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Adherence to dietary guidelines and 15-year risk of all-cause mortality

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Abstract
Past investigation of diet in relation to disease or mortality has tended to focus on individual nutrients. However, there has been a recent shift to now focus on overall patterns of food intake. The present study aims to investigate the relationship between diet quality reflecting adherence to dietary guidelines and mortality in a sample of older Australians, and to report on the relationship between core food groups and diet quality. This was a population-based cohort study of persons aged 49 years or older at baseline, living in two postcode areas west of Sydney, Australia. Baseline dietary data were collected during 1992–4, from 2897 people using a 145-item Willett-derived FFQ. A modified version of the Healthy Eating Index for Australians was developed to determine diet quality scores. The Australian National Death Index provided 15-year mortality data using multiple data linkage steps. Hazard risk (HR) ratios and 95 % CI for mortality were assessed for diet quality. Subjects in quintile 5 (highest) of the Total Diet Score had a 21 % reduced risk of all-cause mortality (HR 0·79, 95 % CI 0·63, 0·98, $P_{trend} = 0·04$) compared with those in quintile 1 (lowest) after multivariate adjustment. The present study provides longitudinal support for a reduced risk of all-cause mortality in an older population who have greater compliance with published dietary guidelines.

Key words: Total Diet Score: Mortality: Older adults

In the past, research has focused on examining the relationship of individual nutrients to total and cause-specific mortality. There is a need, however, to examine total diet, as nutrients are not consumed independently but together within a variety of foods in the diet. In recent years, research into the relationship between overall diet quality and the risk of mortality or of developing chronic disease has expanded[1–6]. There have been two frequent approaches used to measure diet quality, one that uses statistical methods such as cluster analysis, factor analysis or principal component analysis to derive dietary patterns from collected data giving an indication of eating behaviours[5,7–10]. The alternative approach group foods '*a priori*' that are representative of current nutrition knowledge in the form of dietary guidelines or other dietary recommendations[11,12]. This may be a more useful tool in public health practice to assess a population's adherence to current dietary guidelines based on empirical evidence.

Based on the latter approach, a number of diet quality indices have already been developed based on dietary guidelines including the Diet Quality Index[13], Healthy Eating Index[14] and Dietary Guidelines Index[15]. In Australia, one study has shown overall improvement in diet quality over time and cross-sectional findings have reported that higher diet quality scores were inversely associated with prevalent diabetes in men and pre-diabetes in women[16]. However, no studies have assessed the effect of diet quality, in terms of adhering to dietary guidelines, on mortality or morbidity over time. Nor have any known studies addressed diet quality in an older adult population.

To investigate the longitudinal effect of dietary guideline adherence and all-cause mortality in a cohort of older Australians, we developed a tool modelled on both Australian and US diet quality indices[17,18]. The objectives of the present study were, first, to investigate diet quality, defined as adherence to the Dietary Guidelines for Australian Adults (DGAA) at

Abbreviations: AGHE, Australian Guide to Healthy Eating; BMES, Blue Mountains Eye Study; DGAA, Dietary Guidelines for Australian Adults; HR, hazard risk; MET.min, metabolic equivalents.min; TDS, Total Diet Score.

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baseline and report its relationship to core food groups among older adults living in the Blue Mountains region of Australia. The second objective was to identify the relationship between diet quality and mortality risk after 15 years follow-up of this cohort.

Methods

Study used

The data used for this analysis were collected as part of the Blue Mountains Eye Study (BMES). Full details of the study design have been reported previously[19,20]. Briefly, the BMES is a population-based cohort study of vision and common eye diseases in residents aged 49 years or older living in a two-postcode region, west of Sydney, Australia. Baseline data were collected from 1992 to 1994 (BMES1) with follow-up conducted at 5-year intervals (1997–9, 2002–4 and 2007–9). BMES1 baseline examinations included 3654 subjects aged 49–97 years. Mortality data were obtained from the Australian National Death Index by matching with BMES1 subjects up until December 2007. The study followed the recommendations of the Declaration of Helsinki and was approved by the University of Sydney and Sydney West Area Health Service Human Research Ethics Committees. All subjects provided written informed consent.

