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Dietary patterns in rural and metropolitan Australia: a cross-sectional study exploring dietary patterns, inflammation and association with cardiovascular disease risk factors

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ABSTRACT

Objectives This study sought first to empirically define dietary patterns and to apply the novel Dietary Inflammation Score (DIS) in data from rural and metropolitan populations in Australia, and second to investigate associations with cardiovascular disease (CVD) risk factors.

Design Cross-sectional study.

Setting Rural and metropolitan Australia.

Participants Adults over the age of 18 years living in rural or metropolitan Australia who participated in the Australian Health survey.

Primary outcomes A posteriori dietary patterns for participants separated into rural and metropolitan populations using principal component analysis. Secondary outcomes: association of each dietary pattern and DIS with CVD risk factors was explored using logistic regression.

Results The sample included 713 rural and 1185 metropolitan participants. The rural sample was significantly older (mean age 52.7 compared with 48.6 years) and had a higher prevalence of CVD risk factors. Two primary dietary patterns were derived from each population (four in total), and dietary patterns were different between the rural and metropolitan areas. None of the identified patterns were associated with CVD risk factors in metropolitan or rural areas, aside diet pattern 2 being strongly associated with from self-reported ischaemic heart disease (OR 13.90 95% CI 2.29 to 84.3) in rural areas. There were no significant differences between the DIS and CVD risk factors across the two populations, except for a higher DIS being associated with overweight/obesity in rural areas.

Conclusion Exploration of dietary patterns between rural and metropolitan Australia shows differences between the two populations, possibly reflective of distinct cultures, socioeconomic factors, geography, food access and/or food environments in the different areas. Our study provides evidence that action targeting healthier dietary intakes needs to be tailored to rurality in the Australian context.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This study used representative national data sets, which represent the most recent, highest quality and comprehensive diet, disease and biomedical measures population data available currently for Australia.

⇒ This study provided the first exploration of dietary patterns by rurality in Australia.

⇒ Due to the nature of the data, remoteness was dichotomised and may not fully consider the heterogeneity of rural areas. Further, the AHS did not sample from very remote populations in Australia.

⇒ A further strength is that the researchers involved in the data analysis have specific nutrition and dietetics expertise (LA and SEJ), and used eigenvalues and scree plots to guide the determination of the best number of components to extract from the dietary pattern analysis.

INTRODUCTION

For most populations residing in rural, remote or non-urban areas around the world, the experience of suboptimal health relative to urban (or metropolitan) counterparts is well documented.[1–4] In high-income countries including Australia and the USA, diet-related risk factors, such as obesity, hypertension, diabetes and dyslipidaemia, are among the largest contributors to preventable disease and mortality.[5] Acknowledging that all levels of remoteness, and the populations within these, are highly heterogeneous, we refer to rural, regional, remote and non-urban areas, as 'rural' here-in and metropolitan as 'metro'. In Australia, residents of rural areas experience higher rates of cardiovascular disease (CVD), diabetes, some cancers and obesity when compared

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with metro populations.[1 4] Furthermore, residents outside metro areas in Australia live almost exclusively in areas of lower socioeconomic status when compared using the nationally consistent Index of Relative Socio-economic Advantage and Disadvantage.[6]

A lack of action and attention towards prevention in rural settings has been further exacerbated by a lack of research and evidence in these communities.[7–10] Barclay *et al* demonstrated that there has been minimal research investment in rural areas of Australia, relative to need.[10] More recently, research by Alston *et al* outlined the absolute scarcity of research funding allocated to understanding or improving dietary behaviours in rural, regional and remote Australia.[11] This translates to many gaps in our knowledge around the role of diet in driving health disparities in rural areas and extends to how we can advance prevention activity that enables better health in future rural-dwelling generations.

