



Original article

Do dietary patterns in older age influence the development of cancer and cardiovascular disease: A longitudinal study of ageing



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ARTICLE INFO

Article history:

Received 14 April 2014

Accepted 2 April 2015

Keywords:

Diet

Dietary patterns

Cancer

Cardiovascular disease

Older adults

SUMMARY

Background: The association between diet and cancer, and diet and cardiovascular disease (CVD) is well established in younger adults, however limited evidence exists to demonstrate that these associations persist for older adults, particularly in the context of dietary patterns.

Aims: To investigate whether the dominant dietary patterns identified in a cohort of older adults are predictive of cancer or CVD development.

Methods: This study was a secondary analysis of data from the Australian Longitudinal Study of Ageing (ALSA). The ALSA is a multi-dimensional population based study of human ageing which commenced in 1992 with 2087 participants aged 65 years or more. Data from a 170-item food frequency questionnaire administered at baseline in 1992 to 1034 older adults free from cancer and CVD was explored using factor analysis to identify dominant dietary patterns, being those patterns which comprise foods commonly consumed by the sample. Pooled logistic regression from data available at baseline, 2 and 8 years of follow-up was used to determine whether any associations existed between dietary patterns and development of or death from cancer or CVD.

Results: Five dominant dietary patterns were identified and labelled 'discretionary choices and breads and cereals', 'vegetable and fruit', 'white meat and milk products', 'breads and cereals, sweet bakery goods and milk products' and 'red meat and protein alternatives'. None of the dominant dietary patterns demonstrated a significant overall trend for the development of or death from cancer or CVD with the exception of the 'red meat and protein alternatives' pattern where an increased risk of cancer development or death was observed with adjustment for age, gender, smoking, overweight and obesity and total number of comorbidities (tertile 2: OR 1.46, 95% CI 1.03–2.07; tertile 3: OR 1.28, 95% CI 0.87–1.90). **Conclusions:** These results suggest that the development of or death from cancer and CVD may be independent of most dietary patterns in those who are free of either condition at age 70 years or older. Importantly, there was an association observed between the 'red meat and protein alternatives' pattern and cancer development and death. If these findings are confirmed then dietary guidelines for older adults may require further revision.

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1. Introduction

Increasing life expectancy will see the proportion of the world's population aged over 60 years increase from 11% to 22% by 2050,

whilst those aged over 80 years will increase fourfold [1]. Increasing age corresponds with increasing prevalence of chronic disease, including cancer and cardiovascular disease (CVD), thus posing critical challenges to health systems and policies [2,3]. Collectively these conditions contribute most (30%) to burden of disease in Australasia [4] and share common risk and protective factors [5,6]. A better understanding of the elements which contribute to the prevention of chronic disease and successful

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ageing in older persons is therefore warranted, with diet suggested to be a key influence on disease prevention and health maintenance.

The role of diet in health promotion and disease is complex to elucidate, as diet comprises a network of foods and nutrients [7]. A significant proportion of research has focused on individual nutrients, however, diet is multidimensional and encompasses various nutrient and non-nutrient interactions which occur as nutrients are eaten in combination. Multiple nutrients are also contained within the same foods, making isolation of their individual effects virtually impossible [8]. Furthermore, dietary composition can differ significantly between individuals and between populations hence dietary patterns, rather than individual nutrients, may better reflect the complexity of diet and its influential factors and may be more relevant when considering diet-disease associations.

There is sufficient evidence to support an association between diet and cancer, and diet and CVD in younger adults [9–11]. However, evidence to support the same associations in older people is limited. Existing evidence highlights that adherence to recommended dietary guidelines may positively influence quality of life and functional ability in older adults [12], however with respect to chronic disease it has been suggested that a diet inconsistent with recommendations from local dietary guidelines may not adversely influence risk in persons aged over 65 years [13,14]. Higher BMI has been associated with reduced mortality from chronic diseases including CVD in older people [15,16] and it has been suggested that a liberal diet may protect against malnutrition and frailty, whilst dietary restrictions advised for chronic disease management may confer increased risk [13,14]. A review by William and Kannel exploring associations between diet and CVD in older adults concluded that the rationale to support dietary restrictions for CVD prevention in older persons was undermined by a lack of evidence [17]. A similar review by Balducci et al. [18] highlighted the lack of evidence to suggest the effectiveness of dietary modification for prevention of cancer in the aged. Both reviews encompassed literature exploring diet in the form of nutrients only and are now almost 30 years old however very little research has been undertaken in this area since that time.

