Original Article

Longitudinal nutritional changes in aging Australian women

Edward Hill BSc[1,2], Allison Hodge PhD[3,4], Peter Clifton FRACP[5], Nitin Shivappa PhD[6,7,8], James R Hebert ScD[6,7,8], Lorraine Dennerstein AO[9], Stephen Campbell FRACP[10], Cassandra Szoeke GAICD[1,2]

[1]*Centre for Medical Research, Department of Medicine-Royal Melbourne Hospital, University of Melbourne, Victoria, Australia*
[2]*Institute for Health & Ageing, Melbourne, Victoria, Australia*
[3]*Cancer Epidemiology and Intelligence Division, Cancer Council of Victoria, Melbourne, Victoria, Australia*
[4]*Centre for Epidemiology and Biostatistics, University of Melbourne, Australia*
[5]*School of Pharmacy and Medical Sciences, University of South Australia, Adelaide, South Australia, Australia*
[6]*South Carolina Statewide Cancer Prevention and Control Program, University of South Carolina, Columbia, USA*
[7]*Department of Epidemiology and Biostatistics, Arnold School of Public Health, University of South Carolina, Columbia, USA*
[8]*Connecting Health Innovations LLC, Columbia, USA*
[9]*Department of Psychiatry, University of Melbourne, Victoria, Australia*
[10]*Melbourne Health, Melbourne, Australia*

Background and Objectives: The importance of diet for the maintenance of health during aging is attracting a growing body of research interest. Given dietary intakes, along with BMI, are substantial contributors to disease burden, this study aimed to investigate prospective changes in dietary patterns and nutrient intakes in a sample of mid to late-life women over 14 years. **Methods and Study Design:** Participants were from the Women's Healthy Ageing Project (WHAP); a longitudinal cohort of Australian-born women within the Melbourne metropolitan area. 173 participants were included in this analysis, their mean age in 1998 was 55 years (range 51-62) and in 2012 was 70 years (range 66-76). Diet was assessed using the Dietary Questionnaire for Epidemiological Studies Version 2 in 1998 and 2012. Nutritional intakes, Dietary Inflammatory Index (DII®) scores, Mediterranean Diet (MD) scores, sociodemographic and physical measures were calculated for all participants at both time points. **Results:** Energy intake was found to significantly decrease over time ($p<0.005$). Energy-adjusted (i.e., energy density) total fat, saturated fat, monounsaturated fat and cholesterol intakes increased over time (all $p<0.002$), while energy-adjusted and absolute carbohydrate intake decreased ($p<0.002$). Adherence to the MD decreased over time ($p<0.001$) whilst DII scores increased slightly over time, although this result was not significant. **Conclusions:** This study shows significant changes in the intake of energy and several nutrients in a cohort of aging Australian women in the Melbourne metropolitan area over a period of 14 years. Between 1998 and 2012, changes in indices reflecting overall diet were consistently in the direction of a poorer diet.

Key Words: epidemiology, nutrition, Mediterranean diet, dietary inflammatory index, prospective studies

INTRODUCTION

With global populations surviving longer, research is shifting focus toward the promotion of healthy aging. A growing body of research acknowledges the importance of diet for the maintenance of health during aging.[1] Because there is a natural decrease in caloric intake with aging,[2,3] the investigation of nutritional sufficiency in aging adults is particularly important in order to maximize quality of life and the independence of individuals in the community. Over the last few decades there has been a great change in the cooking and eating habits of the Australian population. Greater consumption of energy-dense foods and larger portion sizes have resulted in excessive energy intake, leading to overweight and obesity.[4] A comparative investigation into the 1995 and 2011-2012

Corresponding Author: Cassandra Szoeke, Department of Medicine (Royal Melbourne Hospital), University of Melbourne, Level 4, Centre for Medical Research, Parkville, VIC, Australia, 3050.
Tel: + 61 3 8344 1835
Email: cszoeke@unimelb.edu.au
Manuscript received 13 September 2018. Initial review completed 14 October 2018. Revision accepted 11 November 2018.
doi:

National Nutrition Surveys found per capita decreases in fruit and vegetable intake but increases in per capita wine, cocoa, nuts and seafood intake.[5] Furthermore, the substantial differences in health and longevity between men and women may be attributed to nutritional status.[6-9] According to the most recent Australian Health Survey (2011-2012), the proportion of overweight and obese adult women has risen from 54.7% in 2007-2008 to 56.2% in 2011-2012.[10] As dietary intakes, along with BMI, are among the leading risk factors contributing to the burden of disease in Australasia,[11,12] research into the changing dietary patterns of aging Australians is important.

The sociodemographic circumstances of aging individuals can impact nutritional inadequacies that may contribute to loss of function and disease. Widowhood is common in older women and has been associated with a decrease in dietary quality.[13,14] Widowhood also places older adults at a greater risk for depression,[15] which has been associated with several chronic diseases such as diabetes,[16] cancer[17] and coronary heart disease.[18] Dietary variety also is decreased for those living alone.[19] Education is consistently associated with higher diet quality in elderly men and women,[20] and a systematic review found dietary intake changed as a function of employment transition to retirement.[21]

In contrast with conventional nutritional approaches that focus on a single nutrient, dietary pattern analysis examines the diet overall.[22] Dietary patterns reflect interrelated actions of multiple food components and have been shown to represent dietary intake and to be consistently associated with all-cause, cardiovascular and cancer mortality.[23] A growing body of evidence supports the beneficial role of the Mediterranean Diet (MD),[24] characterized by high consumption of fruits, vegetables, nuts, legumes, cereals and fish; a moderate intake of alcohol; and a low intake of meat and dairy.

The dietary inflammatory index (DII®) has been established as an indicator of an individual's dietary inflammatory potential. Based on an extensive literature review of the pro- or anti-inflammatory properties of foods and nutrients, the DII identified 45 items with reported associations with biomarkers of inflammation and derives a total score based on the individual intakes of these food parameters.[25] A higher DII score reflects a more pro-inflammatory diet while a lower DII score is more anti-inflammatory. The method of deriving the DII as an overall marker of dietary quality based on a physiological mechanism, inflammation, is in contrast to previously used methods which have assessed adherence to a predefined dietary pattern (e.g., Med Diet Score, Alternate Healthy Eating Index) or have used statistical techniques to find patterns within dietary data (e.g., principal components analysis/factor analysis or cluster analysis).[26] Diets having a low DII score are characterized by high intakes of fruit and vegetables and other plant-based foods, and would be considered 'healthy' according to other methods.[27,28] Higher DII scores have been associated with inflammatory biomarkers and HOMA insulin resistance.[29-31] Prospective studies have reported positive associations between DII scores and myocardial infarction,[32] lung cancer,[27] prostate cancer,[33] breast cancer,[34] and metabolic syndrome.[35] DII scores also have been shown to be associated with all-cause, cardiovascular and cancer mortality.[36]

Despite the expanding use of dietary patterns in nutritional epidemiology,[37-39] relatively few studies have investigated temporal changes in dietary patterns. Adherence to a MD pattern remained stable in women in the Nurse's Health Study over 14 years.[40] Mishra et al (2006)[41] used a modified factor analysis to derive dietary patterns from three time points for men and women in the UK. For women, three patterns were identified, over time there was an increase in consumption of foods from ethnic foods and alcohol; and fruit, vegetables and dairy patterns; while consumption of foods from the meat, potatoes and sweet food pattern decreased.[41] In a prospective investigation over 4 years, Mulder et al (1998)[42] found age and socioeconomic status influenced lifestyle behaviors, including alcohol consumption and diet. Cross-sectional research in a prospective cohort study in Melbourne found greater MD adherence was associated with a reduction in mortality among Anglo-Celts and Greek-Australians.[43] Knowledge of the longitudinal stability and influencers of dietary intake could aid researchers in suggesting dietary interventions, tracking trends in dietary stability and minimizing the necessity for frequent data collection. Furthermore, investigating the temporal nature of dietary patterns and disease course could elucidate the ideal window for the timing of interventions.

