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Association between dietary inflammatory index, and cause-specific mortality in the MONICA/KORA Augsburg Cohort Study

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Background: Chronic diseases such as cancer and cardiovascular diseases (CVDs) are well-established causes of disability and premature death. Dietary components have been implicated in the etiology of these chronic diseases. **Methods:** We examined the ability of the Dietary Inflammatory Index (DII™) to predict all-cause, coronary heart disease (CHD), CVD and cancer mortality and incident CHD in the MONICA-KORA Cohort Studies. DII scores were computed from baseline 7-day dietary records in this cohort of 1297 men, who were aged 45–64 years when enrolled. During the follow-up period, 551 total (155 CHD, 244 CVD and 175 cancer-related deaths) and 213 validated incident CHD events were identified through mortality record linkage and active follow-up. Spearman correlation coefficients were calculated between DII scores and the inflammatory marker C-reactive protein (CRP). Cox proportional hazards regression was used to estimate hazard ratios (HR) for the endpoints described above. **Results:** DII scores were significantly positively correlated with CRP (*P* value <0.0001). Positive associations were noted between DII and all-cause mortality (HR_{Q4vsQ1}: 1.41; 95%CI 1.04–1.90; *P*-trend = 0.007) and incident CHD (HR_{Q4vsQ1}: 1.83; 95%CI 1.12–3.01; *P*-trend = 0.008). These associations were attenuated after further adjustment for smoking status, but remained significant for all-cause mortality. When stratified by smoking status, DII was associated with all-cause and cancer mortality among ex-smokers, in the absence of significant heterogeneity. **Conclusion:** These results indicate that a pro-inflammatory diet as expressed by higher DII scores is associated with all-cause mortality. This association was more pronounced among ex-smokers in whom a significant association with cancer mortality was observed.

Introduction

Various studies have been conducted exploring overall diet and dietary components and both all-cause and cause-specific mortality.[1] Recently, there has been a shift in focus from individual nutrients and foods to dietary patterns because dietary components are never consumed in isolation and are generally highly correlated with one another.[2] The dietary pattern approach takes into account the complexity of the diet and the potentially synergistic or antagonistic effects of all individual dietary components.[3] Chronic inflammation is known to be associated with a variety of chronic health conditions including arthritis, diverticulitis, cardiovascular disease (CVD), diabetes[4,5] and common epithelial cancers, with colorectal cancer[6,7] being the most extensively studied. There is growing evidence that specific dietary components influence inflammation[8] and this may influence all-cause, cancer and CVD mortality.[9,10]

The Dietary Inflammatory Index (DII™) is a literature-derived, population-based dietary index developed to characterize an individual's diet on a continuum from maximally anti- to pro-inflammatory.[11] Thus far, the DII has been found to be associated with C-reactive protein (CRP),[12] interleukin-6[13] and tumor necrosis factor-alpha.[13] The DII also has been shown to be associated with a variety of outcomes including cancer and CVD incidence[14,15] and mortality.[16,17]

Until now, the DII has not been applied to mortality outcomes and incident CHD in a German population. The purpose of this study was to examine the association between DII scores and all-cause, coronary heart disease (CHD), CVD and cancer mortality among men in the 'MONItoring of Trends and Determinants in CArdiovascular Diseases' (MONICA) Augsburg/Cooperative Health Research in the Region of Augsburg (KORA) Studies. Our working hypothesis was that a higher DII score (indicating a pro-inflammatory diet) is associated with increased risk of all-cause and cause-specific mortality as well as incident CHD.