Given the paucity of evidence concerning associations between dietary patterns and chronic disease in older populations, the aims of the present study were to explore the dominant dietary patterns of older adults participating in the longest and largest Australian cohort study and to investigate whether dominant dietary patterns were predictive of cancer or CVD development.

2. Subjects and methods

2.1. Study design

The study was a secondary analysis of data from the Australian Longitudinal Study of Ageing (ALSA). The ALSA is a multi-dimensional population based study of human ageing that has generated longitudinal data over 12 waves of data collection since original recruitment in 1992 [19]. For the purpose of this study, baseline data collected at wave 1 in 1992 was used. Follow up data collected at wave 3 in 1994 and wave 6 in 2000 was used to ensure adequate time for disease development and mitigate against attrition due to age related mortality. Ethical approval for the study was obtained from the Southern Adelaide Clinical Human Research Ethics Committee. Written informed consent was obtained from all participants as part of the ALSA. The analyses in this study were conducted using data from waves 1, 3 and 6 of the ALSA which were sourced from the Centre for Ageing Studies at Flinders University (available at <http://www.flinders.edu.au/sabs/fcas/home.cfm>).

2.2. Subjects

The ALSA cohort was randomly selected from the database of the South Australian Electoral Roll. Participants were aged over 70 years on entry to the ALSA. Spouses of primary respondents aged over 65 years and other household members aged over 70 years also were invited to be included in the study. Males and females over 85 years were deliberately over sampled in order to compensate for the expected higher mortality rates of this group. A total of 2087 persons participated at wave 1 of the study. For the purpose of this secondary analysis, only those participants ($n = 1034$) who had completed a food frequency questionnaire (FFQ), were free of the chronic conditions of interest at baseline (cancer and CVD) and provided data at both the 2 and 8 year follow up were included, as illustrated by Fig. 1.

2.3. Dietary exposure

Dietary intake was measured at baseline using the 170-item FFQ 'You and Your Diet'. The FFQ is a validated self-completed survey used to determine a participant's usual food intake [20,21]. Food frequency questionnaire analysis occurred with assistance from the Commonwealth Scientific and Industrial Research Organisation and all data were independently double entered to minimise error [20]. The nutrient intake of individual foods were ascertained using the NUTTAB database which contains nutrient data for a wide variety of foods available in Australia [22]. In the absence of NUTTAB data McCance and Widdowson food tables and USDA (US Department of Agriculture) data was used [23,24]. Where a new food was introduced to the market, data sourced from manufacturers and product labels were used if necessary.

2.4. Food grouping

In order to aid interpretability and minimise individual variations in intakes of food items, intakes of the 170 food and beverage items were reclassified into 18 food groups (see Table 1) to use as input variables for principal components analysis (PCA), a form of factor analysis. Given that the ALSA cohort comprises mostly Australian citizens, food groups were primarily defined according to recommendations by the current Australian dietary guidelines [25], so that any derived dietary patterns could be compared to dietary recommendations relevant to the cohort. Food groups were also further defined where necessary according to hypothesised or previously demonstrated associations between food items and major nutrient content of certain foods and cancer or CVD (e.g. fats and oils associated with CVD risk [26] and red meat associated with the risk of some cancers [27]).

2.5. Outcomes

The diseases of interest were all forms of cancer and CVD or death from either. Development of disease was determined by participant diagnoses reports (answered 'yes' to question 'do you suffer from this condition at present?' regarding conditions relevant to cancer and CVD). ALSA participants were excluded from further analyses pertaining to the development of cancer or CVD if they reported suffering from the relevant conditions at baseline. Cardiovascular disease was defined as all diseases of the heart and blood vessels as defined by the World Health Organisation (WHO) [28], and those who answered yes to suffering from a 'heart attack', 'heart condition', 'small stroke', 'stroke/CVA' or 'other vascular disease' were considered to have CVD. Participants were considered to have cancer if they answered yes to 'have you been diagnosed with cancer?' Deaths (date and cause) were systematically

