RESEARCH REPORT

Residential area deprivation predicts fruit and vegetable consumption independently of individual educational level and occupational social class: a cross sectional population study in the Norfolk cohort of the European Prospective Investigation into Cancer (EPIC-Norfolk)

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Study objective: To investigate the independent association between individual and area based socioeconomic measures and fruit and vegetable consumption.
Design: Cross sectional population based study.
Setting and participants: 22 562 men and women aged 39–79 years living in the general community in Norfolk, United Kingdom, recruited using general practice age-sex registers.
Outcome measures: Fruit and vegetable intake assessed using a food frequency questionnaire.
Main results: Being in a manual occupational social class, having no educational qualifications, and living in a deprived area all independently predicted significantly lower consumption of fruit and vegetables. The effect of residential area deprivation was predominantly in those in manual occupational social class and no educational qualifications.
Conclusions: Understanding some of the community level barriers to changing health related behaviours may lead to more effective interventions to improving health in the whole community, particularly those who are most vulnerable.

Socioeconomic inequalities in health are well reported. Several studies[1 2] have shown an association between socioeconomic status and cardiovascular diseases, which may be partly explained by differences in health related behaviours such as smoking habit or diet. The consumption of fruit and vegetables specifically has been associated with lower risks for chronic diseases such as cancer[3] and coronary heart disease.[4] Several studies investigating the association between socioeconomic status and fruit and vegetable intake reported higher consumption of fruit and vegetables among people of higher socioeconomic status.[5–8] These studies however only used individual level measures of socioeconomic status and thus may not have captured the potential influence of the area where the people live. Only a few studies have examined the effect of area of residence on fruit and vegetable consumption.[9 10] These studies reported higher intake of fruit and vegetables in more affluent neighbourhoods. In this study, we investigated the cross sectional relation between individual and area based measures of socioeconomic status and fruit and vegetable consumption. Understanding how specific socioeconomic factors might influence lifestyle may lead to more effective interventions to reduce social inequalities in health.

METHODS

The study population is based on general practices in Norfolk, United Kingdom and includes the city of Norwich as well as surrounding small towns and rural areas. The cohort was recruited between 1993–1997 as part of the Norfolk component of the European Prospective Investigation into Cancer (EPIC-Norfolk). Detailed descriptions of the recruitment and study methodology have been previously reported.[11] Men and women aged between 39–79 years were identified from collaborating general practice registers and were invited by mail to participate in the baseline survey. The response rate was about 45%. Altogether 30 445 agreed to participate and gave informed consent and completed a detailed health and lifestyle questionnaire. Of these, 25 633 agreed to attend a health check. Social class was classified according to the registrar general's occupation based classification scheme. For men, social class was coded using their current occupation at the time of survey except when they were unemployed or retired in which case their partner's social class was used. Unemployed men without partners were unclassified. Social class in women was based on their partner's except when the partner's social class was unclassified, missing, or if they had no partner in which case social class was based on their own occupation. An unemployed woman without a partner was coded as unclassified.

Educational status was based on the highest qualification attained and was categorised into four groups: degree or equivalent, A level or equivalent, O level or equivalent, and less than O level or no qualifications. O level indicates educational attainment to the equivalent of completion of schooling to the age of 15 years and A level indicates educational attainment to the equivalent of completion of schooling to the age of 17 years.

We used the Townsend deprivation index rather than any other index to obtain the residential area based socioeconomic measure as the score does not include occupational social class data. The Townsend deprivation score is a composite index used to identify material deprivation and is calculated using variables derived from the 1991 census.[12]

Each variable was then standardised by obtaining Z scores using the mean and standard deviation across the enumeration districts in England and Wales. The Townsend deprivation score at the enumeration district level is derived from the sum of the Z scores and is relative to England and Wales. The home address at the time of the survey was assigned a postcode. The postcodes were linked to enumeration districts and the deprivation score for the enumeration district is then assigned to the person. The Townsend deprivation scores for the study population ranged from −6 to +7 with a median of −2.6. Larger numbers indicate higher level of deprivation. The scores were divided into quintiles with cut off points of −3.8, −2.9, −2.1, and −0.55 respectively.

