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A multilevel study of socio-economic inequalities in food choice behaviour and dietary intake among the Dutch population: the GLOBE study

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Abstract

Objective: To examine the influence of individual- and area-level socio-economic characteristics on food choice behaviour and dietary intake.

Setting: The city of Eindhoven in the south-east Netherlands.

Design: A total of 1339 men and women aged 25–79 years were sampled from 85 areas (mean number of participants per area = 18.4, range 2–49). Information on socio-economic position (SEP) and diet was collected by structured face-to-face interviews (response rate 80.9%). Individual-level SEP was measured by education and household income, and area-level deprivation was measured using a composite index that included residents' education, occupation and employment status. Diet was measured on the basis of (1) a grocery food index that captured compliance with dietary guidelines, (2) breakfast consumption and (3) intakes of fruit, total fat and saturated fat. Multilevel analyses were performed to examine the independent effects of individual- and area-level socio-economic characteristics on the dietary outcome variables.

Results: After adjusting for individual-level SEP, few trends or significant effects of area deprivation were found for the dietary outcomes. Significant associations were found between individual-level SEP and food choice, breakfast consumption and fruit intake, with participants from disadvantaged backgrounds being less likely to report food behaviours or nutrient intakes consistent with dietary recommendations.

Conclusions: The findings suggest that an individual's socio-economic characteristics play a more important role in shaping diet than the socio-economic characteristics of the area in which they live. In this Dutch study, no independent influence of area-level socio-economic characteristics on diet was detected, which contrasts with findings from the USA, the UK and Finland.

Keywords
Food choice
Socio-economic position
Education
Income
Area deprivation
Multilevel

Health inequalities between education, occupation and income groups have been documented extensively in the literature, and research in industrialised countries has repeatedly shown a higher prevalence of many chronic diseases among the socio-economically disadvantaged[1–3]. Inequalities in some diseases, such as cardiovascular diseases and some cancers, may be partially due to socio-economic differences in diet[4–6].

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The influence of socio-economic position (SEP) on diet has been the focus of much research over the last decade. Findings in the USA, Australia and several European countries have shown that individuals with low education, working in blue-collar occupations or with low incomes have less healthy diets as well as poorer diet-related chronic disease profiles than those with higher education, in professional occupations and with high incomes[7–10]. While considerable research has focused on individual-level socio-economic factors influencing dietary behaviour, one issue that has been less studied in health inequalities research, until recently, is how the socio-economic

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characteristics of the area in which people live influence their health behaviour. Living in a disadvantaged area may contribute to poorer dietary intakes via limited availability of food shops and/or healthy foods, difficulty in accessing shops and higher prices of healthy foods[7,11].

A number of studies have examined whether area-level socio-economic characteristics influence diet. Research in the USA, the UK and Finland has shown that people residing in prosperous areas have healthier dietary behaviours and nutrient intakes than those in disadvantaged areas, independent of their individual-level SEP[7,12–17]. However, in an Australian multilevel study food choices did not show any variation between areas differing in their socio-economic characteristics[11]. This raises the question of whether the influence of area socio-economic characteristics on diet might differ between countries.

The current study adds to this international evidence base by using multilevel modelling to examine the influence of individual- and area-level socio-economic characteristics on a range of food choice behaviours and dietary intakes among the Dutch population.

Method

Sampling and data collection

Participants in this study were a sub-sample from the longitudinal GLOBE study that was conducted in the south-east Netherlands. The aim of GLOBE was to identify factors that may contribute to socio-economic inequalities in health. Participants were sampled from population registers by stratified random sampling. In spring 1991 a baseline postal questionnaire was sent to 27 070 inhabitants of the region aged 15–78 years (response rate 70.1%, $n = 18\,973$). More detailed information on the sampling and design of the larger GLOBE study is provided elsewhere[18].

In April 1991 a sub-sample of respondents to the baseline postal questionnaire ($n = 3529$) were selected to participate in an additional survey on their food choices and dietary intakes (response rate 80.9%, $n = 2856$). Face-to-face dietary intake interviews were conducted between April and June 1991. Participants were asked to complete a validated quantitative food-frequency questionnaire (FFQ) focusing on intakes of total fat, saturated, mono- and polyunsaturated fatty acids. The FFQ demonstrated acceptable levels of validity for estimating intakes of these nutrients (Pearson correlation coefficients ≥ 0.60)[19].

As the aim of the current study was to examine the influence of area deprivation on diet, it was necessary to confine the study to a geographic area in which the smaller administrative units had similar characteristics in terms of population density, housing and degree of remoteness, so that these factors did not confound the relationship. The study therefore focused on participants living in urbanised areas of the major city in the region (Eindhoven) ($n = 1566$). A total of 85 areas were included in the study (mean number of participants per area = 18.4, range 2–49), which covered 98% of the city areas. Areas were defined on the basis of municipality administrative units, which are the smallest area-level units used by the municipality for town planning, the provision of basic services (e.g. waste disposal, street cleaning) and for statistical purposes.

