EVIDENCE BASED PUBLIC HEALTH POLICY AND PRACTICE

Large scale food retailing as an intervention for diet and health: quasi-experimental evaluation of a natural experiment

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Objectives: To assess the effect on fruit and vegetable consumption, self reported, and psychological health of a ''natural experiment''—the introduction of large scale food retailing in a deprived Scottish community.
Design: Prospective quasi-experimental design comparing baseline and follow up data in an ''intervention'' community with a matched ''comparison'' community in Glasgow, UK.
Participants: 412 men and women aged 16 or over for whom follow up data on fruit and vegetable consumption and GHQ-12 were available.
Main outcome measures: Fruit and vegetable consumption in portions per day, poor self reported health, and poor psychological health (GHQ-12).
Main results: Adjusting for age, sex, educational attainment, and employment status there was no population impact on daily fruit and vegetable consumption, self reported, and psychological health. There was some evidence for a net reduction in the prevalence of poor psychological health for residents who directly engaged with the intervention.
Conclusions: Government policy has advocated using large scale food retailing as a social intervention to improve diet and health in poor communities. In contrast with a previous uncontrolled study this study did not find evidence for a net intervention effect on fruit and vegetable consumption, although there was evidence for an improvement in psychological health for those who directly engaged with the intervention. Although definitive conclusions about the effect of large scale retailing on diet and health in deprived communities cannot be drawn from non-randomised controlled study designs, evaluations of the impacts of natural experiments may offer the best opportunity to generate evidence about the health impacts of retail interventions in poor communities.

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Studies investigating neighbourhood effects on diet have reported lower fruit and vegetable intakes in deprived areas[1 2] as well as independent associations between area deprivation and reduced fruit and vegetable intake, particularly for the manual social classes with no educational qualifications.[3] Studies have also shown that ''healthy'' foods are more expensive and less readily available in deprived compared with more affluent areas.[4–6] Researchers have thus hypothesised that deprived areas have poorer physical access to food compared with their more affluent counterparts and that this has contributed to increases in diet related disease within these areas. Such areas have been popularly described as ''food deserts'',[7] the existence of which has been partly blamed on a strategy of locational decentralisation by the major food retailers.[8 9] However, there has been debate over the presumed existence of food deserts in the UK with authors highlighting the sparse and equivocal nature of the evidence[10] and reports that retail provision is not independently associated with diet.[11] Whatever the evidence, such popular concerns have lead policymakers to conclude that there is a need to improve local shopping opportunities to improve diet, and thus population health, in poor neighbourhoods.[12–14]

One previous study has evaluated the effect of new large scale food retail provision on food consumption patterns in a food desert.[15] This study, using an uncontrolled before/after design, reported a mean increase in fruit and vegetable consumption of between 0.01 ($p = 0.953$) and 0.47 ($p<0.001$) portions per day among shoppers who ''switched'' to using the new food retail provision.[16] The greatest increase (of 0.47 portions) was found for those switchers with the lowest intake per day (two or less portions) at baseline.[16] However, the uncontrolled nature of the study ensured that establishment of a causal association was problematic.

In addition to changes in diet the modernisation of food retailing provision may act as an indicator of local economic regeneration. Published evidence on the health effects of regeneration of urban areas is limited, fragmented, and equivocal[17 18] and has found positive[19 20] and negative[21 22] effects. Hypothetical mechanisms by which retail led regeneration can lead to improvements in psychological health status include; improved opportunities for social interaction and improvements in community perceptions of neighbourhood environment and self esteem due to visible investment in a previously resource-poor community.

The evaluation of natural experiments to generate evidence of the effectiveness of interventions has been advocated.[23 24] Natural experiments are ''a form of…study where the researcher cannot control or withhold the allocation of an intervention to particular areas or communities, but where natural variation in allocation occurs''.[23] Such studies can have important contributions to make in the identification of effective interventions in an area where a good evidence base is lacking.[25] In this paper we report results from an evaluation of the diet and health effects of a naturally occurring intervention—the provision a new food hypermarket—in a ''food-retail deficit'' community.[26]

Table 1 Survey response rates

	Overall	Comparison	Intervention
Baseline	603 (15.16%)	310 (15.5%)	293 (14.84%)
Follow up	412 (68.40%)	221 (71.29%)	191 (65.18%)