Persons who returned the health and lifestyle questionnaire and agreed to participate in a clinic assessment were then asked to complete a 130 item food frequency questionnaire (FFQ), details of which have been previously reported elsewhere.[11 13] Data on fruit and vegetable intake were obtained from this FFQ. There were 11 types of fruit and 26 types of vegetables listed in the FFQ. For each fruit and vegetable intake, participants were asked to indicate their usual consumption from nine frequency categories ranging from never or less than once a month to more than six times per day. There were no specific questions with regard to portion size; instead the FFQ used specified medium servings defined by natural (for example, a slice of bread) or households units (for example, cup, spoon). The gram weights of medium servings were obtained from estimates of mean values derived from previous validation studies[14] and other published values.[15] The fruit and vegetable intakes were calculated by multiplying the frequency consumed by standard portion weights to obtain a total estimate of grams of fruit and vegetable consumed per day.

Statistical analyses were performed using SPSS version 10.0 (SPSS, Chicago, IL). The analyses were undertaken separately for men and women. The mean fruit and vegetable intake was tabulated according to the three measures of socioeconomic status: social class, level of education, and deprivation level. One way analysis of variance and the GLM test for linearity was used with the p value of <0.05 for significance.

The independent effect of the area based measure of socioeconomic status on average intake of fruit and vegetables, adjusted for individual based measures was investigated. To compare the relative strength of association between the three socioeconomic status indicators and mean intake of fruit and vegetables, regression models were constructed. In the first model we categorised social class, educational level, and area based deprivation as dichotomous variables. Social classes I, II, and III non-manual were classified as ''non-manual'', while social classes III manual, IV and V were classified as ''manual''. Educational level was categorised into ''at least O level'' (which includes O level, A level, and degree) and ''no qualifications''. For residential deprivation, subjects with Townsend scores of less than 0 were classified as ''less deprived'', while those with Townsend scores of more than 0 were categorised as ''most deprived''. The use of 0 as the cut off point for the Townsend deprivation level allows for comparisons with those who are below the national average in terms of deprivation based on the Townsend deprivation scores. We further investigated the effects of deprivation level on fruit and vegetable consumption in a population stratified by social class and educational status. Age was included as a covariate in all the models.

RESULTS

From the total 25 633 who completed the health and lifestyle examination, 2024 were excluded because of missing Townsend deprivation scores. Occupational social class data were missing for 612 participants and 96 had their social class coded as unclassified while two people did not indicate their educational level. These people were excluded from analysis. Participants who did not complete the FFQ were also excluded. These analyses are therefore based on 10 321 men and 12 241 women who had available data on all socioeconomic and dietary variables used in the analyses.

Table 1 shows the distribution of crude average fruit and vegetable consumption according to occupational social class, level of education, and quintiles of Townsend deprivation scores. We initially analysed fruit and vegetable intakes separately, however, because the results for each component were similar to the combined fruit and vegetable intakes, only the results of the combined intakes are shown. Both men and women consumed more fruit than vegetables, while women on average had higher intakes of fruit and vegetables compared with men. The average daily intake of fruit and vegetables combined for this population (442 grams per day) was higher than the UK average of 310 grams per day[16] and reflects the more rural population of Norfolk. The distribution of fruit and vegetable intake across social class, educational level, and Townsend quintiles indicated a statistically significant social gradient with those in the higher social groups, with more education, and living in more affluent areas consuming on average higher amounts of fruit and vegetables.

When residential area deprivation quintiles were cross tabulated first with social class and then educational level as dichotomous variables (table 2), the association between residential area deprivation and fruit and vegetable consumption was only statistically significant in those in the manual social classes and those with no qualifications. While there were only slight differences between the first four quintiles, there appeared to be an interaction between low social class and low educational level and living in the most deprived residential quintile where the mean fruit and vegetable intake was significantly lower than in the first four quintiles.