Measures

Education

The baseline postal survey asked participants about their highest level of completed education and this was re-categorised into four groups: primary school only, lower secondary (intermediate high school, intermediate vocational education), higher secondary (higher levels of secondary school) and tertiary education (university degree, higher vocational and technical education).

Household income

During the interview, participants were asked to indicate their household income from 13 income ranges. Household income was defined as the respondent's income plus that of their partner (if applicable), and only included the income of children if it was shared among the household. Net income was defined as income after the subtraction of taxes, premiums and pension contributions. Household income was grouped into quartiles: 0–1900, 1901–2800, 2801–3500 and ≥3501 NLG (guilders) per month.

Area deprivation

The measure of area deprivation was derived from the socio-economic characteristics of respondents to the baseline survey ($n = 18\,793$) and not the dietary survey used here ($n = 2856$). An area deprivation indicator was developed from three socio-economic and deprivation items: percentage of residents with primary school as their highest attained education level; percentage who were employed in unskilled manual occupations; and percentage who were unemployed. These percentages were summed and the measure was categorised into quartiles. This measure has been used in the same dataset with other health outcomes[20] and was calculated from the baseline survey as no deprivation indicators are available at the neighbourhood level from population statistics in The Netherlands. The deprivation index used in the current study has been shown to correlate highly with area-level housing tenure data available from population statistics ($r = 0.89$).

Food choice behaviour and dietary intake

A grocery index was used to assess the healthiness of food choices. This summary measure was based on participants' selections of six staple food items: type of fats used on bread and for cooking, type of cheese used, type of meat used on bread, type of meat eaten with main meal, type of milk used, and type of dairy dessert consumed (e.g. yoghurt, custard, cottage cheese). For each food item,

Table 1 Regular and recommended categories used for scoring the grocery food choice index

Grocery food choice index	
Regular*	Recommended†
Type of fat used	
Butter	Fatty acid-modified margarine
Cooking fat (animal origin)	Cooking fat (plant origin)
Lard	Olive oil
Margarine (table and package types)	Other oils
	Reduced-fat margarine
	Reduced-fat margarine, fatty acid-modified
Type of cheese eaten on bread	
Full-fat cheese	Reduced- and low-fat cheese
Type of meat eaten on bread	
Sausage varieties	Ham
Salami	Smoked meats
Bacon	Corned beef
Pâté	
Type of meat eaten at main meal	
Sausages	Medium-/low-fat cuts of beef and pork
Bacon	Fillet cuts of chicken, beef, pork
Hamburger	Liver
High-fat cuts of beef	
High-fat cuts of pork	
Type of milk used	
Full cream	Reduced-fat
	Skimmed (low-fat)
Type of dairy dessert	
Yoghurt (full cream)	Yoghurt (reduced-/low-fat)
Pudding (full cream)	Pudding (reduced-/low-fat)
Cottage cheese (full cream)	Cottage cheese (reduced-/low-fat)

* Food choices higher in total fat and saturated fat.
† Food choices consistent with Dutch Dietary Guidelines[21], recommending choices lower in total fat and saturated fat.

'regular' and 'recommended' choices were identified (see Table 1). In accordance with dietary guidelines and health-promotion recommendations, 'recommended' choices were those lowest in total fat and saturated fat.

Each food selection was scored as follows: participant consumed only the regular choice (scored 1), participant consumed both the regular and recommended choices (scored 2), or participant consumed exclusively the recommended choice (scored 3). These scores were summed, then standardised on the basis of the number of items consumed and re-scored to range from 0 to 100 (mean = 43.23, standard deviation = 18.98). Higher scores represented choices more consistent with recommendations. A similar method of scoring and categorising food choices has been used elsewhere[11]. For the purposes of this study, the food choice index was divided into quartiles.

To ascertain fruit consumption, participants were asked to estimate how many portions of fruit they consumed on an average day or week. A portion was defined as being one piece of fruit (in the case of apples, pears, oranges and bananas), two mandarins/kiwi fruits or a handful of smaller fruits (such as grapes, berries and cherries). The average number of portions consumed daily was calculated for respondents who reported their weekly fruit consumption. The lowest quartile of daily consumption of all participants was determined (<1 portion per day) and was used as the outcome category of interest in these analyses.

Breakfast consumption was determined by asking participants how many days per week (on average) they consumed breakfast, and their responses were recorded as a number between zero and seven. For the current analyses, breakfast consumption was dichotomised into participants who consumed breakfast every day and those who skipped breakfast once or more per week.

