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Does the neighbourhood food environment contribute to ethnic differences in diet quality? Results from the HELIUS study in Amsterdam, the Netherlands

Maartje P Poelman[1,*], Mary Nicolaou[2], S Coosje Dijkstra[3], Joreintje D Mackenbach[4,5], Meng Lu[6], Derek Karssenberg[6], Marieke B Snijder[2], Ilonca Vaartjes[7] and Karien Stronks[2]

[1]Chair Group Consumption and Healthy Lifestyles, Wageningen University & Research, PO Box 8130, Wageningen, The Netherlands: [2]Department of Public Health, University of Amsterdam, Amsterdam Public Health Research Institute, Meibergdreef, Amsterdam, The Netherlands: [3]Department of Health Sciences, Faculty of Science, Vrije Universiteit Amsterdam, Amsterdam Public Health Research Institute, De Boelelaan, Amsterdam, The Netherlands: [4]Department of Epidemiology and Biostatistics, Amsterdam UMC, Vrije Universiteit, Amsterdam Public Health Research Institute, Amsterdam, The Netherlands: [5]Upstream Team, Amsterdam UMC, The Netherlands: [6]Department of Physical Geography, Utrecht University, The Netherlands: [7]Julius Centre for Health Sciences and Primary Care, University Medical Centre Utrecht, The Netherlands

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Abstract

Objective: The aim of the current study was to establish whether the neighbourhood food environment, characterised by the healthiness of food outlets, the diversity of food outlets and fast-food outlet density within a 500 m or 1000 m street network buffer around the home address, contributed to ethnic differences in diet quality.
Design: Cross-sectional cohort study.
Setting: Amsterdam, the Netherlands.
Participants: Data on adult participants of Dutch, South-Asian Surinamese, African Surinamese, Turkish and Moroccan descent (n total 4728) in the HELIUS study were analysed.
Results: The neighbourhood food environment of ethnic minority groups living in Amsterdam is less supportive of a healthy diet and of less diversity than that of participants of Dutch origin. For example, participants of Turkish, Moroccan and South-Asian Surinamese descent reside in a neighbourhood with a significantly higher fast-food outlet density (≤1000 m) than participants of Dutch descent. However, we found no evidence that neighbourhood food environment characteristics directly contributed to ethnic differences in diet quality.
Conclusion: Although ethnic minority groups lived in less healthy food environments than participants of ethnic Dutch origin, this did not contribute to ethnic differences in diet quality. Future research should investigate other direct or indirect consequences of residing in less supportive food environments and gain a better understanding of how different ethnic groups make use of their neighbourhood food environment.

Keywords
Food environment
Food outlets
Mediterranean diet score
Fast food
Ethnic differences

Dietary behaviours have been found to vary among ethnic groups all over the world[1–3]. For example, studies in the Netherlands showed ethnic differences in meeting dietary recommendations for individual food groups as well as composite diet quality scores[4]. To illustrate, individuals with a Surinamese or Moroccan background adhere relative less frequent to daily recommendations for vegetable consumption and individuals of Turkish origin adhere less frequent to recommendations for fish consumption and consumed higher amounts of saturated fat than to those from Dutch origin. Moreover, non-western ethnic minority groups had generally lower intake of fibre and micronutrients like Ca and vitamins A and B_1[5].

*Corresponding author: Email maartje.poelman@wur.nl

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Different mechanisms have been proposed to explain ethnic differences in diet quality, including cultural and migration-related factors[6,7]. To illustrate, cultural eating habits including the consumption of traditional foods may impact on diet quality, while the process of migration and contact between cultures may in turn induce dietary change due to acculturation[8,9]. In addition to these ethnic specific factors, contextual variables may shape food choices and thus influence dietary intake and health[10,11]. The food environment has been recognised as a strong determinant of food choices and health[12]. More specifically, the *community* food environment is defined as the number, type, location and accessibility of food outlets in the direct living environment[13].

There is some evidence that individuals living in ethnic minority neighbourhoods have less access to food outlets selling foods contributing to a healthy diet (e.g. fruit and vegetables) and greater access to food outlets selling foods hindering a healthy diet (e.g. fast food)[14,15]. If the presence of food outlets in the neighbourhood steer food choices, this could contribute to ethnic differences in dietary quality. Yet, evidence is mixed. A review indicated that 65 % (13 out of the 20) of the included studies found that the food environment (expressed as geographic availability of food outlets) was associated with multiple dietary outcomes[16], although it should be acknowledged that the food environment–diet relationship remains ambiguous to date. Nevertheless, if the *community* food environment does contribute to ethnic differences in diet quality, food environment interventions – for example, banning fast-food outlets in certain areas, as has recently been proposed by a number of municipalities around the world, including Amsterdam – could also contribute to a decrease in ethnic dietary differences.

The aim of the present study was to establish whether the neighbourhood food environment is a contributor to ethnic differences in diet quality. To do so, we conducted mediation analyses. First, we assessed ethnic differences in diet quality, including Mediterranean diet score (MDS) and fast-food consumption. We then assessed ethnic differences in the neighbourhood food environment (500 m or 1000 m street network buffer around the home address), including three food environment proxies (healthiness of food outlets, diversity of food outlets and fast-food outlet density). Finally, we determined the association between this neighbourhood food environment and dietary quality and analysed its contribution to ethnic differences in dietary quality.

Methods

Study design

The HELIUS study is a multi-ethnic population-based cohort study of residents of Amsterdam, the Netherlands[17,18]. The primary aim is to unravel the causes of the unequal burden of disease across ethnic groups. HELIUS study participants are residents of Dutch, African Surinamese, South-Asian Surinamese, Turkish, Moroccan or Ghanaian origin. Adults aged 18–70 years were randomly sampled, stratified by ethnic origin, through the municipal registry of Amsterdam. Data were collected by means of a questionnaire – either self-reported or completed by researchers – and a physical examination. Detailed information about the HELIUS study and procedure can be found elsewhere[18]. Data from a cross-sectional study of dietary patterns within a sub-population of the HELIUS study (the 'HELIUS dietary patterns study'[19]) were used for the current study.