To the best of our knowledge, only one study has investigated longitudinal DII changes in women.[44] In the observational study of the Women's Health Initiative, DII scores fell from -1.14 (+/-2.58) at baseline to -1.50 (+/-2.60) three years later, indicating a move to a slightly less inflammatory diet. Decreases in DII scores over time were associated with demographic and lifestyle characteristics, including having a normal BMI, being highly educated and of Asian/Pacific Island or European-American origin rather than African-American or Hispanic origin. Despite the large numbers (around 76,000 women) this study does not provide information on dietary change over the longer term. Our aim in this paper is to describe prospective changes in dietary patterns and nutrient intakes in a sample of mid to late-life women in the Melbourne metropolitan area. We hypothesized temporal changes in indices reflecting dietary choices would be in the direction of a poorer diet.

METHODS

Cohort

This study utilised data collected as part of the 1998 and 2012 follow-up (Table 1) of the ongoing cohort study; The Women's Healthy Aging Project (WHAP). WHAP is a longitudinal, epidemiological study of 438 midlife women in the Melbourne (Australia) metropolitan area. Participants were originally recruited in 1991 by random digit dialing and were eligible for the study if they were Australian-born, aged 45-55 years, had menstruated in the three months prior to recruitment and were not on any form of hormone replacement therapy.[45] The WHAP has been approved by the University of Melbourne Human Research Ethics Committee (HREC: 931149X , 1034765 & 1750632.1). The study was conducted in accordance

Table 1. Sociodemographic characteristics of WHAP in 1998 and 2012 (n=173)

	1998	2012
Age		
Mean age in years	55.1	69.8
Marital Status		
Single	6 (3.5%)	5 (2.9%)
Married	132 (76.3%)	107 (61.8%)
Divorced	18 (10.4%)	24 (13.9%)
Separated	5 (2.9%)	5 (2.9%)
Widowed	8 (4.6%)	25 (14.5%)
Other	4 (2.3%)	7 (4%)
Education		
Primary school	3 (1.7%)	
Secondary school	88 (50.9%)	
Technical or commercial/TAFE	8 (4.6%)	
Tertiary diploma	29 (16.8%)	
University or CAE degree	45 (26.0%)	
BMI		
Underweight (18.5 kg/m^2)	0 (0%)	0 (0%)
Healthy weight (≥18.5 and <25 kg/m^2)	64 (37%)	52 (30.1%)
Overweight (≥25 and <30 kg/m^2)	68 (39.3%)	69 (39.9%)
Obese (≥30 kg/m^2)	41 (23.7%)	52 (30.1%)
Smoking status		
Current smoker	23 (13.3%)	14 (8.1%)
Current non-smoker	150 (86.7%)	159 (91.9%)
Paid employment		
Currently in paid employment	122 (70.5%)	40 (23.1%)
Currently not in paid employment	51 (29.5%)	133 (76.9%)
Volunteer work		
Currently doing unpaid work	96 (55.5%)	95 (54.9%)
Currently not doing unpaid work	77 (44.5%)	78 (45.1%)

TAFE: Technical and Further Education; CAE: Centre for Adult Education; BMI, body mass index.
Expressed are numbers (%). Percentage is of time point population total.

with the National Health and Medical Council Ethical Conduct in Human Research and Declaration of Helsinki. A full WHAP study protocol has been previously published.[45]

Materials and procedure

Nutritional data

Participants completed a validated FFQ (DQES v2) prior to their assessments in 1998 and again in 2012. The Dietary Questionnaire for Epidemiological Studies Version 2 (DQES) was developed by the Cancer Council of Victoria (CCV) and incorporates 80 food items with frequency response options on 74 of these items.[46] The DQES v2 covers five types of dietary intake; cereals/sweets/snacks, dairy/meat/fish, fruit, vegetables and alcoholic beverages. Data collected using the DQES v2 was used to calculate nutrient intakes, based on the Australian nutrient composition data from NUTTAB95, which is based on the published Composition of Foods, Australia.[47] The data from the questionnaires were used to compute food group intakes MD and DII scores. Daily food intakes for all 104 foods were estimated (in grams/day) from the DQES v2 and grouped into 33 food groups defined a priori (Supplementary table 1) in a similar method to those used by others.[48,49]

Mediterranean diet adherence

Adherence to a Mediterranean Diet (MD) was assessed using a scoring tool devised by Sofi et al (2014)[24], based on the original method by Trichopoulou et al (2003)[50] The MD score is based on intake of nine dietary components: vegetables, legumes, fruit dairy, cereals, meat and meat products, fish, alcohol and olive oil. This scoring system uses three-tiers, with zero, one or two points allocated for each component. The mean value of the weighted medians from all the cohort studies analyzed by Sofi et al (2014)[24] ±2 standard deviations were used to define the three tiers with zero points for the lowest intakes of fruit, vegetables, legumes, cereals and fish, the highest intakes of meat and meat products, and dairy products, and highest or lowest alcohol intakes. While fruit, vegetables, legumes, cereals and fish scored 2 points for the highest intake, meat and dairy products scored 2 points for the lowest intakes, and alcohol scored 2 points for the mid-level intake. The component regarding olive oil consumption was modified to a proxy measure, monounsaturated fatty acids to saturated fatty acids (MUFA:SFA) ratio for our study, due to the FFQ not including questions on oil intake.[51] Population-specific tertiles of MUFA:SFA were created (cut-points of 0.83 and 1.00 for 1998 and 0.79 and 0.95 for 2012) and 2 points were assigned to the highest MUFA:SFA ratio. This literature-based MD score allocates an individual score of 0 points for minimal adherence or 18 for maximal adherence.

Dietary Inflammatory Index

Details on the development,[25] and validation,[29,30] of the DII have been described previously. Briefly, an extensive literature review identified publications on specific foods

and nutrients and their associations with six inflammatory biomarkers; IL-1β, IL-4, IL-6, IL-10, TNF-α and CRP. These publications were indexed and scored to derive component-specific inflammatory effect scores. The 27 components used to calculate DII scores in this study are presented in Table 2.

Covariates

Participants' education in years was collected in 1998. Marital, employment and smoking status were collected during assessments in both 1998 and 2012 and used as categorical variables. Weight and height were measured in 1998 and 2012 and BMI calculated as weight in kilograms divided by height in meters squared. Underweight was defined as <18.5 kg/m^2, healthy weight as ≥18.5 kg/m^2 and <25 kg/m^2, overweight as ≥25 kg/m^2 and <30 kg/m^2, obese as ≥30 kg/m^2.

