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Association of education with dietary intake among young adults in the bi-ethnic Coronary Artery Risk Development in Young Adults (CARDIA) cohort

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Abstract

Objective: To examine associations of changes in dietary intake with education in young black and white men and women.
Design: The Coronary Artery Risk Development in Young Adults (CARDIA) study, a multi-centre population-based prospective study. Dietary intake data at baseline and year 7 were obtained from an extensive nutritionist-administered diet history questionnaire with 700 items developed for CARDIA.
Setting: Participants were recruited in 1985–1986 from four sites: Birmingham, Alabama; Chicago, Illinois; Minneapolis, Minnesota; and Oakland, California.
Subjects: Participants were from a general community sample of 703 black men (BM), 1006 black women (BW), 963 white men (WM) and 1054 white women (WW) who were aged 18–30 years at baseline. Analyses here include data for baseline (1985–1986) and year 7 (1992–1993).
Results: Most changes in dietary intake were observed among those with high education ($\geq$12 years) at both examinations. There was a significant decrease in intake of energy from saturated fat and cholesterol and a significant increase in energy from starch for each race–gender group ($P < 0.001$). Regardless of education, taste was considered an important influence on food choice.
Conclusion: The inverse relationship of education with changes in saturated fat and cholesterol intakes suggests that national public health campaigns may have a greater impact among those with more education.

Keywords
Education
Dietary choices
Nutrient intakes

Epidemiological studies have reported an inverse association between socio-economic status (SES) and risk of coronary heart disease (CHD)[1–3]. Most investigators have used a cross-sectional design to investigate the association between diet and CHD risk factors[4–6]; however, some of these studies lack data from different race and gender groups[7–9]. Lifestyle habits formed at a young age, such as dietary intake, have consequences on health that may be long-term[10]. These lifestyle habits are often influenced by educational attainment[11], one of the key markers of SES. Education is often the measure of choice because it is easy to quantify and more stable over time than other SES factors such as occupation and income[12]. Education also has an impact on exposure to public health messages.

In the present paper, we report (1) the associations of education with changes in dietary intake and habits among the bi-ethnic cohort of young adult men and women in the Coronary Artery Risk Development in Young Adults (CARDIA) study; and (2) factors that influence dietary intake by education level.

Methods

CARDIA is a prospective, multi-centre study investigating the evolution of cardiovascular disease risk factors in young black and white men and women. Participants, aged 18–30 years, were recruited in 1985–1986 from four sites: Birmingham, Alabama; Chicago, Illinois; Minneapolis, Minnesota; and Oakland, California[13]. All procedures were conducted in accordance with CARDIA protocols approved by the institutional review boards at each centre, with signed informed consent forms being obtained from the participants[14–17]. Data for these analyses were

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obtained during examinations at baseline (1985–1986) and year 7 (1992–1993; retention rate 81%). At baseline, 5115 participants were recruited. This analysis includes only those with complete dietary and educational data for both baseline and year 7: 703 black men (BM), 1006 black women (BW), 963 white men (WM) and 1054 white women (WW). Excluded from the analyses are those with missing dietary or education data at baseline or year 7 ($n = 1180$); those with extreme values for energy intake (≤ 3.3 MJ day^{-1} or ≥ 33.3 MJ day^{-1} for men and ≤ 2.5 MJ day^{-1} or ≥ 25 MJ day^{-1} for women) ($n = 171$); participants who changed gender ($n = 2$); and those with any errors in reported years of education ($n = 36$). The minimum and maximum cut-offs of reported energy intake account for under- or overreporting of habitual energy intake, below or above which a person may not be able to function in a normal lifestyle[18]. This report includes a total of 3726 participants.

Dietary intake data at both examinations were obtained from an extensive nutritionist-administered diet history questionnaire developed for the CARDIA study[19]. The CARDIA diet history tool was modelled after the Burke method[20] and is similar in organisation to the diet history tools used in the Western Electric Study[21]. Validity and quality control issues concerning administration of the diet history questionnaire have been described previously[22,23]. In brief, the history was validated in a cohort of 128 participants demographically similar to those in the CARDIA study. The correlations between mean daily nutrient intakes from the CARDIA Diet History and means from seven random 24-hour recalls were usually above 0.50[23].