Despite the lack of research on rural dietary intakes in Australia,[11] there is evidence to show diet plays a role in health inequities between rural and metro areas[12 13] and that understanding dietsin rural populations are important to inform future evidence-based health promotion initiatives.[14] Analysis of the most recent national-level dietary intake and modifiable risk factor data showed that if people living in rural Australia were able to achieve the same behaviour and risk factor profiles as their metro counterparts, the absolute gap in mortality between the two geographies would be reduced by 38%.[12] Other modelling has shown that meeting fruit and vegetable recommendations would achieve the highest CVD mortality reductions (~40%) in CVD in rural areas out of all modifiable behaviours.[15] Further evidence has shown that public health nutrition priorities are different between rural and metro Australia.[15] A recent review that sought to synthesise all dietary data collected from rural Australians highlighted multiple gaps in dietary data collection outside of major cities in Australia, finding only 21 studies in the past 20 years.[11] Of the data available on rural dietary intakes, over 50% of the studies collected data using non-validated tools and none looked at dietary pattern analysis specifically for rural populations.[11] The majority of studies also did not compare dietary intakes with public health recommendations, meaning it was difficult for the authors to make meaningful conclusions and identify areas for improving dietary intakes in rural areas.[11] Alston and Partridge recently highlighted that despite knowledge on the role of diet in the mortality gaps between rural and metro areas, few interventions have been conducted in these settings,[16] and further research into dietary intakes across different geography is needed to understand areas of focus.[16]

Exploration of dietary patterns in rural areas of Australia and comparison with metro areas has been minimal to date.[11] Population-level dietary patterns reflect different dietary practices and culture, and may be linked to inflammation and chronic disease patterns, such as CVD.[17 18] Dietary pattern analysis is useful in providing easy to translate information for the general public and also informs public health nutrition campaigns.[19] Usually, remoteness is and included in dietary analyses as a confounder rather than analysed separately to assess the possibility of differing diet patterns in rural and metro regions.[2] Alongside a lack of dietary data collection and analysis, there has been limited application of dietary inflammatory scoring methods in Australian populations.

The REasons for Geographic and Racial Differences in Stroke (REGARDS) study has provided comprehensive regional evidence of the association between particular dietary patterns and the risk of stroke in the USA.[20] From this study, REGARDS researchers have developed and validated a 'Dietary Inflammation Score' (DIS) based on data from intake of food groups and association with inflammatory biomarkers.[21] The DIS allows for an estimation of the influence of dietary patterns on systemic inflammation, which increases the risk of chronic disease.[21] Exploration of the how the DIS differs between rural and metro areas may provide evidence to further understand areas for nutrition intervention and research that will address health disparities for rural Australians. Using Australia's most recent comprehensive national survey of biomedical measures and dietary intakes,[22] we set out to:

1. Empirically define dietary patterns and to apply the novel DIS, in data from rural and metropolitan populations in Australia.
2. Investigate associations of both dietary patterns and the DIS with CVD risk factors.

METHODS

Setting

Metro and rural Australia. Very remote areas of Australia were not included in the sampling.[23]

Patient and public involvement

None.

Study design

The AHS consists of two separate surveys: the National Health Survey (NHS), which includes the National Nutrition and Physical Activity Survey (NNPAS) and the National Health Measures Survey (NHMS).[23] These behavioural and biomedical survey data are the most recently available nationally representative data that include comprehensive dietary data coupled with disease and biomedical measures data.[23] The survey was conducted using a stratified multistage area sample of private dwellings, which generated detailed estimates across remoteness areas of Australia.[23] Dwellings were selected at random using a multistage area sample of private dwellings for the NHS (25 080 households and 31 837 respondents aged 2 years and over in the core sample), and for the subset NNPAS component, initially included 12 400 dwellings.[23] Within each dwelling, a random subsample was selected of one adult over the age of 18 years (and one child aged 2–17

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years, data not analysed here). Of those dwellings, 9519 dwellings included people who adequately responded to the survey, yielding a total sample for the survey of 12 153. Dietary intakes were collected in the NNPAS using two, 24-hour dietary recalls (n=12 153, 77.0% response rate).[24] A total of 11 246 people participated in the NHMS. For the present analysis, individuals were split into two data sets: 'rural' and 'metro' population. The 'rural' population was defined as all included participants who were not classified by the Australian Bureau of Statistics Australian Geographical Standard Remoteness Areas[25] as living in major cities (ie, those living in Inner Regional Australia, Outer Regional Australia and Remote Australia). Self-report measures (such as whether or not participants had ever been told they have high blood pressure, high cholesterol, diabetes mellitus or ischaemic heart disease (IHD)) were collected via the NNPAS survey.[23] Biomedical measures were collected via the NHMS and participants were asked to provide both a blood and urine sample, which were then analysed for specific biomarkers.[23] Detailed specific sampling and data collection methods are outlined elsewhere.[23]

Individuals were excluded if they:

- Reported had implausible energy intakes, defined as an energy intake to basal metabolic rate ratio of less than 0.9, as per recommendation from the ABS[23] from both day 1 or day 2 (removed 4528 participants).
- Were <18 years of age (removed 3418 participants).
- Did not participate in the biomedical measure component of the study (removed 1898).