Data analysis

IBM SPSS Statistics 22® software was used to conduct the statistical analyses for the present research. Multiple analyses were adjusted using the Bonferonni method. Nutrient intakes were adjusted for energy by dividing individual nutrient intake (e.g. g/day) by total energy intake (kJ/day). Macronutrients were expressed as percentages of total energy intake and were calculated according to energy contents of fat 37 kJ/g, protein 17 kJ/g, carbohydrate 16 kJ/g and alcohol 29 kJ/g. Categorical characteristics were described using cross-tabulation and frequency tables and compared between groups using the Pearson's chi-squared or Fisher's exact test as appropriate. Paired sample t-tests were conducted to evaluate individual differences in energy, absolute intakes, energy-adjusted intakes, DII and MD between 1998 and 2012. Estimated energy-adjusted food group intakes in 1998 and 2012 were compared using paired sample t-tests (Supplementary table 2). A conceptual diagram illustrating the background, study design, and key findings of this study is presented in Supplementary figure 1.

RESULTS

Sociodemographic characteristics of participants for whom all data were available from both time points are presented in Table 1. The proportion of married parti-

Table 2. Energy density means of WHAP intakes

Nutrients	1998	1998 CI	2012	2012 CI	*p* values
Energy (kJ/day)†	5772.56	5438.25- 6106.86	5322.81	5072.14-5573.48	0.004**
All fat (% of kJ/day)†	33.39%	32.53-34.24	35.47%	34.72-36.23	<0.001***
Saturated fat (% of kJ/day)	12.7%	12.21-13.19	14.18%	13.71-14.65	<0.001***
Monounsaturated fat (% of kJ/day)†	11.61%	11.24-11.98	12.39%	12.07-12.72	0.001**
Polyunsaturated fat (% of kJ/day)†	6.01%	5.63-6.39	5.78%	5.43-6.12	0.344
Fiber (g/mJ)†	3.31	3.18-3.44	3.20	3.20 (3.09-3.32)	0.122
Carbohydrate (% of kJ/day)†	47.4%	46.5-48.3	44.8%	44.0-45.6	<0.001***
Protein (% of kJ/day)†	20.0%	19.5-20.4	20.5%	20.0-20.9	0.047
Cholesterol (mg/mJ)†	32.6	31.3-34.0	38.7	37.1-40.4	<0.001***
Beta Carotene (ug/kJ)†	0.36	0.33-0.38	0.38	0.35-0.41	0.100
Folate (ug/mJ)†	40.8	39.2-42.4	42.1	40.5-43.7	0.152
Thiamin (mg/mJ)†	0.22	0.21-0.23	0.22	0.21-0.22	0.483
Niacin (mg/mJ)†	2.71	2.62-2.8	2.65	2.57-2.73	0.208
Niacin equivalent (mg/mJ)†	4.99	4.87-5.11	5.00	4.90-5.11	0.859
Riboflavin (mg/mJ)†	0.35	0.33-0.36	0.37	0.36-0.39	0.003**
Vitamin C (mg/mJ)†	19.4	18.1-20.7	17.8	16.673-18.9	0.013
Vitamin E (mg/mJ)†	0.92	0.88-0.95	0.97	0.93-1.01	0.028
Retinol (ug/kJ)†	46.6	44.0-49.2	50.7	48.2-53.2	0.006*
Retinol equivalent (ug/mJ)†	106	101-1101	114	109-120	0.003**
Iron (mg/mJ)†	1.74	1.68-1.80	1.77	1.7-1.83	0.480
Zinc (mg/mJ)†	1.51	1.48-1.55	1.54	1.51-1.58	0.099
Magnesium (mg/mJ)†	42.3	41.0-43.6	43.9	42.8-45.1	0.018
Sodium (mg/mJ)	318	312-325	309	303-316	0.015
α-linolenic acid n-3 (g/mJ)†	0.14	0.13-0.14	0.13	0.12-0.13	0.067
Long chain n-3 (g/mJ)†	0.05	0.044-0.060	0.057	0.051-0.064	0.782
Omega n-6 (g/mJ)†	1.34	1.25-1.43	1.32	1.24-1.41	0.798
Alcohol (grams) (% of kJ/day)†	8.32%	6.85-9.8	9.42%	7.44-11.41	0.168
Heavy beer‡ (g/mJ)	1.41	-0.75-3.58	1.35	-0.79-3.49	0.573
Light beer‡ (g/mJ)	2.38	0.58-4.18	1.10	0.06-2.13	0.036
Red wine‡ (g/mJ)	10.1	7.36-12.8	15.8	10.6-21.1	0.017
Spirits‡ (g/mJ)	0.90	0.54-1.26	0.55	0.33-0.76	0.048
White wine‡ (g/mJ)	15.1	11.0-19.3	15.7	10.5-20.9	0.798
Garlic‡ (g/day)†	0.09	0.08-0.11	0.10	0.09-0.12	0.229
Onion‡ (g/day)†	0.82	0.73-0.92	0.81	0.71-0.91	0.764
DII	-0.60	-0.80- -0.41	-0.46	-0.67-0.25	0.150
MD Adherence Score	7.14	6.78-7.51	5.95	5.65-6.26	<0.001***

CI: confidence intervals (95%); DII: Dietary Inflammatory Index; MD: Mediterranean diet.
T-test for difference. Daily intakes expressed. Macronutrients expressed as % of total energy kJ/day
†Item included in the DII calculation. ‡mL of beverage.
*p<0.01, **p<0.005, ***p<0.001.

cipants declined between 1998 (76.3%) and 2012 (61.8%) whilst the proportion of divorced (10.4% in 1998 and 13.9% in 2012) and widowed (4.6% in 1998 and 14.0 % in 2012) participants increased. The number of overweight individuals in the study remained stable (39.3% in 1998 and 39.9% in 2012). The percentage of healthy weight decreased (37.0% in 1998 and 30.1% in 2012) whilst the proportion of individuals categorized as obese increased (23.7% in 1998 and 30.1% in 2012). Overall, 63% of the participants were either overweight or obese in 1998, compared to 70% in 2012. The proportion of smokers decreased over time (13.3% in 1998 and 8.1% in 2012). There was a dramatic decrease in the proportion of participants in paid employment (70.5% in 1998 and 23.1% in 2012); however, the percentage of participants in volunteer work remained stable (55.5% in 1998 and 54.9% in 2012).

Energy-adjusted means and confidence intervals for nutrient intakes, DII and MD adherence are presented in Table 2. Total energy intake decreased over time (p<0.005). Percentage of total daily energy intake from the macronutrients total fat, saturated fat, and monounsaturated fat significantly increased while the contribution from carbohydrate significantly decreased over time. Cholesterol displayed a significant increase in intake over time (p<0.001). A non-significant trend was observed for an increase in the energy-adjusted intakes of riboflavin, retinol, magnesium and red wine, while a decreasing non-significant trend was evident for vitamin C and sodium (p<0.02). MD adherence significantly decreased (p<0.001) over time, whilst DII scores displayed a non-significant trend (p=0.15) towards a pro-inflammatory diet over time.

Absolute energy and nutrient intakes are provided in Table 3. Carbohydrate (p<0.001), vitamin C (p<0.001), sodium (p=0.001) and α-linolenic acid n-3 (p<0.001) significantly decreased over time. A non-significant trend was observed for an increase in the absolute intakes of cholesterol and red wine (p<0.02), while a decreasing but non-significant trend was observed in the absolute intakes of polyunsaturated fat, fiber, protein, thiamin, niacin, iron, zinc, light beer and spirits (p<0.02).