METHODS

Sample selection

A prospective controlled ''before and after'' postal survey of a representative sample of residents in two areas—intervention and comparison—using a quasi-experimental design was undertaken in the east of Glasgow. The boundaries of each study site were delineated by the postcode district that encompassed the main shopping provision (pre-intervention) of each defined area. Within each site a random sample of households were selected from postcode sectors with Carstairs-Morris DEPCATs of 7 (a score of 1 represents the most affluent and 7 represents the most deprived) to reduce bias. DEPCAT score of 7 was chosen as it was hypothesised that the greatest positive effects were likely to occur in the most deprived populations. Addresses were drawn from the postcode address file supplied by CACI Ltd. The two study areas were geographically distant—about five kilometres apart—which helped to reduce contamination. Households were no more than one kilometre from the main shopping provision in each area. A total of 3975 postal questionnaires were administered pre-intervention during early October 2001 and respondents were followed up after a 12 month interval. The superstore opened and was fully functional by November 2001 giving a period of 10 months post-intervention before follow up data were collected. At baseline, non-respondents were sent a postal reminder at two weeks, followed by a second reminder two weeks later accompanied by another copy of the questionnaire. At follow up a £10 shopping voucher (for redemption in shops not affiliated with our intervention store) was offered to each respondent as an incentive. Table 1 shows the response rates. Ethical approval for this study was given by the University of Glasgow local ethics committee.

Individual data

Data on fruit and vegetable consumption, self reported and psychological health, and sociodemographic variables were available from 412 respondents for which responses were available before and after intervention. Respondents were asked ''How many portions of [fruit/vegetables] do you usually eat per day''. A portion of fruit was defined as a medium sized single item. Vegetables were equal to three heaped tablespoons or in the case of salads a medium bowl. Responses to a question on self reported health were dichotomised to either ''good or excellent'' or ''poor or fair''. Data on psychological health were collected using the general health questionnaire (GHQ-12). We dichotomised this variable with a score of 4+ indicating poor psychological health. Information on age, sex, educational attainment, and employment status of the respondent was also collected. Data were obtained from the main household food shopper.

Data analysis

For fruit and vegetable consumption multivariate analyses were undertaken using analysis of covariance (ANCOVA). ANCOVA models allow for dependency of repeated observations of a continuous outcome variable and thus increase the precision of standard errors compared witho simple linear regression. We tested whether post-intervention mean consumption per day in the comparison area was equal to the post-intervention mean in the intervention area, adjusting for the pre-intervention mean difference between the two areas. We then tested the same association controlling for age, sex, economic activity, and education. The variables were forward fitted to the model sequentially. We also tested for linearity in the ANCOVA model by introducing a quadratic term and testing whether this model was an improvement on the original ANCOVA model.

For general health outcomes, data were analysed using logistic regression. Models were adjusted for age, sex, economic activity, and education and were tested for interactions between confounders and general health outcomes. It was hypothesised that larger effects on women (women are the main food shoppers in this sample), the economically active (who may be better able to act on increased local availability), the elderly (who may be better able to act if availability improves within a reasonable travel distance), and those with lower levels of education (who tend to have lower levels of consumption of fruit and vegetables) would be observed. Where interactions were indicated ($p<0.05$) we present stratum specific results.

We also explored the effects of the intervention on respondents who reported ''switching'' their main food purchase from other stores to the hypermarket at follow up, irrespective of whether they resided in the experimental or comparison area. The number of switchers available for analysis was low (n = 61) with 95.1% of these residing in the intervention area. The same analytical procedure, as outlined above, was carried out on this subgroup.

RESULTS

Table 2 summarises the characteristics of the respondents for which data before and after intervention were available (n = 412). Women account for 61.9% of the overall sample (64.4% in the comparison area and 58.9% in the intervention area). The sample is comparatively old with 32.3% aged 55 years or over. Only 1.5% of respondents are aged 16–24. This is unsurprising as the main household food purchaser completed the questionnaire. The intervention area has a younger demographic profile compared with the comparison area, with 23.4% *v* 10.45% of respondents at baseline aged 16–34. Some 60.9% of respondents were retired, a student, unemployed, or not undertaking paid work. Most survey respondents (72.8%) had either standard grade or higher grade/work based training or education. The number of respondents consuming five or more portions of fruit and vegetables per day is high. Data from the Health Education Board of Scotland[27] suggest that 29% of men and women eat five or more portions per day compared with the 37% reported in our cohort. Between area differences in variables at baseline were not statistically significant.