This resulted in the current analysis samples of 1185 and 713 participants from metro and rural areas, respectively (figure 1). Data were analysed using a complete analysis approach.[26]

Dietary and person-level data

Food items in the NNPAS basic Confidentialised Unit Record File were classified into 56 food groups based on previous research[20] using a combination of 3-digit, 5-digit and 8-digit food codes as required (online supplemental table 1), with reference to nutrient composition and traditional food groupings derived from the AUSNUT 2011–2013 food nutrient database.[27] The mean consumption of each group over days 1 and 2 of the recall was calculated.[22] If data were from day 1 or 2 of the recall, a single day of data was used. Food consumption data were then matched and merged with person-level demographic and self-report data from the NNPAS and biomedical level data from the NHMS using the ABS unique person identifiers. Data from the NNPAS and NHMS also included both self-report and measured cholesterol, blood pressure, diabetes and the presence of IHD. The mean intakes of key nutrients were calculated for each population.[27]

Dietary pattern analysis

The 56 food groups were then used to derive dietary patterns using principal component analysis (PCA), replicating methods previously used in the REGARDS study[20] and consistent with recommendations of a recent systematic review of dietary pattern analysis methodologies.[28] PCA is commonly used in dietary patterns research and replaces a set of potentially correlated, predefined food groups with a new set of principal components that are uncorrelated and retain as much of the food variance as possible.[29] Patterns were derived separately for rural and metro adult populations. PCA was used for extraction of factors and varimax rotation was used to derive non-correlated factors.[29] Following factor analysis in the two populations, we used the Kaiser criterion and scree plots to determine how many patterns to select in each population.[29] The Kaiser criterion is defined as an Eigenvalue of >1.0 and widely used for the choice of the number of factors in factor analysis.[29] For everyone in the sample, the factor loading of each food group was multiplied by the mean consumption of each food group (in grams per day) to calculate factor scores for each dietary pattern. Adherence to dietary pattern was determined by splitting individual factor scores into quartiles, consistent with previous studies.[20 30 31] For example, for a given dietary pattern, participants with a factor score in the top 25% were categorised as high adherers, whereas individuals with a factor score in the lowest 25% were categorised as low adherers.[20 30 31] The adherence of a participant to any given dietary pattern did not preclude the participant from being a high or low adherer to any other dietary pattern.

Dietary Inflammation Score

The validated DIS was developed by Byrd *et al*, using REGARDS data from >30 000 participants, and has been applied to multiple other studies exploring dietary data.[21 31 32] To apply the DIS to the data in this study, food groups and supplements were categorised according to the DIS 19 groupings (consisting of 18 food groups and 1 multivitamin/mineral supplement group).[21] The DIS weights were developed in the REGARDS study data, by assessing the strengths of the multivariable-adjusted associations of each food group component with measured circulating biomarkers of inflammation, including high-sensitivity C reactive protein, interleukin-6 (IL-6), IL-8 and

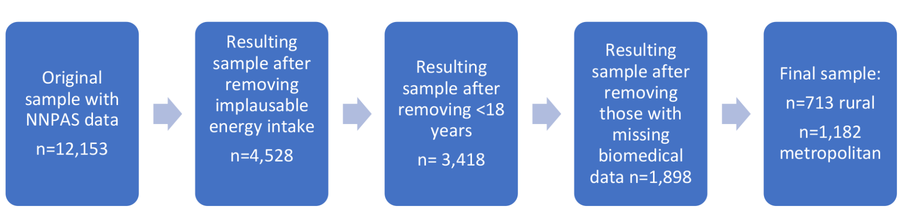

Figure 1 Analytical sample from n=12 153. NNPAS, National Nutrition and Physical Activity Survey.