Estimated energy-adjusted daily intakes in 1998 and 2012 of 33 a priori defined food groups are provided in Supplementary table 2. Fresh fruit (p<0.001), refined grains (p<0.001), red meats (p<0.02), poultry (p<0.02), fruit juice (p<0.001), added sugar (p<0.001), unsaturated spreads (p=0.02) and alcoholic spirits (p<0.001) significantly decreased over time. Full-fat dairy products (p<0.01), nuts (p<0.001) and eggs (p<0.001) all signifi-

Table 3. Absolute daily intakes for WHAP intakes

Nutrients	1998	1998 CI	2012	2012 CI	*p* values
Energy (kJ/day)	5773	5438-6107	5323	5072-5574	0.004**
All fat (g/day)	52.9	48.9-56.8	51.5	48.7-54.4	0.471
Saturated fat (g/day	20.2	18.5-21.8	20.7	19.4-22.1	0.488
Monounsaturated fat (g/day)	18.5	17.0-20.0	18.0	16.9-19.0	0.439
Polyunsaturated fat (g/day)	9.37	8.59-10.15	8.37	7.74-90.0	0.016
Fiber (g/day)	18.69	17.64-19.74	16.92	15.97-17.86	0.002**
Carbohydrate (g/day)	160	151-168	140	133-147	<0.001***
Protein (g/day)	67.2	63.1-71.3	63.1	60.2-66.0	0.022
Cholesterol (mg/day)	189	174-203	204	191-216	0.021
Beta Carotene (ug/day)	1997	1840-2155	1921	1802-2039	0.372
Folate (mg/day)	229	216-242	219	207-230	0.125
Thiamin (mg/day)	1.25	1.17-1.34	1.14	1.08-1.21	0.011
Niacin (mg/day)	15.8	14.6-17.0	14.1	13.3-14.9	0.005*
Niacin equivalent (mg/day)	28.8	26.9-30.8	26.5	25.2-27.8	0.008
Riboflavin (mg/day)	1.96	1.83-2.09	1.94	1.83-2.04	0.696
Vitamin C (mg/day	107	99.6-114	90.2	84.3-96.1	<0.001***
Vitamin E (mg/day)	5.20	4.88-5.52	5.11	4.82-5.40	0.556
Retinol (ug/day)	267	248-286	269	251-288	0.781
Retinol equivalent (ug/day)	601	565-636	590	561-620	0.579
Iron (mg/day)	9.98	9.34-10.62	9.38	8.83-9.92	0.092
Zinc (mg/day)	8.64	8.12-9.16	8.11	7.73-8.49	0.032
Magnesium (mg/day)	239	227-251	231	219-242	0.195
Sodium (mg/day)	1856	1722-1991	1637	1554-1721	0.001**
α-linolenic acid n-3 (g/day)	0.81	0.74-0.88	0.69	0.65-0.73	<0.001***
Long chain n-3 (g/day)	0.33	0.26-0.40	0.31	0.27-0.35	0.580
Omega n-6 (g/day)	7.69	7.04-8.34	7.13	6.57-7.69	0.121
Alcohol (g/day)	14.5	12.16-16.83	15.35	12.6-18.09	0.482
Heavy beer (g/day)	6.37	-2.79-15.53	5.94	-2.68-14.56	0.547
Light beer (g/day)	15.1	3.04-27.3	5.74	0.16-11.3	0.061
Red wine (g/day)	51.2	37.7-64.6	75.4	53.3-97.4	0.020
Spirits (g/day)	4.64	2.93-6.35	2.66	1.61-3.70	0.016
White wine (g/day)	75.1	57.7-92.6	73.5	54.4-92.5	0.862
Garlic (g/day)	0.47	0.41-0.54	0.50	0.43-0.57	0.451
Onion (g/day)	4.56	4.02-5.10	4.15	3.63-4.66	0.139

CI: confidence intervals (95%).
Daily intakes expressed.
*p<0.01, **p<0.005, ***p<0.001.

cantly increased.

The associations of changes in employment status (paid/volunteer), marital status and BMI with diet were assessed. The majority of participants who transitioned out of paid employment over the 14 years showed a decrease in MD adherence. Only 2 participants transitioned into paid employment and they also displayed a decreased MD (p=0.19). Taking on volunteer work tended to be associated with increased MD adherence, whilst giving up volunteer work tended to be associated with a decreased MD score (p=0.13). Those who became widowed over the 14 years tended to decrease MD adherence, whilst those who married tended to increase their MD score (p=0.16). There were no relationships observed between change in MD adherence and age, education, smoking status or BMI.

DISCUSSION

This study shows significant changes in the intake of several nutrients and MD adherence in a cohort of aging Australian women in the Melbourne metropolitan area over a period of 14 years. Energy intake decreased over time as might be expected with aging and some absolute and energy-adjusted nutrients and macronutrients showed significant changes. Scores on both the DII and the MD adherence showed change towards poorer diet quality between the two time points; DII values tended to increase, becoming more pro-inflammatory over time, although they remained on the anti-inflammatory side of the scale and the observed change was not significant.

Our results, showing a decrease in total energy intake over 14 years, is in line with a British study in adults followed over 17 years that found a decrease in energy consumption in men and women between the ages of 43 and 53 years, although energy intake had increased between ages 36 and 43 years.[52] These changes observed in the British study may reflect changes in food choices as well as well as the amount of food consumed. Prynne et al (2005)[52] also found fat intake, as a percentage of energy, decreased over time; however, the current study found significant increases in the contribution of fat to energy intake in Australian women from mean age 55 years to 70 years. In the current study there was a non-significant trend for vitamin C intake to decrease and vitamin E intake to increase, however, Prynne et al (2005)[52] found energy-adjusted increases for both reflecting an overall change to a diet more closely reflecting dietary guidelines.

As a percentage of total energy and as an absolute value, carbohydrate intake significantly decreased over time in the WHAP participants. This is in contrast to the findings of Prynne et al (2005)[52] where women's total carbohydrate and percentage of energy from carbohydrate intake gradually increased over a period of 17 years (aged 36 to 53 years). Given the overall trend in the birth cohort studied by Prynne et al (2005)[52] towards a more healthy diet over time, it is possible the increase in carbohydrate intake was in favour of more complex carbohydrates, although this is not noted.

The current study found that the proportion of energy contributed by total fat, saturated fat and monounsaturated fat all increased significantly over 14 years, as did the intake of cholesterol relative to energy, consistent with increased consumption of animal-based foods. The small increase in riboflavin intake over time and the significant increase of full-fat dairy products also suggests an increase in the relative consumption of milk and milk products, one of the main sources of riboflavin in the Australian diet.[53]

The changes reported are in line with a transition towards a less healthy diet and are reflected in the BMI shifting towards obesity in the context of declining physical activity and reduced energy requirements with age.[54] We also observed widowhood becoming more prevalent over 14 years, with participants who were widowed more likely to decrease MD adherence compared with participants experiencing a stable marital situation. Widowhood can have a dramatic impact on the surviving spouse, catalyzing changes in daily routines and dietary choices that may adversely affect their nutritional status.[13] Widowed individuals are more likely to consume non-nutritious foods, fewer vegetables and are less likely to prepare homemade meals than their married peers.[13,14,55,56] The loss of a spouse also is related to a decrease in dietary diversity,[55,56] reflecting a deprioritization of personal nutrition. In the WHAP cohort, becoming a widow was associated with a transition towards a less healthy dietary pattern, consistent with a reorientation of cooking habits and food behaviors. Conversely, women who married during the period were more likely to display an increase in MD adherence. Individuals who marry in later life are likely to reprioritize personal nutrition to coincide with changes in their social environment and may display healthier dietary patterns than their unmarried peers.[55,57] We observed an increased MD adherence for those women taking up voluntary work when compared with those giving up volunteer work over the 14 years. Volunteer responsibilities can catalyse social engagement and offer opportunities for the dissemination of healthy eating habits.