Participants were asked to recall their usual dietary intake using the prior month as the time frame. Participants reported on the frequency, amount and method of food preparation for each food item reported during this period. Approximately 700 items were included to improve the ability to assess dietary intakes in various populations and ethnic groups.

Specific nutrients analysed for this report include total fat, saturated fat (SFA), polyunsaturated fat (PUFA), monounsaturated fat (MUFA), protein, total carbohydrate, sucrose, starch and dietary cholesterol. Nutrients were calculated from reported food items using the University of Minnesota Nutrition Coordinating Center Nutrient Database tapes 10 (baseline) and 20 (year 7)[24]. For dietary analyses, nutrient densities (% energy) were used for all macronutrients and dietary cholesterol was calculated as mg/1000 kcal (4 MJ). Additionally, at year 7, participants were asked to rank how much certain factors influenced their choice of food. They were instructed to use 1 for the most important factor that influenced their food choice, 2 for the second most important, and so on. The choices listed on the questionnaire were cost, taste, nutritional quality, philosophical/religious beliefs, convenience, and other. Data on years of completed education were obtained at baseline and year 7 using an interviewer-administered questionnaire.

Repeated measures analysis of variance was used to compare dietary intake at baseline to dietary intake at year 7 for three educational groups: <12 years of education at baseline and year 7; ≥ 12 years of education at baseline and year 7; and <12 years of education at baseline and ≥ 12 years of education at year 7. All models were age-adjusted using the PROC MIXED procedure from SAS statistical software. For analyses that assessed the relationship between years of education and factors influencing food choices, education at year 7 was categorised as <12 years, 12 years, 13–15 years and >16 years. The percentage of participants who gave a score of 1 as the most important factor influencing food choices was calculated. Version 8.0 of the SAS software package (SAS Institute, Cary, NC, USA) was used for all analyses.

Results

Among those with <12 years of education at baseline and year 7, there were very few significant changes in macronutrient intakes. BW with low education had a significant increase in energy intake from PUFA ($P < 0.01$) but also a significant decrease in cholesterol intake ($P < 0.001$). WM with low education had significant increases in energy from PUFA and starch (Table 1).

Most dietary changes occurred among persons whose education levels were high (≥ 12 years at baseline and year 7) (Table 1). Total energy increased among all race–gender groups, significantly so for BW ($P < 0.01$) and WW ($P < 0.001$). Percentage of energy from total fat declined significantly among WM and WW ($P < 0.001$), but increased slightly among BM. Percentage of energy from SFA declined significantly among all race–gender groups ($P < 0.001$). MUFA intake declined significantly among WM and WW ($P < 0.001$) but increased among BM ($P < 0.01$). Energy from PUFA increased among BM, BW and WM ($P < 0.001$). Dietary cholesterol levels decreased significantly in all groups ($P < 0.001$) and starch intake increased significantly in all groups ($P < 0.001$). Among three of the race–gender groups, BW, WM and WW, there was a significant increase in carbohydrate intake ($P < 0.01$). Intake of energy from sucrose decreased among BM ($P < 0.01$) and BW, while it increased among WW ($P < 0.001$).

Among those who had <12 years of education at baseline but ≥ 12 years of education by year 7, there was a significant increase in energy from PUFA ($P < 0.05$) among BM, BW and WM (Table 1). WW had a decrease in energy from total fat whereas BW had an increase. Three of the race–gender groups had a decrease in energy from SFA that was significant for WW ($P < 0.05$). Intake of energy from dietary cholesterol declined significantly

Table 1 Age-adjusted means (standard error) of dietary factors at CARDIA baseline and year 7 examinations, by education level