Changes within areas

Table 3 shows the five outcome variables in both the intervention and control area at baseline and follow up. These data show that there were positive health changes for all outcome variables in both communities with the exception of the proportion reporting fair to poor self reported health in the intervention community. However, these improvements were only statistically significant for two of

Table 2 Descriptive characteristics of 412 respondents for whom follow up data were available

	All	Comparison area*	Intervention area*
Variables	N (%)	N (%)	N (%)
Sex			
Male	118 (28.64)	57 (25.90)	61 (31.77)
Female	255 (61.89)	142 (64.55)	113 (58.85)
Missing	39 (9.47)	21 (9.55)	18 (9.38)
Age			
16–24	6 (1.45)	2 (0.91)	4 (2.08)
25–34	62 (15.05)	21 (9.54)	41 (21.35)
35–44	57 (13.83)	28 (12.72)	29 (15.10)
45–54	63 (15.29)	35 (15.91)	28 (14.58)
55–64	58 (14.08)	36 (16.36)	22 (11.45)
65+	75 (18.20)	45 (20.45)	30 (15.63)
Missing	91 (22.09)	53 (24.09)	38 (19.80)
Employment			
Employed	123 (29.85)	71 (32.27)	52 (27.08)
Not employed	251 (60.92)	128 (58.18)	123 (64.06)
Missing	38 (9.22)	21 (9.54)	17 (8.85)
Education			
Standard grade	162 (39.32)	92 (41.82)	70 (36.46)
Highers/work based further training	138 (33.50)	71 (32.27)	67 (34.90)
Higher education	32 (7.77)	20 (9.09)	12 (6.25)
Missing	80 (19.42)	37 (16.82)	43 (22.40)
Fruit and veg (5+)	152 (36.89)	86 (39.09)	66 (34.38)
Poor psychological health (GHQ-12 4+)	119 (28.88)	53 (24.09)	66 (34.38)
Poor self rated health (excludes missing values)	141 (34.22)	78 (35.45)	63 (32.81)

*Z tests to compare these proportions suggest that none of the differences between the areas are significant (p<0.05).

five indicators in the intervention community (fruit and vegetable consumption combined and poor psychological health) and two of five indicators in the control community (vegetable and fruit and vegetable consumption).

Fruit and vegetable consumption: comparing intervention and comparison areas

Table 4 shows estimates for change in the intervention community compared with change in the comparison community for fruit and vegetable consumption. Adjusting for baseline consumption, sex, age, employment, and education there is weak evidence for an effect of the intervention on mean fruit consumption (−0.03, 95% CI −0.25 to 0.30), mean vegetable consumption (−0.11, 95% CI −0.44 to 0.22), and fruit and vegetables combined (−0.10, 95% CI −0.59 to 0.40).

We tested for linearity in this ANCOVA model by introducing a quadratic term and then testing whether this model is an improvement on the original ANCOVA model (which assumes a linear relation between before and after dietary outcome). There is some evidence for an improvement in the model for mean vegetable consumption (p = 0.048) and fruit and vegetables combined (p = 0.012). However, despite introducing this term there was little change in the regression coefficients generated for either mean vegetable consumption (−0.09, 95% CI −0.42 to 0.24) or mean fruit and vegetable consumption (−0.10, 95% CI −0.59 to 0.39) and 95% confidence intervals still included zero.