A growing body of research is acknowledging the importance of the MD categories in nutrition research.[58-61] Of the food groups that made up the MD score; fruit, cereal, meat and vegetable intake decreased; legumes and fish remained constant; whilst intake of dairy products and wine increased. MD adherence and non-significant increases in DII scores both indicated a transition towards a less healthy diet over time. This is in contrast to several longitudinal dietary studies that have found stability for healthier eating patterns in women,[41,62] and in unhealthy Western patterns in men.[63] In a 10-year follow up of individuals aged 50-69 years at baseline, latent class analysis revealed women were significantly more likely to be in the healthy stable group and men in the Western stable group.[62] Consumption of fruit and vegetables increased over time and this increase was greater in women, indicating they may be more responsive to health promotion messages.8 Compared to Prynne et al (2005),[52] who reported a trend towards a better diet over time, the current study observed a trend towards poorer diet quality and this may relate to the older age of women in our cohort. In the WHAP cohort, we observed consumption of fresh fruit and refined grains significantly decreased over time and several vegetable groups displayed non-significant

decreases over 14 years. Given similar changes were observed for Anglo-Celt and Greek-Australian men and women aged above 70 years,[43] we hypothesise the differences between WHAP and the UK cohort studied by Prynne et al (2005)[52] may be age-related. Aged between 36 and 53 years, the UK cohort[52] was at lower risk for the loss of employment, physical function, widowhood and social engagement than would be expected of women aged between 55 and 69 years. Compared to other studies such as Shivappa et al (2014),[30] scores and range of the DII values were low. DII scores were in a similar range to those observed by Tabung (2016)[44] in a cohort of postmenopausal women.

One of the strengths of this study was that the FFQ and method of nutrient calculation were identical for both time points; therefore, reported changes in nutrient intakes are largely due to changes in portion size or frequency of consumption and will not be confused by changes in the dietary methodology. However, as has been previously discussed,[52] our analysis is not able to account for changes in the composition of individual food items by manufacturers over time. Short-term follow-up dietary studies often assume dietary stability without capturing long term change therefore our study was strengthened by 14 years of follow-up dietary data on the same women. Of the 438 WHAP participants who underwent assessments in 1998, 173 who also participated in the 2012 survey were included in this analysis. There were no significant differences in education, employment, age, BMI, smoking status, nutrient intake or MD adherence between the excluded and included participants in this study. This suggests that the loss to follow-up has not introduced bias into this investigation.

A limitation of this study was the lack of socioeconomic status as a covariate and the small sample size; however, this study is part of a longitudinal investigation over 25 years and drop out over this period of time is inevitable.

In conclusion, small changes in intakes of a range of dietary components resulted in changes towards poorer diet quality as assessed by the MD score and, though not statistically significant, the DII in these women as they aged. Given the importance of maintaining a healthy diet in supporting health and function with aging, this is of concern and requires further study to identify factors associated with worsening dietary patterns and thus facilitate targeting dietary interventions to women who need it most.

ACKNOWLEDGEMENTS

We would like to acknowledge the contribution of the participants and their supporters who have contributed their time and commitment for over 20 years to the University. A full list of all researchers contributing to the project and the membership of our Scientific Advisory Board is available at http://www.medrmhwh.unimelb.edu.au/Research/WHAP.html.

AUTHOR DISCLOSURES

CS has provided clinical consultancy and been on scientific advisory committees for the Australian Commonwealth Scientific and Industrial Research Organization, Alzheimer's Australia, University of Melbourne and other relationships which are subject to confidentiality clauses. She has been a named Chief Investigator on investigator driven collaborative research projects in partnership with Pfizer, Merck, Bayer, and GE. She may accrue revenues from patent in pharmacogenomics prediction of seizure recurrence. 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 counselling and dietary intervention in clinical settings. Dr Nitin Shivappa is an employee of CHI. All other authors have no conflict of interest to declare.

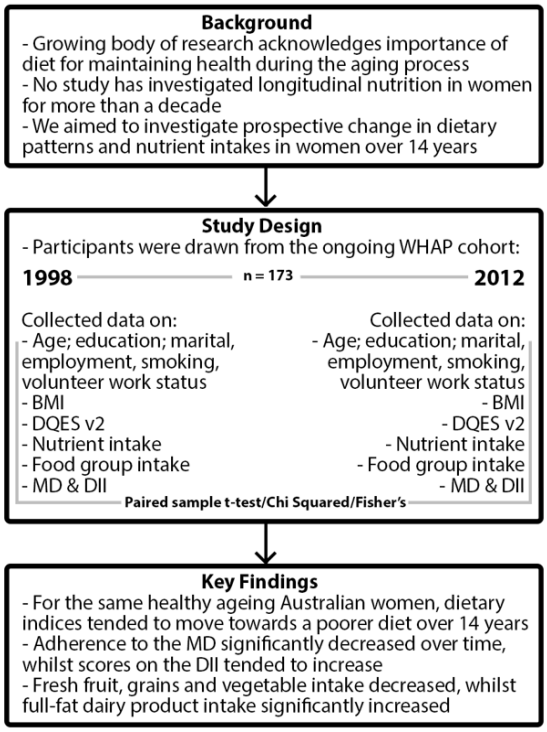
Funding for the Healthy Ageing Program (HAP) has been provided by the National Health and Medical Research Council (NHMRC Grants 547600, 1032350 & 1062133), Ramaciotti Foundation, Australian Healthy Ageing Organisation, the Brain Foundation, the Alzheimer's Association (NIA320312), Australian Menopausal Society, Bayer Healthcare, Shepherd Foundation, Scobie and Claire Mackinnon Foundation, Collier Trust Fund, J.O. & J.R. Wicking Trust, Mason Foundation and the Alzheimer's Association of Australia. Inaugural funding was provided by VicHealth and the NHMRC. The Principal Investigator of HAP (CSz) is supported by the National Health and Medical Research Council. The authors thank Professor Graham Giles of the Cancer Epidemiology & Intelligence Division, Cancer Council Victoria, for permission to use the DQES v2. Edward Hill would like to acknowledge support from the Australian Government Research Training Program Scholarship. Nitin Shivappa and James R. Hébert were supported by grant number R44DK103377 from the United States National Institute of Diabetes and Digestive and Kidney Diseases.