	Years of education					
	<12		≥12		<12	≥12
	Baseline	Year 7	Baseline	Year 7	Baseline	Year 7
Energy (MJ)						
BM	15.3 (0.85)	16.6 (0.98)	14.5 (0.25)	14.9 (0.25)	16.3 (0.93)	16.4 (1.02)
BW	11.4 (0.70)	10.7 (0.59)	9.8 (0.15)	10.3 (0.15)*	10.3 (0.65)	11.3 (0.68)
WM	17.2 (1.15)	15.9 (1.00)	13.3 (0.16)	13.1 (0.16)	15.3 (1.09)	16.6 (1.31)
WW	10.6 (0.83)	10.4 (0.89)	8.7 (0.10)	9.3 (0.10)***	9.2 (0.79)	9.1 (0.68)
Total fat (% of energy)						
BM	38.2 (0.83)	39.3 (1.08)	37.8 (0.22)	38.3 (0.28)	38.0 (0.92)	39.0 (1.38)
BW	38.1 (0.95)	39.6 (0.99)	37.3 (0.19)	37.1 (0.25)	36.6 (0.86)	39.1 (1.00)*
WM	38.0 (1.04)	38.2 (1.03)	37.4 (0.18)	35.4 (0.22)***	34.9 (1.11)	35.5 (1.69)
WW	34.9 (1.87)	36.5 (1.54)	36.2 (0.19)	32.8 (0.23)***	37.0 (1.09)	33.8 (1.16)*
SFA (% of energy)						
BM	14.6 (0.33)	14.1 (0.42)	14.3 (0.11)	13.1 (0.11)***	14.8 (0.58)	13.8 (0.59)
BW	14.1 (0.42)	13.5 (0.35)	13.8 (0.09)	12.5 (1.00)***	13.6 (0.51)	13.7 (0.40)
WM	15.1 (0.58)	13.8 (0.43)	14.2 (0.09)	12.4 (0.10)***	14.5 (0.59)	13.0 (0.76)
WW	12.8 (0.71)	12.7 (0.59)	13.7 (0.10)	11.6 (0.11)***	14.0 (0.63)	12.1 (0.54)*
MUFA (% of energy)						
BM	14.5 (0.37)	15.1 (0.44)	14.2 (0.09)	14.6 (0.13)**	14.3 (0.36)	15.1 (0.70)
BW	14.5 (0.39)	15.2 (0.51)	13.8 (0.08)	14.0 (0.12)	13.7 (0.42)	15.0 (0.56)
WM	13.9 (0.47)	14.1 (0.50)	13.8 (0.08)	13.2 (0.10)***	12.5 (0.45)	12.9 (0.66)
WW	13.4 (0.84)	13.8 (0.80)	12.9 (0.08)	12.0 (0.10)***	13.0 (0.47)	11.9 (0.49)
PUFA (% of energy)						
BM	6.4 (0.28)	7.1 (0.37)	6.6 (0.07)	7.7 (0.10)***	6.2 (0.30)	7.3 (0.32)*
BW	6.7 (0.32)	8.1 (0.44)**	6.9 (0.07)	7.8 (0.08)***	6.7 (0.31)	7.5 (0.26)*
WM	6.3 (0.39)	7.3 (0.32)*	6.8 (0.06)	7.2 (0.08)***	5.4 (0.32)	6.9 (0.51)*
WW	6.3 (0.43)	7.2 (0.57)	6.8 (0.06)	6.6 (0.07)*	7.3 (0.51)	7.2 (0.43)
Cholesterol (mg/1000 kcal; 4 MJ)						
BM	190.8 (11.24)	175.9 (11.74)	183.0 (3.00)	142.5 (1.91)***	192.6 (15.39)	141.7 (7.32)**
BW	196.7 (11.66)	140.6 (6.73)***	166.2 (2.14)	130.2 (1.73)***	141.7 (6.42)	146.2 (8.93)
WM	171.4 (8.98)	149.8 (9.06)	156.2 (1.80)	115.4 (1.35)***	155.0 (8.62)	107.6 (6.05)***
WW	156.7 (14.74)	139.9 (16.50)	150.3 (1.83)	105.3 (1.20)***	160.0 (15.76)	143.4 (16.29)
Total carbohydrates (% of energy)						
BM	43.2 (0.88)	42.0 (1.05)	46.1 (0.28)	46.3 (0.32)	45.1 (1.15)	45.1 (1.65)
BW	46.6 (1.39)	45.1 (1.16)	48.3 (0.24)	49.2 (0.29)**	49.2 (0.92)	46.7 (1.27)
WM	43.1 (1.16)	45.6 (1.22)	44.9 (0.23)	48.5 (0.26)***	46.9 (1.13)	48.1 (2.05)
WW	47.3 (2.40)	50.6 (2.13)	47.1 (0.23)	51.9 (0.25)***	48.5 (1.17)	52.3 (1.40)
Starch (% of energy)						
BM	19.1 (0.60)	19.9 (0.65)	18.8 (0.19)	19.9 (0.17)***	19.5 (0.68)	20.0 (0.67)
BW	19.3 (0.81)	18.5 (0.66)	18.2 (0.15)	19.2 (0.15)***	18.4 (0.76)	19.0 (0.59)
WM	16.8 (0.87)	19.2 (0.70)*	19.0 (0.17)	21.7 (0.17)***	16.0 (1.04)	19.1 (0.84)*
WW	15.9 (1.32)	17.7 (0.96)	18.6 (0.16)	22.1 (0.16)***	18.8 (0.87)	19.7 (0.91)
Sucrose (% of energy)						
BM	6.5 (0.50)	6.6 (0.51)	7.9 (0.19)	7.2 (0.14)**	7.9 (0.92)	6.8 (0.56)
BW	10.2 (1.19)	7.6 (0.62)	9.3 (0.21)	8.3 (0.13)***	9.2 (0.91)	7.9 (0.50)
WM	10.3 (1.48)	7.8 (0.77)	6.9 (0.16)	7.0 (0.12)	10.8 (1.73)	6.3 (0.66)*
WW	13.7 (2.84)	7.8 (0.92)*	6.7 (0.18)	7.8 (0.12)***	8.8 (1.51)	8.5 (0.74)
Protein (% of energy)						
BM	14.5 (0.40)	14.3 (0.39)	14.2 (0.10)	14.1 (0.10)	14.6 (0.38)	13.7 (0.32)
BW	14.0 (0.41)	13.5 (0.39)	14.1 (0.08)	13.9 (0.09)	13.4 (0.40)	14.1 (0.51)
WM	14.4 (0.41)	14.1 (0.45)	15.2 (0.08)	14.8 (0.08)***	14.4 (0.46)	13.8 (0.57)
WW	14.2 (0.68)	13.7 (0.77)	15.4 (0.09)	15.1 (0.09)**	14.1 (0.61)	14.2 (0.42)