Participants

In the HELIUS Dietary Patterns study, a sub-sample of the HELIUS cohort (*n* 24·789) was included that was especially set up as a sub-cohort on itself[17,18]. In this sampling, it was aimed to include equal representation of men and women, of all age groups. Among the migrant groups, it was aimed for equal representation of generations. However, HELIUS participants of Ghanaian origin did not participate in the dietary pattern study, as no Ghanaian-specific FFQ was available at the point in time of data collection.

In total, 5084 individuals (20·5 %) participated in the HELIUS dietary patterns study[19]. The individuals were of Dutch (*n* 1482), South-Asian Surinamese (*n* 1086), African Surinamese (*n* 1068), Turkish (*n* 658) and Moroccan (*n* 790) descent. In the current study, only participants (*n* 4728, 93·0 %) with a representative energy intake using commonly used cut-off values[20] (women=500–3500 kcal/d, men=800–4000 kcal/d), and no other missing values were included, resulting in a total of 4728 participants of *n* 1433 Dutch, *n* 1005 South-Asian Surinamese, *n* 985 African Surinamese, *n* 588 Turkish and *n* 717 Moroccan descent. Participants in the current study were slightly younger and somewhat higher educated than the entire HELIUS cohort.

Study procedure

Dietary intake was collected using ethnic-specific semi-quantitative FFQ with a reference period of 4 weeks. The FFQ included approximately 220 food items covering more than 90 % of the intake of the main nutrients of interest. In brief, the food items used in this ethnic-specific FFQ were selected on the basis of single 24-h recalls of prior cohort studies including Moroccan, Turkish and Surinamese adults as well as an existing validated Dutch FFQ. The selection of the food items was based on two criteria: (1) the percentage of contribution of that food item to absolute nutrient intake and its percentage contribution to the variance in absolute nutrient intake and (2) the comparability of food items with the FFQ for other ethnic groups. Both face validity and relative validity of the HELIUS FFQ have been evaluated[21,22]. Details about the development and characteristics of the FFQ can be found elsewhere[21].

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Participants self-reported the eating frequency and portion size of the food items they might have consumed over the past 4 weeks. Intake of all food items was calculated in g/d, based on the frequency of consumption in the previous 4 weeks and portion size estimation using common and household units and, where relevant, photographs of specific food items (e.g. butter spread on bread). Food items were grouped according to similarity in nutrient profile, culinary use or ethnic origin.

We enriched the HELIUS cohort with food environment data using the data set of Locatus, in which retail food outlets were defined as all places that primarily offer food. Locatus (www.locatus.nl) maintains a database of retail information independently sourced via annual onsite surveys, from which twenty-seven food outlet types were extracted for the year 2013; the outlets include supermarkets, fast-food outlets, greengrocers, bakeries, fish shops and restaurants (a full list of outlets is presented in Appendix 1). The co-authors (D.K. and M.L.) from the Global and Geo Health Data Centre (www.gghdc.nl) calculated food outlet exposure for each food outlet type and each address in Amsterdam. To guarantee participant anonymity, the coordinator of the HELIUS study (M.B.S.) extracted the food environment determinants for each participant from this food outlet exposure dataset.

Measures

Socio-demographic characteristics

Sex, age and educational level

In the HELIUS study, data on sex, age and educational level were obtained from Amsterdam's municipal registry (Gemeentelijke Basis Administratie)[17]. Educational level was indicated by the highest level of education attained in either the Netherlands or the country of origin. This variable was classified into low education (never been to school, elementary schooling, lower vocational schooling or lower secondary schooling only), medium education (intermediate vocational schooling or intermediate/higher secondary education schooling) and high education (higher vocational schooling or university).

Ethnic origin

Ethnic origin was based on the country of birth. The Dutch origin sample comprised individuals who were born in the Netherlands and whose parents were also born in the Netherlands. People were defined as being of non-Dutch ethnic origin if they fulfilled one of two criteria, namely: (1) born outside the Netherlands and having at least one parent who was also born outside the Netherlands (first-generation migrants) or (2) born in the Netherlands and both parents were born outside the Netherlands (second-generation migrants). Participants of Surinamese descent were further classified according to their self-reported ethnic origin, namely African Surinamese (African descent) or South-Asian Surinamese (South Asian/Indian descent).

Mediterranean diet score and fast-food consumption

Diet quality

The FFQ was used to calculate two proxies for participants' diet quality, that is, the MDS and fast-food consumption.

Mediterranean diet score

The Mediterranean diet is defined as a primarily plant-based diet characterised by a high ratio of monounsaturated to saturated fats[23]. The diet has been linked to a variety of health benefits[24], including reduced mortality risk and lower incidence of CVD[25]. The MDS as applied in the current study was calculated using the method described by Panagiotakos *et al.*[26].

For the consumption of items presumed to be typical of Mediterranean dietary patterns (i.e. non-refined cereals, fruits, vegetables, legumes, olive oil, fish and potatoes), scores of 0 to 5 for never, rare, frequent, very frequent, weekly and daily consumption were assigned, while for the consumed foods presumed to be less typical of this pattern (i.e. red meat and red meat products, poultry and full-fat dairy products), scores were assigned on a reverse scale. After summing the individual component scores, the overall MDS ranged from 0 (lowest compliance) to 80 (highest compliance).

Fast-food consumption

Fast food generally consists of processed meat and refined carbohydrates and is high in salt, saturated fat and calories[27]. Fast-food consumption in g/d was calculated by summing the weight of the following products consumed: French fries, deep-fried snacks (including fish snacks, spring rolls, bara, baked banana (pisang goreng)), sausage rolls, kebabs, hamburgers, pizzas (American/Italian and Turkish) and skewered meat.