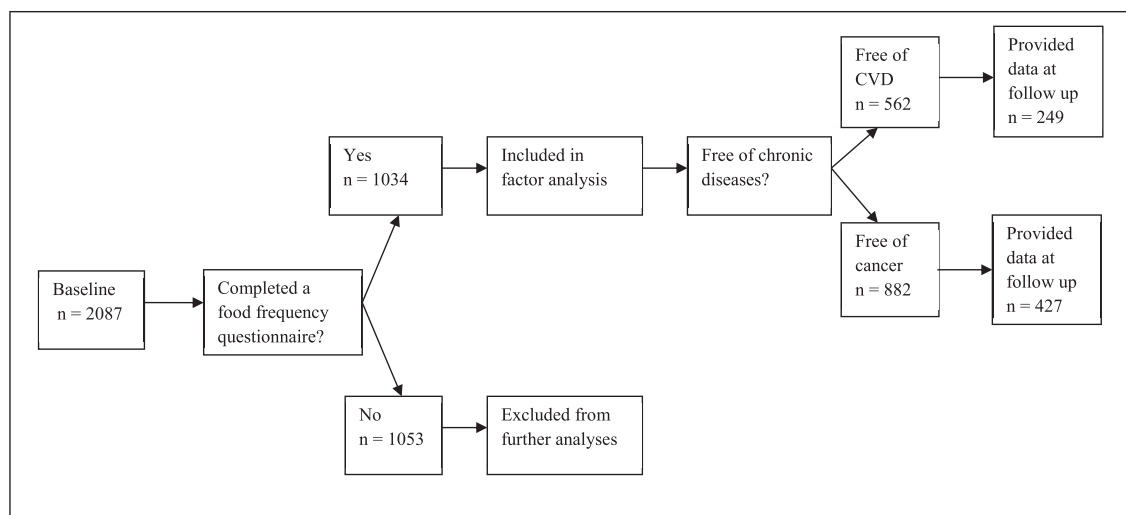


Fig. 1. Participants from the Australian Longitudinal Study of Ageing included in the present study. CVD, cardiovascular disease.

monitored annually for participants of the ALSA through the government Registry of Births, Deaths and Marriages.

2.6. Principal component analysis

Dietary patterns were extracted by factor analysis (PCA) using SPSS version 19.0 (SPSS Inc.). To assess the suitability of data for PCA, several factors were inspected. Examination of the correlation matrix revealed the presence of many coefficients ≥ 0.3 . The Kaiser–Meyer–Olkin measure of sampling adequacy was 0.87, exceeding the recommended value of 0.6 and Bartlett’s test of Sphericity achieved statistical significance, thus confirming the factorability of the data. To aid interpretation of the factor loadings, orthogonal (Varimax) rotation was applied and the variance within factors was increased, thereby providing distinction between factors. Potential PCA solutions were analysed for strength of loadings on food groups and across factors. Higher correlations of individual food groups to the factor indicated a greater contribution of that food group to a specific factor. Five dietary patterns were identified

as based on eigenvalues > 1.0 , parallel analysis, identification of a clear break in the scree plot and interpretability. Dietary pattern regression scores were calculated so that all participants were assigned a score for each dietary pattern based on their FFQ intakes. Dietary pattern scores were separated into tertiles for the purpose of logistic regression. Patterns were named according to those food groups loading ≥ 0.4 [29].

2.7. Statistical analysis

Analyses were performed with the use of the SPSS version 19.0.0 and STATA version 13.0. Results were presented as mean and standard deviation and independent-samples t-tests were used to compare across two groups while ANOVA was used to compare across more than two groups. Chi-squared (χ^2) test of association was used for comparisons between categorical variables. Pooled logistic regression was used with dietary patterns generated from baseline FFQ data identified as the independent variable. Cancer or CVD at follow up, or death from either condition, was identified as

Table 1
Food groupings used in dietary pattern analysis.