CARDIA – Coronary Artery Risk Development in Young Adults; BM – black men; BW – black women; WM – white men; WW – white women; SFA – saturated fat; MUFA – monounsaturated fat; PUFA – polyunsaturated fat.
n from both examinations – baseline and year 7, education <12 years: BM = 55, BW = 52, WM = 27, WW = 23; baseline and year 7, education ≥12 years: BM = 608, BW = 912, WM = 911, WW = 1004; baseline education <12 years and year 7 education ≥12 years: BM = 40, BW = 42, WM = 25, WW = 27.
*, $P < 0.05$; **, $P < 0.01$; ***, $P < 0.001$.

for both BM and WM (from 192.6 to 141.7 and from 155.0 to 107.6 mg/1000 kcal, respectively).

Overall, a majority of the participants rated 'taste' as the most important factor for food choice. Among all race–gender groups, more participants with a college-level or higher education (≥16 years of education) rated nutritional quality as a very important factor influencing food than did those with lower educational attainment

Table 2 Percentage of participants rating factors most important in influencing food choice at CARDIA year 7 examination, by years of education

Years of education	Cost	Taste	Nutritional quality	Convenience	Religion
Black men					
< 12 ($n = 55$)	18	56	18	2	4
12 ($n = 215$)	15	60	15	7	1
13–15 ($n = 258$)	11	57	20	9	2
> 16 ($n = 175$)	10	52	25	10	2
Black women					
< 12 ($n = 52$)	27	50	17	4	0
12 ($n = 270$)	20	53	20	6	1
13–15 ($n = 217$)	15	50	22	10	1
> 16 ($n = 257$)	11	50	26	11	2
White men					
< 12 ($n = 27$)	11	59	7	19	0
12 ($n = 160$)	13	61	21	4	1
13–15 ($n = 239$)	8	59	18	11	2
> 16 ($n = 537$)	5	58	24	12	1
White women					
< 12 ($n = 23$)	22	61	13	0	4
12 ($n = 181$)	13	50	27	10	1
13–15 ($n = 223$)	10	51	28	10	0
> 16 ($n = 627$)	3	48	35	9	3

CARDIA – Coronary Artery Risk Development in Young Adults.
Only those who ranked factors influencing nutrition as 1, i.e. most important, are shown.