Dietary intakes

Items on the FFQ accounted for $>90\%$ of total fat and saturated fat intakes in the Dutch diet[19]. Nutrient intakes were calculated from the FFQ using a nutrient composition database developed for this study. The 'average' nutrient composition of each item on the FFQ was determined by obtaining the nutrient contents of a standard portion of all foods within each FFQ item from the Dutch nutrient composition tables[22]. These were weighted by the population's consumption of the different foods that comprised the item, as reported by the National Dutch Food Consumption Survey 1987/1988, and an

Table 2 Demographic, socio-economic and dietary behaviour characteristics of participants

	Dietary sub-sample*	Baseline postal survey†
Gender		
Male	672 (50.2)	4894 (48.2)
Female	667 (49.8)	5255 (51.8)
Age (years), mean (SD)	51.4 (13.8)	47.3 (16.4)
Education		
Primary	314 (23.5)	2390 (23.5)
Lower secondary	489 (36.5)	3858 (38.0)
Higher secondary	266 (19.9)	2290 (22.6)
Tertiary	270 (20.2)	1611 (15.9)
Monthly household income quartiles		
1 (0–1900 NLG)‡	341 (28.3)	–§
2 (1901–2800 NLG)	337 (28.0)	–
3 (2801–3500 NLG)	260 (21.6)	–
4 (≥3501 NLG)	266 (22.1)	–
Area deprivation score quartiles, number of areas (%)		
1 (≥57.9) (most deprived)	25 (29.4)	2959 (29.1)
2 (45.1–57.8)	18 (21.2)	2613 (25.7)
3 (26.4–45.0)	22 (25.9)	2958 (29.1)
4 (0–26.3) (least deprived)	20 (23.5)	1620 (16.0)
Scores/dietary behaviours of reference quartiles, cut-off (number of participants, %)		
Grocery food choice index	<30 (341, 25.5)	
Fruit consumption (servings per day)	<1 (295, 22.0)	
Breakfast consumption (days per week)	<7 (269, 20.0)	
Fat intake (% of energy)	>43.48 (336, 25.1)	
Saturated fat intake (% of energy)	>16.73 (337, 25.2)	

SD – standard deviation; NLG – guilders.
Values are number of participants (%), except where indicated otherwise.
*The dietary survey (conducted April–June 1991, $n = 2856$) was a sub-sample of participants selected from the baseline postal survey.
†The baseline postal questionnaire was conducted April 1991, $n = 18793$.
‡Conversion factor: 1 NLG = €0.45.
§Household income was not measured in the baseline postal survey.

'average' nutrient composition calculated for each item[19]. Daily intakes of the nutrients were calculated for each participant. The highest total fat and saturated fat intake quartiles were used as the outcome categories of interest in the analyses (see Table 2).

Analyses

Eindhoven is a university city, thus a considerable proportion of the population is aged under 25 years, transient and/or still in education[20]; for these reasons, all participants under 25 years of age were excluded from the analyses ($n = 82$, 5%). Those with missing data on education, household income, age or gender were also excluded ($n = 145$, 5%). These exclusions resulted in a final (analytic) sample of 1339 participants (Table 2).

Separate analyses were conducted using education and household income as individual-level indicators of SEP. Logistic regression models with two levels of variance components were used for all outcome variables. Models consisted of individuals (level 1) nested in areas (level 2) and included fixed effects for gender, age (entered as a continuous variable), education/household income and area deprivation. Odds ratios and 95% confidence intervals were calculated from the beta coefficients (and their standard errors) for all variables in the fixed part of the model. The contribution of area variation to the model was assessed by the area random variation term, which, if significantly greater than zero, suggested there may be significant between-area differences in dietary behaviour. All analyses were performed with MLwiN version 1.10.0007[23], using a predictive quasi-likelihood procedure in combination with a second-order Taylor expansion series and assuming random variation at the individual level to have an extra binomial distribution.

A sensitivity analysis was performed to examine the effect of excluding neighbourhoods with small sample sizes. This was done by firstly excluding neighbourhoods with less than five participants, and then further excluding those with less than 10 participants per neighbourhood. The direction and magnitude of the beta coefficients of the area deprivation effects and random variance between areas were compared with the analyses with no excluded neighbourhoods.

Results

Participant characteristics

Table 2 shows that the baseline postal survey and the dietary sub-sample had similar proportions of men and women. The mean age of participants was relatively high in both surveys: 47.3 years in the baseline postal survey and 51.4 years in the dietary sub-sample. The majority of respondents in both surveys had primary or lower secondary education. The dietary sub-sample contained a slightly larger proportion of tertiary-educated participants and those living in the most advantaged neighbourhoods compared with the baseline survey.

Influence of area- and individual-level socio-economic characteristics on dietary behaviours

Unadjusted analyses using neighbourhood deprivation as the explanatory variable (results not shown) did not show any significant or graded odds ratios for grocery food choice, fruit consumption and intakes of total and saturated fats. A significant and graded effect of neighbourhood deprivation was found for breakfast consumption when individual-level SEP was not adjusted for, with the likelihood of skipping breakfast increasing with deprivation (results not shown). In the unadjusted analyses, there was no significant neighbourhood-level variation for any of the other dietary outcome variables (results not shown).