Food groups	Included food and beverage items
Fats and oils	Butter, fat spreads, oils, polyunsaturated dressings
Confectionary and sugars	Cordial, soft drinks, toffees, lollies, honey, jam, sugar
Other discretionary choices	Cream, ice-cream, ham, fritz, salami, hamburgers, pizza, sausage rolls, meat pies, pasties, pate, crisps, hot chips, sausages, frankfurts, bacon
Salted nuts and salted nut products	Salted peanuts, other salted nuts, peanut butter
Yellow, orange and red vegetables	Carrot, pumpkin, tomato, red capsicum
Leafy and green vegetables	Green beans, zucchini, spinach, lettuce, cucumber, celery, endive
Cruciferous vegetables	Cabbage, Brussel sprouts, broccoli, cauliflower, turnip
Starchy vegetables	Potato (mashed, boiled or roasted), sweet corn
Other vegetables	Pickled onion, pickled vegetables, onion, mushrooms, olives, avocado
Fruit	Orange, apple, banana, berries, pineapple, melon, peach, nectarine, apricot, figs, grapes, dried fruit, tinned fruit
Fish and seafood	Fish (fried, steamed or baked), tuna, sardines, mornay (tuna or salmon based)
Poultry	Chicken (boiled, fried or roasted)
Milk and milk products	Milk, milk based drinks (Sustagen, Aktavite, or milo made with milk), cheese, ricotta cheese, cottage cheese, parmesan cheese, yoghurt, custard
Biscuits, cakes and puddings	Sweet buns, doughnuts, plain biscuits, cream-filled biscuits, chocolate biscuits, cake, milk puddings, fruit pies
Breads and cereals	Porridge, muesli, breakfast cereals, bran, bread, rice, risotto, pasta, crackers, crumpets, muffins, fruit bread
Red meat	Steak, casserole meat, pork chops, lamb chops, roasted red meat, minced meat
Offal meat	Kidney, liver, brains
Protein alternatives	Baked beans, dried beans, other tinned beans, eggs, unsalted nuts

the dependent variable. The regression models were adjusted for potential confounding factors: age, sex, overweight and obesity, smoking status and number of co-morbidities. WHO identifies smoking and overweight and obesity as risk factors for cancer and CVD [3]. As the dietary pattern scores were related to age, gender and number of co-morbidities, statistical analyses also controlled for the effect of these variables. All confounding factors excluding age and number of co-morbidities were treated as categorical variables. Participants who answered yes to 'do you currently smoke cigarettes', 'have you ever smoked cigarettes regularly in the past', or 'have you ever regularly smoked a pipe or cigars' were considered smokers. Overweight and obesity were identified in participants where their BMI was $>25 \text{ kg/m}^2$ or 30 kg/m^2 respectively. Regression coefficients were expressed as odds ratios (OR). The ORs were considered statistically significant if the 95% CI did not include unity. All reported *P*-values are two sided. In all analyses the level of significance was set at $P < 0.05$.

3. Results

Baseline characteristics of 2087 ALSA participants according to FFQ completion are shown in Table 2. Participants who completed the FFQ were more likely to be male, younger, live unsupported in the community and have more co-morbidities. Figure 1 describes the selection of the ALSA sample included in each analysis in the present study. The follow up rate of ALSA participants who completed FFQ at baseline after 8 years was 46% ($n = 480$) due to high rates of mortality. The incidence of cancer over the 8 years of follow up was 19% ($n = 79$) and CVD was 28% ($n = 70$). At follow up, 10% ($n = 100$) of mortality was attributed to cancer cases and 40% ($n = 412$) death cases were attributed to CVD.

Five dietary patterns were extracted by PCA. The five-factor solution explained a total of 52% of the variance, with factor 1 contributing 18%, factor 2 contributing 13%, factor 3 contributing 8%, factor 4 contributing 7% and factor 5 contributing 6%. Factor-correlation matrices for the 5 patterns are listed in Table 3. The first factor was highly correlated with the following food groups: fats and oils, other discretionary choices (including processed meats and takeaway foods) and breads and cereals (labelled as the discretionary choices and breads and cereals pattern); the second with all vegetable groups and fruit (labelled as the vegetable and fruit pattern); the third with fish and seafood, poultry and milk and milk products (labelled as the white meat and milk products pattern); the fourth with milk and milk products, breads and cereals and biscuits, cakes and puddings (labelled as the breads and cereals, sweet bakery goods and milk products pattern); the fifth with red meat, offal meat and protein alternatives (labelled as the red meat and protein alternatives pattern).

Participant characteristics according to dietary pattern scores are shown in Table 4. Those with a higher 'discretionary choices and breads and cereals' pattern score were more likely to be younger

and male than those with a lower score for this pattern. Participants with a higher 'vegetable and fruit' pattern score were more likely to be younger, female and have more co-morbidities. In contrast, those with a higher 'breads and cereals, sweet bakery goods and milk products' pattern score were more likely to be older and male, as were those with a higher score of the 'red meat and protein alternatives' pattern. No significant differences were found for those with higher scores of the 'white meat and milk products' pattern.