Self reported and psychological health

Table 5 shows unadjusted and adjusted odds ratios (OR) and 95% confidence intervals (95% CI) for the net effect on fair to poor self reported health and poor psychological health (GHQ-12) in the intervention community compared with the comparison community. For self reported health, the unadjusted odds of having fair to poor health increased among respondents in the intervention community (OR 1.29, 95% CI 0.86 to 1.93) although this was not statistically significant. The unadjusted odds of having poor psychological health slightly increased in the intervention group compared

Table 3 Key outcomes in intervention and control communities, before and after intervention and magnitude of change

	Intervention community			Control community		
Outcome	Before intervention	After intervention	Change	Before intervention	After intervention	Change
Diet*						
Fruits (portions/day)	1.97	2.06	0.09 (p = 0.35)	2.11	2.23	0.12 (p = 0.19)
Vegetables (portions/day)	2.06	2.21	0.15 (p = 0.14)	2.16	2.41	0.25 (p = 0.01)
Fruits and vegetables (portions/day)	3.92	4.21	0.29 (p = 0.07)	4.16	4.60	0.44 (p = 0.003)
Health†						
Fair to poor self reported health (prevalence)	37.7	45.05	7.35 (p = 0.17)	40.41	38.94	−1.47 (p = 0.76)
Poor psychological health (prevalence)	38.6	26.47	−12.13 (p = 0.017)	26.63	25.79	−0.84 (p = 0.85)

**t* Test for difference in means; †Z test of two proportions.

Table 4 Intervention effect estimates (95% confidence intervals) for fruit, vegetable, fruit and vegetable consumption in portions per day for intervention compared with comparison community and for switchers compared with non-switchers

	Model 1	Model 2	Model 3	Model 4
Outcome	Unadjusted	Adjusted for baseline	Model 2 adjusting for sex, age, employment, and education	Model 3 plus a quadratic term
Intervention community				
Fruits	−0.19 (−0.44 to −0.05)	−0.10 (−0.32 to 0.12)	0.03 (−0.25 to 0.30)	–
Vegetables	−0.21 (−0.48 to 0.06)	−0.16 (−0.42 to 0.10)	−0.11 (−0.44 to 0.22)	−0.11 (−0.44 to 0.22)
Fruits and vegetables	−0.44 (−0.86 to −0.01)	−0.28 (−0.67 to 0.11)	−0.10 (−0.59 to 0.40)	−0.10 (−0.59 to 0.40)
Switchers				
Fruits	0.16 (−0.19 to 0.50)	0.09 (−0.21 to 0.40)	0.23 (−0.15 to 0.60)	–
Vegetables	0.11 (−0.26 to 0.49)	0.00 (−0.36 to 0.36)	0.09 (−0.36 to 0.54)	0.12 (−0.33 to 0.57)
Fruits and vegetables	0.30 (−0.30 to 0.90)	0.15 (−0.39 to 0.69)	0.35 (−0.33 to 1.03)	0.35 (−0.32 to 1.02)

with the comparison group (unadjusted OR 1.04 95% CI 0.65 to 1.66) but were not statistically significant. For both outcomes we then adjusted for baseline outcome, and then baseline outcome plus age, sex, education, and educational status (see table 5). Comparing the intervention with the comparison community the adjusted odds of having fair to poor self rated health rose (OR 1.52, 95% CI 0.77 to 2.99) showing that the proportion of respondents with fair to poor self reported health increased in the intervention area compared with the comparison area during the follow up period. Conversely, the odds of having poor psychological health were reduced but were not statistically significant (OR 0.57 95% 0.29 to 1.11). We also investigated potential interactions between confounding variables and outcome variables. There was no evidence for interactions with all variables ($p>0.15$) with the exception of borderline evidence for education ($p = 0.057$) with self rated health, and age with poor psychological health ($p = 0.052$).

Switchers

Among respondents in the intervention area, 30.21% ($n = 58$) reported switching their main food shopping to the hypermarket at follow up compared with 1.36% ($n = 3$) in the comparison site, showing that contamination was limited. This is in line with previous studies.[28] About half of all switchers changed from alternative superstores located outside the area. Table 4 shows unadjusted and adjusted regression coefficients estimating the effect on fruit and vegetable consumption of the intervention on all switchers (those in intervention and comparison sites) compared with non-switchers. Unadjusted analyses show a minor increase in fruit (0.16, 95% CI −0.19 to 0.50) vegetable (0.11, 95% CI −0.26 to 0.49), and fruit and vegetable (0.30, 95% CI −0.30 to 0.90) consumption in portions per day for switchers compared with non-switchers but confidence intervals included zero. Adjusting for baseline consumption age, sex, education, and economic activity attenuated the effects but they remained non-significant.

