted after the adjustment for individual and area level confounders, showing the importance of considering neighbourhood in our understanding of relationships. Deprivation was an important statistical predictor of uptake, with uptake of strategies higher in affluent areas. There was also a significant interaction between the level of deprivation in an area and an individual’s education level, with individuals of low education disproportionally affected by a neighbourhood’s level of deprivation.

### Limitations

There are several limitations to this study. The analysis is cross-sectional and therefore no conclusions can be drawn regarding causation. Research using future waves of data collection in the Yorkshire Health Study (or other data sources) may be able to suggest or refute causal mechanisms and posit future recommendations for research.

The measurement of the social environment was limited in scope. The only area level variables included in the model were deprivation and population turnover. This limits the power of the analysis to test possible causal mechanism. Social capital in particular is a difficult concept to precisely define and measure. Future research should look to devise a more detailed analysis and understanding of the social environment, and the mechanisms for how it may influence weight management decisions. Extending the analysis longitudinally to measure how long individuals were exposed to neighbourhood factors would improve our understanding of the role of the social environment.

LSOAs were used as the unit of analysis, and therefore as the proxy for a neighbourhood. However, LSOAs are geographical administrative zones, rather than the perceived neighbourhoods of individuals and therefore their ability to accurately capture true neighbourhood effects is restricted (43). LSOA are designed to be socially homogenous and consistent in their size (36), allowing fairer comparisons between individuals. They also allow a more convenient unit for the aggregation and analysis of data than does an individual’s actual neighbourhood. Further research that can accurately define ‘local’ neighbourhoods is warranted.

## Interpretation

The results of this study have suggested the importance of neighbourhood in influencing the uptake of weight maintenance strategies. Previous research has tended to focus on just physical exercise as a weight management strategy (18,20–22), and only considered individual level explanatory factors (7,8,13).

The observed association between neighbourhood and propensity to attend a slimming club may be because each club, which is located in a particular neighbourhood, is likely to attract individuals from within the local area. However, the analysis is limited as data on the location of slimming clubs is not known. The location of slimming clubs would help to identify whether the use of slimming clubs is due to the accessibility of the service and/or the characteristics of an individual's neighbourhood. Whereas the other strategies are heavily dependent upon the individual (i.e. nothing additional is required to exercise, eat healthier or control portion size), slimming clubs differ since they must be provided by an external resource to be used. Further research should incorporate such information to test these possible relationships to be able to assess the role of the neighbourhood. However given the social gradient presented in Figure 2, alongside the results for the other strategies, the role of neighbourhood appears to be important and availability is unlikely to account for all of the relationship.

One explanation of the area effects for 'healthy exercise' and 'increasing exercise' seen in this study would follow Link and Phelan's fundamental causation hypothesis (34). They argue that individuals of high SES are more likely to be engaged in healthier behaviours compared to individuals of lower SES due to a variety of factors including; higher education allowing individuals to understand and act on the benefits of healthy behaviour, greater disposable income and lower prevalence of factors which mitigate against a healthy lifestyle (44). A concentration of affluent individuals in an area can lead to a localised culture that prioritises these behaviours, partly to differentiate the group from deprived areas (34,45). This is because different social groups have different perceptions about body size (12). Obesity becomes stigmatised greater in affluent areas, leading to differences in the uptake of weight management strategies in comparison to other neighbourhoods where the localised culture is less prevalent. Developing and incorporating this understanding is important for designing effective community-based interventions.

Neighbourhood social capital showed a positive association against the uptake of any strategy (Table 2), however this significant effect disappeared once the type of strategy was discriminated between (Table 3). Research suggests that social capital can influence health through building community networks through which health information (and support) can be easily diffused (39,46,47). The results would suggest that this process exists for explaining overall uptake (i.e. promoting an overall health message) rather than specific strategies.

Neighbourhood deprivation was an important explanatory variable for an individual's behaviour and explained a large proportion of the variation between areas. Usage of weight management was higher in more affluent areas, independent of other factors. The use of the interaction term (see Figures 1 and 2) also improved the understanding of the effects of

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deprivation, showing it to be more than just a single fixed effect (27,28). As an area becomes more deprived, the difference in uptake between the highest and lowest SES groups diverges.

The results suggest that neighbourhoods modify and/or amplify individual disadvantage, with individuals of low education being disproportionally affected by deprivation. This is in line with theories of ‘deprivation amplification’ and ‘double jeopardy’ which argue that the poor are disadvantaged by the effects of neighbourhood and individual SES, as well as how they interact together (17). By contrast, individuals of high SES have greater material, education and relational resources at their disposal to protect them from neighbourhood effects (34,44).