REFERENCES

1. Leslie W, Hankey C. Aging, nutritional status and health. Healthcare. 2015;3:648-58. doi: 10.3390/healthcare3030648
2. Garcia-Calzon S, Zalba G, Ruiz-Canela M, Shivappa N, Hebert JR, Martinez JA et al. Dietary inflammatory index and telomere length in subjects with a high cardiovascular disease risk from the PREDIMED-NAVARRA study: cross-sectional and longitudinal analyses over 5 y. Am J Clin Nutr. 2015;102:897-904. doi: 10.3945/ajcn.115.116863
3. Kesse-Guyot E, Assmann KE, Andreeva VA, Touvier M, Neufcourt L, Shivappa N et al. Long-term association between the dietary inflammatory index and cognitive functioning: findings from the SU.VI.MAX study. Eur J Nutr. 2017;56:1647-55. doi: 10.1007/s00394-016-1211-3
4. Brown W. Promoting healthy ageing in Australia. Canberra, Australia: Department of Education, Science and Training; 2003.
5. Ridoutt B, Baird D, Bastiaans K, Hendrie G, Riley M, Sanguansri P, Syrette J, Noakes M. Changes in Food Intake in Australia: Comparing the 1995 and 2011 National Nutrition Survey Results Disaggregated into Basic Foods. Foods. 2016;5:1-13. doi: 10.3390/foods5020040
6. Huang Y-C, Wahlqvist ML, Lo Y-TC, Lin C, Chang H-Y, Lee M-S. A non-invasive modifiable Healthy Ageing Nutrition Index (HANI) predicts longevity in free-living older Taiwanese. Sci Rep. 2018;8:7113. doi: 10.1038/s41598-018-24625-3
7. Singh-Manoux A, Guéguen A, Ferrie J, Shipley M, Martikainen P, Bonenfant S, Goldberg M, Marmot M. Gender differences in the association between morbidity and mortality among middle-aged men and women. Am J Public Health. 2008;98:2251-7. doi: 10.2105/AJPH.2006.107912
8. Wardle J, Haase AM, Steptoe A, Nillapun M, Jonwutiwes K, Bellisle F. Gender differences in food choice: The contribution of health beliefs and dieting. Ann Behav Med. 2004;27:107-16. doi: 10.1207/s15324796abm2702_5

9. Huang Y-C, Cheng H-L, Wahlqvist ML, Lo Y-TC, Lee M-S. Gender differences in longevity in free-living older adults who eat-with-others: a prospective study in Taiwan. BMJ Open. 2017;7:e016575. doi: 10.1136/bmjopen-2017-016575
10. Australian Health Survey: Updated Results 2011-2012. Canberra, Australia: Australian Bureau of Statistics; 2013.
11. Lim SS, Vos T, Flaxman AD, Danaei G, Shibuya K, Adair-Rohani H et al. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet. 2012;380:2224-60. doi: 10.1016/S0140-6736(12)61766-8
12. Begg SJ, Vos T, Barker B, Stanley L, Lopez AD. Burden of disease and injury in Australia in the new millennium: measuring health loss from diseases, injuries and risk factors. Med J Aust. 2008;188:36-40.
13. Heuberger R, Wong H. The association between depression and widowhood and nutritional status in older adults. Geriatr Nurs. 2014;35:428-33. doi: 10.1016/j.gerinurse.2014.06.011
14. Rosenbloom CA, Whittington FJ. The effects of bereavement on eating behaviors and nutrient intakes in elderly widowed persons. J Gerontol. 1993;48:S223-S9.
15. Cole MG, Dendukuri N. Risk factors for depression among elderly community subjects: A systematic review and meta-analysis. Am J Psychiatry. 2003;160:1147-56. doi: 10.1093/geronj/48.4.S223
16. Mezuk B, Eaton WW, Albrecht S, Golden SH. Depression and type 2 diabetes over the lifespan a meta-analysis. Diabetes Care. 2008;31:2383-90. doi: 10.2337/dc08-0985
17. Spiegel D, Giese-Davis J. Depression and cancer: Mechanisms and disease progression. Biol Psychiatry. 2003; 54:269-82. doi: 10.1016/S0006-3223(03)00566-3
18. Lichtman JH, Bigger JT, Jr., Blumenthal JA, Frasure-Smith N, Kaufmann PG, Lesperance F et al. AHA science advisory. Depression and coronary heart disease. Recommendations for screening, referral, and treatment. A science advisory from the American Heart Association Prevention Committee to the Council on Cardiovascular Nursing, Council on Clinical Cardiology, Council on Epidemiology and Prevention, and Interdisciplinary Council on Quality of Care Outcomes Research. Endorsed by the American Psychiatric Association. Prog Cardiovasc Nurs. 2009;24:19-26. doi: 10.1111/j.1751-7117.2009.00028.x
19. Conklin AI, Forouhi NG, Surtees P, Khaw KT, Wareham NJ, Monsivais P. Social relationships and healthful dietary behaviour: Evidence from over-50s in the EPIC cohort, UK. Soc Sci Med. 2014;100:167-75. doi: 10.1016/j.socscimed.2013.08.018
20. Irz X, Fratiglioni L, Kuosmanen N, Mazzocchi M, Modugno L, Nocella G et al. Sociodemographic determinants of diet quality of the EU elderly: a comparative analysis in four countries. Public Health Nutr. 2014;17:1177-89. doi: 10.1017/S1368980013001146
21. Conklin AI, Maguire ER, Monsivais P. Economic determinants of diet in older adults: systematic review. J Epidemiol Community Health. 2013;67:721-7. doi: 10.1136/jech-2013-202513
22. Hu FB. Dietary pattern analysis: a new direction in nutritional epidemiology. Curr Opin Lipidol. 2002;13:3-9.
23. Liese AD, Krebs-Smith SM, Subar AF, George SM, Harmon BE, Neuhouser ML, Boushey CJ, Schap TE, Reedy J. The Dietary Patterns Methods Project: synthesis of findings across cohorts and relevance to dietary guidance. J Nutr. 2015;145:393-402. doi: 10.3945/jn.114.205336
24. Sofi F, Macchi C, Abbate R, Gensini GF, Casini A. Mediterranean diet and health status: an updated meta-analysis and a proposal for a literature-based adherence score. Public Health Nutr. 2014;17:2769-82. doi: 10.1017/S1368980013003169
25. Shivappa N, Steck SE, Hurley TG, Hussey JR, Hébert JR. Designing and developing a literature-derived, population-based dietary inflammatory index. Public Health Nutr. 2014; 17:1689-96. doi: 10.1017/S1368980013002115
26. Hodge A, Bassett J. What can we learn from dietary pattern analysis? Public Health Nutr. 2016;19:191-4. doi: 10.1017/S1368980015003730
27. Hodge AM, Bassett JK, Shivappa N, Hébert JR, English DR, Giles GG, Severi G. Dietary inflammatory index, Mediterranean diet score, and lung cancer: a prospective study. Cancer Causes Control. 2016;27:907-17. doi: 10.1007/s10552-016-0770-1
28. Wirth MD, Hebert JR, Shivappa N, Hand GA, Hurley TG, Drenowatz C, McMahon D, Shook RP, Blair SN. Anti-inflammatory Dietary Inflammatory Index scores are associated with healthier scores on other dietary indices. Nutr Res. 2016;36:214-9. doi: 10.1016/j.nutres.2015.11.009
29. Tabung FK, Steck SE, Zhang J, Ma Y, Liese AD, Agalliu I et al. Construct validation of the dietary inflammatory index among postmenopausal women. Ann Epidemiol. 2015;25: 398-405. doi: 10.1016/j.annepidem.2015.03.009
30. Shivappa N, Steck SE, Hurley TG, Hussey JR, Ma Y, Ockene IS, Tabung F, Hebert JR. A population-based dietary inflammatory index predicts levels of C-reactive protein in the Seasonal Variation of Blood Cholesterol Study (SEASONS). Public Health Nutr. 2014;17:1825-33. doi: 10.1017/S1368980013002565
31. Shivappa N, Hebert JR, Rietzschel ER, De Buyzere ML, Langlois M, Debruyne E, Marcos A, Huybrechts I. Associations between dietary inflammatory index and inflammatory markers in the Asklepios Study. Br J Nutr. 2015;113:665-71. doi: 10.1017/S000711451400395X
32. Boden S, Wennberg M, Van Guelpen B, Johansson I, Lindahl B, Andersson J, Shivappa N, Hebert JR, Nilsson LM. Dietary inflammatory index and risk of first myocardial infarction; a prospective population-based study. Nutr J. 2017;16:21. doi: 10.1186/s12937-017-0243-8
33. Graffouillere L, Deschasaux M, Mariotti F, Neufcourt L, Shivappa N, Hebert JR et al. The dietary inflammatory index is associated with prostate cancer risk in French middle-aged adults in a prospective study. J Nutr. 2016;146: 785-91. doi: 10.3945/jn.115.225623
34. Shivappa N, Sandin S, Lof M, Hebert JR, Adami HO, Weiderpass E. Prospective study of dietary inflammatory index and risk of breast cancer in Swedish women. Br J Cancer. 2015;113:1099-103. doi: 10.1038/bjc.2015.304
35. Neufcourt L, Assmann KE, Fezeu LK, Touvier M, Graffouillere L, Shivappa N et al. Prospective association between the dietary inflammatory index and metabolic syndrome: Findings from the SU.VI.MAX study. Nutr Metab Cardiovasc Dis. 2015;25:988-96. doi: 10.1016/j.numecd.2015.09.002
36. Shivappa N, Steck SE, Hussey JR, Ma Y, Hebert JR. Inflammatory potential of diet and all-cause, cardiovascular, and cancer mortality in National Health and Nutrition Examination Survey III Study. Eur J Nutr. 2015. doi: 10.1007/s00394-015-1112-x
37. Jacques PF, Tucker KL. Are dietary patterns useful for understanding the role of diet in chronic disease? Am J Clin Nutr. 2001;73:1-2.
38. Reedy J, Krebs-Smith SM, Miller PE, Liese AD, Kahle LL, Yikyung P, Subar AF. Higher diet quality is associated with decreased risk of all-cause, cardiovascular disease, and