We tested for parallel regression lines in the ANCOVA models between switchers and non-switchers. In our models there was no evidence against the parallel line assumption for fruit consumption ($p = 0.08$), vegetable consumption ($p = 0.075$), and fruit and vegetable consumption combined ($p = 0.180$). Testing for linearity in the model there was evidence for improvement in the model through introducing a quadratic term for mean vegetable consumption ($p = 0.042$) and mean fruit and vegetable consumption combined ($p = 0.012$), but not for mean fruit consumption ($p = 0.323$). For the last two consumption measures this represents the final model. We can see that for switchers there is a small improvement in mean fruit and vegetable consumption of 0.31 portions per day, but this is not significant ($p = 0.3$).

Table 5 shows unadjusted odds ratios and 95% confidence intervals for poor self rated health and poor psychological health for switchers compared with non-switchers at follow up. Unadjusted odds ratio for poor self rated health showed improvement in self rated health among switchers (OR 0.62, 95% CI 0.34 to 1.11). A larger reduction in poor psychological health (OR 0.81, 95% CI: 0.41 to 1.58) was found, but both 95% confidence intervals included 1.0, showing no statistically significant change.

Differences between switchers and non-switchers at baseline showed that further analysis controlling for baseline

Table 5 Odds ratios (95% confidence intervals) of reporting fair to poor self reported health and poor psychological health for the intervention compared with comparison community and for switchers compared with non-switchers

	Model 1	Model 2	Model 3
Outcome	Unadjusted odds ratio	Odds ratio adjusted for baseline outcome	Odds ratio adjusting for model 2, sex, age, employment, and education
Intervention community			
Fair to poor self rated health	1.29 (0.86 to 1.93)	1.55 (0.93 to 2.62)	1.52 (0.77 to 2.99)
Poor psychological health	1.04 (0.65 to 1.66)	0.81 (0.48 to 1.38)	0.57 (0.29 to 1.11)
Switchers			
Fair to poor self rated health	0.62 (0.34 to 1.11)	0.69 (0.33 to 1.42)	0.50 (0.19 to1.32)
Poor psychological health	0.81 (0.41 to 1.58)	0.42 (0.19 to 0.92)	0.24 (0.09 to 0.66)

health status was required, in addition to controlling for other confounding variables. Adjusted odds ratios and associated 95% confidence intervals for fair to poor self rated health and poor psychological health improved the protective effect of switching for both outcomes. After adjustment for baseline health status, sex, age, education, and economic activity the odds of reporting fair to poor self rated health was 0.50 although this was not significant (95% CI: 0.19 to 1.32). For poor psychological health there was good evidence for a protective effect of switching to the new store after adjustment (OR 0.24, 95% CI: 0.09 to 0.66).

We checked for interactions between the two general health outcomes and potential effect modifiers. There was no evidence of any interactions with self rated health.

DISCUSSION

The exploitation of natural experiments has been described as one important way of strengthening the evidence base for the efficacy of community based public health interventions.[22 23] Within the UK, policymakers have advocated improvements in local physical access to food as one way of combating food deserts; improving local food consumption patterns and thus diet related health in deprived areas.[11 12] Regenerating the local economic environment through private sector commercial investment in deprived neighbourhoods has also been hypothesised to improve general health although the evidence is more equivocal.[17] In this quasi-experimental evaluation of a naturally occurring intervention we found that there was little evidence for a positive intervention effect at the community level on fruit and vegetable consumption after adjustment for confounding variables. Self reported health worsened and psychological health improved in the intervention area, although these changes were not statistically significant. Among respondents who we know were directly affected by the new store—those who switched to using the store as their main shop—there was an improvement in fruit and vegetable consumption of between 0.12 to 0.35 portions per day; although this was not statistically significant. Although the number of switchers was low (n = 61), with limited power to detect a statistically significant intervention effect, about one third of respondents in our intervention area did switch to the new store. This shows that there was an effect on shopping patterns for a large minority of respondents. For general health measures there was a reduction in the prevalence of fair to poor self reported and poor psychological health among switchers, although this was only statistically significant for psychological health as measured by GHQ-12.