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IL-10.[21] The DIS was then calculated by multiplying the food group components (in g/day) by the DIS weightings for each group. The population was then standardised by sex, to standardised to have a mean of 0 z-scores with a mean of 0 and SD of 1. Detailed scoring methods for the DIS are documented elsewhere.[21]

Statistical analysis

Data were analysed using STATA (V.17.0, StataCorp) using weightings to account for the complex survey design. T-tests of means and proportions were used to understand differences between rural and metro samples' demographic characteristics and overall nutrient intakes. Logistic regression was used to assess the association of each dietary pattern with dichotomous outcome variables, including: self-reported presence of IHD (yes/no), self-reported diabetes (yes/no), self-reported high cholesterol (yes/no) and self-reported hypertension (yes/no), measured cholesterol (normal/high), measured blood pressure (normal/high), diabetes (estimated from average HbA1c (high/low) and weight status category (normal/overweight and obesity, calculated from measured body mass index (BMI). The DIS s were compared with the four measured biomedical outcomes due to the objective measure of these biomedical data, against the validated DIS, as opposed to self-reported outcomes. Confounders were selected based on the dietary patterns literature and included sex, age (65 years and over vs below 65 years), socioeconomic status (using the Socio-Economic Index for Areas (SEIFA) 2011, Index of Relative Socio-Economic Disadvantage quintiles,[33] mean energy intake (kilojoules per day), physical activity (meeting vs not meeting physical activity recommendations of 150 min/week,[34] categories for highest level of education attained (bachelor degree, diploma, certificate, certificate not otherwise classified) and smoking status (current weekly, current less than weekly, ex-smoker or non-smoker).[20 22 35]

RESULTS

Demographics

There were differences in demographic characteristics between the rural and metro sample (outlined in online supplemental table 2). The rural sample was significantly older than the metro sample, with a mean age of 52.7 compared with 48.6 years in metro areas, and a significantly higher proportion of the population disadvantaged (SEIFA), compared with the metro population. Significantly higher proportions of the rural population reported having hypertension, high cholesterol and IHD than the metro population. The rural population also had significantly higher saturated fat and sodium intakes and measured overweight/obesity compared with the metro population.

Dietary patterns

Based on the Kaiser criterion and scree plots,[28] two primary dietary patterns emerged in each of the rural and metro populations (ie, a total of four dietary patterns). The top 10 factor loadings for each dietary pattern are outlined in figure 2 (full factor loadings presented in online supplemental table 3). In rural areas, pattern 1 'veg, red meat and fruit diet' (2A) had high factor loadings for other vegetables, tomatoes, red meat, potatoes, cruciferous vegetables, fruit, leafy green vegetables, dark vegetables, yoghurt. Pattern 2, 'high fat, sweet biscuits and coffee diet' in rural areas had high loadings for added fat, butter, added sugars, white bread, sweet biscuits, soup, processed meat, high fat milk, coffee and tea (2B). In metro areas, pattern 1 'high fat, sugar-sweetened beverages (SSB), beer and chips diet' (2C) had high factor loadings for high fat milk, high fat dairy, SSBs, white bread, beer, chips, salty snacks, butter, processed meat and added fats. Pattern 2 includes, 'vegetable, butter and red meat diet' other vegetables, tomatoes, potatoes, added fats, butter, red meat, eggs, dark vegetables, wine and leafy green vegetables (2D). Table 1 shows the mean intake of nutrients by dietary pattern among the highest adherers by either rural or metro population. The table shows differences between the mean intakes among high adherers of either pattern.

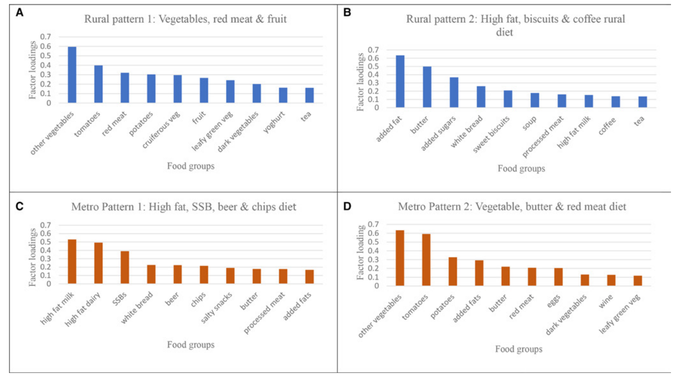

Figure 2 Retained factors for rural and metro populations with top 10 weighted food groups.

Table 2 shows the ORs for the association of each quartile of adherence to either pattern 1 or 2 in rural and metro populations with self-reported IHD and with CVD risk factors. In rural areas, the highest and second quartiles of adherence to dietary pattern 1 were both strongly associated with having self-reported hypertension (Q1 OR 2.54, 95% CI 0.97 to 6.63; Q2 OR 2.90, 95% CI 1.16 to 4.36). The metro population also had significant results for the hypertension for the highest and Q2 of diet pattern 1. Self-reported diabetes or high cholesterol was not significantly associated with adherence to either dietary pattern in either population. People in rural areas with self-reported IHD were significantly more likely to be high adherers to diet pattern 2 (OR 13.90, 95% CI 2.29 to84.3).