Food environment characteristics

Many food environment studies disregard the spatial mix and diversity of opportunities[14,28] by, for example, assessing only the density of fast-food outlets[29]. Yet, a high density of healthier outlets can compensate for a high density of fast-food outlets, and vice versa, a low number of fast-food outlets surrounded by an even lower number of healthy alternatives may provide even less options for healthy food choices. People are often exposed simultaneously to outlets that sell both 'healthy' and 'unhealthy' foods[30]. Capturing a wider food environment spectrum may provide a more nuanced insight into the potential contribution of the neighbourhood food environment to ethnic differences in dietary intake. Therefore, two comprehensive measures were used for the purpose of the current study and were included along with the commonly used food environment measure 'density of fast-food outlets'. These three exposure measures were calculated within a walking distance (i.e. 500 m and 1000 m) based on the street network TOP10L (https://zakelijk.kadaster.nl/-/top10nl). The highways were removed from the street network, and the road vectors were rasterised to a 10 m resolution.

Food environment healthiness index
In line with prior international studies[31–33], we create a food environment healthiness index (FEHI) for the Netherlands, and we assigned to each food outlet a corresponding 'healthiness score'[15], ranging from −5 (unhealthy) to +5 (healthy), derived through a Delphi procedure. These scores were included to avoid a dichotomous categorisation of retail outlets into either 'healthy' or 'unhealthy' and to give a more nuanced indication of the healthiness of the neighbourhood food environment, based on the overall number of retailers selling food. For each street network buffer around the home address (500 m and 1000 m), an overall FEHI score was calculated by summing the scores corresponding to all food outlets within the buffer. A higher (positive) FEHI score represents a healthier neighbourhood food environment.

Food environment diversity index
To gain better understanding of the diversity of food outlets in the neighbourhood, we created the food environment diversity index (FEDI), and we defined the relative diversity of shops offering core foods (i.e. fruit, vegetables, nut and, fish) as opposed to those selling predominantly non-core foods (i.e. snacks, fast food, sweets), irrespective of the number of shops. To assess the diversity of outlets offering core foods, we assessed whether one or more of the following shops were present (present yes = 1, present no = 0) within a 500 m or 1000 m street network buffer around the home address: fruit and vegetable shop, nut shop, organic shop, fish shop, oriental supermarket, supermarket and mini-supermarket. To assess the diversity of outlets selling predominately non-core foods, we assessed whether one or more of the following shops were present (present yes = 1, present no = 0) within the 500 m or 1000 m residential street network buffer: fast-food outlet, grillroom/kebab, takeaway, ice-cream shop, sweet shop, chocolate shop and cake shop. The diversity of food outlets offering core foods relative to the diversity of outlets selling predominantly non-core foods was calculated (500 m and 1000 m) with a score above 1·0 indicates a higher diversity of food outlets offering core foods as opposed to food outlets selling predominantly non-core foods. A score below 1·0 indicates a higher diversity of food outlets selling predominantly non-core foods as opposed to food outlets offering core foods.

Fast-food density
Fast-food density was defined as the total number of fast-food outlets, grillrooms, kebab outlets and takeaways within a 500 m or 1000 m street network buffer around the home address.

Covariates
Sex and age were included as covariates. To assess the contribution of FEHI and FEDI to MDS, energy intake (in kilocalories) was also included as a covariate. Educational level is highly correlated with ethnicity in our study population and could be a mediator in the association between ethnicity and diet quality. We therefore did not adjust for this variable, as our main aim was to establish whether the food environment contributes to ethnic differences in diet quality, irrespective of participants' socio-economic position.

Statistical analyses

Descriptive statistics were used to describe participant characteristics for the total sample and stratified by ethnicity. Continuous variables were presented as either means or SD or median and inter-quartile range for skewed data. Categorical variables were presented as relative frequencies.

To examine the potential contribution of the neighbourhood food environment to ethnic differences in MDS and fast-food consumption, mediation analyses using the Hayes Process Macro (V3.3, model 4)[34] with IBM SPSS V25.0 were conducted. Mediation models estimated the contribution of either FEHI or FEDI to ethnic differences in MDS and the contribution of fast-food density to ethnic differences in fast-food consumption, for both the 500 m and the 1000 m residential street network buffers. Because data on FEHI and fast food density were skewed, decile groups were created and included in the mediation analyses. We used a parallel mediation model to examine total, direct and indirect associations between ethnicity and diet quality (Fig. 1). The total effect (path c) represents the association between ethnicity and diet quality when no mediators are included in the model, while the direct effect (path c') represents the association between ethnicity and diet quality when mediators are included. Indirect effects (paths a and b) represent the association between ethnicity and diet quality through food environment characteristics. If the indirect association was statistically significant, we concluded that mediation had occurred. The significance of indirect association was tested by bootstrapped 95 % CI, using a resample procedure of 5000 repeated samples. A 95 % CI of the indirect effect that does not cross 0 indicates a statistically significant indirect effect. Models were adjusted for sex, age and kilocalories, SES was not included as confounder because of its strong association with ethnicity. However, we did run sensitivity analysis (path c) with addition for SES as covariate.

Results

Participant characteristics

Participant characteristics for the total sample and stratified by ethnicity are presented in Table 1. The total sample comprised 2821 women and 1907 men, with a mean age of 46·5 (SD 12·6) years. The majority of the participants of Dutch descent had a high educational level (61·8 %), whereas the greater part of the ethnic minority groups had a low educational level.