Tables 3 and 4 show no significant or graded effects of area deprivation on grocery food choice. Inequalities in food choice were more evident for the individual-level socio-economic indicators, and were of greatest magnitude between education groups. All education groups and the two lowest income quartiles had increased odds of a food choice profile least consistent with dietary recommendations compared with the tertiary-educated and high-income groups, respectively. Table 3 shows that the odds were significantly increased in education groups 1–3 compared with group 4, but when household income was used as the socio-economic indicator (Table 4) the only statistically significant differences were between the lowest and highest income groups.

Participants living in more deprived areas had better fruit consumption patterns than their counterparts in prosperous areas, but only the odds of the second-most prosperous quartile excluded the null (Tables 3 and 4). Inequalities were of a greater magnitude and the graded effects were more marked for individual-level socio-economic characteristics. A graded effect of increasing odds of being a low fruit consumer was seen with lower education and income levels. Inequalities were larger between education groups than between income groups.

Tables 3 and 4 show that participants living in the two most deprived quartiles had considerably increased odds of skipping breakfast compared with those living in the most prosperous areas. Education had a stronger independent effect on breakfast consumption than household income, as evidenced by larger odds ratios than those seen for household income. All education groups were more likely to skip breakfast compared with the tertiary-educated group (Table 3). Table 4 shows that only participants in the lowest income quartile were significantly more likely to skip breakfast than their higher-income counterparts.

Influence of area- and individual-level socio-economic characteristics on dietary intakes

Table 3 shows no significant or graded independent effects of area deprivation on fat intakes, taking participants' education level into account. Participants with primary or lower secondary education, or those in the two lowest income quartiles, had a slight-to-moderate increased likelihood of high fat intakes compared with their tertiary-educated or wealthy counterparts. However, the confidence intervals for these effects included the null.

The findings for saturated fat intake shown in Tables 3 and 4 illustrate no trends or significant odds ratios

Table 3 The influence of area socio-economic characteristics and education on food choice behaviour and dietary intake*

	'Unhealthy' grocery food choices		Low fruit consumption		Skipping breakfast		High total fat intake		High saturated fat intake	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Gender (women)	0.76	0.59, 0.98	0.49	0.37, 0.65	0.65	0.48, 0.87	1.03	0.80, 1.33	1.45	1.12, 1.87
Age	1.00	0.99, 1.01	0.98	0.97, 0.99	0.94	0.93, 0.95	0.99	0.98, 1.00	1.00	0.99, 1.01
Education										
Primary	1.54	1.00, 2.37	2.20	1.38, 3.53	2.66	1.60, 4.44	1.36	0.89, 2.10	0.83	0.54, 1.27
Lower secondary	1.57	1.08, 2.28	1.54	1.04, 2.28	1.90	1.23, 2.92	1.22	0.84, 1.77	1.07	0.74, 1.56
Higher secondary	1.54	1.02, 2.32	1.35	0.88, 2.08	2.01	1.28, 3.16	1.17	0.79, 1.74	1.07	0.72, 1.59
Tertiary	1.00	–	1.00	–	1.00	–	1.00	–	1.00	–
Area deprivation quartile										
1 (most deprived)	1.15	0.79, 1.67	0.85	0.58, 1.26	1.49	0.95, 2.34	0.84	0.58, 1.21	1.17	0.81, 1.70
2	1.00	0.70, 1.42	0.82	0.55, 1.21	1.43	0.93, 2.21	0.99	0.70, 1.41	1.34	0.94, 1.90
3	1.22	0.86, 1.74	0.66	0.44, 0.99	1.15	0.73, 1.81	0.76	0.53, 1.08	0.97	0.67, 1.41
4 (least deprived)	1.00	–	1.00	–	1.00	–	1.00	–	1.00	–
Random variance	Var.	SE	Var.	SE	Var.	SE	Var.	SE	Var.	SE
Between areas	0.00	0.00	0.03	0.06	0.04	0.07	0.00	0.00	0.00	0.00

OR – odds ratio; CI – confidence interval; Var. – variance; SE – standard error.
* Multilevel logistic regression models were used for analyses. Independent variables entered in the models were gender, age, education level and area deprivation.

