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Research paper

Temporal changes in Mediterranean-style diet adherence and ultra-processed food exposure in relation to psychological distress at follow-up: A 12-year analysis of the Melbourne Collaborative Cohort Study

Sarah Gauci [a,b,*,1], Deborah N. Ashtree [a,1], Allison M. Hodge [c,d], Melissa M. Lane [a], Monica Dinu [e], Priscila Machado [f], Rebecca Orr [a], Wolfgang Marx [a], Adrienne O'Neil [a]

[a] Deakin Institute for Mental and Physical Health and Clinical Translation, School of Medicine, Deakin University, Barwon Health, Geelong, VIC, Australia
[b] School of Public Health and Preventive Medicine, Monash University, Melbourne, VIC, Australia
[c] Cancer Epidemiology Division, Cancer Council Victoria, Melbourne, VIC, Australia
[d] Melbourne School of Population and Global Health, The University of Melbourne, Melbourne, VIC, Australia
[e] Department of Experimental and Clinical Medicine, School of Human Health Sciences, University of Florence, Florence, Italy
[f] Deakin Institute for Physical Activity and Nutrition, School of Exercise and Nutrition Sciences, Deakin University, Geelong, VIC, Australia

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ABSTRACT

Background: Consuming a Mediterranean-style diet is associated with lower depression risk. Concurrently, the ultra-processed food (UPF) dietary pattern is associated with increased depression risk. As dietary patterns shift over time, it is important to understand how changes in these dietary patterns relate to psychological distress as an indicator of depression.

Methods: We used a subset of data from the Melbourne Collaborative Cohort Study (n = 21,718). Dietary intake was assessed at baseline and follow-up using food frequency questionnaires, from which Mediterranean diet scores and UPF exposure were derived. Psychological distress at follow-up was measured using the Kessler Psychological Distress Scale (K10). We assessed change in diet from baseline to follow-up using generalised estimating equations to account for repeated measures, and associations of change in diet with psychological distress using Poisson regression. Analyses were conducted in the overall sample and by birthplace (Australian/New Zealand/Northern European; Southern European).

Results: Participants increased both their adherence to the Mediterranean-style diet (β = 0.28, 95%CI = 0.25–0.31) and exposure to UPFs (β = 55.20 g/day, 95%CI = 51.71–58.69). Stratification by birthplace showed similar patterns, except for Southern European participants where no clear change in UPF exposure was observed (β = −2.38 g/day, 95%CI = -12.35–7.59). One-point increases in Mediterranean diet score between baseline and follow-up were associated with a 5% lower risk of psychological distress (RR = 0.95, 95%CI = 0.93–0.98), while increasing UPF by 90 g/day was associated with a 5% higher risk (RR = 1.05, 95%CI = 1.03–1.07).

Conclusions: Adherence to Mediterranean-style diet and UPF exposure increased over time across the overall sample, although patterns varied by birthplace, and these changes were associated with opposing risks of psychological distress.

1. Introduction

Psychological distress and depressive disorders, are among the leading contributors to the global burden of disease (GBD 2019 Mental Disorders Collaborators, 2022). In Australia, approximately 43% of people aged 16 to 85 years will experience some form of psychological distress during their lifetime, and around 16% will experience an affective disorder such as depression (Australian Institute of Health and Welfare, 2025). These conditions place a significant burden on individuals, families, and the health system.

* Corresponding author at: Institute for Mental and Physical Health and Clinical Translation, School of Medicine, Deakin University, Barwon Health, Geelong, VIC, Australia.
E-mail address: sarah.gauci@deakin.edu.au (S. Gauci).
[1] Co-first Authors.