Key points

- Policymakers have suggested that improving local food shopping opportunities may improve diet and health. There is very limited evidence for the effectiveness of such interventions.
- This study did not find any evidence for a net community intervention effect for fruit and vegetable consumption. However, there was some evidence for a positive effect on psychological health for those who directly engage with the intervention.
- Prospective quasi-experimental studies of naturally occurring interventions offer a cost effective way of generating evidence of effectiveness where it is lacking, or where community randomised trial designs are not the most appropriate study method.

Policy, practice, and research implications

- Encouraging the location of large scale food retailing in deprived communities may not be the most effective method of combating poor diet. However, large scale commercial investment in deprived neighbourhoods may have a psychosocial impact upon health, although the evidence presented here is not definitive.
- Controlled rather than uncontrolled study designs should be used in assessing the health impacts of retail interventions.

Within policy documents and the academic literature the common assumption is that locating new food retail outlets in poorer areas may improve food consumption patterns and reduce health inequalities by increasing food access and availability. We did not find any evidence to support that view either at the community level or for those who directly engage with the new shopping provision. Previously published research has reported a supermarket effect on fruit and vegetable consumption of around 0.41 to 0.47 portions per day for those with the lowest fruit and vegetable consumption, and that this effect is particularly pronounced in consumers who switch to the new hypermarket as their main shop.[15] However, that research used an uncontrolled before/after study design to evaluate community health impact. This effect is similar to the uncontrolled magnitude of change reported within our intervention community (see table 3). In our study, once changes in the matched control community had been taken into account the magnitude of positive change was substantially reduced and was not statistically significant. This suggests that the attributing change to superstore development in uncontrolled studies is problematic.

We did find evidence of a positive independent effect on the prevalence of poor psychological health, although there was a (non-significant) negative effect on fair to poor self rated health. It is not clear from this study whether the positive effects for psychological health are "true" effects in the context of conflicting results for self reported health status.

Limitations

The response rate to the postal questionnaire was low, which may make the study prone to selection bias. However, 2001 census data show that the age and sex distribution of the sample was similar to the age and sex distribution of the population from which the sample was drawn. The study also has low power to detect a true effect, particularly for the analysis of the switchers subgroup. Poaching of customers from other large stores to the new hypermarket could have diluted effects on the switchers subgroup, but excluding those poached customers would have rendered the subgroup analysis meaningless. This means that some analyses cannot exclude the possibility of a small positive effect on fruit and vegetable consumption. Our respondents had higher than expected consumption of five or more fruit and vegetables per day at baseline, which may suggest over-reporting, although this may be partly attributable to the age of our cohort (which is older). The wording of our questions may have also promoted over-reporting, which would reduce our ability to detect small positive changes. The study was also undertaken in areas that suffered from the highest levels of deprivation. Further studies need to be undertaken in a variety of areas that reflect a wider range of socioeconomic characteristics.

Quasi-experimental studies like this one cannot easily disentangle the effect of the hypermarket from other known or unknown interventions. For example, ongoing economic regeneration as part of wider national or regional policy in the two areas may have had positive effect on psychological health during follow up particularly through improvements in the built environment and decreases in unemployment. In terms of diet, it was discovered that a ''free-fruit in schools'' programme was underway during the follow up period of the project. This may have eroded comparative differences between the study sites.

CONCLUSIONS

This study is the first controlled study of the effect of large scale food retailing on diet and general health in the UK. In contrast with a previous uncontrolled study we did not find any evidence of a net intervention effect on fruit and vegetable consumption, although there is some evidence for a net reduction in poor psychological health for those who directly engaged with the intervention. However, a low response to the postal survey cannot allow us to make definitive statements about the impacts of the superstore—we cannot rule out the possibility that positive effects on behaviour exist. Further studies, using face to face interviews and other methods to maximise response rates are required to effectively investigate the impact of large scale food retailing on diet and general health, particularly focusing on those consumers who directly engage with change in the local community. In the absence of randomised controlled trials, the evaluation of the impacts of similar natural experiments may offer the best opportunity to learn about the health impacts of retail interventions in poor areas.[29] However, as the first study of its kind in this field, it is clear that there are limitations, and thus this is an exploratory study, whose methods can be improved by future researchers.

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