Dietary assessment

The semi-quantitative FFQ included 145 items and was adapted for the Australian diet from a Willett FFQ[19]. Subjects used a nine-category frequency scale, ranging from never to four times per d, to indicate usual consumption of particular food items during the past year. The FFQ was attempted and returned by 3267 participants (82·4 % response); of these FFQ, 2897 were available for analysis (79·3 % of subjects examined). Participants were excluded if their FFQ had more than twelve FFQ items missing, had energy intakes <2500 kJ or $>18\,000$ kJ, or had implausible records in the upper or lower 2 % of the distribution after the nutrient data had been re-examined.

The FFQ was validated by comparing nutrients from the FFQ with three 4 d weighed food records collected over 1 year (n 79). Most nutrient correlations were between 0·50 and 0·60 for energy-adjusted intakes, similar to other validated FFQ studies[19,21]. The Australian Tables of Food Composition were used to estimate nutrient intakes, and data were entered and analysed using NUTTAB90 and a purpose-built software analysis system[21].

Total Diet Score development

A modified version of the Australian diet quality index[17], based on the DGAA[22] and the Australian Guide to Healthy Eating (AGHE)[23], was used to establish the Total Diet Score (TDS), assessing adherence to the Australian dietary guidelines. Our version closely follows the US 2005 Dietary Guidelines Adherence Index which takes account of changes to the 2005 American Dietary Guidelines that has a focus on overconsumption and energy density[18], issues also applicable to the Australian population. TDS were allocated for intake of selected food groups and nutrients for each participant as described in the DGAA (for details on FFQ food groupings, see Supplementary material 1, available online). The TDS is divided into ten components, and each component has a possible score ranging from 0 to 2 (Fig. 1). A maximum score of 2 was given to subjects who met the recommendations with prorated scores for lower intakes. These were then summed, providing a final score ranging between 0 and 20, with higher scores indicating closer adherence to the dietary guidelines.

The TDS account for both food intake and optimal choice, with scores allocated to reflect intake characteristics from both sources. Food intake scores were based on total intakes of vegetables, fruit, cereals and breads, meat, fish, poultry and/or alternatives and dairy as well as Na, alcohol, sugar and extra food intakes. Optimal choice scores determined intakes of foods with greater dietary benefits including serves of whole-grain cereals, lean red meat, low- or reduced-fat milk *v.* whole milk, low saturated fat intake and fish consumption. Cut points for scores were determined from the recommended number of serves given in the AGHE with some exceptions[23]. We replaced the AGHE's recommended two serves per d of fruit with three serves per d and the number of vegetables consumed per d from five serves to seven serves to allow for self-reported FFQ overestimation as determined by the validity study[19]. The alcohol cut points reflect the guidelines about alcohol consumption in Australia (DGAA), in which it is recommended, when alcohol is consumed, that men consume a maximum of two standard drinks per d and women one standard drink per d[22]. Moderate intakes of sugar were determined from the DGAA where they found no evidence that consuming a diet up to 15–20 % of energy from sugar was detrimental to a healthy diet[22]. Extra foods were defined as foods that were energy dense containing higher levels of sugar, fat or salt with one serve equivalent to 600 kJ[23]. Examples described in the AGHE include biscuits, cakes, soft drinks, ice cream, pies, hot chips and high-fat takeaway items. Identification and characterisation of additional extra foods were determined from research by Rangan *et al.*[24].

To follow dietary guideline recommendations as closely as possible, the non-dietary component of the AGHE, preventing weight gain, was included in the TDS. In this way, half the score was assigned to energy balance, calculated as the ratio of energy intake:energy expenditure with a maximum score given for ratios falling between 0·76 and 1·24, defined as the 95 % confidence levels of agreement between energy intake and energy expenditure[25]. The other half of the score was assigned to leisure-time physical activity. Physical activity levels were self-reported using questions from the Australian National Heart Foundation's Risk Factor Prevalence Surveys[26]. Details of walking exercise and the performance of moderate or vigorous activities were used to calculate metabolic equivalents.min (MET.min) as described by Brown & Bauman[27]. Subjects were categorised into low (0 to <600 MET.min), moderate (≥600 to <1500 MET.min) and high (≥1500 MET.min) tertiles of physical activity. The physical activity guidelines suggest 30 min of moderate activity, preferably on all days of the week and 600 MET.min is comparable to 30 min of physical activity on 5 d of a week[27]. Subjects in the highest MET tertile scored 1 point, reducing to a 0 point score for subjects in the lowest MET tertile.