Multivariate regression analyses indicated that social class, educational level, and residential area deprivation level independently predicted fruit and vegetable consumption (table 3). People who were in manual social classes, with no educational qualifications or those who live in the most deprived areas consumed significantly lower amounts of fruit and vegetables compared with those in non-manual social classes, with at least O level or equivalent educational attainment or who lived in less deprived areas. In men, the magnitude of effect of residential area deprivation was stronger than either occupational social class or educational level. Men who lived in the most deprived areas were estimated to consume 27 g less fruit and vegetables per day compared with those in the less deprived areas while the difference between non-manual and manual men and those with high and low education was 20 g and 13 g per day respectively. For women, educational level was the strongest socioeconomic measure independently predicting fruit and vegetable intake; those with no qualifications consuming as much as 30 g less fruit and vegetables per day than those with at least O levels. Women living in the most deprived area consumed 16 g less fruit and vegetables per day compared with those living in the less deprived area while women in the manual social class had 13 g less fruit and vegetables per day compared with those who are in the non-manual social class.

Further regression analyses appear to indicate an interaction between living in the most deprived residential areas and social class or education: when stratified by social class or educational level, residential deprivation no longer was significantly related to fruit and vegetable intake in persons

Table 1 Distribution of average fruit and vegetable intake (unadjusted) (g/day) at baseline survey by social class, educational level and deprivation category for 10321 men and 12241 women aged 39–79 years, EPIC-Norfolk cohort, 1993–1997

		Men n = 10321		Women n = 12241
		Mean (SD)		Mean (SD)
Age (y)		59.2 (9.3)		58.2 (9.3)
Fruit intake (g/day)		207 (148)		267 (168)
Vegetable intake (g/day)		187 (95)		214 (102)
Fruit and vegetable intake (combined)(g/day)		397 (204)		486 (230)
Social class		**Fruit and vegetable intake (g/d)**		**Fruit and vegetable intake (g/d)**
	Number	**Mean (SD)**	**Number**	**Mean (SD)**
I	770	416 (201)	782	499 (223)
II	3960	411 (204)	4284	503 (233)
III Non-manual	1309	392 (199)	2474	479 (223)
III Manual	2626	382 (204)	2618	475 (224)
IV	1347	383 (200)	1607	474 (239)
V	309	373 (220)	476	442 (234)
p value for trend		<0.001		<0.001
Educational level				
Degree or equivalent	1573	423 (204)	1329	517 (222)
A level or equivalent	4727	395 (200)	3161	502 (234)
O level or equivalent	902	385 (200)	2011	475 (219)
No qualifications	3119	389 (209)	5740	473 (232)
p value for trend		<0.001		<0.001
Deprivation category*				
1 (<−3.80)	2122	404 (200)	2495	490 (227)
2 (−3.79 to −2.92)	2206	406 (206)	2554	489 (230)
3 (−2.91 to −2.09)	1983	400 (201)	2327	486 (228)
4 (−2.08 to −0.55)	2063	398 (209)	2505	489 (232)
5 (>−0.54)	1947	373 (201)	2360	473 (232)
p value for trend		<0.001		0.03

*Based on Townsend deprivation scores.

from non-manual social classes or who had completed school, but was a strong predictor in persons from manual social classes and without educational qualifications (table 4).

This was confirmed by regression analyses in which interaction terms for social class and residential deprivation index ($\beta = -23.2$, $p<0.01$) and for education and residential deprivation index ($\beta = -17.25$, $p<0.05$) were both significantly related to fruit and vegetable intake independent of age, sex, social class, education, and residential deprivation.

DISCUSSION

There have been several studies examining the association between socioeconomic status and diet[17–21] and to a lesser extent fruit and vegetable consumption.[5–7] However, the socioeconomic variables used in these studies were measured at the individual level only and thus may not have captured the potential influence of the area where they live. Other studies have used residential area indices such as postcodes as a general surrogate indicator of an individual socioeconomic status.[22 23] However, this may not be appropriate if different socioeconomic indicators are measuring different exposure components. Studies have shown that both individual and area based measures of socioeconomic status may have independent effects on health.[2 24] The distinction between individual or area based measures in influencing health or health related behaviour is vital in understanding what the specific factors are and hence, the most effective interventions. For example, health promoting interventions may be either community based or aimed at individuals and their behaviours. Few studies have been able to compare the independent relations between different individual and