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Over the past decade, habitual dietary patterns have emerged as an important target for the prevention and treatment of psychological distress. Adherence to dietary patterns characterised by whole, minimally processed, and plant-based foods, such as the Mediterranean-style diet, is associated with a reduced risk of psychological distress and depression (Altun et al., 2019) and a Mediterranean-style diet may serve as an effective treatment strategy for depression (Firth et al., 2020; Jacka et al., 2017; O'Neil et al., 2024). However, in Australia, the predominant dietary pattern is characterised by a high intake of ultra-processed foods (UPFs) (Machado et al., 2020). This is concerning, given the association between the UPF dietary pattern and increased risk of adverse health outcomes, including depression (Lane et al., 2023a; Mengist et al., 2025). Concurrently, even modest dietary changes are associated with reduced depression risk. For example, in a study of Swedish women, each unit increase in adherence to the Mediterranean-style diet was associated with an approximately 5% reduction in depression risk (Yin et al., 2021). Therefore, even small shifts toward a Mediterranean-style diet, could yield meaningful mental health benefits. Yet an important limitation of prior research is that most studies have investigated dietary patterns at a single time point (Altun et al., 2019; Lane et al., 2022a, 2022b; Yin et al., 2021), rather than examining how changes in dietary patterns over time influence depression outcomes.

Much of the research investigating the role of the Mediterranean-style diet on health outcomes comes from Mediterranean countries, where it represents a traditional dietary pattern (Altun et al., 2019). Studies conducted in non-Mediterranean countries, such as Australia, have had more variable findings (Allcock et al., 2024; Hodge et al., 2013). These inconsistencies likely reflect cultural differences, traditional eating habits, and the broader food environment.

The Melbourne Collaborative Cohort Study (MCCS) offers a unique opportunity to explore dietary change and a greater range of dietary patterns, as approximately one-quarter of participants were migrants from Southern Europe, including Greece, Italy, and Malta, countries where the Mediterranean-style diet is traditionally followed (Milne et al., 2017; Obeid et al., 2022). This culturally diverse cohort provides an opportunity to explore how adherence to the Mediterranean-style diet and exposure to UPFs evolve over time, particularly comparing participants of Southern European origin with those from non-Mediterranean backgrounds. We aimed to investigate how changes in adherence to a Mediterranean-style diet and changes in exposure to an UPF dietary pattern over time are associated with the risk of psychological distress in the MCCS cohort (primary aim). We also investigated whether these associations differed by birthplace group (Southern European vs Australian/New Zealand/Northern European) and explored which specific dietary and nutrient components (GBD-defined dietary exposures) were associated with risk of psychological distress (secondary aim). To be consistent with previous studies, we also investigated the cross-sectional association with baseline diet and risk of psychological distress.

2. Methods

2.1. Ethics approval and pre-registration

This manuscript has been prepared in accordance with the requirements of the GLAD Taskforce, as part of a global collaborative project to inform the Global Burden of Diseases, Injuries, and Risk Factors Study. The GLAD data analysis plan was prospectively registered with Open Science Framework (OSF; osf.io/67qfs), and the data analysis plan and GLAD project protocol have been published elsewhere (Ashtree et al., 2025).

The MCCS was originally approved by the Cancer Council Victoria's Human Research Ethics Committee, and participants provided written informed consent to participate and for researchers' access to their medical records (Milne et al., 2017). The current study was approved for exemption from ethical review in accordance with the National Statement on Ethical Conduct in Human Research (Section 5.1.22) by the Deakin University Human Research Ethics Committee (project number: 2023-385).

2.2. Cohort profile

A detailed description of the MCCS cohort has been previously published (Milne et al., 2017). In brief, 41,513 participants aged 27 to 76 were recruited in Melbourne and surrounding areas between 1990 and 1994. Of these, 59% were women, and 99% were aged 40–69 years. Approximately 24% of the sample were migrants from Southern Europe (comprised of the following ethnic groups: Greek, Italian, Macedonian, Maltese, and Spanish). These participants have distinct dietary and lifestyle patterns from those born in Australia or New Zealand (69%) and Northern Europe (6%; Northern European group was comprised of the following ethnic groups: English, Irish, Latvian, Scottish, Dutch and Welsh) (Hodge et al., 2007a, 2007b). Baseline data collection included questionnaires on lifestyle, medical history, medication use, and a food frequency questionnaire. All questionnaires were available in English, Greek, and Italian, and bilingual staff were employed to assist participants. The first wave of follow-up was completed between 1995 and 1998 (follow-up 1), with a second follow-up (follow-up 2) completed between 2003 and 2007. We used baseline data and data from the second follow-up in these analyses. Full details of measured data at each wave are available in the MCCS Cohort Profile (see Table 1 in the reference (Milne et al., 2017)).