Drinking adequate water and food safety categories from the DGAA were not included in the analysis because data on these items were not available in the present study.

Analysis variables

Demographic and lifestyle covariates used in this analysis were taken from an interviewer-administered questionnaire completed at the baseline visit. BMI was calculated as

Dietary guideline/ component	Score	Component subscore		Total score
1. Eat plenty of vegetables, legumes and fruit	Total vegetable serves/d*	7 serves	0·5	
		5·6 serves	0·4	
		4·2 serves	0·3	
		2·8 serves	0·2	
		1·4 serves	0·1	
	Vegetable variety score/d	≥1 serve green	0·1	
		≥1 serve orange	0·1	
		≥1 serve of cruciferous	0·1	
		≥1 serve of tuber or bulb	0·1	
		≥0·5 serves of legumes	0·1	
	Total fruit serves/d†	3 serves	1	
		2 serves	0·5	2
2. Eat plenty of cereals, preferably whole grain/ meal	Total cereals serves/d			
	Women	4 serves	1	
		3 serves	0·75	
		2 serves	0·5	
		1 serve	0·25	
	Men	6 serves	1	
		5 serves	0·83	
		4 serves	0·66	
		3 serves	0·5	
		2 serves	0·33	
		1 serve	0·166	
	Whole-grain cereal serves/d			
	Women	4 serves	1	
		3 serves	0·75	
		2 serves	0·5	
		1 serve	0·25	
	Men	6 serves	1	
		5 serves	0·83	
		4 serves	0·66	
		3 serves	0·5	
		2 serves	0·33	
		1 serve	0·166	2
3. Include lean meats, fish, poultry and/ or alternatives	Meat/alternative/d	≥1 serve	1·5	
	Lean red meat/week (i.e. > 0·428/d)	≥3 serves	0·5	2
4. Include milk, yoghurts, cheese and/or alternatives	Total dairy serves/d	≥2–3 serves	1·5	
		≥3–4 serves	1·0	
		1–<2 serves	1·0	
		>4 serves	0·5	
		0–<1 serves	0	
	Ratio of skimmed/low fat (S/LF) intake: whole milk intake	S/LF>whole milk	0·5	
		S/LF=whole milk	0·25	
		Whole milk>S/LF	0	2

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Dietary guideline/ component	Score	Component subscore		Total score
5. Limit saturated fat and moderate total fat intake	Percentage of energy from saturated fat	<10% energy	1	
		10–12% energy	0·5	
		>12% energy	0	
	Fish serves/week	≥ 2 serves	1	
		1–<2 serves	0·5	2
		<1 serve	0	
6. Choose foods low in salt	Na intake/d	≤ 40 mmol (920 mg)	2	
		> 40–≤100 mmol (920–2300 mg)	1	
		>100 mmol (2300 mg)	0	2
7. Limit alcohol intake if you choose to drink	Alcohol intake/d			
	Women	≥0 g–<10 g	2	
		≥10 g–<20 g	1	
		≥20 g	0	
	Men	≥0g–<20 g	2	
		≥20 g	0	2
8. Consume only moderate amounts of sugars and foods with added sugars	Percentage of energy from sugar	<15% total energy	2	
		≥15–<20% total energy	1	2
		≥20% energy	0	
9. Extra foods, not essential to provide nutrients and maybe high in salt, fat or sugar	Extra food serves/d			
	Women	<2·5 serves	2	
		2·5–<4 serves	1	
		>4 serves	0	
	Men	<3 serves/d	2	
		3–<5 serves	1	
		≥5 serves	0	2
10. Prevent weight gain: be physically active and eat according to energy needs	Ratio of energy intake to energy expenditure	0·76–1·24	1	
		<0·76 or >1·24	0	
	Physical activity (METs)	Lowest tertile	0	
		Middle tertile	0·5	
		Highest tertile	1	2
Drink plenty of water	Not scored			
Care for food	Not scored			
Total score				20