Table 3 shows dietary pattern adherence and associations with measured CVD risk factors. The odds of having high measured cholesterol increased with adhering to dietary pattern 1 across rural and metro populations but was not significant. Neither dietary pattern was

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Table 1 Mean intakes of nutrients by dietary pattern among the highest adherers and rurality

	Rural pattern 1	Rural pattern 2	Metro pattern 1	Metro pattern 2
Nutrients (mean (linearised std error))	High adherers to the ‘rural veg, red meat and fruit’ diet	High adherers to ‘rural high fat, biscuits and coffee’ diet	High adherers to ‘metro high fat, SSBs, biscuits and chips’ diet	High adherers to the ‘veg, butter and read meat’ diet
Energy intake (kilojoules/day)	9902 (273.5)	11 049.2814 (287.2)	9254 (174.6)	11 046 (208.9)
%EI from total fat	31.2 (0.5)	32.8 (0.5)	31.5 (0.50)	32.4 (0.47)
%EI from saturated fat	12.3 (0.3)	14.0 (0.3)	11.1 (0.24)	13.2 (0.26)
%EI from protein	19.4 (0.4)	16.5 (0.35)	18.4 (0.3)	18.0 (0.32)
%EI from carbohydrates	41.1 (0.7)	43.7 (0.75)	41.5 (0.67)	41.7 (0.62)
Sodium (mg/day)	2415.7 (1122.2)	2415.7 (110.2)	2298 (73.4)	2298.2 (73.4)

EI, energy intake.

significantly associated with having diabetes across the two populations. In the metro population high adherers to diet pattern 1 were more likely to have high blood pressure (OR 1.78, 95% CI 1.00 to 31.6) and overweight/obese if they were high adherers to diet pattern 2.

Dietary inflammatory score

Table 4 shows the association of each quartile of the DIS with measured CVD risk factors. Across the rural and metro populations, there were mixed results, with a higher DIS trending toward having suboptimal measured risk factors compared with the lowest DIS for hypertension and obesity. The associations were not statistically significant except in rural populations, where Q2 and the highest quartile of the DIS were associated with being overweight/obese

DISCUSSION

This is the first to explore differences in diet through dietary pattern analyses separately for rural and metro populations using AHS data and the first to apply the novel DIS developed by REGARDS researchers[21] to Australian data. Our study provides evidence that dietary patterns are different between rural and metro populations in Australia. Research seeking to improve nutrition and prevent CVD needs to consider the influence of remoteness as a factor impacting on dietary intakes and risk factor profiles. Further, approaches that are effective and appropriate for preventing CVD and improving dietary intake patterns may differ between rural and metro areas.

Unsurprisingly, the dietary patterns identified in both rural and metro areas across the Australian population were not in accordance with public health recommendations (ie, no pattern was consistently high in vegetables, fruit, wholegrains and whole grains lean meats or included minimal processed foods), consistent with the wider literature on diet patterns.[4 36] There were few strong associations between dietary patterns and self-reported or measured CVD risk factors. The exceptions included that high adherence to dietary pattern 2 (‘high fat, biscuits and coffee diet’) in rural areas was significantly associated with self-reported IHD, and high adherers to diet pattern 2 (‘vegetable, butter and red meat diet’) in metro areas being more likely to have a higher measured BMI. Differences in results between measured and self-reported factors may be explained by differences in the proportion of people reporting a diagnosis of hypertension, compared with those who were measured to have higher blood pressure. A previous analysis found that 16% of a national sample of Australians under-reported hypertension in comparison to their measured blood pressure.[37]

Reflective of the broader literature on differences in health and health behaviours by rurality,[4 12 13 15] our study showed differences between dietary patterns by location. The dietary pattern 2 in rural areas showed a higher factor loading for added fats, compared with metro dietary patterns, which is consistent with previous research.[15] A study by Alston *et al* found that there were differences in the relative contribution of different diet components to CVD deaths in rural compared with metro areas, concluding that addressing high fat intakes needs to be a priority in rural Australia.[15] Potential reasons for the different dietary patterns in rural compared with metro areas may include different food culture, socioeconomic factors environments and food access in the different areas.[38 39] For example, food environments in rural areas have been shown to be relatively unhealthy,[39] with rural communities tending to experience high food insecurity,[40] which may encourage consumption of higher fat and energy dense processed foods.