The findings from this study have important implications in devising community based interventions to improve uptake of weight management strategies to tackle obesity. To improve efficiency of such policies, the role of neighbourhoods needs active consideration when seeking to account for their role in influencing individual behaviours. The interplay between neighbourhood deprivation and individual education suggests particular attention and resources should be concentrated in improving and negating these effects to effectively tackle the high levels of obesity.

## Acknowledgements

This work was supported by the ‘National Institute for Health Research’ (NIHR) ‘Collaborations for Leadership in Applied Health Research and Care’ (CLAHRC) for South Yorkshire (Obesity Theme) and the University of Sheffield. This paper presents independent research by the NIHR CLAHRC for South Yorkshire. The views and opinions expressed are those of the authors, and not necessarily those of the NHS, the NIHR or the Department of Health. CLAHRC South Yorkshire would also like to acknowledge the participation and resources of our partner organisations. Further details can be found at www.clahrc-sy.nihr.ac.uk.

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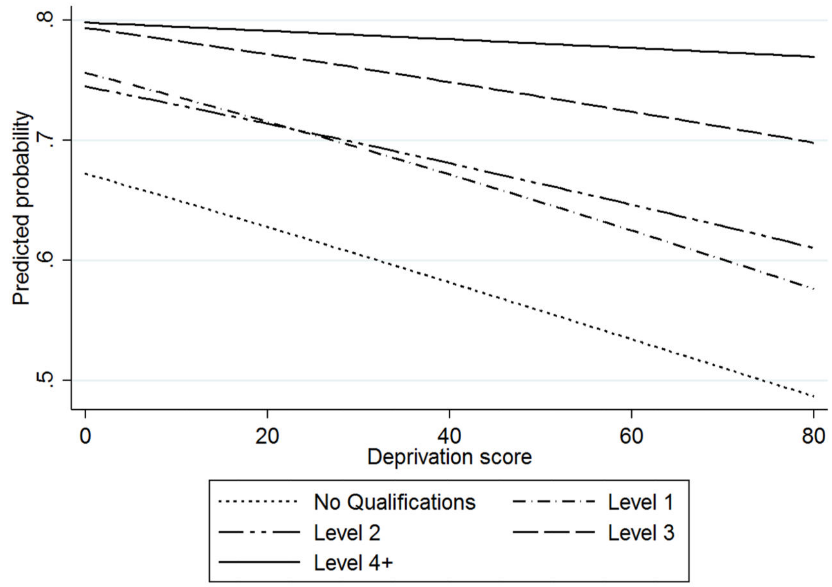


**Figure 1.**

The predicted probabilities of uptake of any weight management strategy by education group across the values of deprivation, accounting for modelled fixed and random effects.

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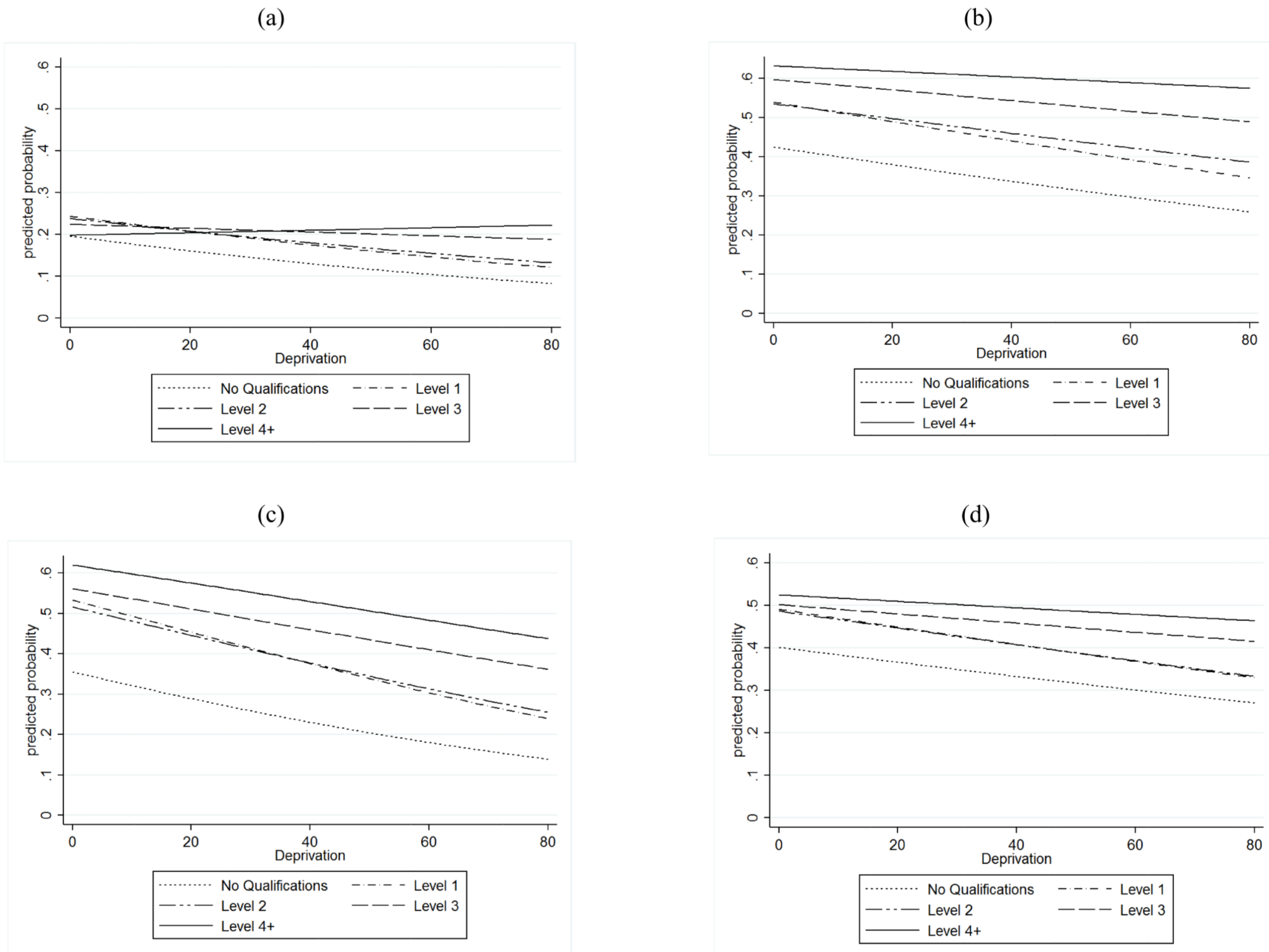