Fig. 1. Scoring system for the Total Diet Score based on the Australian Dietary Guidelines and the Australian Guide to Healthy Eating. * Vegetables: 7 serves, as indicated by weighed food records (FFQ overestimates) (replacing five serves). † Fruit: 3 serves, as indicated by weighed food records (FFQ overestimates) (replacing two serves). S/LF, skimmed/low fat; MET, metabolic equivalents.

weight (kg) divided by height (m^2), which were measured at baseline examinations using standardised methods. The following two BMI variables were created: 'low BMI' defined as $<20\,kg/m^2$ and 'high BMI' defined as $\geq 30\,kg/m^2$. Education was classified as either 'non-qualified', having a high school diploma or less, or 'qualified', having any post-school qualification (including trade certificate, diploma and/or degree).

Blood pressure was measured after sitting for at least 10 min, using standardised methods. Hypertension was defined using the 2003 WHO guidelines, taking as hypertensive grade 2 or above (severe hypertension), which included persons previously diagnosed as hypertensive and currently using anti-hypertensive medications, or those with a systolic blood pressure ≥160 mmHg or diastolic blood pressure ≥100 mmHg at examination. A history of acute myocardial infarction, stroke or cancer was self-reported by subjects who answered yes to the question 'Has a doctor advised you that you have any of the following conditions?'. Walking disability was assessed by the examiner during the clinic visit in subjects who had walking difficulties or used a cane/crutches/walker or a wheel chair. Leucocyte count was measured from fasting blood samples and determined using the Coulter counter method. Dietary

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supplement users were defined as individuals who consumed supplement(s) for a minimum of 4 d/week at least 2 months before the study.

Statistical analysis

All statistical analyses were performed using SAS (version 9.1; SAS Institute). Quintiles of TDS were created from the overall study population and the mean intake of selected foods was calculated for each quintile. Regression models were used to calculate mortality hazard risk (HR) ratios with 95 % CI for each quintile. The first multivariate model was adjusted for age and sex; the second model adjusted for age, sex and lifestyle variables including smoking, BMI, education and diet supplement use. A final multivariate model was adjusted additionally for poor self-reported health, hypertension, diabetes, acute myocardial infarction, stroke, cancer, leucocyte count and walking disability. Quintile 1 (lowest) was used as the reference group and P for trend $<0{\cdot}05$ was considered significant. The data were also analysed as continuous scores to determine mortality risk for each standard deviation increase in TDS for all multivariate models (1 SD = 2·19). Sensitivity analysis was performed by excluding one component at a time from the TDS to determine whether any individual component influenced the total score.

Results

Baseline characteristics of the subjects are given by quintile of TDS in Table 1. Women, non-smoking subjects and those with post-high school qualifications had trends for increasing TDS. Decreasing trends by TDS quintile (P for trend $<0{\cdot}05$) were found for the number of subjects who self-reported fair or poor health.

In this population of older Australians, the baseline TDS ranged from a minimum score of 2·97 to a maximum of 15·40, out of a possible score of 20 (Table 2). Table 2 gives the total mean intakes of the core food groups with greater intakes of fish, fruit and vegetables, cereals, breads and cereal-based products and all milk products in persons with higher TDS (P for trend $<0{\cdot}0001$ for all). As an important part of the core food groups, the mean intakes of optimal choice foods were also analysed separately (Table 2). Consistent with the design of the TDS, the number of older

Table 1. Baseline characteristics of the subjects by Total Diet Score quintile (*n* 2897)