cancer mortality among older adults. J Nutr. 2014;144:881-9. doi: 10.3945/jn.113.189407
39. Miller PE, Cross AJ, Subar AF, Krebs-Smith SM, Park Y, Powell-Wiley T, Hollenbeck A, Reedy J. Comparison of 4 established DASH diet indexes: examining associations of index scores and colorectal cancer. Am J Clin Nutr. 2013;98: 794-803. doi: 10.3945/ajcn.113.063602
40. Samieri C, Okereke OI, Devore EE, Grodstein F. Long-term adherence to the Mediterranean diet is associated with overall cognitive status, but not cognitive decline, in women. J Nutr. 2013;143:493-9. doi: 10.3945/jn.112.169896
41. Mishra GD, McNaughton SA, Bramwell GD, Wadsworth MEJ. Longitudinal changes in dietary patterns during adult life. Br J Nutr. 2006;96:735-44.
42. Mulder M, Ranchor AV, Sanderman R, Bouma J, van den Heuvel WJA. The stability of lifestyle behaviour. Int J Epidemiol. 1998;27:199-207. doi: 10.1093/ije/27.2.199
43. Kouris-Blazos A, Gnardellis C, Wahlqvist ML, Trichopoulos D, Lukito W, Trichopoulou A. Are the advantages of the Mediterranean diet transferable to other populations? A cohort study in Melbourne, Australia. Br J Nutr. 1999;82:57-61.
44. Tabung FK. Longitudinal changes in the dietary inflammatory index: an assessment of the inflammatory potential of diet over time in postmenopausal women. Eur J Clin Nutr. 2016;70:1374-80. doi: 10.1038/ejcn.2016.116
45. Szoeke CEI, Robertson JS, Rowe CC, Yates P, Campbell K, Masters CL, Ames D, Dennerstein L, Desmond P. The Women's Healthy Ageing Project: Fertile ground for investigation of healthy participants 'at risk' for dementia. Int Rev Psychiatry. 2013;25:726-37. doi: 10.3109/09540261.2013.873394
46. Hodge A, Patterson A, Brown W, Ireland P, Giles G. The Anti Cancer Council of Victoria FFQ: relative validity of nutrient intakes compared with weighed food records in young to middle-aged women in a study of iron supplementation. Aust N Z J Public Health. 2000;24:576-83. Erratum in Aust N Z J Public Health. 2003 Aug;27(4):468
47. Thomas S, Corden M. Metric tables of composition of Australian foods. Canberra: Australian Government Publishing Service; 1977.
48. Ambrosini GL, Oddy WH, Robinson M, O'Sullivan TA, Hands BP, De Klerk NH et al. Adolescent dietary patterns are associated with lifestyle and family psycho-social factors. Public Health Nutr. 2009;12:1807-15. doi: 10.1017/S1368980008004618. Erratum in Public Health Nutr. 2016 Mar;19(4):765. doi: 10.1017/S1368980015001810
49. Ambrosini GL, Fritschi L, De Klerk NH, Mackerras D, Leavy J. Dietary patterns identified using factor analysis and prostate cancer risk: a case control study in Western Australia. Ann Epidemiol. 2008;18:364-70. doi: 10.1016/j.annepidem.2007.11.010
50. Trichopoulou A, Costacou T, Bamia C, Trichopoulos D. Adherence to a Mediterranean diet and survival in a Greek population. N Engl J Med. 2003;348:2599-608. doi: 10.1056/NEJMoa025039
51. Giles GG, Ireland PD. Dietary questionnaire for epidemiological studies (Version 2). Melbourne: Cancer Council Victoria; 1996.
52. Prynne CJ, Paul AA, Mishra GD, Greenberg DC, Wadsworth MEJ. Changes in intake of key nutrients over 17 years during adult life of a British birth cohort. Br J Nutr. 2005;94:368-76.
53. Nutrient reference values for Australia and New Zealand. Food Australia. 2006;58:298.
54. Picavet HSJ, Wendel-Vos GCW, Vreeken HL, Schuit AJ, Verschuren WMM. How stable are physical activity habits among adults? The Doetinchem Cohort Study. Med Sci Sports Exerc. 2011;43:74-9. doi: 10.1249/MSS.0b013e3181e57a6a
55. Lee S, Cho E, Grodstein F, Kawachi I, Hu FB, Colditz GA. Effects of marital transitions on changes in dietary and other health behaviours in US women. Int J Epidemiol. 2005;34: 69-78. doi: 10.1093/ije/dyh258
56. Shahar DR, Schultz R, Shahar A, Wing RR. The effect of widowhood on weight change, dietary intake, and eating behavior in the elderly population. J Aging Health. 2001;13: 189-99.
57. Eng PM, Kawachi I, Fitzmaurice G, Rimm EB. Effects of marital transitions on changes in dietary and other health behaviours in US male health professionals. J Epidemiol Community Health. 2005;59:56-62. doi: 10.1136/jech.2004.020073
58. Foyer CH, Lam H-M, Nguyen HT, Siddique KH, Varshney RK, Colmer TD et al. Neglecting legumes has compromised human health and sustainable food production. Nat Plants. 2016;2:16112. doi: 10.1038/nplants
59. Mozaffarian D, Kumanyika SK, Lemaitre RN, Olson JL, Burke GL, Siscovick DS. Cereal, fruit, and vegetable fiber intake and the risk of cardiovascular disease in elderly individuals. J Am Med Assoc. 2003;289:1659-66. doi: 10.1001/jama.289.13.1659
60. Panza F, Frisardi V, Seripa D, Logroscino G, Santamato A, Imbimbo BP, Scafato E, Pilotto A, Solfrizzi V. Alcohol consumption in mild cognitive impairment and dementia: harmful or neuroprotective? Int J Geriatr Psychiatry. 2012; 27:1218-38. doi: 10.1002/gps.3772
61. Barberger-Gateau P, Letenneur L, Deschamps V, Peres K, Dartigues JF, Renaud S. Fish, meat, and risk of dementia: cohort study. Br Med J. 2002;325:932-3. doi: 10.1136/bmj.325.7370.932
62. Harrington JM, Dahly DL, Fitzgerald AP, Gilthorpe MS, Perry IJ. Capturing changes in dietary patterns among older adults: a latent class analysis of an ageing Irish cohort. Public Health Nutr. 2014;17:2674-86. doi: 10.1017/S1368980014000111
63. van Dam RM, Rimm EB, Willett WC, Stampfer MJ, Hu FB. Dietary patterns and risk for type 2 diabetes mellitus in US men. Ann Intern Med. 2002;136:201-9. doi: 10.7326/0003-4819-136-3-200202050-00008
64. Gardener SL, Rainey-Smith SR, Barnes MB, Sohrabi HR, Weinborn M, Lim YY et al. Dietary patterns and cognitive decline in an Australian study of ageing. Mol Psychiatry. 2015;20:860. doi: 10.1038/mp.2014.79