Methods

Participants and study design

In 1984–95, three independent cross-sectional surveys were conducted at intervals of 5 years in Southern Germany as part of the multinational World Health Organization-sponsored MONICA project. Our study population consisted of male participants aged 45–64 years from survey 1 (S1, $n = 899$) and survey 3 (S3, $n = 430$) conducted in 1984–85 and 1994–95, respectively, who completed a 7-day dietary record and for whom complete data for the causes of death and all covariables required for the Cox proportional hazards models were available ($n = 1297$, S1, $n = 879$, S3, $n = 418$). By study

design according to the recommendations on the nutritional substudies within the international WHO MONICA project, assessment of 7-day dietary records was only planned for a random sample of men aged 45–64 years living in the urban district of Augsburg and the rural districts of Augsburg and Aichach–Friedberg in S1 (eligible $n = 1{,}284$; response 70%) and for a random sample of men aged 45–64 years living in the urban district of Augsburg in S3 (eligible $n = 607$; response 71%).[18,19] Subjects were followed up until 2009 for incident CHD and until 2011 for total and cause-specific mortality within the frame of KORA. Further details of the study design can be found elsewhere.[20–22] During a median follow-up time of 25.8 and 16.7 years for S1 and S3, respectively, there were 551 deaths out of which 155 were due to CHD, 244 due to CVD, and 175 due to cancer. In 1252 participants (S1, $n = 847$. S3, $n = 405$) with available information on CHD morbidity there were 213 incident cases of CHD during median follow-up time of 21.4 and 13.9 years for S1 and S3, respectively.

Dietary assessment and Dietary Inflammatory Index

Each participant of the dietary sub-study completed a 7-day dietary record. The exact amount of food consumed was assessed through a combination of weighing with scales and using household measures. Further details can be found elsewhere.[19] Recipes were divided into single food items. Subsequently, all items were coded according to the German National Database BLS (Bundeslebensmittelschluessel = German Federal Food Key) version II.2.

The DII is based on literature published through 2010 linking diet to inflammation. Individual intakes of food parameters on which the DII is based are then compared to a world standard database. A complete description of the DII is available elsewhere.[11] A description of validation work, including both dietary recalls and the 7-day dietary recall (7DDR)[12] and the FFQ used in the Women's Health Initiative,[13] also are available. In brief, to calculate DII for the participants of this study, the dietary data were first linked to the regionally representative world database that we created that provided a robust estimate of a mean and standard deviation for each parameter. These then become the multipliers to express an individual's exposure, relative to the ''standard global mean,'' as a *z*-score. This is achieved by subtracting the ''standard global mean'' from the amount reported and dividing this value by the standard deviation. To minimize the effect of ''right skewing,'' this value is then converted to a centered percentile score. The centered percentile score for each food parameter for everyone was then multiplied by the respective food parameter effect score, which is derived from the literature review, to obtain a food parameter-specific DII score for an individual. All of the food parameter-specific DII scores are then summed to create the overall DII score for every participant in the study.[11] A higher DII indicates a more inflammatory diet. The range of DII scores in the KORA study was −3.46 to +4.23.

Covariable assessment

All participants underwent standardized interviews conducted by trained medical staff to assess the information on sociodemographic variables, leisure time physical activity, smoking habits and history of diseases. Furthermore, medical examinations, including blood pressure measurements, weighing, and drawing of non-fasting venous blood samples, were conducted using standard protocols. Details about examination methods were reported previously.[20]

Inflammation marker measurement

CRP levels were measured in serum samples stored at −80°C using a high-sensitivity immunoradiometric assay (IRMA).[23] The intra- and inter-assay coefficients of variation of quality control test sera for CRP were 4.0 and 12.0%, respectively.

Ascertainment and classification of mortality and incident CHD

Deaths were ascertained by checking the vital status of all participants through the population registries at several time points throughout the follow-up period. Death certificates were coded for the underlying cause of death by a single trained person using the 9th revision of the International Classification of Diseases (ICD9). Myocardial infarctions occurring before the age of 75 years were identified through the population-based MONICA/KORA Augsburg coronary event registry and follow-up questionnaires for participants residing out of the study area. Through 31 December 2000, the diagnosis of a major non-fatal MI event was based on the MONICA algorithm considering symptoms, cardiac enzymes and ECG changes. Afterwards, MI events were diagnosed by the European Society of Cardiology and American College of Cardiology criteria.[24] Deaths from MI were validated by chart reviews, death certificates, autopsy reports and information from the last treating physician. Self-reported cases of non-fatal incident myocardial infarctions that occurred out of the study area were validated using hospital records or information provided by the treating physicians. The end points used in this study were all-cause and cause-specific mortality codes as follows: CHD-mortality (ICD9: 410–414, 798), CVD-mortality (ICD9: 390–459, 798), cancer-mortality (ICD9: 140–208). Furthermore, the endpoint incident CHD included all incident fatal CHD and all non-fatal incident myocardial infarctions.