	Quintile 1 (%)	Quintile 2 (%)	Quintile 3 (%)	Quintile 4 (%)	Quintile 5 (%)
n	579	580	578	583	577
Age (years)					
Mean	65·5	65·8	65·3	64·6	65·7
SD	9·9	9·5	9·7	8·9	8·5
Sex (*n* 2897)					
Female	43·7	51·0	56·1	59·0	70·0*
Marital status (*n* 2893)					
Married or *de facto*	64·7	67·0	66·9	70·8	62·2
Divorced or separated	10·9	10·5	11·1	9·6	13·0
Widowed	16·4	15·4	14·9	12·5	17·5
Never married	8·0	7·1	7·1	7·0	7·3
BMI (kg/m^2) (*n* 2856)					
Low <20 kg/m^2	6·2	5·5	5·1	3·3	5·2
Moderate 20– <30 kg/m^2	77·1	77·3	74·6	79·5	79·3
High ≥ 30 kg/m^2	16·7	17·3	20·3	17·2	15·5
Smoking status (*n* 2777)					
Never	38·0	41·0	48·8	57·2	59·3
Past	38·7	41·3	35·7	34·3	34·3
Current	23·3	17·7	15·6	8·5	6·4*
Physical activity (*n* 2841)					
Low	59·9	58·1	50·7	43·2	37·5
Moderate	27·0	22·5	26·7	29·1	31·3
High	13·1	19·4	22·6	27·7	31·3*
Education (*n* 2762)					
Tertiary	54·5	60·2	59·1	62·5	61·8*
Diet supplement use (*n* 2897)	30·1	35·0	34·3	36·7	48·3*
Self-reported health (*n* 2858)					
Excellent/good	70·9	74·3	77·2	82·0	79·9
Fair/poor	29·1	25·8	22·8	18·0	20·1*
Walking disability (*n* 2888)	7·3	3·1	5·7	4·0	4·4
Hypertension (*n* 2888)	45·9	46·0	46·3	42·1	46·7
Diabetes (*n* 2897)	5·2	6·9	5·4	8·9	10·1*
AMI (*n* 2893)	6·2	7·9	8·7	8·6	10·8*
Stroke (*n* 2894)	6·0	5·0	4·5	4·0	4·0
Cancer (*n* 2894)	8·5	7·9	9·2	8·3	8·5

AMI, acute myocardial infarction.
* *P* for trend $<0{\cdot}05$.

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Australians reporting consumption of optimal choice foods increased through the quintiles for all major food groups. For example, mean wholemeal/whole-grain cereal intake increased by 137 % through quintiles 1–5. Total dairy intake increased by 31 % between quintile 1 and quintile 5, yet intake of low- or reduced-fat milk increased by 224 % from the lowest to the highest quintile of TDS.

During the 15-year follow-up, 1047 (36·2 %) subjects died. Participants with higher TDS had a lower risk of all-cause mortality. Subjects in quintile 5 had a significant 21 % decreased risk of all-cause mortality compared with the reference group (quintile 1) (multivariate-adjusted HR 0·79, 95 % CI 0·63, 0·98, P for trend=0·04) and a 23 % decreased risk of cardiovascular mortality (adjusted HR 0·77, 95 % CI 0·57, 1·05, P for trend=0·1) (Table 3). No association between diet quality and cancer mortality was found in any of the models (Table 3). Sex was assessed as a potential effect modifier but no statistically significant interaction was found (Table 3), and therefore we decided not to stratify by sex. In addition, we re-ran the analysis after excluding subjects (n 98) who died within the first 2 years of follow-up and found similar results for both all-cause mortality (adjusted HR 0·83, 95 % CI 0·66, 1·04) and CVD mortality (adjusted HR 0·76, 0·57, 1·01).

We also examined TDS as a continuous variable and observed an 8 % (P=0·02) decrease in multivariate-adjusted all-cause mortality per standard deviation increase in TDS (1 SD = 2·19 units; HR 0·92, 95 % CI 0·86, 0·99). A similar decrease in cardiovascular mortality was observed for each standard deviation increase in TDS (HR 0·91, 95 % CI 0·82, 1·00) but not for cancer mortality.