Although there is evidence for the role of diet and lifestyle in rural health inequities, this analysis of dietary patterns also showed that the higher prevalence of CVD risk factors in rural areas is likely to be due to more than just dietary factors. Previous studies suggest that rural–metro health inequities are likely to arise from complex interactions between factors that include both health

Table 2 Associations between dietary pattern adherence and self-reported risk factors in rural and metro populations

	High total cholesterol (OR, 95% CI)		Diabetes (OR, 95% CI)		Hypertension (OR, 95% CI)		Ischaemic heart disease (OR, 95% CI)	
Pattern 1 Q1 (lowest adherence)	Rural 1.00 (ref)	Metro 1.00 (ref)	Rural 1.00 (ref)	Metro 1.00 (ref)	Rural 1.00 (ref)	Metro 1.00 (ref)	Rural 1.00 (ref)	Metro 1.00 (ref)
Pattern 1 Q2	0.54 (0.19 to 1.55)	1.26 (0.55 to 2.89)	2.35 ((0.65 to 8.38)	2.35 (0.66 to 8.40)	2.54 (0.97 to 6.63)	2.34 (1.18 to 4.66) p=0.015*	2.57 (0.51 to 12.96)	1.22 (0.31 to 4.89)
Pattern 1 Q3	0.66 (0.218 to 2.03))	1.01 (0.42 to 2.44)	3.08 (0.78 to 12.2)	3.08 0.78 to 12.20)	2.37 (0.93 to 6.04)	1.55 (0.76 to 3.13)	4.21 (0.99 to 17.8)	0.58 (0.13 to 2.56)
Pattern 1 (highest adherence)	0.73 (0.26 to 2.09)	1.57 (0.68 to 3.61)	3.38 (0.81 to 14.1)	3.40 (0.81 to 14 to 12)	2.90 (1.16 to 7.25) p=0.22	2.19 (1.10 to 4.36) p=0.025*	1.80 (0.35 to 9.42)	1.19 (0.28 to 4.97)
P trend	p=0.68	p=0.36	p=0.74	p=0.07	p=0.03*	p=0.14	p=0.69	p=0.95
Pattern 2 Q1 (lowest adherence)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Pattern 2 Q2	0.78 (0.31 to 1.95)	1.05 (0.52 to 2.14)	4.09 (0.9417.67)	0.24 (0.08 to 0.65)	0.52 (0.23 to 1.23)	1.28 (0.70 to 2.35)	2.84 (0 to 37 to 21.9	0.65 (0.17 to 2.52)
Pattern 2 Q3	1.45 (0.65 to 3.27)	1.12 (0.55 to 2.27)	2.61 (0.50 to 14.13)	0.56 (0.21 to 1.54)	0.70 (0.32 to 1.45)	1.16 (0.57 to 2.34)	4.34 (0.66 to 28.2)	0.89 (0.20 to 3.93)
Pattern 2 Q4 (highest adherence)	1.04 (0.37 to 2.940)	0.93 (0.46 to 1.91)	2.12 (0.40 to 11.1)	0.73 (0.29 to 1.88)	1.07 (0.51 to 2.24)	1.66 (0.88 to 3.16)	13.90 (2.29 to 84.3) (p=0.04)*	0.36 (0.09 to 1.52)
P trend	p=0.64	p=0.92	p=0.45	p=0.83	p=0.80	p=0.18	p=0.02*	p=0.28

The lowest quartile (reference) indicates lowest adherence to the diet, and the highest is quartile (Q4) indicates highest adherence to the dietary pattern. Controlled for sex, socioeconomic status, education, energy intake, physical activity, smoking status and age. *indicates significance.

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Table 3 Association between dietary pattern adherence and measured risk factors across rural, metro populations