Both baseline and follow-up studies were approved by the local authorities and all participants provided written informed consent.

Statistical analyses

DII scores were analyzed both as a continuous variable and as quartiles. Correlations between DII and CRP were calculated using Spearman correlation coefficients, as CRP values were not normally distributed. Baseline characteristics were examined by quartiles of DII. The participants' characteristics including demographics, lifestyle factors, medical history and anthropometric characteristics were compared using general linear model or χ^2 test for continuous and categorical variables, respectively. Hazards ratio and 95% confidence intervals (HR; 95% CI) were estimated using three Cox proportional hazards regression models; model 1: adjusting only for age and survey, model 2: additionally adjusting for BMI, BMI^2 (for all-cause mortality), education level ($<11/\geq 11$ years), physical activity (low/high), place of residence (urban/rural), actual hypertension, diabetes, energy intake and the ratio of total cholesterol and HDL-cholesterol and model 3: additionally adjusting for smoking status (current/ex/never smoker). Effect estimates were calculated for a 1-unit increase in DII score. The covariables were chosen *a priori* as they previously had been shown to be strong risk factors for mortality. Linear trend across quartiles was assessed using the median approach. The assumption of proportional hazards was tested by adding to the model an interaction term between follow-up time and DII; there was no evidence that these assumptions were violated. In addition, interaction between DII and smoking status were assessed by inclusion of the respective interaction terms and analyses were carried out stratified by smoking status. Statistical tests were performed using SAS® 9.3, (SAS Institute Inc., Cary, NC); all *P*-values were derived from two-sided tests.

Results

The mean DII at baseline was 0.89 (SD ± 1.38). Baseline characteristics by quartiles of DII are provided in table 1. Men in quartile 4 were more likely to be older, have lower dietary energy intake, be recruited from survey 1, be from rural area, have higher education, be current smokers and be less likely to have actual hypertension.

Table 1 Baseline characteristics in the total study population and stratified by quartiles of the dietary inflammatory index (DII), MONICA/KORA Augsburg cohort study

Characteristics[a]	All Median = 0.965 *N* = 1297	Dietary inflammatory index (higher value more inflammatory)				
		Quartile 1 Median = −0.803 N = 324	Quartile 2 Median = 0.434 N = 324	Quartile 3 Median = 1.408 N = 325	Quartile 4 Median = 2.507 N = 324	*P*-trend [§/] *P*-value
Age (years)	54.5 ± 5.8	54.1 ± 5.7	54.0 ± 5.8	54.8 ± 5.8	54.9 ± 6.0	0.0299 [§]
BMI (kg/m^2)	27.8 ± 3.3	27.6 ± 3.4	27.8± 3.3	28.0 ± 3.1	27.7 ± 3.2	0.6438 [§]
Energy intake (kcal)	2474 ± 555	2871 ± 568	2581 ± 442	2386 ± 435	2059 ± 424	< 0.0001 [§]
Ratio of total cholesterol/ HDL-cholesterol	5.39 ± 2.10	5.27 ± 2.32	5.47 ± 2.04	5.47 ± 1.99	5.35 ± 2.01	0.6827 [§]
Survey (%)						
Survey 1	67.8	52.8	69.8	74.8	73.8	< 0.0001
Survey 3	32.2	47.2	30.2	25.2	26.2	
Reporting Unit (%)						
Urban	63.8	74.7	61.1	60.9	58.3	< 0.0001
Rural	36.2	25.3	38.9	39.1	41.7	
Actual hypertension (%)						
Yes	51.5	49.1	54.3	56.6	46.0	0.0275
No	48.5	50.9	45.7	43.4	54.0	
Education level (%)						
<11 years	30.5	38.3	30.9	29.2	23.8	0.0009
≥11 years	69.5	61.7	69.1	70.8	76.2	
Smoking Status (%)						
Current	30.0	21.6	25.9	35.7	37.4	< 0.0001
Former	43.0	44.4	43.5	43.7	40.1	
Never	26.9	34.0	30.6	20.6	22.5	
Diabetes (%)						
Yes	5.0	5.9	4.6	5.5	4.0	0.6908
No	95.0	94.1	95.4	94.5	96.0	
Physical activity (%)						
Active	39.7	44.4	41.0	34.8	38.6	0.0799
Inactive	60.3	55.6	59.0	65.2	61.4	