We performed sensitivity analysis to determine whether the association between TDS and mortality was influenced by any specific individual TDS component. Each component was removed, one at a time, from the total score and the analysis was then conducted again. This analysis demonstrated that the present results were not sensitive to the removal of any single component and the trend was similar for all models (see Supplementary material 2, available online).

Discussion

The present findings show that, overall, older Australians who more closely followed the DGAA had a significantly lower all-cause mortality risk over the next 15 years. Further, participants with higher levels of diet quality included significantly greater quantities of a range of recommended optimal choice foods in their diets, suggesting that following the current Australian dietary guidelines may reduce the likelihood of all-cause mortality.

The goals of different diet quality indices may influence the relationship between diet quality and the risk of chronic disease and/or mortality[12]. Predicting health outcomes often depends on the purpose of the index, for example both the Diet Quality Index and Healthy Eating Index (HEI) were adapted to improve chronic disease risk prediction and the alternative HEI was found to have greater capacity to

Table 2. Description of the range of Total Diet Scores (TDS) in each quintile, with associated consumptions of lean red meat, fish and fruit and vegetables

(Mean values and 95 % confidence intervals)

	Quintile 1		Quintile 2		Quintile 3		Quintile 4		Quintile 5	
	Mean (g)	95 % CI	Mean (g)	95 % CI	Mean (g)	95 % CI	Mean (g)	95 % CI	Mean (g)	95 % CI
n	579		580		578		583		577	
Mean TDS	6·22		8·02		9·19		10·45		12·39	
Median TDS	6·53		8·00		9·16		10·45		12·20	
Minimum TDS	2·97		7·36		8·63		9·77		11·17	
Maximum TDS	7·35		8·63		9·75		11·15		15·40	
All fruit (including dried and canned fruit)	227·8	209·8, 245·8	306·4	287·5, 325·2	342·4	324·5, 360·3	381·4	357·9, 404·9	449·4**	428·5, 470·3
Fresh fruit	202·9	186·5, 219·4	276·1	258·1, 294·1	308·5	291·5, 325·6	345·9	323·5, 368·4	409·5**	389·5, 429·5
All vegetables	367·1	351·3, 383·0	413·9	398·9, 428·9	446·4	431·7, 461·1	471·6	456·1, 487·0	507·6**	491·7, 523·5
Vegetables excluding potatoes	255·2	243·1, 267·3	296·4	284·3, 308·5	328·2	315·9, 340·5	352·2	339·2, 365·1	396·8**	383·1, 410·5
Cereals, breads and cereal-based products	156·8	147·9, 165·6	197·4	187·4, 207·3	214·0	204·1, 224·0	232·5	221·8, 243·2	276·1**	264·8, 287·3
Wholemeal/whole-grain cereals	71·6	64·6, 78·6	95·4	87·7, 103·2	116·2	107·6, 124·7	129·7	120·7, 138·7	170·0**	159·9, 180·1
Fish	16·1	14·8, 17·4	23·1	21·1, 25·0	26·6	24·6, 28·5	32·3	30·0, 34·7	39·1**	36·2, 42·0
All red meat	112·8	106·6, 118·9	114·0	107·9, 120·1	110·3	104·8, 115·8	108·6	102·8, 114·4	91·0**	86·0, 96·1
Leaner red meat	38·8	35·3, 42·2	52·4	48·3, 56·4	57·0	53·2, 60·7	62·1	58·1, 66·1	58·7**	55·0, 62·3
Dairy products	286·7	262·2, 311·1	313·2	294·6, 331·7	357·9	336·1, 379·7	368·9	348·6, 389·3	375·5**	356·9, 394·1
Low- or reduced-fat milk	85·2	68·9, 101·4	113·9	98·3, 129·5	161·0	141·5, 180·4	206·9	187·0, 226·8	275·6**	255·7, 295·5
Alcoholic beverages	344·2	305·6, 382·7	205·0	176·4, 233·6	142·1	118·5, 165·7	84·4	71·3, 97·5	57·8**	45·9, 69·7
Extra foods	433·8	401·3, 466·2	378·0	349·1, 406·9	379·4	349·0, 409·8	337·4	308·7, 366·0	318·1**	290·3, 345·9