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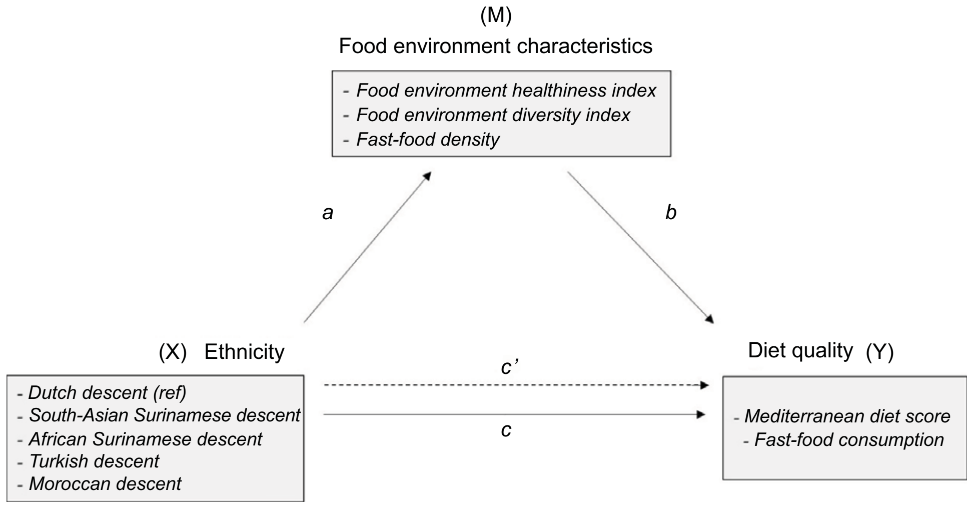

Fig. 1 Path model diagram of parallel mediation analysis. The path model showing the association between ethnicity (X) and diet quality (Y) as mediated by neighbourhood food environment characteristics (M). Path c represents the association between ethnicity and diet quality with no mediators in the model. Path c' represents the association between ethnicity and diet quality when the mediator is included in the model. Indirect effects (paths a and b) represent the association between ethnicity and diet quality through the neighbourhood food environment

Ethnic differences in dietary quality

Mediterranean diet score

Table 1 shows that the participants of Dutch descent had the highest MDS score (Mean = 33·2, SD = 4·9) compared with the other ethnic groups. Tables 2 and 3 show that this was significantly higher than other ethnic groups. For example, participants of South-Asian Surinamese descent scored 2·84 (SE 0·22, 95 % CI −3·27, −2·41) points lower on the MDS than participants of Dutch descent (Table 2). Sensitivity analyses in which we adjusted for educational level indicated that ethnic differences in MDS score remained fairly similar (data not presented).

Fast-food consumption

Table 1 shows that participants of Turkish descent had the highest fast-food consumption, with a median of 38·1 g/d. Table 4 shows that these participants had a significantly higher fast-food consumption than participants of Dutch descent (β = 0·29, SE 0·07, 95 % CI 0·16, 0·42). Participants of African Surinamese descent (β = −0·15, SE 0·06, 95 % CI −0·26, −0·05) and Moroccan descent (β = −0·39, SE 0·06, 95 % CI −0·51, −0·27) consumed less fast food than participants of Dutch descent. No differences were observed between participants of Dutch and those of South-Asian Surinamese descent. Sensitivity analyses in which we adjusted for educational level indicated that ethnic differences in fast food consumption remained similar (data not presented).

Ethnic differences in neighbourhood food environment characteristics

Food environment healthiness index

Table 1 shows the descriptive statistics of the neighbourhood FEHI. For this food environment proxy, a large variance was observed. The median FEHI was lower among ethnic minority groups than among participants of Dutch origin. For example, participants of Turkish descent had a median FEHI of −240 within a 1000 m residential buffer, whereas this figure was −76·4 for participants of Dutch descent. The results presented in Table 2 show that participants of Turkish descent (β = −0·89, SE = 0·15, 95 % CI −1·18, −0·60) and Moroccan descent (β = −0·60, SE = 0·14, 95 % CI −1·18, −0·60) had a lower FEHI score than participants of Dutch descent within 500 m residential buffers. With respect to the FEHI scores within the 1000 m buffers, all ethnic minority groups had a lower FEHI score than the participants of Dutch descent. This indicates that the neighbourhood food environment of ethnic minority groups, taking multiple food outlets into account, is less healthy than that of the participants of Dutch descent.

Food environment density index

Table 1 presents the descriptive statistics of neighbourhood FEDI. Within the 500 m buffers, FEDI scores were below 1 (indicating a higher diversity of food outlets selling predominantly non-core foods as opposed to food outlets offering core foods) for all ethnic groups. Within the 1000 m buffers, however, all scores were slightly above 1. The results presented in Table 3 show that participants of Moroccan descent (β = 0·04, SE = 0·17, 95 % CI 0·009, 0·077) had a higher FEDI compared with those of Dutch descent within 500 m residential buffers, indicating that there was a slightly higher diversity of shops selling core foods as opposed to shops selling highly processed foods. This was in contrast to participants of South-Asian Surinamese descent (β = −0·03, SE = 0·15, 95 % CI −0·06, −0·004). Within the 1000 m residential buffers, statistical

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Table 1 Participant characteristics