Table 4 The influence of area socio-economic characteristics and household income on food choice behaviour and dietary intake*

	'Unhealthy' grocery food choices		Low fruit consumption		Skipping breakfast		High total fat intake		High saturated fat intake	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Gender (women)	0.71	0.54, 0.94	0.52	0.39, 0.70	0.69	0.50, 0.95	1.03	0.78, 1.36	1.38	1.05, 1.81
Age	1.00	0.99, 1.01	0.98	0.96, 1.00	0.95	0.94, 0.96	0.99	0.98, 1.00	1.00	0.99, 1.01
Household income quartile										
1 (low)	1.54	1.02, 2.32	1.99	1.30, 3.07	1.26	0.80, 1.98	1.32	0.88, 2.00	1.12	0.74, 1.68
2	1.32	0.89, 1.96	1.22	0.79, 1.88	0.98	0.62, 1.54	1.28	0.87, 1.90	1.02	0.68, 1.54
3	0.99	0.64, 1.52	1.00	0.64, 1.57	0.84	0.53, 1.35	1.15	0.76, 1.74	1.16	0.77, 1.75
4 (high)	1.00	–	1.00	–	1.00	–	1.00	–	1.00	–
Area deprivation quartile										
1 (most deprived)	1.09	0.74, 1.62	0.82	0.53, 1.26	1.60	1.00, 2.56	0.68	0.46, 1.00	1.01	0.68, 1.49
2	1.09	0.74, 1.62	0.72	0.48, 1.09	1.67	1.04, 2.67	0.90	0.62, 1.30	1.26	0.87, 1.83
3	1.30	0.89, 1.88	0.57	0.36, 0.90	1.28	0.80, 2.06	0.70	0.48, 1.04	1.02	0.69, 1.51
4 (least deprived)	1.00	–	1.00	–	1.00	–	1.00	–	1.00	–
Random variance	Var.	SE	Var.	SE	Var.	SE	Var.	SE	Var.	SE
Between areas	0.00	0.00	0.03	0.06	0.05	0.07	0.00	0.00	0.00	0.00

OR – odds ratio; CI – confidence interval; Var. – variance; SE – standard error.
* Multilevel logistic regression models were used for analyses. Independent variables entered in the models were gender, age, household income and area deprivation.

suggestive of inequalities by area-level socio-economic characteristics. Similarly, no disparities in saturated fat intake were evident for any of the individual-level socio-economic characteristics.

For all outcomes examined, no significant between-area random variance was found in the full models (Tables 3 and 4), models with no predictor variables (results not shown), or models only including age, gender and education/income as predictor variables (results not shown). Thus there were no significant differences between the 85 areas in any of the dietary behaviours examined.

Analyses were also performed using household income adjusted for household composition (results not shown). Adjusted household income was calculated according to the following formula: total net household income/square root of the number of persons in the household (in calculating the number of persons per household, adults counted as 1 person and children were given the weight 0.70). Comparison of these findings with those presented in Table 4 showed that the use of adjusted household income did not change the significance of any of the between-area random variance estimates. There were no important differences in the direction or magnitude of the fixed effects for the individual- and area-level socio-economic characteristics for any of the dietary outcomes.

The sensitivity analyses demonstrated that the same area deprivation effects and between-area random variances were seen after excluding neighbourhoods with less than five and less than 10 participants.

Discussion

The current study examined the influence of area deprivation and individual-level SEP on food choice behaviour and dietary intake among a sample of the Dutch population. Few significant or graded independent effects of area-level socio-economic characteristics were found; thus the results suggest that, in The Netherlands, an individual's SEP has more influence on their diet than the socio-economic characteristics of the area in which they live. Using individual-level SEP, the results demonstrate inequalities in some dietary outcomes that parallel chronic disease disparities.

The finding that area deprivation had a limited impact on diet differs with research conducted in the USA[7,24], the UK[12–14,17] and Finland[15,16]. Studies in these countries showed that living in a deprived area is associated with lower fruit and vegetable consumption[13], less healthy food choices[7,12] and higher fat intakes[7,15,16,24], and that these associations remain after adjusting for individual-level SEP. These results are fairly consistent across studies, despite the use of different individual- and area-level socio-economic measures, different-sized area-level units and diverse statistical methods. It must be noted that the Finnish studies have mainly been conducted among adolescents, and area effects on this group may be different to those among adults because adolescents spend more of their time in their immediate neighbourhood environment. However, the findings of the current study are similar to those of an Australian study which showed no significant influence of area-level disadvantage on choices of fruit, vegetables and grocery food items[11].

Several factors may contribute to the less healthy diets seen among people living in disadvantaged areas in the USA, the UK and Finland. Few supermarkets[25,26] and a high prevalence of fast-food outlets[27] in deprived areas are two factors discussed in the literature. Disadvantaged areas may also be poorly served by public transport, or residents may be less likely to have access to cars, making it difficult to reach stores that sell healthy foods[17]. Additionally, food stores in disadvantaged areas may not stock healthy foods, or their prices may be higher than less healthy alternatives[28–30]. Some research shows that healthy foods are less available[25,26] and more expensive in disadvantaged areas in the USA and the UK[28–30]. However, a limited amount of research has examined whether these factors contribute to the area-level dietary differences seen in other countries. The findings of the current study suggest that differential access, availability or affordability between areas differing in their socio-economic characteristics may not play a role in The Netherlands. In addition, it suggests that the type and quality of foods people have access to are not spatially patterned. Unfortunately, no known empirical studies in The Netherlands have explored whether this is the case.