Table 2 Age adjusted mean fruit and vegetable intake (g/day) by deprivation category and social class and educational level for 10321 men and 12241 women aged 39–79 years, of the EPIC-Norfolk cohort, 1993–1997

		Townsend quintiles										p Value for trend*
		1		2		3		4		5		
Men	**By social class**	**Mean**	**(n)**	**Mean**	**(n)**	**Mean**	**(n)**	**Mean**	**(n)**	**Mean**	**(n)**	
	Non-manual	410	(1410)	412	(1404)	407	(1161)	410	(1178)	395	(886)	0.34
	Manual	392	(712)	398	(802)	391	(822)	380	(885)	356	(1061)	<0.001
	By educational level											
	At least O level	411	(1603)	410	(1646)	404	(1381)	399	(1385)	388	(1187)	0.02
	No qualifications	384	(519)	397	(560)	391	(602)	394	(678)	351	(760)	<0.001
Women	**By social class**											
	Non-manual	495	(1717)	496	(1663)	491	(1429)	494	(1505)	495	(1226)	0.97
	Manual	481	(778)	475	(891)	481	(898)	479	(1000)	447	(1134)	0.002
	By educational level											
	At least O level	509	(1420)	496	(1445)	503	(1259)	497	(1319)	505	(1058)	0.57
	No qualifications	468	(1075)	479	(1109)	468	(1068)	478	(1186)	445	(1302)	0.001

*Test for linearity in one way analysis and GLM.

Table 3 Regression coefficients (95% confidence intervals) for mean fruit and vegetable intake (g/day) in 10321 men and 12241 women aged 39–79 years, of the EPIC-Norfolk cohort, 1993–1997 for models based on age, social class, level of education, and deprivation level

	Men		Women	
Predictor variables	Regression coefficients* β (95% CI)	p Value	Regression coefficients* β (95% CI)	p Value
Social class (manual *v* non-manual†)	−20.0 (−28.3 to −11.6)	<0.001	−13.2 (−22.0 to −4.5)	0.003
Education (no qualifications *v* at least O level†)	−13.2 (−22.3 to −4.0)	0.005	−30.0 (−38.8 to −21.2)	<0.001
Deprivation level (highly deprived *v* less deprived†)	−26.5 (−37.5 to 15.6)	<0.001	−16.0 (27.2 to −4.9)	0.005

*Regression coefficients are shown as the difference in grams per day from the reference category, adjusted for the other factors in the model. †Reference category. Predictor variables: social class—non-manual = social classes I, II, and III non-manual, manual = social classes III manual, IV, and V. Education—at least O level, no qualifications. Deprivation level—based on Townsend deprivation scores: <0 = less deprived, >0 = highly deprived

area based measures of socioeconomic status on individual behaviour such as fruit and vegetable consumption.[9 10]

In this study we found strong independent effects of occupational social class, educational level, and residential area deprivation on fruit and vegetable consumption. Men and women in manual social classes and without educational qualifications reported eating significantly less fruit and vegetables compared with those in non-manual social class or those who had attained minimal educational qualifications. This is consistent with the findings of a systematic review of socioeconomic differences in consumption of fruit and vegetables among adults in European countries.[8] In the UK, Billson *et al*[7] found that manual social class and those in receipt of benefits were negatively associated with fruit and vegetables consumption, while in a cohort study for women, Pollard *et al*[6] found that higher consumers of fruit and vegetables were among others, women with a degree level education and those of higher social class. In addition to educational level and occupational social class, we also found that residential area based deprivation as measured by Townsend deprivation scores independently significantly predicted the intake of fruit and vegetables. This is in agreement with findings from studies conducted by Ellaway *et al*[10] and Diez-Roux *et al*[9] that reported differences in fruit and vegetable intake among neighbourhoods with varying levels of affluence. People living in more affluent neighbourhoods were more likely to report higher intakes of fruit and vegetables.