a: Mean ± SD for continuous variables and % for categorical variables.

DII scores were significantly positively correlated with CRP ($r = 0.12$, P values <0.0001, $n = 1222$). Table 2 shows the results from the Cox proportional hazards models. When used as a continuous variable DII was associated with all-cause mortality ($HR_{continuous}$: 1.14; 95%CI 1.05–1.24) and incident CHD ($HR_{continuous}$: 1.18; 95%CI 1.03–1.35) for model 2. When coded as quartiles, men in quartile 4 had a higher risk of all-cause mortality (HR_{Q4vsQ1}: 1.41; 95%CI 1.04–1.90; P-trend = 0.007) and incident CHD (HR_{Q4vsQ1}: 1.83; 95%CI 1.12–3.01; P-trend = 0.008). All associations were attenuated and became non-significant, except for all-cause mortality, after additionally adjusting for smoking in model 3. When analyses were stratified by smoking status using DII as a continuous variable, higher DII scores were associated with an increased risk of all-cause ($HR_{continuous}$: 1.15; 95%CI 1.01–1.30) and cancer mortality ($HR_{continuous}$: 1.30; 95%CI 1.02–1.64) among ex-smokers in the absence of significant heterogeneity (table 3).

Discussion

In this prospective cohort study of men, we observed an association between consuming a more pro-inflammatory diet, as reflected in higher DII scores, with increased risk of all-cause mortality and incident CHD, which was attenuated after adjusting for smoking. The association was stronger among ex-smokers for all-cause mortality and DII score also was related to cancer- mortality in this group; however, in the absence of significant heterogeneity. Tobacco smoke is considered to be a strong pro-inflammatory agent which, in addition to the pro-inflammatory diet, appears to increase the risk of mortality, in particular CVD and cancer mortality.[25,26] We did not observe any significant positive association between all-cause or cause-specific mortality or incident CHD and DII scores among current smokers. This may be due to the relatively large inflammatory effect of smoking, which may dominate that of diet-related inflammation across levels of the DII observed in this study.[27,28] The test for heterogeneity was not significant; hence, these findings should be viewed with caution. The findings among ex-smokers could have implications for public health messaging in the sense that synergistic and antagonistic effects call attention to focus on factors that may be especially effective or ineffective as prescriptions for prevention. We also observed a positive correlation between DII scores and chronic inflammation as reflected by CRP concentrations. Previously, in the same study, participants adhering to higher dietary pattern scores derived by reduced rank regression using several pro-inflammatory markers as response variables and characterized by high intakes of meat, soft drinks and beer and low intakes of vegetables, fresh fruit, chocolates, cake, pastries, whole meal bread, cereals, muesli, curd, condensed milk, cream, butter, nuts, sweet bread spread and tea had higher risk for CHD and all-cause mortality. Previously, smoking was observed to be an important confounder, especially for CHD outcomes.[29]