Supplementary figure 1. Conceptual diagram of background, study design and key findings.

Supplementary table 1. Food groupings for DQES v2

Food group	Items in the DQES v2
Whole grains	All bran, bran flakes, high fibre white bread, muesli, multigrain bread, porridge, rye bread, Weet-Bix, wholemeal bread
Refined grains	Corn flakes, crackers, pasta, rice, white bread
Red meats	Beef, lamb, pork, veal
Processed meats	Bacon, salami, sausages
Poultry	Chicken
Takeaway foods	Hamburger, meat pies, pizza
Fried fish	Fried fish
Other fish	Fish (non-fried), tinned fish
Fried potatoes	Chips (French fries)
Other potato	Potatoes
Yellow or red vegetables	Capsicum, carrots, pumpkin
Legumes	Baked beans, green beans, other beans, peas, tofu
Cruciferous vegetables	Broccoli, cabbage, cauliflower
Leafy green vegetables	Lettuce, spinach
Other vegetables	Bean sprouts, beetroot, celery, cucumber, garlic, mushrooms, onion, zucchini
Tomato	Tomatoes
Fresh fruit	Apples, apricots, avocado, bananas, mango, melon, oranges, peaches, pears, pineapple, strawberries
Canned fruit	Tinned fruit
Cakes, biscuits, sweet pastries	Cakes, sweet biscuits
Low-fat dairy products	Flavoured milk drink, low-fat cheese, reduced fat milk, ricotta cheese, cottage cheese, skim milk
Full- fat dairy products	Cream cheese, firm cheese, full-cream milk, hard cheese, ice cream, soft cheese, yoghurt
Soya milk	Soya milk
Confectionery	Chocolate
Added sugar	Jam, sugar
Crisps	Crisps
Nuts	Nuts, peanut butter
Eggs	Eggs
Fruit juice	Fruit juice
Saturated spreads	Butter, butter-margarine blends, margarine
Unsaturated spreads	Monounsaturated margarine, polyunsaturated margarine
Alcohol - beer	Heavy beer, light beer
Alcohol - wine	Red wine, white wine
Alcohol - spirits	Fortified wines, spirits
Food Group	Items in the DQES v2

Supplementary table 2. Mean daily intakes for DQES v2 food groupings

Food group	1998 Mean	1998 CI	2012 Mean	2012 CI	*p* values
Whole grains (g/day)	109	97.5-120	101	91.1-112	0.211
Refined grains (g/day)	87.1	73.0-101	51.6	43.9-59.4	<0.001***
Red meats (g/day)	40.0	35.7-44.3	34.4	30.6-38.3	0.0118*
Processed meats (g/day)	10.4	5.7-15.1	7.39	5.91-8.86	0.121
Poultry (g/day)	19.9	16.0-23.7	15.2	13.5-16.8	0.014
Takeaway foods (g/day)	25.2	21.7-28.6	24.3	19.4-29.2	0.749
Fried fish (g/day)	3.31	2.20-4.41	3.02	2.22-3.81	0.654
Other fish (g/day)	23.5	18.6-28.4	22.8	19.0-26.7	0.790
Fried potatoes (g/day)	7.39	6.14-8.64	8.76	7.13-10.4	0.102
Other potato (g/day)	27.4	24.1-30.8	24.6	20.9-28.2	0.177
Yellow or red vegetables (g/day)	21.9	19.9-23.9	22.4	20.3-24.5	0.697
Legumes (g/day)	21.0	18.7-23.2	21.6	19.6-23.7	0.586
Cruciferous vegetables (g/day)	22.0	19.7-24.3	23.1	20.7-25.5	0.395
Leafy green vegetables (g/day)	11.7	10.2-13.1	13.1	12.0-14.3	0.087
Other vegetables (g/day)	24.5	22.5-26.4	24.01	22.2-25.8	0.662
Tomato (g/day)	11.7	10.1-13.3	13.0	11.2-14.8	0.251
Fresh fruit (g/day)	217	200-234	187	171-203	<0.001***
Canned fruit (g/day)	10.2	6.53-13.8	10.3	7.34-13.3	0.944
Cakes, biscuits, sweet pastries (g/day)	19.3	15.6-23.1	17.9	15.2-20.5	0.462
Low-fat dairy products (g/day)	218	190-246	220	191-245	0.927
Full-fat dairy products (g/day)	105	88.0-123	136	116-156	0.006*
Soya milk (g/day)	47.1	27.3-66.9	36.3	21.2-51.3	0.312
Confectionery (g/day)	4.63	3.22-6.04	6.36	4.85-7.87	0.066
Added sugar (g/day)	11.8	9.67-13.9	8.12	6.59-9.65	<0.001***
Crisps (g/day)	1.9	1.38-2.38	1.52	1.02-2.02	0.294
Nuts (g/day)	2.8	2.04-3.60	4.89	3.85-5.93	<0.001***
Eggs (g/day)	11.5	10.2-12.8	16.6	14.8-18.3	<0.001***
Fruit juice (g/day)	49.9	39.5-60.4	24.3	18.1-30.4	<0.001***
Saturated spreads (g/day)	3.68	2.49-4.87	2.37	1.58-3.15	0.057
Unsaturated spreads (g/day)	8.07	6.46-9.69	6.05	4.77-7.33	0.020
Alcohol beverage - beer (g/day)	21.5	6.38-36.6	11.7	1.40-22.0	0.056
Alcohol beverage - wine (g/day)	126	104-148	149	120-177	0.069
Alcohol beverage - spirits (g/day)	13.4	9.44-17.4	7.18	4.09-10.3	<0.001***

CI: confidence intervals (95%).
Daily intakes expressed.
$^{*}p<0.01$, $^{**}p<0.005$, $^{***}p<0.001$.