Participants were eligible for this study if they completed the baseline dietary questionnaire and both dietary and psychological distress measures at the second follow-up (Fig. 1). We excluded participants taking antidepressant medication at baseline, as a proxy for pre-existing psychological distress, and additionally excluded participants reporting dietary intake $<$1st or $>$ 99th percentile at baseline or follow-up, leaving $n = 21{,}718$ eligible for inclusion in these analyses.

2.3. Exposure: dietary assessment

A self-administered 121-item Food Frequency Questionnaire (FFQ), designed and validated for use specifically in the MCCS (Hodge et al., 2007a, 2007b; Hodge et al., 2009; Ireland et al., 1994), was used to assess dietary intake at baseline (1990–1994) and a modified version including some new foods and portion size photos at follow-up 2 (2003–2007). Using this dietary data, scores were derived for adherence to the Mediterranean-style diet (Trichopoulou et al., 2003) and UPF dietary pattern (Monteiro et al., 2019). Mediterranean-style diet adherence was assessed using the method described by Trichopoulou et al. (2003), and in line with other studies that have used this dataset (Hodge et al., 2013; Trichopoulou et al., 2003). Participants received a score of 1 point if their intake was above the MCCS sex-specific median for vegetables, fruit, cereals, legumes, and fish, and scored 0 if their intake was below this median for each dietary component. Additionally, participants were assigned a score of 1 if their intake for dairy and red meat was below the MCCS sex-specific median intake, and a score of 0 if their intake was above this value. For alcohol, 1 point was assigned for daily intakes of 10–50 g in men, and 5–25 g in women; lower or higher intakes scored 0 (Trichopoulou et al., 2003). In this study, olive oil intake was used instead of the ratio of monounsaturated fats to saturated fats as used in the original Trichopoulou scoring system; this is consistent with other studies using this cohort (Hodge et al., 2013). Mediterranean-style diet scores ranged from 0 to 9, with a higher score reflecting greater adherence (Trichopoulou et al., 2003).

Ultra-processed food (UPF) dietary pattern was determined using the Nova classification system, as described in detail elsewhere (Machado et al., 2019). FFQ food items were previously classified according to the Nova food classification system by two researchers with expertise in the Australian food environment, following the methods of Machado et al. (2019) and applied in earlier MCCS studies (Gauci et al., 2025;

Table 1
Baseline descriptive characteristics of the study population according to place of birth.

	Australian and Northern European Born (n = 18,174)	Southern European Born (n = 3544)	Total Sample (n = 21,718)
Age (years)	54.2 (8.7)	54.0 (7.6)	54.2 (8.5)
Female	11,122 (61.2%)	2006 (56.6%)	13,128 (60.4%)
Highest level of education achieved			
Did not complete high school	7956 (43.8%)	2854 (80.5%)	10,810 (49.8%)
Completed high school	2020 (11.1%)	265 (7.5%)	2285 (10.5%)
Some tertiary education	8198 (45.1%)	425 (12.0%)	8623 (39.7%)
BMI (kg/m2)	26.0 (4.1)	28.5 (4.2)	26.4 (4.2)
Level of physical activity	4.6 (3.7)	2.7 (2.9)	4.3 (3.6)
Drinking status			
Never drinker	4102 (22.6%)	1301 (36.7%)	5403 (24.9%)
Former drinker	1816 (10.0%)	413 (11.7%)	2229 (10.3%)
Current drinker	12,123 (66.7%)	1787 (50.4%)	13,910 (64.0%)
Not reported	133 (0.7%)	43 (1.2%)	176 (0.8%)
Smoking status			
Never smoker	10,984 (60.4%)	2179 (61.5%)	13,163 (60.6%)
Former smoker	5738 (31.6%)	952 (26.9%)	6690 (30.8%)
Current smoker	1452 (8.0%)	412 (11.6%)	1864 (8.6%)
Not reported	0 (0.0%)	1 (0.0%)	1 (0.0%)
Mediterranean-style diet score*	4.5 (1.8)	4.3 (1.8)	4.4 (1.8)
Ultra-processed food intake (g/day)	403.4 (214.1)	341.9 (229.6)	393.4 (217.9)