The results of this study are in accordance with the preponderance of findings showing that pro-inflammatory diet is associated with mortality.[13,17] In a previous study conducted among Iowa Women's Health study participants, higher DII scores were associated with total mortality as well as mortality from digestive-tract cancers, CVD, CHD and chronic obstructive pulmonary disease (COPD).[17] Similar results were observed in the National Health and Nutrition Examination Survey (NHANES) III Study except for digestive-tract cancers and COPD mortality.[30] There have been two studies conducted in Europe, one in France and another in Sweden, that have explored the association between the DII and mortality.[13,16] In the French study, DII scores were associated with increased all-cause and cancer mortality[16]; whereas in the Swedish study, which was conducted only among women, higher DII scores were associated

Table 2 HRs with 95% CIs and corresponding *P*-values of the dietary inflammatory index (DII) for different levels of adjustment for all-cause mortality, CHD, CVD and cancer mortality and incident CHD, MONICA/KORA Augsburg cohort study

	DII		DII Quartiles				
	Continuous	*P*-value	1	2	3	4	*P*-trend
Total *N* for mortality	1297		324	324	325	324	
All-cause mortality	551		110	121	157	163	
Model 1	1.10 (1.03–1.17)	0.0048	1.00	0.93 (0.72–1.21)	1.20 (0.94–1.54)	1.26 (0.99–1.62)	0.0142
Model 2[a]	1.14 (1.05–1.24)	0.0019	1.00	0.93 (0.71–1.21)	1.18 (0.90–1.55)	1.41 (1.04–1.90)	0.0069
Model 3[a]	1.09 (1.00–1.19)	0.0419	1.00	0.87 (0.66–1.13)	1.01 (0.77–1.33)	1.23 (0.91–1.66)	0.0929
CHD mortality	155		34	32	47	42	
Model 1	1.03 (0.91–1.16)	0.6371	1.00	0.78 (0.48–1.27)	1.12 (0.71–1.75)	1.00 (0.63–1.59)	0.6295
Model 2	1.08 (0.92–1.27)	0.3346	1.00	0.83 (0.50–1.38)	1.19 (0.72–1.96)	1.25 (0.71–2.21)	0.2444
Model 3	1.01 (0.86–1.18)	0.9323	1.00	0.75 (0.45–1.25)	0.94 (0.57–1.56)	1.02 (0.57–1.82)	0.7242
CVD mortality	244		53	50	67	74	
Model 1	1.06 (0.96–1.16)	0.2847	1.00	0.78 (0.53–1.15)	1.02 (0.71–1.47)	1.13 (0.79–1.62)	0.2464
Model 2	1.11 (0.98–1.26)	0.1160	1.00	0.80 (0.53–1.20)	1.04 (0.70–1.56)	1.37 (0.89–2.15)	0.0755
Model 3	1.05 (0.92–1.20)	0.4445	1.00	0.74 (0.49–1.11)	0.87 (0.58–1.31)	1.19 (0.76–1.86)	0.2950
Cancer deaths	175		36	41	51	47	
Model 1	1.08 (0.96–1.21)	0.2047	1.00	0.97 (0.62–1.53)	1.24 (0.80–1.91)	1.16 (0.75–1.80)	0.3379
Model 2	1.12 (0.97–1.30)	0.1342	1.00	0.94 (0.59–1.50)	1.19 (0.74–1.91)	1.26 (0.74–2.15)	0.2689
Model 3	1.06 (0.91–1.23)	0.4530	1.00	0.88 (0.55–1.40)	0.99 (0.61–1.60)	1.06 (0.62–1.83)	0.7081
Total *N* for incident CHD	1252		313	318	311	312	
Incident CHD	213		40	46	61	66	
Model 1	1.13 (1.02–1.25)	0.0229	1.00	1.00 (0.65–1.53)	1.29 (0.86–1.94)	1.50 (1.01–2.24)	0.0188
Model 2	1.18 (1.03–1.35)	0.0182	1.00	1.08 (0.69–1.70)	1.39 (0.88–2.18)	1.83 (1.12–3.01)	0.0078
Model 3	1.11 (0.97–1.27)	0.1309	1.00	1.00 (0.63–1.57)	1.15 (0.73–1.82)	1.53 (0.93–2.53)	0.0610