	Entire subsample (*n* 4728)		Dutch descent (*n* 1433)		South-Asian Surinamese descent (*n* 1005)		African Surinamese descent (*n* 985)		Turkish descent (*n* 588)		Moroccan descent (*n* 717)	
Age (mean, SD)												
	46·5	12·6	48·2	13·5	47·6	12·2	49·7	11·2	41·7	11·0	41·1	12·0
Sex (*n*, % female)												
	2821	59·7	798	55·7	597	59·4	668	67·8	311	52·9	447	62·3
Educational level (*n*, %)												
Low	1688	35·7	239	16·7	465	46·3	365	37·1	286	48·6	333	46·4
Mid	1345	28·4	308	21·5	281	28·0	337	34·2	175	29·8	244	34·0
High	1695	35·9	886	61·8	259	25·7	283	28·7	127	21·6	140	19·5
Kilocalories (mean, SD)												
	2088·0	683·1	2182·8	609·7	1975·2	669·8	2042·1	716·0	2158·1	740·4	2062·1	722·9
Mediterranean diet score (mean, SD)												
	31·0	5·5	33·2	4·9	30·0	5·60	29·8	5·6	29·9	5·5	30·3	4·9
Fast-food consumption, g/d, Median (IQR)												
	23·5	40·5	23·6	39·0	23·1	41·6	18·4	36·2	38·1	54·7	20·3	38·0
Neighbourhood food environment healthiness index (FEHI), median (IQR)*,‡												
500 m	–37·2	90·5	–29·9	87·6	–34·2	78·7	–29·7	74·3	–64·0	147·8	–54·3	100·0
1000 m	–134·9	330·95	–76·4	282·2	–141·9	251·4	–82·5	210·9	–240	556·1	–202·4	414·9
Neighbourhood food environment diversity index (FEDI), mean (SD)*,§												
500 m	0·76	0·37	0·77	0·37	0·73	0·37	0·75	0·38	0·76	0·34	0·81	0·37
1000 m	1·18	0·37	1·13	0·33	1·13	0·33	1·13	0·35	1·12	0·30	1·16	0·33
Neighbourhood fast-food outlet density, median (IQR)†												
500 m	4·0	12·00	4·0	11·0	4·0	12·0	3·00	10·0	7·0	15·0	6·0	14·0
1000 m	18·0	37·0	13·0	36·0	20·0	32·0	14·0	27·0	32·0	54·0	26·0	41·0

*Only including participants with food outlets present within residential buffers. For the 500 m buffers, *n* 4337 (91·7 %) of the entire sample, *n* 1297 (90·5 %) of the participants of Dutch descent, *n* 937 (93·2 %) of the participants of South-Asian Surinamese descent, *n* 904 (91·8 %) of the participants of African Surinamese descent, *n* 544 (92·5 %) of the participants of Turkish descent and *n* 655 (91·4 %) of the participants of Moroccan descent had at least one food outlet in the neighbourhood environment and were included in the calculation of 500 m buffers. For the 1000 m buffers, *n* 4617 (97·7 %) of the entire sample, *n* 1404 (98·0 %) of the participants of Dutch descent, *n* 983 (97·8 %) of the participants of South-Asian Surinamese descent, *n* 963 (97·8 %) of the participants of African Surinamese descent, *n* 573 (97·4 %) of the participants of Turkish descent and *n* 694 (96·8 %) of the participants of Moroccan descent had at least one food outlet in the neighbourhood environment and were included in the calculation of 1000 m buffers.

†Only including participants with fast-food outlets within the residential buffers. For the 500 and 1000 m buffer, *n* 4697 (99·3 %) of the entire sample, *n* 1421 (99·2 %) of the participants of Dutch descent, *n* 1000 (99·5 %) of the participants of South-Asian Surinamese descent, *n* 980 (99·5 %) of the participants of African Surinamese descent, *n* 585 (99·5 %) of the participants of Turkish descent and *n* 711 (99·2 %) of the participants of Moroccan descent had at least one fast-food outlet within the residential buffers.

‡A higher (positive) score indicates a healthier food environment.

§A higher (positive) score indicates a higher diversity of food outlets offering core foods as opposed to food outlets selling predominantly non-core foods.

Table 2 Parallel mediator model summary of the association between ethnicity and Mediterranean diet score via neighbourhood food environment healthiness index (FEHI, 500 m or 1000 m buffers)

	500 m buffers				1000 m buffers			
			95 % CI				95 % CI	
	β	SE	Lower	Upper	β	SE	Lower	Upper
Total effect = path c (ethnicity differences in Mediterranean diet score)†								
South-Asian Surinamese descent	−2·84*	0·22	−3·27	−2·41	−2·94*	0·21	−3·36	−2·52
African Surinamese descent	−3·50*	0·22	−3·94	−3·06	−3·49*	0·22	−3·92	−3·07
Turkish descent	−2·81*	0·26	−3·31	−2·26	−2·84*	0·26	−3·34	−2·33
Moroccan descent	−2·35*	0·25	−2·82	−1·84	−2·41*	0·24	−2·88	−1·93
Direct effect = path c' (ethnicity differences in Mediterranean diet score, with FEHI in the model)†,§								
South-Asian Surinamese descent	−2·84*	0·22	−3·27	−2·41	−2·92*	0·21	−3·34	−2·50
African Surinamese descent	−3·50*	0·22	−3·94	−3·06	−3·49*	0·22	−3·91	−3·07
Turkish descent	−2·79*	0·27	−3·31	−2·26	−2·79*	0·26	−3·30	−2·28
Moroccan descent	−2·33*	0·25	−2·82	−1·84	−2·38*	0·24	−2·85	−1·90
Path a – ethnicity differences in FEHI†,§								
South-Asian Surinamese descent	−0·06	0·13	−0·31	0·18	−0·42*	0·12	−0·660	−0·19
African Surinamese descent	0·09	0·12	−0·15	0·33	−0·23*	0·12	−0·47	−0·001
Turkish descent	−0·89*	0·15	−1·18	−0·60	−1·20*	0·14	−1·48	−0·92
Moroccan descent	−0·60*	0·14	−1·18	−0·60	−0·81*	0·13	−1·07	−0·54
Path b – association between FEHI and Mediterranean diet score‡,§								
FEHI	0·03	0·03	−0·02	0·08	0·04	0·03	−0·01	0·09
Indirect effect (paths a, b) – ethnicity differences in Mediterranean diet score through FEHI†,§								
South-Asian Surinamese descent	−0·0	0·01	−0·02	0·01	−0·02	0·01	−0·04	0·01
African Surinamese descent	0·00	0·01	−0·08	0·02	−0·01	0·08	−0·03	0·00
Turkish descent	−0·03	0·03	−0·08	0·02	−0·05	0·03	−0·11	0·02
Moroccan descent	−0·02	0·02	−0·06	0·01	−0·03	0·02	−0·08	0·01