The independent effects observed for residential deprivation are unlikely to be explained by selection biases or confounding. There was a wide range of social class, educational status, and residential area deprivation in this cohort. While deprivation based on the mean Townsend score seems to be shifted in a favourable direction, the Townsend score uses indices such as car ownership and overcrowded housing that may be more appropriate for urban environments and may not be sensitive to rural deprivation such as that which occurs in Norfolk. Measurement error is likely therefore to be greatest for the residential index and such errors are likely to minimise its effects. The exclusion of people whose social class and deprivation scores were missing or not classified and those without fruit and vegetable data could cause bias only if they differed from those included in the study with respect to the relation between socioeconomic status and fruit and vegetable consumption, which seems unlikely. With regard to the use of FFQ as the method of dietary assessment, while there may be bias in reporting fruit and vegetable consumption, it is not likely

Table 4 Regression coefficients (95% confidence intervals) for average intake of fruit and vegetables (g/day) in 10321 men and 12241 women aged 39–79 years, of the EPIC-Norfolk cohort, 1993(1997, stratified by (a) social class, (b) educational level, and (c) deprivation level adjusted for age

	Non-manual		Manual	
Predictor variables	Regression coefficients* β (95% CI)	p Value	Regression coefficients* β (95% CI)	p Value
(a) By social class				
Men	n = 6039		n = 4282	
Townsend index	−18.2 (−34.3 to −2.2)	0.03	−33.7 (−48.7 to −18.7)	<0.001
Educational level	−12.2 (−25.5 to 1.0)	0.07	−13.6 (−26.2 to −0.97)	0.04
Women	n = 7540		n = 4701	
Townsend index	2.3 (−13.0 to 17.6)	0.77	−37.4 (−53.8 to −21.1)	<0.001
Educational level	−35.1 (−46.2 to −24.0)	<0.001	−20.5 (−34.8 to −6.3)	0.005
(b) By educational level	**At least O level**		**No qualifications**	
Men	n = 7202		n = 3119	
Townsend index	−20.1 (−33.9 to −6.4)	0.004	−37.2 (−55.5 to −18.9)	<0.001
Social class	−19.8 (−29.8 to −9.8)	<0.001	−19.9 (−35.1 to −4.7)	0.01
Women	n = 6501		n = 5740	
Townsend index	3.4 (−12.9 to 19.7)	0.68	−33.5 (−48.8 to −18.1)	<0.001
Social class	−20.9 (−33.5 to −8.3)	0.001	−5.2 (−17.3 to 6.9)	0.40
(c) By deprivation level	**Less deprived**		**Highly deprived**	
Men	n = 8746		n = 1575	
Social class	−18.1 (−27.2 to −9.0)	<0.001	−29.4 (−50.4 to −8.5)	0.006
Educational level	−10.9 (−20.9 to −0.8)	0.03	−23.4 (−45.2 to −1.6)	0.04
Women	n = 10306		n = 1935	
Social class	−7.8 (−17.3 to 1.7)	0.11	−37.8 (−59.9 to −15.6)	0.001
Educational level	−25.8 (−35.3 to −16.4)	<0.001	−50.9 (−74.0 to −27.8)	<0.001

*Regression coefficients are shown as the difference in grams per day from the reference category, adjusted for the other factors in the model. Predictor variables: social class—non-manual = social classes I, II, and III non-manual; manual = social classes III manual, IV, and V. Education—at least O level, no qualifications. Deprivation level—based on Townsend deprivation scores: <0 = less deprived, >0 = highly deprived.

Key points

- Being in a manual occupational social class, having no educational qualifications, and living in a deprived area all independently predicted significantly lower consumption of fruit and vegetables.
- The effect of residential area deprivation was predominantly in those in manual occupational social class and no educational qualifications.

Policy implications

Understanding some of the community level barriers to changing health related behaviours may lead to more effective interventions to improving health in the whole community, particularly those who are most vulnerable.

that a person's residential postcode could influence their self report of fruit and vegetable intake. While FFQ has its limitations, it is the best method for assessing fruit and vegetable intake in large epidemiological studies like ours. We did not have information on the types of fruit and vegetable consumed, however studies that reported benefits of fruit and vegetable intake in protecting health have used total fruit and vegetables consumed (g/day), which does not take into account variation of fruit and vegetable.[4 25] There is also the possibility that low consumption of fruit and vegetables in the lower socioeconomic groups could be attributable to low energy reporting. However, in this study there was no association between socioeconomic status and total energy intake (results not shown).