Table 5 describes the results for the pooled logistic regression analyses where the outcome of incident cancer or CVD is combined with death from either cause respectively. A statistically significant positive association was observed between the 'red meat and protein alternatives' dietary pattern and development or death from cancer (tertile 2: OR 1.46, 95% CI 1.03–2.07; tertile 3: OR 1.28, 95% CI 0.87–1.90) following adjustment for age, sex, overweight and obesity, smoking status and number of comorbidities. No further associations between the dominant dietary patterns of the ALSA cohort and CVD or cancer development or death were identified.

4. Discussion

This study found that the dominant dietary patterns of the ALSA cohort included those labelled 'discretionary choices and breads and cereals', 'vegetable and fruit', 'white meat and milk products', 'breads and cereals, sweet bakery goods and milk products' and 'red meat and protein alternatives'. After 8 years of follow up, there were no significant overall trends between the five dominant dietary patterns identified and the development or death from cancer or CVD except for the 'red meat and protein alternatives' pattern which increased risk of cancer and death from cancer.

The two most dominant dietary patterns of the ALSA cohort are similar to those identified in previous studies of younger adults. Commonly identified patterns in the literature are generally deemed 'healthy' or 'unhealthy', or 'prudent' or 'Western' [30–32]. Hu et al. [30] identified 2 major patterns using factor analysis labelled 'Western' characterised by intakes of high fat foods, refined grains and sweet foods, and 'prudent' characterised by high intakes of vegetables, fruits, legumes, grains, fish and poultry. Slattery et al. [31] and Kerver [32] also derived two major dietary patterns labelled 'Western' and 'prudent' which were characterised similarly. The similarity between the two dominant dietary patterns in this study and the previously published 'Western' and 'prudent' patterns increases confidence that factor analysis generated meaningful dietary patterns.

Slattery et al. [31] and Hu et al. [30] identified additional patterns however these patterns were not included in their analyses. Further analyses of minor dietary patterns may have shown additional associations between dietary patterns and disease risk. The exploration of additional dietary patterns within the present study allows a more comprehensive evaluation of diet-disease risk associations at a population level, as a greater proportion of between-

Table 2

Baseline characteristics of participants in the Australian Longitudinal Study of Ageing, according to Food Frequency Questionnaire completion.^a

Variable	Completed FFQ ($n = 1034$)	Did not complete FFQ ($n = 1053$)	P-value
Age, mean (SD)	77.3 (5.4)	79.1 (7.6)	<0.001
Community living, %	100%	88%	<0.001
Males, %	55%	46%	<0.001
Number of co-morbidities, mean (SD)	5.6 (2.9)	5.0 (3.1)	<0.001
BMI, mean (SD)	26.1 (4.0)	26.0 (4.2)	0.492
Cardiovascular disease, %	37%	35%	0.298
Cancer, %	15%	14%	0.462
Self-rated health, excellent, %	10%	8%	0.059

^a FFQ food frequency questionnaire, SD standard deviation.

Table 3
Factor-loading matrix for the dominant factors (dietary patterns) identified using food and beverage intake data from the Food Frequency Questionnaire ‘You and Your Diet’ administered at baseline in 1992.^a

Grouped food items	Factor loadings				
	Discretionary choices and breads and cereals	Vegetable and fruit	White meat and milk products	Breads and cereals, sweet bakery goods and milk products	Red meat and protein alternatives
Fats and oils	0.948	0.046	0.002	0.012	0.017
Confectionary and sugars	0.152	−0.111	−0.069	0.178	0.224
Other discretionary choices	0.852	0.023	−0.020	0.178	0.195
Salted nuts and salted nut products	0.110	0.060	0.012	0.102	0.368
Yellow, orange and red vegetables	0.017	0.810	−0.004	−0.004	−0.043
Leafy and green vegetables	0.011	0.776	0.065	0.009	0.092
Cruciferous vegetables	0.026	0.576	0.292	−0.068	0.028
Starchy vegetables	0.069	0.515		0.064	0.259
Other vegetables	0.120	0.452	0.363	−0.214	0.223
Fruit	0.005	0.529	0.241	0.168	−0.043
Fish and seafood	0.020	0.068	0.760	−0.019	0.140
Poultry	0.040	0.119	0.575	−0.016	−0.010
Milk and milk products	0.056	0.096	0.470	0.462	0.002
Biscuits, cakes and puddings	0.077	0.037	−0.008	0.817	−0.020
Breads and cereals	0.875	0.067	0.161	0.653	−0.019
Red meat	0.114	0.242	−0.064	0.152	0.510
Offal meat	−0.105	−0.028	0.009	−0.083	0.660
Protein alternatives	0.026	−0.006	0.294	0.000	0.600

Bold values highlight the most prominent food items in terms of factor loadings for each of the identified dietary patterns.