** P for trend < 0·0001.

Table 3. Total Diet Score (TDS) and risk of total and cause-specific mortality by quintile of TDS and as a continuous variable (Hazard risk ratios (HRR) and 95 % confidence intervals)

TDS quintile	Subjects (*n*)	Deaths *n*	Deaths %	HRR by TDS quintile* HRR	95 % CI	*P* for trend	Sex interaction	HRR by standard deviation of TDS* HRR	95 % CI	*P* for trend
All-cause mortality								0·92	0·86, 0·99	0·02
Quintile 1	477	194	41	1·0	Ref	0·04	*P*= 0·62			
Quintile 2	484	180	37	0·92	0·75, 1·13					
Quintile 3	503	179	36	0·95	0·78, 1·17					
Quintile 4	509	162	32	0·90	0·73, 1·11					
Quintile 5	517	153	30	0·79	0·63, 0·98					
Cardiovascular mortality								0·91	0·82, 1·00	0·06
Quintile 1	477	95	20	1·0	Ref	0·1	*P*= 0·74			
Quintile 2	484	94	19	0·92	0·69, 1·23					
Quintile 3	502	100	20	1·05	0·79, 1·40					
Quintile 4	509	85	17	0·92	0·68, 1·25					
Quintile 5	517	79	15	0·77	0·57, 1·05					
Cancer mortality								0·98	0·87, 1·11	0·8
Quintile 1	477	57	12	1·0	Ref	0·8	*P*= 0·94			
Quintile 2	484	64	13	1·14	0·80, 1·63					
Quintile 3	503	61	12	1·09	0·76, 1·58					
Quintile 4	509	56	11	1·01	0·69, 1·47					
Quintile 5	517	54	10	1·01	0·69, 1·49					

Ref, reference.
* Adjusted for age, smoking BMI (low, high), education, dietary supplement use, self-reported poor health, hypertension, diabetes, acute myocardial infarction, stroke, cancer, leucocyte count and walking disability.

predict chronic disease risk[28]. The aim of the TDS was to examine overall diet and how closely participants adhered to the DGAA and the AGHE as well as to determine whether following the dietary guidelines reduced the risk of mortality. Another diet quality index, the Recommended Food Score, has been found to predict chronic disease risk better than more complex indices. However, the Recommended Food Score scoring system only scores intakes of recommended foods in the diet, in particular fruit and vegetable intake, and does not consider energy-dense nutrient-poor foods, such as extra foods[2].

An inverse association between diet quality and the risk of all-cause mortality and cause-specific mortality has been reported in a number of studies. These findings were based on reduced mortality risk and adherence to a Mediterranean diet pattern[29] and the WHO's guidelines for preventing chronic disease[30]. However, results from indices that are based more closely on published dietary guidelines do not show a consistent inverse relationship between diet quality and all-cause mortality, CVD or cancer mortality[31,32]. The evidence for a relationship between diet quality and cancer mortality is inconsistent in adults. The present non-significant findings for cancer mortality after multivariate adjustment are similar to other studies that have used different diet quality indices[31–33]. There are many different types of cancer and the effect of dietary factors varies between different cancer sites. However, we only investigated total cancer mortality and had insufficient power to explore site-specific cancer types.

The inconsistent findings could be explained by the low level of compliance to dietary guidelines and the reduction in the risk of mortality or the development of chronic disease may be improved if overall diets were improved. The results from the present study suggest poor compliance with dietary guidelines with the maximum score reaching approximately 75 % compliance to dietary guidelines, which is consistent with other findings in the Australian population[34,35]. However, even at this level, we found a significant decrease in the risk of all-cause mortality in those who had greater compliance. The present significant findings of higher diet quality in those who had an existing diagnosis of diabetes or acute myocardial infarction suggest that older adults may be willing to change their diet due to health reasons but as the baseline data in the present study were cross-sectional, it is not possible to explain these results fully.