Note. Level of physical activity: a score was calculated ranging from 0 to 16 based on the frequency of walking, less vigorous and vigorous activity multiplied by two.

Lane et al., 2023a). Food items were grouped into four Nova categories: Groups 1–3 represent non-UPF, while Group 4 consists of UPF. Only Group 4 intake was considered as an exposure of interest in this study. Examples of Group 4 products include regular and diet soft drinks, sweet or savoury packaged snacks, confectionery, margarine, reconstituted meat products, and many pre-prepared frozen or shelf-stable dishes when these products are made up of food substances of no culinary use and/or contain classes of additives with cosmetic function. The mean daily intake of UPFs was determined by converting frequencies into grams. This was based on sex-specific portion sizes of each food and multiplied by the daily equivalent frequency as per previous research (Bassett et al., 2016; Ireland et al., 1994; The Cancer Council Victoria Epidemiology Centre, 2008). Energy was estimated based on the Nutrient Data Table for Use in Australia 1995 (NUTTAB 95), a food composition database containing information for 1800 foods and beverages available in Australia (Lewis et al., 1995) or AUStralian Food and NUTrient Database (AUSNUT) 2007 for FUP 2.

To comprehensively evaluate the relationship between the Mediterranean-style diet and UPF with psychological distress, we further disaggregated dietary intake into food groups and nutrients for exploratory analysis. These groups included 1) Mediterranean-style diet components: grams per day of fruit, vegetables, legumes, cereals (wholegrains, pasta, rice, bread, etc), fish/seafood and olive oil; 2) broader dietary exposures as defined by the Global Burden of Disease study (GBD dietary exposures): grams per day of nuts and seeds, milk, red meat, processed meat, sugar-sweetened beverages, fibre, calcium, omega-3 and sodium, and percentage energy per day of omega-6, polyunsaturated fat, monounsaturated fat and saturated fat. We scaled the units for each dietary exposure to be equivalent to serving sizes (for food groups) or recommended daily intakes (for nutrients) to assist with interpretation (see supplementary tables 5–8). Both scaled and unscaled units are presented in the supplementary material.

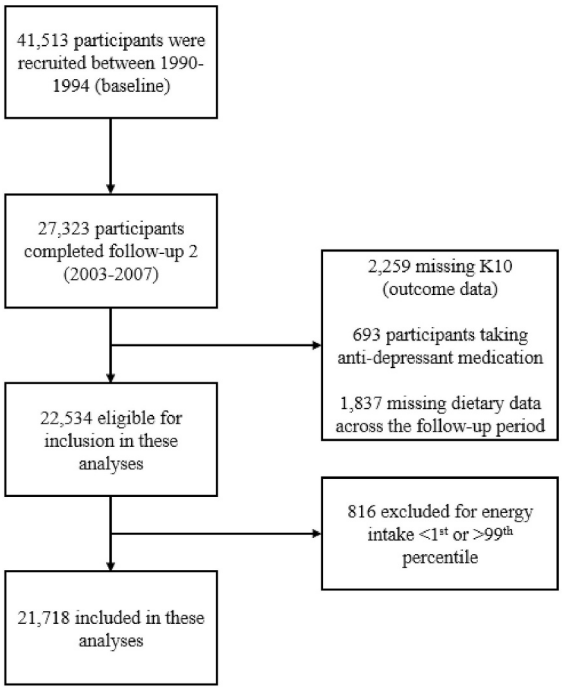

Fig. 1. Flow-chart of participant selection. K10 = Kessler Psychological Distress Scale.