A number of other factors may also contribute to the observation that area-level socio-economic circumstances have little independent influence on dietary behaviour among Dutch adults. First, Dutch cities are geographically compact compared with those in the USA or the UK[31], and therefore most residents are never far from food shops. Second, supermarkets and food stores in The Netherlands are decentralised and are still located conveniently within neighbourhoods or at least within reach of most neighbourhoods, although this assertion has not been confirmed by research. This contrasts with the USA and the UK, where food stores have shown a trend of relocating outside cities into fringe suburbs, where they have more space and lower operation costs, but are less accessible to lower socio-economic groups[26,32]. Third, many city municipalities in The Netherlands have policies preventing the spatial segregation of socio-economic groups[33] by regulating the housing market and making a predefined proportion of housing throughout the city available to low-income people. Therefore, the socio-economic distribution of areas in most Dutch cities may not be as extreme as in the USA and UK, and this may contribute to some of the null effects of area deprivation found in the current study.

The finding that individual- or household-level SEP is a stronger determinant than area-level characteristics is in accordance with other research. Studies in many countries show that the lower-educated, those in blue-collar occupations and on low incomes have food choices less consistent with dietary recommendations[11,12] and lower fruit and vegetable consumption[13,29], separate from the characteristics of the area in which they reside. The magnitude of these inequalities is larger than the independent effects seen for area-level deprivation, suggesting that dietary inequalities may stem more from differences in individual- or household-level resources, such as nutrition knowledge, food preparation skills and money available to purchase foods, than area-level factors. Associations between individual SEP and nutrient intakes reported in the literature are less uniform. Some research has shown that lower socio-economic groups have higher fat and saturated fat intakes[21,34,35] while no differences are evident in other studies[36,37]. Almost all previous studies examining nutrient intakes do not study the separate influence of individual-level SEP independent of area-level deprivation.

In the current study, inequalities in dietary behaviours (i.e. grocery food choice, fruit and breakfast consumption) were generally larger using education than using household income. This may be because education captures a person's nutrition knowledge and skills, whereas household income reflects more on the economic resources of households[8]. Therefore, making healthy grocery food choices, consuming adequate amounts of fruit and not skipping breakfast in The Netherlands may be more influenced by an individual's knowledge of these health-promoting behaviours and their skills to perform them, rather than their economic resources.

The findings also provide some insight into the factors that may contribute to a greater likelihood of overweight among residents of deprived areas, which has been documented among the same study population[20]. Weight gain results from dietary factors and physical inactivity[38,39]. Results of previous research among the current study population show that participants in deprived areas were less likely to walk, cycle or do gardening in their leisure time and were also less likely to participate in sporting activities, independent of their own socio-economic characteristics[40]. The results of the current study suggest that skipping breakfast may play a role, together with physical activity, in the clustering of overweight in deprived areas. Skipping breakfast has been shown to be associated with higher body mass index in population studies[38,39].

A number of methodological limitations of the current study should be noted. First, rural areas were excluded to avoid confounding the relationship between area deprivation and dietary behaviour, and this may have decreased the amount of between-area variance seen in the dietary outcomes due to there being a greater number of deprived administrative units in rural areas. Second, the geographical area in which participants did their food shopping was not assessed; therefore it was not possible to determine whether the administrative areas corresponded to the areas in which participants also did their food shopping. We are unaware of any research that has examined these issues in The Netherlands. This limitation is common to most multilevel studies of health behaviours, which often use administrative areas as their basic area-level unit[41]. Third, the dietary sub-sample slightly over-represented participants with high individual- and area-level SEP, and this may have underestimated the magnitude of inequalities between education/income and area deprivation groups. Fourth, the study relied on participants' self-reported dietary behaviours. Higher socio-economic groups generally have a greater knowledge of dietary recommendations[5,42] and therefore they may be more inclined to report 'more favourable' dietary behaviours. Additionally, the prevalence of overweight and obesity has been shown to be greater among lower socio-economic groups in the Dutch population[20]. Overweight and obese participants are more likely to report socially desirable dietary intakes[43], so it would be expected that this might decrease the magnitude of the inequalities observed. FFQs also rely heavily on participants' ability to accurately recall, describe and quantify their dietary behaviours. Some research suggests that disadvantaged groups perform these less accurately than their more advantaged counterparts[44,45]. Given these opposing sources of reporting bias, it is unclear in which direction these effects may have influenced the results of the current study. Finally, the cross-sectional nature of the study makes it difficult to demonstrate (beyond speculation) any causal inferences between the socio-economic characteristics of residential area and dietary behaviour.