	High cholesterol (OR, 95% CI)		Diabetes (HbA1c (Glycated haemoglobin) (OR, 95% CI)		High blood pressure (OR, 95% CI)		Overweight/ obesity (OR, 95% CI)	
Diet pattern (lowest adherence)	Rural 1.00 (ref)	Metro 1.00 (ref)	Rural 1.00 (ref)	Metro 1.00 (ref)	Rural 1.00 (ref)	Metro 1.00 (ref)	Rural 1.00 (ref)	Metro 1.00 (ref)
Pattern 1 Q2	1.02 (0.51 to 2.04)	1.47 (0.91 to 2.38)	0.64 (0.12 to 3.33)	0.84 (0.27 to 2.61)	0.58 (0.25 to 1.32)	1.44 (0.82 to 2 to 54)	0.64 (0.122 to 3.33)	0.84 (0.51 to 1.40)
Pattern 1 Q3	0.94 (0.47 to 1.88)	1.23 (0.76 to 2.01)	0.87 (0.15 to 5.11) (0.45 to 3.20)	1.59 (0.50 to 5.16)	0.99 (0.46 to 2.10) (0.66 to 2.02)	1.59 (0.93 to 2.72)	0.87 (0.12 to 5.11)	1.19 (0.72 to 1.94)
Pattern 1 highest adherence	1.47 (0.75 to 2.86)	1.50 (0.92 to 2 to 42)	0.85 (0.18 to 3.88)	1.63 (0.47 to 5.60)	0.60 (0.27 to 1.31)	1.78 (1.00 to 3.16) p=0.05*	0.850 (0.18 to 3.88)	1.42 (0.86 to 2.34)
P trend	p=0.31	p=0.20	p=0.98	p=0.26	p=0.38	p=0.06	p=0.87	p-0.07
Pattern 2 Q1 (lowest adherence)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Pattern 2 Q2	0.59 (0.31 to 1.12)	0.96 (0.62 to 1.50)	2.70 (0.67 to 10.9)	0.51 (0.18 to 1.50)	1.35 (0.62 to 2.96)	1.03 (0.60 to 1.79)	1.12 (0.55 to 2.27)	1.32 (0.83 to 2.11)
Pattern 2 Q 3	0.62 (0.32 to 1.21)	1.09 (0.69 to 1.75)	1.53 (0.310 to 7.62)	0.81 (0.29 to 2.24)	0.88 (0.39 to 1.94)	0.74 (0.41 to 1.34)	1.74 (0.79 to 3.80)	1.76 (1.07 to 2.89) p=0.02*
Pattern 2 highest adherence	0.59 (0.30 to 1.15)	1.28 (0.81 to 2.02)	2.46 (0.55 to 10.9)	1.13 (0.43 to 2.98)	0.91 (0.39 to 2.10)	1.15 (0.66 to 2.02)	1.62 (0.75 to 3.50)	1.83 (1.10 to 3.04) p=0.02*
P trend	p=0.13	p=0.25	p=0.35	p=0.65	p=0.63	p=0.88	p=0.13	p=0.09

The lowest quartile (reference) is lowest adherence to the diet, and the highest is highest adherence to the dietary pattern. Adjusted for sex, socioeconomic status, education, energy intake, physical activity, smoking status and age. Bold indicates significance.
*p<0.05.

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Table 4 Dietary inflammation score and association with measured cardiovascular disease risk factors

	High cholesterol (OR, 95% CI)		Diabetes (OR, 95% CI)		Hypertension (OR, 95% CI)		Overweight/obesity (OR, 95% CI)	
	Rural	Metro	Rural	Metro	Rural	Metro	Rural	Metro
DIS Q1 (ref—least inflammatory diet) reference:1.0	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
DIS Q2	0.93 (0.46 to 1.84)	1.03 (0.67 to 1.58)	1.95 (0.51 to 7.53)	0.67 (0.28 to 1.60)	1.80 (0.79 to 4.07)	0.97 (0.57 to 1.64)	2.48 (1.15 to 5.35) p=0.02	1.17 (0.73 to 1.90)
DIS Q3	1.64 (0.85 to 3.15)	0.86 (0.55 to 1.36)	1.97 (0.62 to 0.62)	0.61 (0.21 to 1.79)	2.14 (0.97 to 4.71)	1.04 (0.60 to 1.80)	1.40 (0.66 to 2.99)	1.34 (0.81 to 2.20)
DIS Q4 More inflammatory diet	0.82 (0.41 to 1.62)	0.71 (0.44 to 1.16)	0.46 (0.101 to 2.12)	0.77 (0.27 to 2.11)	2.42 (1.07 to 5.40))	0.89 (0.51 to 1.60) (0.81 to 1.87)	2.26 (10.6 to 4.84) p=0.03	0.98 (0.59 to 1.62)
P trend	p=0.95	p=0.12	p=0.20	p=0.55	p=0.05	p=0.78	p=0.11	p=0.93

Adjusted for sex, socioeconomic status, education, energy intake, physical activity, smoking status and age. The lowest quartile (reference) is the most inflammatory and Q4 is the most inflammatory diet. Bold indicates significance.