2.4. Outcome: psychological distress

The risk of psychological distress as an indicator of depression was derived from the ten-item Kessler Psychological Distress Scale (K10) (Kessler et al., 2002). Although the K10 assesses non-specific psychological distress, higher K10 scores correlate with the diagnosis of common mental disorders. A cut-off score of 20 (Andrews and Slade, 2001) has sound sensitivity (0.66) and high specificity (0.92) for the diagnosis of depressive disorder (Andrews and Slade, 2001). As a measure of psychological distress could not be derived at baseline because it was not assessed, antidepressant medication use was considered as a proxy of baseline psychological distress. Participants who reported taking antidepressants at baseline were excluded from the analysis to reduce confounding, which is consistent with previous analyses in this cohort (Lane et al., 2023a). Medication use has previously been found to correlate with depression (r = 0.60 to 0.73), with a sensitivity of 0.80 and specificity of 0.67 for depression diagnosis (Gardarsdottir et al., 2009; Skelton et al., 2021).

2.5. Assessment of covariates

Covariates were identified a priori in the GLAD protocol paper (Ashtree et al., 2025) in order to ensure a consistent minimal adjustment set for all studies participating in the GLAD Taskforce. These covariates included age, sex and education, and we included an adjustment for energy intake via Willett's residual method for all dietary exposures

reported in grams per day, as defined above (Brauer et al., 2024; Willett et al., 1997). We additionally included body mass index (BMI), alcohol intake (lifetime abstainers, ex-drinkers, and current drinkers), smoking (never smoked, current smoker, and former smoker), and physical activity in a sensitivity model. Physical activity was scored from 0 to 16, depending on the frequency and intensity of activities (Hodge et al., 2016).

2.6. Statistical analyses

Participant characteristics were summarised using means and standard deviations (SD) for continuous variables and frequencies and percentages for categorical variables. Descriptive statistics for dietary exposures were additionally summarised using means (SD) and medians (Q1 to Q3).

To assess whether dietary intake changed over time, we fitted a generalised estimating equations linear regression with robust standard errors between each dietary exposure and time to account for the repeated measurements within participants. This model was fitted for the overall sample, and for subgroups corresponding to birthplace 1) Australian, New Zealand and Northern European-born participants, and 2) Southern European-born participants. To formally assess whether changes in dietary intake over time differed by birthplace, we included an exploratory interaction term between time and birthplace in these models. To determine the associations between the specified dietary exposures and psychological distress, we fitted three models:

1) a Poisson regression with robust standard errors to estimate the risk ratios for psychological distress associated with *change* in each dietary exposure. Change in diet was calculated as follow-up intake minus baseline intake (main model). To test whether changes in dietary exposures over time differed by birthplace, we included an interaction term between time and birthplace in the GEE models. To determine whether simultaneous changes to UPF and Mediterranean diet were associated with psychological distress, we additionally created an exploratory four-level joint-change categorical variable representing 1) participants who decreased adherence to the Mediterranean-style diet *and* increased UPF intake (reference category); 2) participants who reduced adherence to the Mediterranean-style diet but decreased UPF intake; 3) participants who increased adherence to the Mediterranean-style diet but increased UPF intake; and 4) participants who increased adherence to the Mediterranean-style diet and reduced UPF intake. This categorical variable was then included in a supplementary analysis.
2) a Poisson regression with robust standard errors to estimate psychological distress risk associated with diet at baseline (longitudinal model)
3) a logistic regression to determine the cross-sectional association between diet at follow-up and odds of psychological distress at follow-up.

All models were fitted for the overall sample, and separately for the subgroups, as described above and using a complete-case approach. We also fitted an exploratory subgroup analysis model, disaggregating the results by sex. Three levels of adjustment were included: 1) dietary exposures (all dietary measures reported in grams) were first re-modelled for energy intake using Willett's residual method; 2) as in 1 but additionally adjusted for age, sex, education, and ethnicity (except for place of birth subgroups), and 3) as in 2 but additionally adjusted for BMI, physical activity, smoking and alcohol.