**Figure 2.**

The predicted probabilities of uptake of each weight management strategy by education group across the values of deprivation, accounting for modelled fixed and random effects: (a) slimming clubs, (b) healthy eating, (c) increasing exercise, (d) controlling portion size.

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**Table 1**

Demographic characteristics of the study population.

| Variable | Sample size | Percentage (%) |
|---|---|---|
| *Gender:* | | |
| Female | 15 651 | 56.3 |
| Male | 12 157 | 43.7 |
| *Age:* | | |
| ≤24 | 1 735 | 6.3 |
| 25-34 | 2 639 | 9.6 |
| 35-44 | 3 516 | 12.8 |
| 45-54 | 4 490 | 16.4 |
| 55-64 | 5 938 | 21.7 |
| 65-74 | 5 827 | 21.3 |
| ≥75 | 3 254 | 11.9 |
| *Education:* | | |
| No Qualifications | 9 536 | 34.3 |
| Level-1 | 3 129 | 11.3 |
| Level-2 | 5 034 | 18.1 |
| Level-3 | 2 773 | 10.0 |
| Level-4 | 7 336 | 26.4 |
| *Body Mass Index (kg/m2):* | | |
| Underweight (<18.5) | 436 | 1.7 |
| Normal (18.5-25) | 11 103 | 42.1 |
| Overweight (25-30) | 9 671 | 36.6 |
| Obese (30-40) | 4 671 | 17.7 |
| Morbidly Obese (≥40) | 519 | 2.0 |
| *Weight Management Usage:* | | |
| Slimming clubs | 5 126 | 18.4 |
| Healthy eating | 13 446 | 48.4 |
| Increasing exercise | 13 446 | 45.6 |
| Controlling portion size | 11 968 | 43.0 |

## Table 2

The results of a multi-level model analysing the characteristics of individuals who are engaged in any weight management strategy.

| Variable | Model A | | Model B | | Model C | |
|---|---|---|---|---|---|---|
| | **Odds Ratio** | **95% C.I.'s** | **Odds Ratio** | **95% C.I.'s** | **Odds Ratio** | **95% C.I.'s** |
| Constant | 0.029*** | | 0.038*** | | 0.041*** | |
| *Individual level covariates* | | | | | | |
| Age | 0.994*** | (0.992-0.996) | 0.993*** | (0.991-0.995) | 0.993*** | (0.991-0.995) |
| Sex | 0.381*** | (0.359-0.404) | 0.382*** | (0.360-0.405) | 0.382*** | (0.360-0.405) |
| BMI | 1.201*** | (1.191-1.211) | 1.204*** | (1.194-1.214) | 1.204*** | (1.194-1.214) |
| Education | | | | | | |
| No Qualifications | Reference | | Reference | | Reference | |
| Level-1 | 1.652*** | (1.493-1.828) | 1.588*** | (1.434-1.757) | 1.597*** | (1.330-1.918) |
| Level-2 | 1.690*** | (1.546-1.847) | 1.596*** | (1.460-1.746) | 1.493*** | (1.283-1.738) |
| Level-3 | 2.412*** | (2.147-2.710) | 2.258*** | (2.009-2.538) | 2.028*** | (1.666-2.469) |
| Level-4 | 2.786*** | (2.562-3.029) | 2.487*** | (2.282-2.709) | 2.092*** | (1.827-2.396) |
| *Area level covariates* | | | | | | |
| Deprivation | | | 0.991*** | (0.989-0.993) | 0.989*** | (0.986-0.992) |
| Population Turnover | | | 1.002** | (1.001-1.004) | 1.002** | (1.001-1.004) |
| *Interaction term* | | | | | | |
| Education × deprivation | | | | | | |
| No Qualifications | | | | | Reference | |
| Level-1 | | | | | 0.999 | (0.994-1.005) |
| Level-2 | | | | | 1.003 | (0.997-1.007) |
| Level-3 | | | | | 1.004 | (0.997-1.011) |
| Level-4 | | | | | 1.009** | (1.004-1.014) |
| *Random effects parameters* | | | | | | |
| LSOA intercept σ | 0.13 | | 1.01E-05 | | 2.03E-06 | |
| Likelihood ratio test | 7.07** | | 0 | | 0 | |