behaviours and structural challenges such as access to services and resources.[1] Broadly, the literature investigating the link between dietary patterns and CVD and risk factors is mixed, with the use of multiple different methods making it difficult to draw comparisons between studies. For example, another Australian study using the AHS dataset, but different categorisations of foods to define patterns and different statistical analysis methods, identified a healthier dietary pattern that was associated with a healthier metabolic profile across the entire population (but did not separate the population by rurality).[35] Another study, that produced results more similar to our findings, looked at adults aged 45 years and older across the whole Australian population (ie, not split by rurality), and identified three dietary patterns using factor analysis, yet found that adhering to a healthier dietary pattern was not associated with a healthier metabolic profile.[41]

It is difficult to make comparisons with the wider literature using the DIS, as our study examined its cross-sectional association with measured risk factors at a single point in time rather than its longitudinal association with CVD risk factors or mortality, as has more commonly been analysed.[21 31 32] Most studies that have examined the association of the DIS and mortality in cohort data have shown associations between a more inflammatory diet, and increased risk of mortality for CVD and cancers. Our findings are similar to another study in a healthy population that found no association between the DIS and cardiorespiratory fitness.[30] A major difference may also be that the DIS components were derived and validated with data from a food frequency questionnaire, that assesses diet over an extended period, whereas the AHS used a 24-hour dietary recall to assess diet, which collects information on dietary intake over the previous 24 hours.[22]22 The lack of statistically significant results (aside from Q2 and Q4 of the DIS and overweight/obesity in the rural population) may also be due to the small sample size used in this study.

Although the dietary patterns identified in this study did not show strong associations with CVD risk factors overall, this may reflect limitations of the dietary data (including limited number of foods on the instrument). In addition, dietary intakes at a single point in time do not capture the cumulative impact of lifetime diet, and there is a potential for reverse causality in cross-sectional data (where, eg, those with known CVD risk factors may have altered their dietary intakes). Also, we were only able to analyse metro compared with rural populations as a dichotomous indicator of rurality, due to the limited nature of these data. This meant that our study could not examine the heterogeneity of health and environments across different areas of remoteness. More dietary intake data are needed to understand dietary patterns across all areas of remoteness, considering updated remoteness measures in Australia, such as the Modified Monash Model.[6 11 42] This is of particular need, following years of low investment in diet research in rural Australia despite well-documented health inequities in which diet

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plays an important role.[2] Future surveys that capture remoteness, dietary patterns, and also clinical variables that allow the calculation of CVD risk (eg, Framingham Risk Equation[43]) would not only allow for investigations into remoteness with more granularity than undertaken here,[43–45] but also an examination of the interaction between these variables.

This study used representative national data sets, which represent the most recent, highest quality and comprehensive diet, disease and biomedical measures population data available currently for Australia. This study provided the first exploration of dietary intakes by rurality; however, due to the nature of the data, remoteness was dichotomised and does not consider the heterogeneity of rural areas. Further, the AHS did not sample from very remote populations in Australia,[23] and due to missing data and implausible intakes, our sample size was greatly reduced from the original sample which may further reduce generalisability of the results. The nature of the data removed was also not at random and based on recommendation from the AHS and previous literature. As there is evidence that there has been a lack of nutrition research specific to rural areas,[2 11] we did not explore rurality as a subgroup analysis and analysed the two groups separately to ensure a detailed understanding of different dietary patterns. This may reduce the generalisability of the results. Another limitation is that the PCA method that we used does require some subjectivity to extract dietary components. Decisions that are influenced by subjectivity include those around the number of factors to extract and description of the components for each of the dietary patterns identified. However, the researchers involved in the data analysis have specific nutrition and dietetics expertise (LA and SEJ), and the use of eigenvalues and scree plots guided determination of the best number of components to extract. Further, the cross-sectional study design used here cannot infer causal relationships or the influence of unmeasured confounding factors such as access to healthy food, local food environment differences or other social norms that may influence diet, that are not assessed in the AHS. The identification of confounders was selected based on previous literature.[35]

CONCLUSION

Two primary dietary patterns emerged each in rural and in metro areas, with differences between the two populations. Neither pattern was strongly associated with self-reported or measured CVD risk factors, aside from IHD in rural areas and overweight/obesity in metro areas. Our study provides evidence that action targeting healthier dietary intakes and CVD risk factors needs to be tailored to rurality. Further dietary analyses comparing rural and metro areas is required to build knowledge on different dietary intervention priorities between the two populations.

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