Given the number of statistical models fitted, we adjusted for multiple testing using Simes Q values (Simes, 1986), which are interpreted in the same way as *p*-values with a $q < 0.05$ threshold. Adjustment was done separately for each level of covariate adjustment, with overall and birthplace subgroups combined, sex subgroups were done in a separate adjustment again separately for each level of covariate adjustment. Models were fitted in Stata 18.0, and all assumptions were assessed prior to analysis.

3. Results

3.1. Demographic characteristics

This study included 21,718 participants (60.4% female) at baseline. Table 1 describes the participants' sociodemographic and lifestyle characteristics at baseline for the total sample and according to place of birth. Participants born in Southern Europe reported lower education, lower physical activity, higher BMI, and were less likely to be current drinkers. Baseline and follow-up values for all dietary measures are presented in Supplementary Table 1. A comparison of participants included in the analytic sample and those excluded is presented in Supplementary Table 2, with minimal differences observed between groups and little missing data remaining after application of exclusion criteria (Supplementary Table 3).

3.2. Change in diet over time

On average, over a follow-up period of 12 years, participants increased both adherence to the Mediterranean-style diet ($\beta = 0.28$, 95% CI = 0.25–0.31) and intake of UPF ($\beta = 55.20$ g/day, 95%CI = 51.71–58.69) (Table 2). Both Southern European-born and those born in Australia, New Zealand, or Northern Europe increased adherence to the Mediterranean-style diet, but those born in Southern Europe showed a larger increase (p for interaction <0.001). In contrast, while participants born in Australia, New Zealand and Northern Europe increased their UPF intake ($\beta = 66.23$ g/day, 95%CI = 62.55–69.90), we did not observe any change for those born in Southern Europe ($\beta = -2.38$ g/day, 95%CI = -12.35–7.59).

For exploratory GBD-defined dietary exposures, participants increased consumption of vegetables, legumes, wholegrains, nuts and seeds, milk, processed meats, sugary sweetened beverages, seafood, olive oil, omega 6, polyunsaturated fat and monounsaturated fat, but decreased consumption of fruit, red meat, saturated fat, sodium, omega 3 and fibre (Supplementary Table 4). We observed differences between participants born in Australia, New Zealand and Northern Europe compared to participants born in Southern Europe, whereby Southern European-born participants decreased vegetable intake.

3.3. Association of change in diet with psychological distress as an indicator of depression

For every unit increase in Mediterranean-style diet score between baseline and follow-up, risk of psychological distress decreased by 5% (RR = 0.95, 95%CI = 0.93–0.98) in the overall sample, and for birthplace subgroups (Table 3). This association was consistent in supplementary models where we examined diet at baseline only (longitudinal) and diet at follow-up only (cross-sectional) (Supplementary Tables 6 and 7), and for both males and females (Supplementary Table 8). Further, for every 90-g/day increase in UPF between baseline and follow-up, the risk of psychological distress increased by 5% (RR = 1.05, 95%CI = 1.03–1.07) in the overall sample and for Australian, New Zealand and Northern European-born participants (RR = 1.06, 95%CI = 1.03–1.08), but not for Southern European-born participants. Again, these results were consistent when considering associations at singular time points (Supplementarys Table 6 and 7), and for males and females separately (Supplementary Table 8). Exploratory interaction displayed in Supplementary Table 9 demonstrates that the birthplace may modify the association between UPF exposure and psychological distress, but there was no evidence for an interaction for the Mediterranean diet.

For exploratory GBD-defined dietary exposures, full results are presented in Supplementary Table 5. Across the whole sample, each additional serve of fruit, vegetables, legumes, wholegrains, nuts and seeds,

Table 2
Change in diet over time.