FEHI: food environment healthiness index.
Outcomes of path c for the 500 m and 1000 buffers are slightly different because these models only include participants with food outlets present within residential buffers (see footnote Table 1).
Data were obtained from the Hayes Process Macro[34].
β: linear regression estimates; total β effect (path c) represents the association between ethnicity and Mediterranean diet score with no mediators in the model. Direct β effect (path c') represents the association between ethnicity and Mediterranean diet score when FEHI (mediator – 500 m or 1000 m) is included in the model.
Indirect effects (paths a and b) represent the association between ethnicity and Mediterranean diet score through FEHI.
Models are adjusted for age, sex and energy intake (in kilocalories).
*$P \leq 0.05$.
†Dutch Ethnic descent is the reference category/constant (data not presented in the model).
‡Additionally adjusted for ethnicity.
§A higher (positive) score indicates a healthier food environment.

differences in the FEDI disappeared between participants of Moroccan and those of Dutch descent. However, participants of South-Asian Surinamese descent ($\beta = -0.05$, SE = 0·01, 95 % CI −0·08, −0·02), African Surinamese descent ($\beta = -0.05$, SE = 0·01, 95 % CI −0·08, −0·20) and Turkish descent ($\beta = -0.07$, SE = 0·02, 95 % CI −0·10, −0·03) had a lower FEDI than those of Dutch descent. This indicates a slightly higher diversity of shops predominantly selling non-core foods compared with shops selling core foods in the 1000 m residential buffer of these ethnic minority groups.

Fast-food outlet density

Table 1 presents the descriptive statistics of the neighbourhood fast-food outlet density. The inter-quartile range shows that there was a wide spread in the number of fast-food outlets within the 500 m and 1000 m buffers. However, the median number of fast-food outlets within the 1000 m buffers was higher among all the ethnic minority groups compared with the participants of Dutch descent. For example, participants of Turkish descent had a median of thirty-two fast-food outlets within a 1000 m residential buffer, whereas the figure was thirteen for participants of Dutch descent. Table 4 shows that participants of Turkish descent ($\beta = 0.73$, SE = 0·15, 95 % CI 0·44, 1·01 and $\beta = 1.00$, SE = 0·14, 95 % CI 0·72, 1·27) and Moroccan descent ($\beta = 0.49$, SE = 0·14, 95 % CI 0·22, 0·76 and $\beta = 0.64$, SE = 0·13, 95 % CI 0·38, 0·90) had a significantly higher fast-food outlet density within both 500 m and 1000 m residential buffers, respectively, in comparison with participants of Dutch descent. In addition, the 1000 m neighbourhood environment of participants of South-Asian Surinamese descent ($\beta = 0.35$, SE = 0·12, 95 % CI 0·12, 0·58) had a larger number of fast-food outlets than that of participants of Dutch descent. No differences in neighbourhood fast-food density were observed between participants of Dutch and those of African Surinamese descent.

Neighbourhood food environment–diet quality association

The results (path b) presented in Table 2 (FEHI), Table 3 (FEDI) Table 4 (fast-food density) show the absence of a statistically significant association between the neighbourhood food environment characteristics (FEHI, FEDI/fast-food density) and diet quality (MDS/fast-food consumption) within both the 500 m and the 1000 m buffer.

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Table 3 Parallel mediator model summary of the association between ethnicity and Mediterranean diet score via neighbourhood food environment diversity index (FEDI, 500 m or 1000 m buffers)

	500 m buffers				1000 m buffers			
			95 % CI				95 % CI	
	β	SE	Lower	Upper	*β*	SE	Lower	Upper
Total effect = path c (ethnicity differences in Mediterranean diet score)†								
South-Asian Surinamese descent	−2·93*	0·21	−3·35	−2·52	−2·94	0·21	−3·36	−2·52
African Surinamese descent	−3·46*	0·21	−3·87	−3·04	−3·50	0·22	−3·92	−3·07
Turkish descent	−2·83*	0·25	−3·33	−2·33	−2·84	0·26	−3·34	−2·33
Moroccan descent	−2·35*	0·24	−2·82	−1·88	−2·41	0·24	−2·88	−1·93
Direct effect = path c' (ethnicity differences in Mediterranean diet score, with FEDI in the model†,§								
South-Asian Surinamese descent	−2·93*	0·21	−3·35	−2·52	−2·92	0·21	−3·34	−2·50
African Surinamese descent	−3·46*	0·21	−3·87	−3·04	−3·49	0·22	−3·91	−3·07
Turkish descent	−2·83*	0·25	−3·33	−2·33	−2·79	0·26	−3·30	−2·28
Moroccan descent	−2·35*	0·24	−2·81	−1·88	−2·38	0·24	−2·85	−1·30
Path a – ethnicity differences in FEDI†,§								
South-Asian Surinamese descent	−0·03*	0·15	−0·06	−0·004	−0·05*	0·01	−0·08	−0·02
African Surinamese descent	−0·014	0·015	−0·04	0·016	−0·05*	0·01	−0·08	−0·20
Turkish descent	−0·01	0·02	−0·046	0·026	−0·07*	0·02	−0·10	−0·03
Moroccan descent	0·043*	0·17	0·009	0·077	−0·02	0·02	−0·05	0·01
Path b – association between FEDI and Mediterranean diet score‡,§								
FEHI	−0·02	0·20	−0·42	0·38	0·19	0·22	−0·23	0·62
Indirect effect (paths a, b) – ethnicity differences in Mediterranean diet score through FEDI†,§								
South-Asian Surinamese descent	0·00	0·00	−0·02	0·02	−0·01	0·01	−0·04	0·01
African Surinamese descent	0·00	0·00	−0·01	0·01	0·01	0·01	−0·03	0·01
Turkish descent	0·00	0·00	−0·01	0·01	−0·01	0·02	−0·05	0·02
Moroccan descent	−0·00	0·01	−0·02	0·17	−0·01	0·01	−0·02	0·01