In summary, the results of the present study suggest that the food choice behaviours and dietary intakes of lower socio-economic groups in The Netherlands should continue to be addressed as part of a larger strategy to prevent chronic disease inequalities. The findings also suggest that individual-level factors are the most likely contributors to inequalities in diet rather than the socio-economic characteristics of neighbourhoods, although this needs to be further examined in other areas in The Netherlands.

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References

1 Dalstra JA, Kunst AE, Geurts JJ, Frenken FJ, Mackenbach JP. Trends in socioeconomic health inequalities in the Netherlands, 1981–1999. *Journal of Epidemiology and Community Health* 2002; **56**: 927–34.
2 Kaplan G, Keil J. Socioeconomic factors and cardiovascular disease: a review of the literature. *Circulation* 1993; **88**: 1973–98.
3 Davey Smith G, Hart C, Watt G, Hole D, Hawthorne V. Individual social class, area-based deprivation, cardiovascular disease risk factors, and mortality: the Renfrew and Paisley Study. *Journal of Epidemiology and Community Health* 1998; **52**: 399–405.
4 Davey Smith G, Brunner E. Socio-economic differentials in health: the role of nutrition. *Proceedings of the Nutrition Society* 1997; **56**: 75–90.
5 James WP, Nelson M, Ralph A, Leather S. Socioeconomic determinants of health. The contribution of nutrition to inequalities in health. *British Medical Journal* 1997; **314**: 1545–9.
6 Mackenbach J, Cavelaars A, Kunst A, Groenhof F. Socioeconomic inequalities in cardiovascular disease mortality; an international study. *European Heart Journal* 2000; **21**: 1141–51.
7 Diez-Roux A, Nieto F, Caulfield L, Tyroler H, Watson R, Szklo M. Neighbourhood differences in diet: the Atherosclerosis Risk in Communities (ARIC) Study. *Journal of Epidemiology and Community Health* 1999; **53**: 55–63.
8 Galobardes B, Morabia A, Bernstein MS. Diet and socioeconomic position: does the use of different indicators matter? *International Journal of Epidemiology* 2001; **30**: 334–40.
9 Giskes K, Turrell G, Patterson C, Newman B. Socioeconomic differences in fruit and vegetable consumption among Australian adolescents and adults. *Public Health Nutrition* 2002; **5**: 663–9.
10 Roos E, Prattala R, Lahelma E, Kleemola P, Pietinen P. Modern and healthy?: socioeconomic differences in the quality of diet. *European Journal of Clinical Nutrition* 1996; **50**: 753–60.
11 Turrell G, Blakely T, Patterson C, Oldenburg B. A multilevel analysis of socioeconomic (small area) differences in household food purchasing behaviour. *Journal of Epidemiology and Community Health* 2004; **58**: 208–15.
12 Forsyth A, Macintyre S, Anderson A. Diets for disease? Intraurban variation in reported food consumption in Glasgow. *Appetite* 1994; **22**: 259–74.
13 Shohaimi S, Welch A, Bingham S, Luben R, Day N, Wareham N, *et al*. 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). *Journal of Epidemiology and Community Health* 2004; **58**: 686–91.
14 Wardle J, Jarvis M, Steggles N, Sutton S, Williamson S, Farimond H, *et al*. Socioeconomic disparities in cancer-risk behaviours in adolescence: baseline results from the Health and Behaviour in Teenagers Study (HABITS). *Preventive Medicine* 2003; **36**: 721–30.
15 Karvonen S, Rimpela A. Socio-regional context as a determinant of adolescents' health behaviour in Finland. *Social Science & Medicine* 1996; **43**: 1467–74.
16 Karvonen S, Rimpela A. Urban small area variation in adolescents' health behaviour. *Social Science & Medicine* 1997; **45**: 1089–98.
17 Ecob R, Macintyre S. Small area variations in health related behaviours; do these depend on the behaviour itself, its measurement, or on personal characteristics? *Health & Place* 2000; **6**: 261–74.
18 Mackenbach J, van de Mheen H, Stronks K. A prospective cohort study investigating the explanation of socioeconomic inequalities in health in the Netherlands. *Social Science & Medicine* 1994; **38**: 299–308.
19 Camps M, Abden D. *De ENVET-lijst: Ontwikkeling en validering van een korte voedelsfrequentievragenlijst naar energie en vet- tweede fase*. Geldrop-Valkenswaard: GGD regio Geldrop-Valkenswaard, 1994.