The association between occupational social class and educational level with fruit and vegetable consumption could be attributed to a higher awareness of the benefits of eating fruit and vegetables among those in higher social class and with higher levels of education and/or more willingness or ability to act on this.[26] In a study examining the relation between nutrition knowledge and food intake, Wardle *et al*[27] found that knowledge of healthy eating mediates some of the socioeconomic variation in fruit and vegetable consumption. The stronger effect of educational level on fruit and vegetable consumption observed in women compared with social class may be attributable to the difficulty in classifying social class for women[28] or it could be attributable to gender differences, which may reflect women's greater health consciousness compared with men.[29] The sex difference, if real, is of interest as it suggests that different factors may have quantitatively different impact on behaviours in men and women and may influence different choices of individually based strategies for behaviour change in men and women.

Additionally, apart from individually based strategies to influence health related behaviours (for example psychological or behavioural interventions) strategies may be policy based at state or national level (for example taxation, pricing, and advertising). However, if small area variations as indicated by residential area deprivation indicators appear to predict dietary intake, it suggests that local community based factors may play an important part in influencing behavioural choices and suggest more specific and effective interventions.

While social class and educational level affect intake of fruit and vegetables possibly through the food choices an individual makes, area based deprivation may influence fruit and vegetable consumption through the characteristics of the area itself. In deprived areas, fresh fruit and vegetables usually cost more and may be of limited availability. Instead, highly processed bulk food with better storage life may be more readily available.[30] The interaction between residential deprivation and manual social class or education suggests that those who are better off or better educated may be more willing or able to obtain access to fruit and vegetables for example by shopping outside the area. Another possible explanation for the effect of area based deprivation on intake of fruit and vegetables is the role of psychosocial factors. It has been suggested that people's behaviour is influenced by the norms and values of those around them.[31] Therefore, people who are surrounded by people who do not eat a lot of fruit and vegetables are less likely to consume high amounts of fruit and vegetables.

The findings of a differential effect of residential deprivation on fruit and vegetable intake in those from manual and non-manual social classes or those with and without minimal educational qualifications is in contrast with our earlier findings in this cohort for smoking[32] in which all three measures independently predicted cigarette smoking but without any evidence of interaction. The interaction suggests that, at least for dietary intake, occupational social class or education can mitigate some of the effects of residential area deprivation.

While the magnitude of effect—about 30 g of fruit and vegetables daily—was not large, that such a significant finding could be shown at all was surprising given the large measurement errors inherent in characterising people with respect to the exposures—our measures of social class, educational status, and residential deprivation as applied to individual—and to the outcome—the estimate of daily fruit and vegetable intake from FFQ. In particular, the residential deprivation measure was based on postcodes and therefore likely to have substantial error in characterising individual exposure compared with individual social class and education. Random measurement errors are likely to minimise any differences and not produce spurious differences, so the estimate of size of effect is likely to be an underestimate. Nevertheless, even a 30 g daily difference in intake of fruit and vegetables has been associated with differences of about 10%–20% in cardiovascular or cancer risk[33] so even small differences in health related behaviours such as diet, might plausibly explain some of the observed socioeconomic differences in health.

The potential health benefits of dietary patterns that include high fruit and vegetable intake have led to many local and national efforts to increase fruit and vegetable intake. The findings of this study indicate that residential deprivation has a particularly strong effect in those in manual social classes and of low educational attainment. An understanding of the local area characteristics that influence food choices and dietary intake may lead to more appropriate community level strategies to increase fruit and vegetable intake.

It is probable that at least some of the pronounced socioeconomic inequalities in health can be explained by differences in health related behaviours. Many health interventions are aimed at individuals. However, if we can understand some of the community level barriers to changing health related behaviours, that may lead to more effective interventions to improving health in the whole community, particularly those who are most vulnerable.

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CONTRIBUTORS

KTK, ND, SB, and NW are principal investigators in the EPIC-Norfolk population study. AW and SB are responsible for the dietary measurements and analyses. RL is responsible for data management and computing and data linkages for post coding. SS conducted the data analyses and wrote the paper with KTK with contributions from other co-authors. KTK is guarantor for this paper.

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