The TDS differs from other indices in a number of ways. The dietary guidelines were designed to be applied to the total diet with no individual guidelines being considered in isolation; therefore, we gave each component equal weighting. Under the heading of enjoying a wide variety of nutritious foods, we considered four core groups, keeping vegetables, legumes and fruits as one component as described in the DGAA. We included a score for the non-dietary component prevention of weight gain measured by energy balance ratio and physical activity levels that has been excluded from previous diet quality indices[18,34]. The importance of regular physical activity is emphasised by its inclusion in the DGAA since 1992 as part of maintaining a healthy body weight[22]. 'Extra' foods were considered as an individual component because they capture many energy-dense nutrient-poor foods that are not included in the core food groups and may only partly contribute to nutrient intake. These are highlighted in the AGHE which provides materials for the general public to use to help manage their diet. It has been reported that 'extra' foods contributed 36 % of energy from sugars in Australian adults, considerably higher than

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the recommended levels and 99·1 % consumed at least one 'extra' food[24].

To our knowledge, this is the first Australian study to examine longitudinal data assessing the relationship between diet quality and mortality using a tool based on the DGAA and AGHE. Cross-sectional studies in Australia to date have reported generally higher nutrient intakes with higher diet quality scores[34,36]. There were no known validated Australian diet quality indices at the time the TDS was developed; therefore, an index assessing the 2005 American Dietary Guidelines was reviewed that distinguished between food intake relating to energy and optimal choice recommendations to make improvements to the TDS[18]. The significant trend for higher consumption of fruits and vegetables, fish, whole-grain breads and cereals across the TDS quintiles is similar to the findings from studies in the USA, Europe and Australia[16,37–40]. However, the variety of scoring methods for diet quality such as the Recommended Food Score and Mediterranean Diet Score, length of mortality follow-up and differing covariate adjustments limits direct comparison of the present findings with other studies. With regard to potential confounders, we adjusted for known modifiable health behaviours in the second model but not for alcohol and physical activity levels, as these were included as components of the TDS. For the final multivariate model, we adjusted for a range of health conditions including chronic diseases and walking disability which are known to be related to diet[41].

The present study has a number of limitations. Using FFQ for self-reported dietary intake can underestimate energy intake[42] or overestimate fruit, vegetable and dairy intakes[43,44]. To allow for this overestimation, we increased the cut point for fruit and vegetable intake per d to three serves and seven serves, respectively. However, the present results provide a good indicator of the proportion of optimal foods consumed between those in the lowest to highest quintile of TDS. For example, total red meat intake reduced from quintile 1 to quintile 5, while choosing leaner red meat cuts increased across the quintiles in the opposite direction. The reduction in red meat intake could be explained by higher fish intake with intakes increasing by 143 % from the lowest to the highest quintile of TDS. In addition, the FFQ only measures diet at one time point and not over a lifetime. However, older adults may have established eating patterns that remain constant over time[42].

A further limitation is the assumption that the dietary guidelines used to define diet quality indices are based on the best available scientific knowledge, though this may not necessarily be the case as it is difficult to keep dietary guidelines up to date[45]. The DGAA were developed to provide guidelines for diet targeting overall health and well-being, but they are not disease specific and may provide protective benefits for some diseases and not others[46]. Many subjects had at least one chronic disease at baseline, which was adjusted for in model 2 of the present analysis. The data were reanalysed, excluding participants who died within 2 years of baseline and the results were similar throughout. However, there is the possibility that residual confounding may have influenced the associations between mortality and dietary intakes. Although we accounted for known confounders, mortality causation is multifactorial and there may be other confounding factors that need to be considered. The strengths of the present study include its high response rate in a population-based sample as well as detailed data collection enabling us to assess a wide range of potential confounders. The present study population is representative of the Australian population in the same age group, except for a slightly higher SES shown by a higher proportion who owned their home, a higher proportion with qualifications after leaving school and a lower proportion of manual workers[47].

In conclusion, these data provide useful information about the relationship between adhering to dietary guidelines and mortality risk in a representative older Australian population. As assessment of diet quality was based on adherence to the DGAA, the TDS could be applied to longitudinal data assessing the effects of diet quality and morbidity or mortality risk in other Australian adult populations.

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Supplementary material is available online at http://journals.cambridge.org/bjn

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