		Adjusted for energy[a] (Willett's method)					
		β	L95%CI	U95%CI	P	Q	P for interaction^
Mediterranean-style Diet Score	Total Sample	0.28	0.25	0.31	<0.001	0.000	
	ANZNE	0.16	0.13	0.19	<0.001	0.000	0.000
	SE	0.92	0.85	0.99	<0.001	0.000	
Ultra-processed Food (g/day)	Total Sample	55.20	51.71	58.69	<0.001	0.000	
	ANZNE	66.23	62.55	69.90	<0.001	0.000	0.000
	SE	−2.38	−12.35	7.59	0.640	0.640	

ANZNE = Australian, New Zealand or Northern European; SE = Southern European.
[a] Energy adjustment was performed for dietary UPF, but not for the Mediterranean-style diet score.

Table 3
Association of change in diet with psychological distress as an indicator of depression at follow-up.

Dietary variable	Subgroup	RR	L95% CI	U95% CI	P-value	Q-value
Model 1						
Mediterranean-style Diet Score	Total Sample	0.98	0.96	1.00	0.084	0.143
	ANZNE Born	0.95	0.93	0.98	0.001	0.004
	SE Born	0.91	0.86	0.96	0.000	0.000
Ultra-processed Food (90 g/day)	Total Sample	1.02	1.01	1.04	0.000	0.000
	ANZNE Born	1.06	1.04	1.08	0.000	0.000
	SE Born	1.01	0.98	1.05	0.494	0.587
Model 2						
Mediterranean-style Diet Score	Total Sample	0.95	0.93	0.98	0.000	0.000
	ANZNE Born	0.95	0.93	0.98	0.001	0.004
	SE Born	0.94	0.89	0.99	0.017	0.045
Ultra-processed Food (90 g/day)	Total Sample	1.05	1.03	1.07	0.000	0.000
	ANZNE Born	1.06	1.03	1.08	0.000	0.000
	SE Born	1.04	1.00	1.08	0.063	0.124

ANZNE = Australian, New Zealand or Northern European; SE = Southern European; RR = Risk Ratio; L95%CI = lower 95% confidence interval; Model 1. Adjusted for energy* (Willett's method).
Model 2, as in 1, but additionally adjusted for age, sex, education, and ethnicity (except for place of birth subgroups).

and red meat was associated with a reduced risk of psychological distress (Supplementary Table 5). However, the associations for legumes, wholegrains, and nuts and seeds were not observed in Southern European-born participants. We observed an association for milk intake for Southern European participants, whereby every increase in milk servings between baseline and follow-up was associated with a lower risk of psychological distress.

In a supplementary exploratory analysis, we examined simultaneous changes in UPF intake and Mediterranean-style diet adherence together (Supplementary Table 10). Among the overall sample, as well as participants born in Australia, New Zealand, and Northern Europe, those who reduced their UPF intake, regardless of whether they increased their adherence to the Mediterranean-style diet, had a lower risk of psychological distress compared with those who simultaneously decreased their adherence to the Mediterranean-style diet and increased their UPF intake. Among participants born in Southern Europe, any combination of dietary improvement, either reducing UPF intake or increasing adherence to the Mediterranean-style diet, was associated with a lower risk of psychological distress compared to those who simultaneously reduced Mediterranean-style diet and increased UPF. There was no evidence for an additive relationship whereby simultaneously increasing Mediterranean-style diet and reducing UPF intake led to a greater reduction in psychological distress risk. Sensitivity analyses using UPF intake as a percentage of total intake (grams/day) were consistent with the primary findings (Supplementary Tables 4–7).

4. Discussion

In this prospective cohort study of 21,718 participants, we examined how changes in diet composition were associated with risk of psychological distress as an indicator of depression. Overall, both Mediterranean-style diet adherence and UPF dietary pattern exposure increased over time, while overall energy intake decreased over time. However, contrary to expectations, participants born in Southern Europe did not increase their exposure to the UPF dietary pattern over the follow-up period. Increasing adherence to the Mediterranean-style diet over time was associated with a lower risk of psychological distress across all birthplace groups. In contrast, increasing exposure to UPF over the follow-up period was linked to an increased risk of psychological distress in the whole sample and among participants born in Australia, New Zealand, and Northern Europe, but not in those born in Southern Europe, likely reflecting the absence of a meaningful change in UPF exposure within this group.