^a Dietary patterns named according to food groups loading >0.4.

person dietary variance is accounted for. The inconsistencies observed between the additional dietary patterns identified within the ALSA cohort and those previously published may reflect expected disparities in eating habits across different cultures and younger and older populations [33].

The ‘red meat and protein alternatives’ pattern was significantly associated with development of or death from cancer, with increasing intakes increasing risk. This may relate to the pattern being high in saturated fat, an established predictor of cancer [34]. We did not however observe the same association between this

Table 4
Baseline characteristics of participants in the Australian Longitudinal Study of Ageing according to tertiles of factor (dietary pattern) scores.^a

Dietary patterns	Participant characteristics							
	Age, mean (SD) n = 1034	Community Living, % n = 1034	Males, % n = 573	Number of co-morbidities, mean (SD) n = 1034	BMI, mean (SD) n = 1034	CVD, % n = 472	Cancer, % n = 152	Self-rated health, excellent, % n = 107
Discretionary choices and breads and cereals								
T1 ^b	77.9 (5.6) ^a	100%	45%	5.9 (2.9)	26.2 (4.2)	50%	13%	9%
T2	77.3 (5.3)	100%	53%	5.5 (2.7)	26.0 (3.8)	46%	15%	9%
T3	76.6 (5.4)	100%	69%	5.6 (2.9)	26.2 (3.9)	41%	16%	13%
P for trend	0.011	—	<0.001	0.169	0.776	0.054	0.354	0.105
Vegetable and fruit								
T1	78.0 (5.7)	100%	66%	5.2 (2.9)	25.8 (3.9)	45%	15%	11%
T2	77.1 (5.4)	100%	57%	5.7 (2.7)	26.3 (4.1)	45%	12%	9%
T3	76.6 (5.2)	100%	42%	6.0 (3.0)	26.1 (3.9)	47%	17%	11%
P for trend	0.003	—	<0.001	0.001	0.492	0.837	0.188	0.621
White meat and milk products								
T1	77.4 (5.5)	100%	59%	5.4 (2.7)	26.2 (4.0)	40%	14%	11%
T2	77.5 (5.7)	100%	54%	5.7 (3.0)	26.0 (4.0)	48%	17%	9%
T3	76.9 (5.2)	100%	55%	5.8 (2.8)	26.2 (3.9)	49%	13%	12%
P for trend	—	—	0.454	0.244	0.885	0.059	0.220	0.453
Breads and cereals, sweet bakery goods and milk products								
T1	76.7 (5.5)	100%	50%	5.7 (2.8)	26.0 (4.1)	48%	14%	12%
T2	77.3 (5.3)	100%	53%	5.5 (2.8)	26.3 (3.9)	43%	14%	9%
T3	77.8 (5.5)	100%	64%	5.7 (3.0)	26.1 (3.9)	45%	17%	11%
P for trend	0.022	—	0.001	0.575	0.754	0.429	0.404	0.457
Red meat and protein alternatives								
T1	76.9 (5.3)	100%	46%	5.6 (2.9)	26.1 (4.0)	51%	15%	10%
T2	77.0 (5.4)	100%	56%	5.7 (2.8)	26.2 (3.9)	45%	12%	9%
T3	78.0 (5.7)	100%	66%	5.6 (3.0)	26.1 (4.2)	40%	18%	12%
P for trend	0.025	—	<0.001	0.965	0.980	0.27	0.143	0.630

Bold values highlight the most prominent food items in terms of factor loadings for each of the identified dietary patterns.

^a SD standard deviation, CVD cardiovascular disease.

^b Tertile 1 (lowest tertile of intake), Tertile 2 (middle tertile of intake), Tertile 3 (highest tertile of intake).