20 van Lenthe FJ, Mackenbach JP. Neighbourhood deprivation and overweight: the GLOBE study. *International Journal Obesity and Related Metabolic Disorders* 2002; **26**: 234–40.
21 Hulshof K, Lowik M, Kok F, Wedel M, Brants H, Hermus R, *et al*. Diet and other life-style factors in high and low socioeconomic groups (Dutch Nutrition Surveillance System). *European Journal of Clinical Nutrition* 1991; **45**: 441–50.
22 Nederlands Stichting Voedingsstoffenbestand. *NEVO-tabel 1986/1987*. Ziest: Nederlands Voedingsstoffenbestand, 1987.
23 Rasbash J, Browne W, Healy M, Cameron B, Charlton C. *MLwiN version 1.10.0007*. London: Multilevel Models Project, 2001.
24 Diehr P, Koepsell T, Cheadle A, Psaty B, Wagner E, Curry S. Do communities differ in health behaviour? *Journal of Clinical Epidemiology* 1993; **46**: 1141–9.
25 Alwitt L, Donley T. Retail stores in poor urban neighbourhoods. *Journal of Consumer Affairs* 1997; **31**: 139–64.
26 Morland K, Wing S, Diez-Roux A. The contextual effect of the local food environment on resident's diets: the Atherosclerosis Risk in Communities Study. *American Journal of Public Health* 2002; **92**: 1761–7.
27 Reidpath D, Burns C, Garrad J, Mahoney M, Townsend M. An ecological study of the relationship between social and environmental determinants of obesity. *Health & Place* 2002; **8**: 141–5.
28 Chung C, Myers S. Do the poor pay more for food? An analysis of grocery store availability and food price disparities. *Journal of Consumer Affairs* 1999; **33**: 276–96.
29 Dibsdall L, Lambert N, Bobbin R, Frewer L. Low-income consumer's attitudes and behaviours towards access, availability and motivation to eat fruit and vegetables. *Public Health Nutrition* 2003; **6**: 159–68.
30 Mooney C. Cost and availability of healthy food choices in a London health district. *Journal of Human Nutrition and Dietetics* 1990; **3**: 111–20.
31 Brinkhoff T. *City Population* [online], 2004. Available at http://www.citypopulation.de. Accessed November 2004.
32 Wrigley N. 'Food deserts' in British cities: policy context and research priorities. *Urban Studies* 2002; **39**: 2029–40.
33 Ostendorf W, Musterd S, de Vos S. Social mix and the neighbourhood effect. Policy ambitions and empirical evidence. *Housing Studies* 2001; **16**: 371–80.
34 Bolton-Smith C, Smith W, Woodward M, Tunstall-Pedoe H. Nutrient intakes of different social-class groups: results from the Scottish Heart Health Study. *British Journal of Nutrition* 1991; **65**: 321–35.
35 Pomerleau J, Pederson L, Ostbye T, Speechley M, Speechley K. Health behaviours and socio-economic status in Ontario, Canada. *European Journal of Epidemiology* 1997; **13**: 613–22.
36 Murphy S, Rose D, Hudes M, Viteri F. Demographic and economic factors associated with dietary quality for adults in the 1987–1988 Nationwide Food Consumption Survey. *Journal of the American Dietetic Association* 1992; **92**: 1352–7.
37 Stallone D, Brunner E, Bingham S, Marmot M. Dietary assessment in Whitehall II: the influence of reporting bias on apparent socioeconomic variation in nutrient intakes. *European Journal of Clinical Nutrition* 1997; **51**: 815–25.
38 Cho S, Dietrich M, Brown C, Clark C, Block G. The effect of breakfast type on total daily energy intake and body mass index: results from the Third National Health and Nutrition Examination Survey (NHANES III). *Journal of the American College of Nutrition* 2003; **22**: 296–302.
39 Ma Y, Bertone E, Stanek E, Reed G, Hebert J, Cohen N, *et al*. Association between eating patterns and obesity in a free-living US adult population. *American Journal of Epidemiology* 2003; **158**: 85–92.
40 van Lenthe FJ, Brug J, Mackenbach JP. Neighbourhood inequalities in physical activity: the role of neighbourhood attractiveness, proximity to local facilities and safety in the Netherlands. *Social Science & Medicine* 2005; **60**: 763–75.
41 Diez-Roux A. Estimating neighbourhood health effects: the challenges of causal inference in a complex world. *Social Science & Medicine* 2004; **58**: 1953–60.
42 Winkleby M, Jatulis D, Frank E, Fortmann S. Socioeconomic status and health: how education, income and occupation contribute to risk factors for cardiovascular disease. *American Journal of Public Health* 1992; **82**: 816–20.
43 Johansson G, Wikman A, Ahren A, Hallmans G, Johansson I. Underreporting of energy intake in repeated 24-hour recalls related to gender, age, weight status, day of interview, educational level, reported food intake, smoking habits and area of living. *Public Health Nutrition* 2001; **4**: 919–27.
44 Kaplan G, Turrell G, Lynch J, Everson S, Helkala E, Salonen J. Childhood socioeconomic position and cognitive function in adulthood. *International Journal of Epidemiology* 2001; **30**: 256–63.
45 Turrell G, Najman J. Collecting food-related data from low socioeconomic groups: how adequate are our current research designs? *Australian and New Zealand Journal of Public Health* 1995; **19**: 410–6.