Model 1—adjusting for age and survey (S1/S3).
Model 2—additionally adjusting for BMI, place of residence, actual hypertension, education level, diabetes, physical activity, energy intake, ratio of total cholesterol and HDL cholesterol.
Model 3—additionally adjusting for smoking status.
a: Additionally adjusting for BMI^2.

with all-cause and digestive-tract cancer mortality.[13] In a recent article from the ATTICA study which used dietary anti-inflammatory index (D-AII), a modified version of the DII, after adjusting for several confounding factors, an anti-inflammatory diet, as expressed by higher DII scores, was borderline associated with 10-year CVD incidence.[31] In addition to the DII, other dietary indices such as the Alternate Healthy Eating Index (AHEI) and the A Priori Diet Quality Score predicted total, CVD-, cancer-related and non-CVD, non-CA, non-acute deaths.[32] In the Netherlands component of the EPIC study, increasing Mediterranean diet scores were found to have significant inverse association with CVD deaths.[33] It is important to note here that higher scores for these indices represent healthier diet, whereas for DII an increasing score indicates a more pro-inflammatory (i.e. unhealthy) diet.

Previous dietary patterns or indices focus on a limited number of food groups or nutrients specific to dietary guidelines or cultural ways of eating. In formulating the DII, an entirely different approach was taken by focusing on the functional effects of up to 45 foods and nutrients. As such, it relies on the very careful review and scoring of around 2000 publications in the medical literature specifically in relation to diet and inflammation. Also, it standardizes individual dietary intakes of pro- and anti-inflammatory food constituents to world referent values.

One of the possible mechanisms for this association would be through the effect of a pro-inflammatory diet on insulin resistance by increasing systemic inflammation.[34] Insulin resistance can act as a common pathway for both cancer[35] and CVD.[36] Calorie-restricted diets are known to reduce circulating levels of CRP, which is a marker of systemic inflammation that also may play a role itself in the inflammatory process, thus explaining why it has been shown to predict cardiovascular events in many studies.[37] Diets rich in omega-3 fatty acids appear to reduce atherosclerosis by the process of down-regulation of the intracellular mechanisms that lead to the expression of pro-atherogenic genes.[37] For mechanisms specific to cancer, consumption of food items such as meat and butter have been shown to be associated with markers of inflammation such as CRP, E-selectin and soluble vascular cell adhesion molecule-1,[38] which then is responsible for increasing insulin resistance.[34] Increased insulin resistance is associated with cancer, presumably by increasing circulating levels of insulin, triglycerides and non-esterified fatty acids.[39] These circulating factors promote excessive proliferation of epithelial cells.

Strengths of this study include prospective data collection with extended follow-up; near-complete outcome ascertainment; adjustment for multiple potential confounding factors. Availability of data on inflammatory markers allowed us to investigate the

Table 3 Hazard ratios (HRs) with 95% CIs and corresponding *P*-values of the DII for different levels of adjustment for all-cause mortality, CHD, CVD and cancer mortality and incident CHD stratified by smoking status, MONICA/KORA Augsburg cohort study