FEDI: food environment diversity index.
Outcomes of the c path for the 500 m and 1000 m buffers are slightly different because these models only include participants with food outlets present within residential buffers (see footnote Table 1).
Data were obtained from the Hayes Process Macro[34].
β: Linear regression estimates; total *β* effect (path c) represents the association between ethnicity and Mediterranean diet score with no mediators in the model. Direct *β* effect (path c') represents the association between ethnicity and Mediterranean diet score when FEDI (mediator – 500 m or 1000 m) is included in the model.
Indirect effects (paths a and b) represent the association between ethnicity and Mediterranean diet score through FEDI.
Models are adjusted for age, sex and energy intake (in kilocalories).
*$P \leq 0·05$.
†Dutch ethnic descent is the reference category/constant (data not presented in the model).
‡Additionally adjusted for ethnicity.
§A higher (positive) score indicates a higher diversity of food outlets offering core foods as opposed to food outlets selling predominantly non-core foods.

Contribution of neighbourhood food environment characteristics to ethnic differences in diet quality

The direct effects (c') remained similar or nearly similar to the total effects (c) when the food environment variables were entered into the model, determining the association between ethnicity and diet quality. Accordingly, the estimates of the indirect effects (paths a, b) of the contribution of the neighbourhood food environment characteristics to ethnic differences in dietary quality were low and non-significant (Tables 2–4).

Discussion

The results of the current study indicate a difference in diet quality and neighbourhood food environment characteristics between different ethnic groups living in Amsterdam. For example, ethnic minority groups had lower MDS than participants of Dutch origin, and they lived in less healthy and less diverse neighbourhood food environments. In contrast, participants of Dutch origin consumed more fast food than most ethnic minority groups, yet they resided in neighbourhoods with a lower number of fast-food outlets. The neighbourhood food environment characteristics did not contribute to the ethnic differences in dietary quality observed in the current study.

There are a number of possible explanations for our findings. Although the ethnic minority groups included in our study tend to reside in less healthy food environments, all ethnic groups – including participants of Dutch origin – had a relatively 'unhealthy' neighbourhood food environment with a high level of access to fast food, namely a median of thirteen and thirty-two fast-food outlets for participants of Dutch and Turkish descent, respectively, within 1000 m. Thus, the level of access to fast food is high for all residents, which may mean that neighbourhood food environments do not play a direct role in explaining ethnic differences in diet quality. This might be especially the case for dense cities like Amsterdam, where food outlets are highly accessible[35].

Previous studies mentioned the 'lack of availability of traditional food' as influencing the dietary behaviour of ethnic minority groups, which could mean that foods are

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Table 4 Parallel mediator model summary of the association between ethnicity and fast food consumption via neighbourhood fast-food environment (500 m or 1000 m buffers)

	500 m buffers				1000 m buffers			
			95 % CI				95 % CI	
	β	SE	Lower	Upper	*β*	SE	Lower	Upper
Total effect = path c (ethnicity differences in fast-food intake)†								
South-Asian Surinamese descent	0·06	0·06	−0·05	0·17	0·06	0·06	−0·05	0·17
African Surinamese descent	−0·15*	0·06	−0·26	−0·05	−0·15*	0·06	−0·26	−0·05
Turkish descent	0·29*	0·07	0·16	0·42	0·29*	0·07	0·16	0·42
Moroccan descent	−0·39*	0·06	−0·51	−0·27	−0·39*	0·06	−0·51	−0·27
Direct effect = path c' (ethnicity differences in fast-food intake, with fast-food density in the model)†								
South-Asian Surinamese descent	0·06	0·06	−0·05	0·17	0·06	0·06	−0·05	0·17
African Surinamese descent	−0·15*	0·06	−0·26	−0·04	−0·15*	0·06	−0·26	−0·04
Turkish descent	0·29*	0·07	0·16	0·42	0·29*	0·07	0·16	0·42
Moroccan descent	−0·40*	0·06	−0·51	−0·27	−0·39*	0·06	−0·51	−0·27
Path a – ethnic differences in the fast-food environment†								
South-Asian Surinamese descent	0·14	0·12	−0·10	0·38	0·35*	0·12	0·12	0·58
African Surinamese descent	0·06	0·12	−0·18	0·30	0·18	0·12	−0·05	0·41
Turkish descent	0·73*	0·15	0·44	1·01	1·00*	0·14	0·72	1·27
Moroccan descent	0·49*	0·14	0·22	0·76	0·64*	0·13	0·38	0·90
Path b – association between fast-food environment and fast-food consumption‡								
Fast-food density	−0·01	0·01	−0·17	0·01	−0·01	0·01	−0·17	0·01
Indirect effect (paths a, b) – ethnicity differences in fast-food consumption through fast-food environment†								
South-Asian Surinamese descent	−0·01	0·00	−0·00	0·00	−0·00	0·00	−0·01	0·00
African Surinamese descent	−0·00	0·00	−0·00	0·00	−0·00	0·00	−0·00	0·00
Turkish descent	−0·00	0·00	−0·01	0·01	−0·00	0·01	−0·02	0·01
Moroccan descent	−0·00	0·00	−0·01	0·00	−0·00	0·01	−0·01	0·01

**P*= <0·05.
†Dutch ethnic descent is the reference category/constant (data not presented in the model).
‡Additionally adjusted for ethnicity.Outcomes of path c for the 500 m and 1000 buffers are slightly different because these models only include participants with food outlets present within residential buffers (see footnote Table 1).
Data were obtained from the Hayes Process Macro(34).
β: Linear regression estimates; total *β* effect (path c) represents the association between ethnicity and fast-food consumption with no mediators in the model. Direct *β* effect (path c') represents the association between ethnicity and fast-food consumption when fast-food density (mediator – 500 m or 1000 m) is included in the model.
Indirect effects (paths a, b) represent the association between ethnicity and fast-food consumption through fast-food density.
Models are adjusted for age and sex.

sourced via channels other than the food outlets in the neighbourhood environment(36). However, we lack insight into where the food consumed was obtained. Another explanation could be the age of our participants that was on average 46·5 years. It could be speculated that this sample has more traditional dietary habits and may be less influenced by the modern fast-food environment than younger people (e.g. adolescents)(37). Moreover, determinants other than the neighbourhood food environment – such as family preferences(38), cooking skills(39) or lack of time to prepare food(40) – explain ethnic differences in diet quality, but were not included in our study.