(<12 years of education) (Table 2). More BM and WW with less education rated taste as a very important influence on their food choices. Cost was reported as an important factor influencing food choices among those with less education.

Discussion

Our most notable finding was a decrease in energy from SFA and cholesterol (mg/1000 kcal) among those who had ≥12 years of education at baseline and year 7. High education was also associated with an increase in energy from starch for each of the race–gender groups, indicating that a reduction in energy from fat may be replaced with energy from other nutrients. Although nutritional quality was rated as an important factor for those with higher levels of education in all race–gender groups, taste was the most important factor influencing food choices for all race–gender groups, regardless of education.

Various cross-sectional and longitudinal studies have documented inverse associations between SES and intake of energy, total fats, SFA, cholesterol and MUFA[4,7,25]. The Atherosclerosis Risk in Communities study reported an association between higher educational attainment and healthier diets characterised by a lower percentage of energy from SFA and cholesterol[4]. We also report a decline in energy intake from SFA and cholesterol among the higher educated young adults in the CARDIA study. We believe that the CARDIA study has many unique points. The longitudinal results permit us to examine changes in both diet and education, and the cohort is composed of community dwelling individuals and not a selected patient sample or group of individuals on a special diet. Diet was assessed using a very detailed interviewer-administered diet history in a bi-ethnic cohort of black and white men and women from different geographic regions. In addition, the diet of a relatively young cohort (18–30 years old at baseline) was captured; this is when many adults begin to live independently and have a greater involvement in their dietary choices.

The reduction in energy from dietary SFA and cholesterol among those with higher education at both examinations may also reflect the impact of public health efforts for prevention of cardiovascular disease. One of the key recommendations of the Expert Panel of Population Strategies for Blood Cholesterol Reduction was to decrease average cholesterol levels through population-wide adoption of eating patterns low in SFA and cholesterol[26]. In CARDIA there was an overall decrease in SFA and cholesterol intakes. However, it appears that these changes were made by young adults with a higher education, since it was these participants who had greater decreases longitudinally in SFA and cholesterol. Among those with lower education at baseline and year 7, there were no significant decreases in intakes of energy from fat, SFA and, for three of the race–gender groups, cholesterol. Nusbaum reported that the fewer healthy changes in diet of those with low incomes may translate to the fact that those who have greater access to 'evolving nutritional recommendations' may also be those who have the disposable income to use at the grocery store to follow advice on dietary changes[27]. It is possible that participants in the CARDIA study with higher education, who had greater decreases in dietary cholesterol and saturated fat intakes, may also be those who have greater access to nutrition- and health-related messages as well as resources to make the healthy lifestyle changes. As an indicator of SES, these results are consistent with the assertion that the better off are more likely or able to adopt healthy lifestyles. Although the association between education and a decrease in dietary fat intake was significant for many race–gender groups in the CARDIA study, the biological significance of these differences is not entirely clear. Results from the Nurses' Health Study showed that each increase of 5% in energy intake from saturated fat was associated with a 17% increase in the risk of coronary disease[28]. The Seven Countries study also reported that death rates in 15 cohorts were related positively to average percentage of dietary energy from SFA intake[29]. It may be that the additive effect of small changes over a long period of time may influence health. These results suggest that public health efforts are needed that help to improve the ability of those with less resources to make heart-healthy lifestyle choices.

Kumanyika reported that not all dietary trends in the USA since the 1980s have been healthy, possibly due to an increase in eating outside the home and the use of packaged foods during the last half century; these factors may result in eating less healthy foods[30]. In CARDIA, we found that among those with high education at both examinations there was an increase in energy from starch for each of the race–gender groups. This may be due to the popularity of foods that are high in carbohydrate content and low in fat. Therefore, educated consumers may believe that they are eating a product low in fat and cholesterol, unaware of the increased caloric content. There are several issues that are related to this 'trade-off' phenomenon. First is the issue of how we balance our diet. The US Department of Agriculture reported that at least 80% of people interviewed in a survey made a 'trade-off' in their diet and that this was more likely to occur among those with more education[31]. Second, the issue of 'trade-offs' is related to the overall pattern of limiting dietary fat intake. In 1990, the Dietary Guidelines set for the first time a numerical value recommending the consumption of 30% or less of energy from dietary fat. From 1965 to 1990, both men and women in the USA reduced their fat consumption. However, between 1990 and 1995, although fat consumption remained unchanged or increased slightly, the overall total caloric intake increased significantly. Most of this increase in calories is attributed to an increase in carbohydrate consumption from grain products and the consumption of beverages such as colas[32]. It is possible that the public health messages to decrease SFA and dietary cholesterol are being received among certain segments of the population but that these nutrients may be substituted with other nutrients that increase overall caloric intake and therefore also increase body mass index. Therefore, the success of educational efforts may be beneficial in changing some aspects of the diet but not necessarily in providing a beneficial change in overall eating behaviour.