	Smokers	P-value	Ex-smokers	P-value	Never-smokers	P-value
Total *N* for Mortality	391		557		349	
All-cause Mortality	207		241		103	
Model 1	1.05 (0.95–1.17)	0.3557	1.11 (1.01–1.23)	0.0352	0.95 (0.82–1.10)	0.4562
Model 2[a]	1.03 (0.89–1.20)	0.6604	1.15 (1.01–1.30)	0.0311	1.05 (0.86–1.28)	0.6156
CHD mortality	64		70		21	
Model 1	0.97 (0.80–1.18)	0.7878	0.98 (0.81–1.17)	0.7924	0.98 (0.71–1.36)	0.9137
Model 2	1.12 (0.85–1.46)	0.4148	0.93 (0.73–1.17)	0.5120	1.01 (0.64–1.57)	0.9804
CVD mortality	91		110		43	
Model 1	1.05 (0.89–1.24)	0.5488	1.01 (0.87–1.18)	0.8613	0.92 (0.73–1.15)	0.4721
Model 2	1.16 (0.93–1.46)	0.1851	1.02 (0.85–1.23)	0.8356	0.95 (0.70–1.29)	0.7416
Cancer mortality	75		68		32	
Model 1	0.95 (0.80–1.13)	0.5703	1.22 (1.01–1.47)	0.0411	0.87 (0.67–1.14)	0.3078
Model 2	0.85 (0.67–1.07)	0.1700	1.30 (1.02–1.64)	0.0307	1.08 (0.75–1.55)	0.6761
Total *N* for incident CHD	382		525		345	
Incident CHD	93		87		33	
Model 1	1.10 (0.93–1.29)	0.2543	1.06 (0.90–1.25)	0.5078	1.15 (0.90–1.49)	0.2681
Model 2	1.16 (0.94–1.45)	0.1695	1.05 (0.85–1.30)	0.6303	1.14 (0.82–1.57)	0.4455

Model 1—adjusting for age and survey (S1/S3).
Model 2—additionally adjusting for BMI, place of residence, actual hypertension, education level, diabetes, physical activity, energy intake, ratio of total cholesterol and HDL cholesterol.
a: Additionally adjusting for BMI^2.

correlation between DII scores and inflammatory markers before exploring the association between DII and mortality. 7-day dietary records were used as the dietary assessment tool; this allowed for almost accurate measurement of the food consumed over each of the reference days. One recognized limitation is that dietary data were collected at baseline only, so DII scores were calculated just once. The follow-up times were quite long, especially for participants from survey S1. Dietary behavior might have changed over time, which could attenuate the observed effects between dietary behavior at baseline and outcomes. However, adult dietary patterns appear to remain relatively stable over time.[40] Another limitation is that these results were specific to men; so, further studies are needed to generalize these results to women in Germany. The study population is small, therefore, the number of events and consequently the power of the study were limited. Another reason for the small number of events is the relatively lower risk of all-cause mortality and cardiovascular events in the study population, as we analyzed men aged between 45 and 64 years at baseline from the general German population; hence, the results cannot be generalized to the overall adult population. Furthermore, while follow-up is almost complete for all incident fatal CHD cases and all non-fatal cases of myocardial infarction which occurred in the study area below the age of 75 years due to coverage by the MONICA/KORA myocardial infarction registry and mortality follow-up, we may have missed a few non-fatal cases occurring in persons aged 75 years and older due to non-response. As we analyzed our data with Cox proportional hazards models and censored these persons at the last date for which we had information or at the date when they moved out of the study area, this should only marginally affect our analysis results.

In conclusion, a pro-inflammatory diet, as evidenced by higher DII scores, was associated with a modest increase in risk of all-cause mortality and incident CHD. The associations were attenuated after adjusting for smoking and the associations were persistent and stronger for all-cause and cancer-related mortality among ex-smokers. The logical next steps would include using the DII in other studies with participants representing different age groups and include females; this would help to discern the generalizability of the study results.

Disclosure

Dr. James R. Hébert owns controlling interest in Connecting Health Innovations LLC (CHI), a company planning to license the right to his invention of the dietary inflammatory index (DII) from the University of South Carolina in order to develop computer and smart phone applications for patient counseling and dietary intervention in clinical settings. Dr. Nitin Shivappa is an employee of CHI. It is anticipated that this work will not have any direct bearing on that work.

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Key points

- Dietary Inflammatory Index is a tool that measures the inflammatory potential of individual's diet.
- In this study, we examine the association between inflammatory potential of diet and all-cause, CHD, CVD and cancer mortality and incident CHD in the MONICA-KORA Cohort Studies.
- The results from this study indicate a detrimental role of a pro-inflammatory diet, on mortality risk through a process of inflammation

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