Table 5

Odds ratios (95% confidence intervals) of cancer and cardiovascular disease development and mortality according to tertiles of dietary pattern scores.

Dietary pattern		Model 1 ^a	P for trend	Model 2 ^b	p for trend
Cardiovascular disease					
Discretionary choices and breads and cereals					
T1	212/336	1.0	0.213	1.0	0.307
T2	219/348	1.70 (0.94, 3.07)		1.61 (0.88, 2.96)	
T3	200/350	1.40 (0.78, 2.51)		1.37 (0.72, 2.45)	
Vegetable and fruit					
T1	203/346	1.0	0.053	1.0	0.056
T2	227/371	1.66 (0.92, 2.98)		1.77 (0.96, 3.28)	
T3	201/317	2.07 (1.14, 3.77)		2.16 (1.14, 4.09)	
White meat and milk products					
T1	184/321	1.0	0.471	1.0	0.463
T2	232/365	0.97 (0.55, 1.70)		0.93(0.52, 1.65)	
T3	215/348	0.72 (0.40, 1.29)		0.70 (0.38, 1.27)	
Breads and cereals, sweet bakery goods and milk products					
T1	224/361	1.0	0.302	1.0	0.311
T2	200/321	1.50 (0.84, 2.67)		1.58 (0.87, 2.87)	
T3	207/352	1.04 (0.60, 2.83)		1.18 (0.65, 2.15)	
Red meat and protein alternatives					
T1	229/349	1.0	0.315	1.0	0.424
T2	239/384	1.14 (0.65, 1.98)		1.12 (0.67, 2.12)	
T3	163/301	0.73 (0.40, 1.34)		0.80 (0.42, 1.53)	
Cancer					
Discretionary choices and breads and cereals					
T1	49/336	1.0	0.223	1.0	0.330
T2	57/348	0.87 (0.48, 1.57)		0.80 (0.44, 1.48)	
T3	54/350	1.40 (0.81, 2.42)		1.25 (0.70, 2.26)	
Vegetable and fruit					
T1	51/346	1.0	0.926	1.0	0.984
T2	56/371	1.10 (0.63, 1.95)		0.95 (0.52, 1.72)	
T3	53/317	1.12 (0.61, 2.02)		0.96 (0.51, 1.81)	
White meat and milk products					
T1	46/321	1.0	0.267	1.0	0.334
T2	60/365	0.77 (0.42, 1.41)		0.71(0.38, 1.32)	
T3	54/348	1.23 (0.71, 2.14)		1.08 (0.61, 1.92)	
Breads and cereals, sweet bakery goods and milk products					
T1	56/361	1.0	0.639	1.0	0.505
T2	45/321	1.05 (0.58, 1.91)		1.18(0.64, 2.19)	
T3	59/352	1.28 (0.74, 2.21)		1.40 (0.80, 2.46)	
Red meat and protein alternatives					
T1	58/349	1.0	0.404	1.0	0.532
T2	60/384	1.67 (0.73, 2.16)		1.63 (0.67, 2.02)	
T3	42/301	0.84 (0.46, 1.56)		0.82 (0.43, 1.55)	

^a Model 1: logistic regression performed on tertiles of respective dietary pattern scores.^b Model 2: logistic regression performed on tertiles of respective dietary pattern scores including adjustment for confounders: smoking (current or past smoker), alcohol use (consumed alcohol at least 2 times per week and typically 3 or more alcoholic drinks on each occasion), overweight (BMI > 25 kg/m²) and obesity (BMI > 30 kg/m²), physical inactivity (did not engage in any exercise in the past 2 weeks) and diabetes (informed by doctor).

dietary pattern and development of or death from CVD which is surprising given the established link between saturated fat and hyperlipidaemia, even amongst older adults [13]. Further research is required to explore this inconsistency further.

There appear to be no prospective studies that have considered the association between dietary patterns and cancer and CVD development or death from either disease in older adults. Limited evidence in the area has explored diet in the form of individual nutrients and outcomes of hypertension, hyperlipidaemia, type 2 diabetes, obesity, overall morbidity and overall mortality [13,14]. Such evidence suggests that with the exception of saturated fat, a diet inconsistent with recommendations may not adversely influence chronic disease in persons aged over 65 years.