We observed few statistically significant changes in dietary intake among those with less education. Since sample sizes were small for those with less education, the lack of association may be due to inadequate sample size and power to detect associations. Other potential factors influencing dietary reporting by education may include differences in the ability to recall foods consumed over a given time period or the ability to quantify amounts of food eaten. Various other factors can also influence dietary reporting, including SES, social desirability and gender[33,34]. Our results are similar to those of the Women's Health Initiative, which reported that African-American and Hispanic women with low SES reported significantly fewer low-fat dietary practices[35]. Another limitation with dietary data collection lies in the precision of a dietary assessment tool to measure changes in dietary intake over time. In CARDIA, tracking of dietary factors over a 7-year period showed that more than 60% of individuals in the lowest quintile of absolute intake at baseline remained in the lowest or second-lowest quintile for most nutrients at year 7, indicating that the relative ranking of individuals was maintained over time[36]. The authors of the study concluded that the CARDIA Diet History was adequate for measuring broad differences in dietary intake groups among young adults of different ethnicity. Most prospective cohort studies have mailed participants list-based methods to capture specific nutrients of interest. However, various studies report response rates as low as 18.6% and often these tools are returned by the participants with sizeable proportions of missing and/or uninterpretable responses[37,38]. Pereira *et al.* reported that the CARDIA Diet History tool is comprehensive and captures habitual dietary intake without influencing recall error. Because it is interviewer-administered there is no burden on the participant due to literacy issues, and thus it is appropriate for populations from different socio-economic and racial groups[39].

Education was also related to food choice priorities. Results from our study show that taste was the most important factor influencing food choices, although nutritional quality became more important with increasing education among all race–gender groups. Fewer people with a limited education reported nutritional quality as the most important factor influencing food choices than did those with a higher level of education.

In summary, results from our study indicate that some significant beneficial dietary changes may have occurred particularly among those young adults who have higher education. The education differential we observed in some of the dietary behaviours suggests that inequalities in the development of risk factors may emerge early in life[40–42]. Although national public health campaigns may have an impact in lowering saturated fat and cholesterol in the American diet, these messages seem to be adopted more by those with a higher education. Therefore traditional messages are either not reaching, or are not effective for, the most vulnerable groups (i.e. those with a low level of education) who also have the most barriers to adopting healthier lifestyles. To narrow these inequalities, nutrition education programmes should be targeted with more emphasis at those with low educational levels during young adulthood in an attempt to improve dietary intake and thereby reduce risk for chronic diseases. More research is needed on policy and environmental approaches that support the ability of individuals to make healthy dietary choices.

References

1 Bennett S. Cardiovascular risk factors in Australia: trends in socioeconomic inequalities. *Journal of Epidemiology and Community Health* 1995; **49**: 363–72.
2 Rose G, Marmot MG. Social class and coronary heart disease. *British Heart Journal* 1981; **45**: 13–9.
3 Holme I, Helgeland A, Hjermann I, Leren P. Socio-economic status as a coronary risk factor: the Oslo study. *Acta Medica Scandinavica Supplementum* 1982; **660**: 147–51.

4 Shimakawa T, Sorlie P, Carpenter MA, Dennis B, Tell GS, Watson R, *et al*. Dietary intake patterns and sociodemographic factors in the Atherosclerosis Risk in Communities Study. ARIC Study Investigators. *Preventive Medicine* 1994; **23**: 769–80.

5 Hulshof KF, Wedel M, Lowik MR, Kok KF, Kistemaker C, Hermus RJ, *et al*. Clustering of dietary variables and other lifestyle factors (Dutch Nutritional Surveillance System). *Journal of Epidemiology and Community Health* 1992; **46**: 417–24.