* = $p < 0.05$,

** = $p < 0.01$,

*** = $p < 0.001$

## Table 3

The results from a set of models exploring variations in weight management strategies.

| Variable | Outcome variable | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Slimming Clubs | | Healthy Eating | | Increasing Exercise | | Controlling Portion Size | |
| | Odds Ratios | 95% C.I.'s | Odds Ratios | 95% C.I.'s | Odds Ratios | 95% C.I.'s | Odds Ratios | 95% C.I.'s |
| Constant | 0.008*** | | 0.131*** | | 0.269*** | | 0.047*** | |
| *Individual level covariates* | | | | | | | | |
| Age | 0.992*** | (0.990-0.994) | 0.999 | (0.997-1.001) | 0.970*** | (0.969-0.972) | 1.001 | (0.999-1.003) |
| Sex | 0.085*** | (0.077-0.094) | 0.517*** | (0.491-0.545) | 0.673*** | (0.637-0.711) | 0.509*** | (0.483-0.536) |
| BMI | 1.179*** | (1.171-1.188) | 1.082*** | (1.076-1.088) | 1.098*** | (1.092-1.105) | 1.115*** | (1.108-1.121) |
| Education: | | | | | | | | |
| No Qualifications | Reference | | Reference | | Reference | | Reference | |
| Level-1 | 1.446** | (1.157-1.807) | 1.629*** | (1.386-1.916) | 2.235*** | (1.883-2.653) | 1.486*** | (1.261-1.751) |
| Level-2 | 1.391** | (1.148-1.684) | 1.601*** | (1.396-1.836) | 2.072*** | (1.788-2.402) | 1.460*** | (1.271-1.678) |
| Level-3 | 1.253 | (0.995-1.577) | 2.090*** | (1.765-2.474) | 2.533*** | (2.120-3.027) | 1.557*** | (1.314-1.846) |
| Level-4+ | 1.019 | (0.850-1.222) | 2.434*** | (2.153-2.752) | 3.301*** | (2.888-3.773) | 1.721*** | (1.522-1.946) |
| *Area level covariates* | | | | | | | | |
| Deprivation | 0.985*** | (0.980-0.989) | 0.990*** | (0.988-0.993) | 0.983*** | (0.980-0.987) | 0.992*** | (0.989-0.995) |
| Population Turnover | 0.999 | (0.997-1.002) | 1.001 | (0.999-1.002) | 1 | (0.999-1.002) | 1.001 | (0.999-1.002) |
| *Interaction term* | | | | | | | | |
| Education × deprivation | | | | | | | | |
| No Qualifications | Reference | | Reference | | Reference | | Reference | |
| Level-1 | 1.002 | (0.994-1.010) | 0.999 | (0.994-1.005) | 0.999 | (0.993-1.005) | 0.999 | (0.993-1.004) |
| Level-2 | 1.004 | (0.997-1.010) | 1.002 | (0.997-1.006) | 1.001 | (0.996-1.006) | 0.999 | (0.995-1.004) |
| Level-3 | 1.012** | (1.004-1.020) | 1.004 | (0.998-1.010) | 1.006 | (0.999-1.012) | 1.003 | (0.998-1.001) |
| Level-4+ | 1.018*** | (1.011-1.025) | 1.007** | (1.002-1.011) | 1.007* | (1.002-1.012) | 1.005* | (1.000-1.009) |
| *Random effects parameters* | | | | | | | | |
| LSOA intercept σ | 0.199 | | 0.088 | | 0.103 | | 0.051 | |
| Likelihood ratio test | 14.78*** | | 3.13* | | 5.19* | | 0.4 | |

* = $p < 0.05$,

** = $p < 0.01$,

*** = $p < 0.001$