Overall, the lack of association observed may be explained by several considerations. Firstly, those who survive to older age may have less risk of chronic disease in general due to protective genetic and/or factors in relation to the development of chronic diseases [35]. Secondly, the process of cancer and CVD development may occur earlier than the mean age of participants (77.3 ± 5.4 years), and thus any diet-disease association may have been missed.

Thirdly, dietary patterns in younger adults are different to those in older adults and thus dietary patterns of the aged may not be representative of aetiology. Finally, it is possible that participants who developed cancer or CVD were unable to participate in wave 6 due to illness, or died prior to wave 6 of causes other than cancer or CVD.

Dietary guidelines are developed to promote health and reduce the risk of chronic diseases with the national dietary guidelines for the United States, United Kingdom, Canada and Australia including recommendations for older age groups. Based on the results of this secondary analysis, with the exception of moderate-high intakes of 'red meat and protein alternatives', the dietary habits of older adults do not influence development or death from either cancer or CVD. However, to our knowledge there have been no investigations into the effect of dietary patterns, on the incidence of other chronic disease such as type 2 diabetes and hyperlipidaemia and should be a consideration for further research in this area, with any similar findings in relation to the development of chronic lifestyle diseases strengthening the evidence for liberalisation of dietary guidelines for older adults.

This study is the first to consider the influence of dietary patterns on the development of and death from cancer and CVD in older adults. The measurement of chronic disease was subjective in its basis on participant self-reports of diagnosis, which introduces the potential for recall bias. Ideally medical diagnoses would be used to identify cancer and CVD, however these clinical data were not collected as part of the ALSA and hence present a limitation of this study worthy of acknowledgement. Furthermore, cancer was identified using the variable 'cancer diagnosed', which encompasses all cancer types, not all of which are related to diet. Logistic regression analysis was trialled using diet-related cancers, however this resulted in an insufficient sample size and the goodness of fit tests for the models produced did not reach statistical significance. It is therefore possible that the lack of association observed for patterns other than 'red meat and protein alternatives' may be attributed to inclusion of non-diet-related cancers. There was, however, a long follow up time between baseline and wave 6 which allowed 8 years for cancer and CVD development, thereby optimising the potential sample size for analyses and minimising potential for type 2 error. The use of dietary pattern analysis, however, can only be as good as the method of dietary assessment upon which it is based. The FFQ is a retrospective measure of diet which carries the potential for recall bias, which is of particular concern given the demographics of this study sample. The FFQ used did not allow differentiation between wholegrain and refined bread and cereal products, and whole fat and low fat milk and dairy products, which may have masked any associations with dietary patterns which incorporated these food groups and disease outcomes. However, the reproducibility and validity of dietary patterns using data from FFQs has been demonstrated [36]. Standard protocols were used for all measurements, and trained professionals conducted all clinical assessments including anthropometric measures, which reduces the potential for systematic error. Finally, the selection of the ALSA cohort from the South Australian electoral roll database was random, thereby minimising the potential for selection bias and increasing confidence in the generalisability of the findings.

In conclusion, none of the dominant dietary patterns were found to be positively associated with the development or death from cancer or CVD in older adults with the exception of the association between 'red meat and protein alternatives' and risk of or death from cancer. This is an important message for the development of future dietary guidelines. Further research exploring dietary patterns and additional chronic diseases may provide additional evidence to support liberalisation of dietary recommendations for healthy older adults.

Author contributions

HN, JT, AY, ML and MM were involved in design of the research, HN performed statistical analysis, HN, JT, AY, ML, CD, BK and MM interpreted data and contributed to the preparation of the manuscript for submission. All authors approved the final draft. None of the authors had any conflicts of interest.

Sources of support/funding

The Australian Longitudinal Study of Ageing was initially funded by a grant from the US National Institute of Health (Grant No. AG 08523-02), with additional funding from the South Australian Government, Flinders University and other NGOs. Subsequent funding has been provided by the Australian Research Council (ARC-LP 0669272, ARC-LP 100200413, ARC-DP 0879152 and ARC-DP 130100428) and the National Health & Medical Research Council (NH&MRC 179839 and 229922).

Conflict of interest

None declared.

Acknowledgements

We would like to thank the participants in the Australian Longitudinal Study of Ageing, who have kindly donated their time over many years. We wish to acknowledge the work of the project team at the Flinders Centre for Ageing Studies, Flinders University who carried out the ALSA and provided data for the present paper.

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