6 Raitakari OT, Leino M, Rakkonen K, Porkka KV, Taimela S, Rasanen L, *et al*. Clustering of risk habits in young adults. The Cardiovascular Risk in Young Finns Study. *American Journal of Epidemiology* 1995; **142**: 36–44.

7 Bolton-Smith C, Smith WC, Woodward M, Tunstall-Pedoe H. Nutrient intakes of different social-class groups: results from the Scottish Heart Health Study (SHHS). *British Journal of Nutrition* 1991; **65**: 321–35.

8 Shea S, Melnik TA, Stein AD, Zansky SM, Maylahn C, Basch CE. Age, sex, educational attainment, and race/ethnicity in relation to consumption of specific foods contributing to the atherogenic potential of diet. *Preventive Medicine* 1993; **22**: 203–18.

9 Smith AM, Baghurst KJ. Public health implications of dietary differences between social status and occupational category groups. *Journal of Epidemiology and Community Health* 1992; **46**: 409–16.

10 Wynn A. Inequalities in nutrition. *Nutrition and Health* 1987; **5**: 79–94.

11 Pardo B, Piotrowski W, Sygnowska E, Waskiewicz A. Relationship of educational attainment to nutritional habits in the Pol-Monica Warsaw population: a 10 year follow-up study. *Nutrition, Metabolism, and Cardiovascular Diseases* 1997; **7**: 16–23.

12 Parraga IM. Determinants of food consumption. *Journal of the American Dietetic Association* 1990; **90**: 661–3.

13 Friedman GD, Cutter GR, Donahue RP, Hughes GH, Hulley SB, Jacobs DR Jr, *et al*. CARDIA: study design, recruitment, and some characteristics of the examined subjects. *Journal of Clinical Epidemiology* 1988; **41**: 1105–16.

14 The CARDIA Study Steering Committee. *Coronary Artery Risk Development in (Young) Adults (CARDIA): Year 0 Exam Protocol*. Birmingham, AL: The CARDIA Study Coordinating Center, University of Alabama at Birmingham, February 1985.

15 The CARDIA Study Steering Committee. *Coronary Artery Risk Development in (Young) Adults (CARDIA): Year 0 Exam Manual of Operations*. Birmingham, AL: The CARDIA Study Coordinating Center, University of Alabama at Birmingham, February 1985.

16 The CARDIA Study Steering Committee. *Coronary Artery Risk Development in (Young) Adults (CARDIA): Year 7 Exam Protocol*. Birmingham, AL: The CARDIA Study Coordinating Center, University of Alabama at Birmingham, April 1992.

17 The CARDIA Study Steering Committee. *Coronary Artery Risk Development in (Young) Adults (CARDIA): Year 7 Exam Manual of Operations*. Birmingham, AL: The CARDIA Study Coordinating Center, University of Alabama at Birmingham, April 1992.

18 Goldberg GR, Black AE, Jebb SA, Cole TJ, Murgatroyd PR, Coward MA, *et al*. Critical evaluation of energy intake data using fundamental principles of energy physiology: 1. Derivations of cut-off limits to identify under-recording. *European Journal of Clinical Nutrition* 1991; **45**: 569–81.

19 McDonald A, Van Horn L, Slattery M, Hilner J, Bragg C, Caan B, *et al*. The CARDIA dietary history: development, implementation, and evaluation. *Journal of the American Dietetic Association* 1991; **91**: 1104–12.

20 Burke BS. The dietary history as a tool in research. *Journal of the American Dietetic Association* 1947; **23**: 1041–6.

21 Shekelle RB, Shryock AM, Paul O, Lepper M, Stamler J, Liu S, *et al*. Diet, serum cholesterol, and death from coronary heart disease. The Western Electric study. *New England Journal of Medicine* 1981; **304**: 65–70.

22 Hilner JE, McDonald A, Van Horn L, Bragg C, Caan B, Slattery ML, *et al*. Quality control of dietary data collection in the CARDIA study. *Controlled Clinical Trials* 1992; **13**: 156–69.

23 Liu K, Slattery M, Jacobs DR Jr, Cutter G, McDonald A, Van Horn L. A study of the reliability and comparative validity of the CARDIA dietary history. *Ethnicity & Disease* 1994; **4**: 15–27.