Another explanation for our findings is that we only assessed neighbourhood food environment (within a < 1000 m range). Although the benefit of this approach is that the exposure of each participant is similar, we could not account for the fact that people are also exposed to and visit food outlets elsewhere(41). Moreover, ethnic groups may use their neighbourhood food environment differently, for example, access to transportation for food shopping may differ between ethnic groups, although we do know from prior research that there are no 'food-deserts' in the city of Amsterdam(42). Furthermore, as mentioned previously, socio-cultural considerations may also influence the choice of food outlets(38); for example, Muslims may prefer to consume halal fast-foods, which might influence their behaviour with regard to food outlet selection in their neighbourhood. As this may have confounded food environment exposure, future research should seek to better understand the role of socio-cultural considerations in ethnic differences in neighbourhood food environment use and exposure.

Our findings are in line with a study in the UK that did not find evidence of a mediating effect of fast-food availability in ethnic differences regarding fast-food intake(43). However, in that study, a modification effect of the fast-food environment was observed, whereby ethnic differences in fast-food intake were the greatest in neighbourhoods that lacked fast-food outlets and narrowed as availability increased(43). Another important consideration is the influence of broader contextual factors in shaping people's engagement with their neighbourhood food environment. In our study, we extended the conceptualisation of neighbourhood food environment exposure with two comprehensive food environment proxies – namely the FEHI and the FEDI – but we did not incorporate the wider, socio-demographic context. For example, a New Zealand study found that the association between

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area-level deprivation and diet quality was stronger than that between fast-food availability and diet quality, stressing the importance of reconsidering pathways linking neighbourhood food environments and diet[44]. Furthermore, other food environment aspects, such as food costs, have been found to be important in explaining ethnic differences in diet quality[45].

The results of our study should be viewed in the light of some limitations. First, we used cross-sectional data, while dietary patterns are likely to be shaped by the food environment (and other factors) over a longer period of time, during which the neighbourhood food environment changes. Thus, a single measure of the neighbourhood food environment may not adequately reflect exposure or access to the food environment, which may have had an impact on diet quality. Moreover, the comprehensive food environment measures included (FEHI and FEDI) were based on the insights of experts and researchers and were thus a rather subjective way of indexing the healthiness and diversity of the neighbourhood food environment. Also, the FEDI does not provide insight in the actual core- and non-core foods for sale (e.g. the consumer food environment) and only captures food outlet typology. This should be taken into consideration when interpreting the outcomes. Methodological limitations should also be addressed. As we created decile groups of the FEHI and the fast-food density measures, only an indication of food environment differences and their contribution to ethnic differences in dietary quality could be defined. Finally, other food environment characteristics (e.g. food prices or special offers) or measures (e.g. size of or distance to outlets) were not taken into account, but are important aspects of the food environment.

The strengths of the study include the large sample of five different ethnic groups, the use of ethnic-specific FFQ to assess dietary intake and the use of individual-level exposure of a wide variety of food outlets of different sizes of street network buffers. Although the FFQ render the risk of social desirability bias (due to self-reporting), the FFQ instrument has been shown to be a valid and easy to use tool that provides a reasonably accurate ranking of low to high food intake[46,47]. We deliberately did not account for socio-economic position in the main analyses. However, sensitivity analyses in which we adjusted for educational level indicated that ethnic differences in all diet quality proxies remained similar. Future studies could further unravel the interaction between ethnicity and socio-economic position to explain group differences in the influence of the neighbourhood food environment on diet. Another point of consideration is that diet quality is a rather relative concept, and ethnic differences in diet quality depend on the outcome measure included. For example, whereas the MDS was lower among ethnic minority groups than among those of Dutch origin, the opposite was found for the Dutch Healthy Diet Index, a score based on the Dutch dietary recommendations[4]. However, we expect that the overall conclusion of our study – namely that the neighbourhood food environment measures did not contribute to ethnic differences in diet quality – would be the same had we used a different diet quality index.

Future research might aim to gain an understanding of intermediate factors of the environment–diet relationship. For example, food purchases are conceptually more directly linked to neighbourhood food environment exposure than dietary intake. However, in our study, we were not able to include those consumed foods that were purchased only within the neighbourhood environment. Moreover, the underlying social-cognitive mechanisms of the potential impact of environmental characteristics on food intake – such as social norms[48] or cultural perceptions[49] about the food environment and its contribution to food choices – are less explored.

In conclusion, we found no evidence that the neighbourhood food environment contributes to ethnic differences in diet quality because an association between the neighbourhood food environment and dietary quality was absent. Yet, the neighbourhood food environment of ethnic minority groups in Amsterdam was considerably less healthy and diverse than that of participants of Dutch origin. More research is needed to confirm our findings and to better understand how different population groups interact with their neighbourhood food environment as a determinant of dietary quality. For example, future research could investigate other consequences (e.g. implicit cognitions (unconscious influences)) of residing in less supportive neighbourhood food environments, or gain a better understanding of how different ethnic groups make use of their neighbourhood food environment.

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Supplementary material

For supplementary material accompanying this paper visit https://doi.org/10.1017/S1368980021001919

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