24 Schakel SF, Sievert YA, Buzzard IM. Sources of data for developing and maintaining a nutrient database. *Journal of the American Dietetic Association* 1988; **88**: 1268–71.

25 Marshall JA, Lopez TK, Shetterly SM, Baxter J, Hamman RF. Association of education level with atherogenic diets in a rural biethnic population. *American Journal of Preventive Medicine* 1995; **11**: 294–300.

26 Cleeman JI, Lenfant C. The National Cholesterol Education Program: progress and prospects. *Journal of the American Medical Association* 1998; **280**: 2099–104.

27 Nusbaum NJ. Dietary trends in the United States. *New England Journal of Medicine* 1997; **336**: 583–5.

28 Hu FB, Stampfer MJ, Manson JE, Rimm E, Colditz GA, Rosner BA, *et al*. Dietary fat intake and the risk of coronary heart disease in women. *New England Journal of Medicine* 1997; **337**: 1491–9.

29 Keys A, Menotti A, Karvonen MJ, Aravanis C, Blackburn H, Buzina R, *et al*. The diet and 15-year death rate in the Seven Countries Study. *American Journal of Epidemiology* 1986; **124**: 903–15.

30 Kumanyika S. Improving our diet – still a long way to go. *New England Journal of Medicine* 1996; **335**: 738–9.

31 US Department of Agriculture (USDA) Center for Nutrition Policy and Promotion. *Food Trade-offs: Choosing How to Balance the Diet*. Nutrition Insight 24. USDA Center for Nutrition Policy and Promotion, Alexandria, VA, USA, May 2001; 1–2.

32 US Department of Agriculture (USDA) Center for Nutrition Policy and Promotion. *Is Total Fat Consumption Really Decreasing?* Nutrition Insight 5. USDA Center for Nutrition Policy and Promotion, Alexandria, VA, USA, April 1998; 1–2.

33 Stallone DD, Brunner EJ, Bingham SA, Marmot MG. 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.

34 Herbert JR, Ma Y, Clemlow L, Ockene JK. Gender differences in social desirability and social approval bias in dietary self-report. *American Journal of Epidemiology* 1997; **146**: 1046–55.

35 Patterson RE, Kristal AR, Coates RJ, Tylavsky FA, Ritenbaugh C, Van Horn L, *et al*. Low-fat diet practices of older women: prevalence and implications of dietary assessment. *Journal of the American Dietetic Association* 1996; **96**: 670–9.

36 Dunn JE, Greenland P, Hilner JE, Jacobs DR Jr. Seven-year tracking of dietary factors in young adults: the CARDIA study. *American Journal of Preventive Medicine* 2000; **18**: 38–45.

37 Kolonel LN, Henderson BE, Hankin JH, Nomura AM, Wilkens LR, Pike MC, *et al*. A multiethnic cohort in Hawaii and Los Angeles: baseline characteristics. *American Journal of Epidemiology* 2000; **151**: 346–57.

38 Subar AF, Ziegler RG, Thompson FE, Johnson CC, Weissfeld JL, Reding D, *et al*. Is shorter always better? Relative importance of questionnaire length and cognitive ease on

response rates and data quality for two dietary questionnaires. *American Journal of Epidemiology* 2001; **153**: 404–9.

39 Pereira MA, Jacobs DR, Van Horn L, Slattery ML, Kartashov AI, Ludwig DS. Dairy consumption, obesity, and the insulin resistance syndrome in young adults. The CARDIA Study. *Journal of the American Medical Association* 2002; **287**: 2082–9.

40 Neumark-Sztainer D, Story M, Hannan PJ, Croll J. Overweight status and eating patterns among adolescents: where do youths stand in comparison with the Healthy People 2010 objectives? *American Journal of Public Health* 2002; **92**: 844–51.

41 Kranz S, Siega-Riz M. Sociodemographic determinants of added sugar intake in preschoolers 2 to 5 years old. *Journal of Pediatrics* 2002; **140**: 667–72.

42 James WPT, Nelson M, Ralph A, Leather S. Socioeconomic determinants of health: the contribution of nutrition to inequalities in health. *British Medical Journal* 1997; **314**: 1545–51.