Consistent with previous studies, we found that exposure to an UPF dietary pattern was associated with increased risk of psychological distress as an indicator of depression (Lane et al., 2023a; Mengist et al., 2025) and that adherence to a Mediterranean-style diet was associated with a reduced risk (Altun et al., 2019). Importantly, we expanded on these past studies by demonstrating that temporal changes in dietary habits and quality were also associated with the risk of depression. However, the interpretation of dietary change in this study warrants careful consideration. While we modelled dietary change over time, these estimates may also reflect changes in overall diet quality rather than actual changes in Mediterranean diet adherence and UPF exposure. This is supported by the consistency of observations across baseline and follow-up, which show similar associations with psychological distress.

We also observed novel exploratory differences across birthplace in this sample, for example, participants born in Southern Europe decreased their vegetable intake, which contrasted with participants born in other regions. Future research is needed to investigate these findings, as the Southern European-born subsample was smaller and may therefore have had low power to detect these associations. In addition, the FFQ validation paper suggests that the dietary data in the Southern European sample may not have been as robust when compared to participants born in other regions (Bassett et al., 2016). Furthermore, the absence of a meaningful increase in UPF exposure in this group may have limited the ability to detect associations with psychological distress. Together, these methodological factors provide possible explanations for the observed subgroup differences. While adherence to the Mediterranean-style diet increased across all groups, exposure to UPFs did not increase for people born in southern European countries. These findings support what has been described as the *Mediterranean diet*

paradox, whereby adherence to the Mediterranean-style diet has declined in Mediterranean countries but remained stable or even increased in non-Mediterranean countries (Damigou et al., 2023; Vilarnau et al., 2019). Mediterranean heritage has also been associated with lower UPF exposure, consistent with evidence that UPF intake remains comparatively low in Mediterranean countries (Marino et al., 2021). These findings may reflect cultural preservation, as immigrant communities often maintain traditional food practices as a means of preserving cultural identity. However, such explanations remain speculative and should be considered alongside the methodological limitations described above and confirmed by future research.

In an exploratory analysis, we examined how simultaneous changes in Mediterranean-style diet adherence and UPF exposure related to psychological distress risk. Among the overall sample, as well as participants born in Australia, New Zealand, and Northern Europe, reducing UPF exposure, regardless of whether adherence to the Mediterranean-style diet increased, was associated with a lower risk of psychological distress. Among those born in Southern Europe, any form of dietary improvement, either reducing UPF exposure or increasing adherence to the Mediterranean-style diet, was linked to lower psychological distress risk. Notably, there was no evidence that making both changes simultaneously conferred additional benefit. This finding differs from a secondary analysis of the *SMILES trial*, which found that the therapeutic benefit of the Mediterranean-style diet was partly explained by reductions in UPF exposure (Lane et al., 2023b). Supporting traditional, health-promoting dietary practices within culturally diverse communities may therefore be a valuable strategy for reducing psychological distress. These findings suggest that traditional dietary habits can be maintained over time even after migrating to a country where the predominant dietary pattern has a high proportion of UPFs. Interestingly, our results also demonstrate that people may simultaneously increase adherence to a Mediterranean-style dietary pattern whilst also increasing exposure to UPFs; this underscores that these are separate but complementary dimensions of diet, each of which may influence health through related yet potentially different mechanisms (Tapsell et al., 2016).

Although we did not explore mechanisms of action in this study, the Mediterranean-style diet and UPFs likely influence psychological distress through distinct yet partially overlapping biological pathways (Marx et al., 2021). One pathway is inflammation. Adherence to a Mediterranean-style diet has been consistently linked to reduced systemic inflammation, including lower levels of pro-inflammatory markers such as C-reactive protein and interleukin-6 (Wu et al., 2021), whereas high consumption of UPFs is associated with elevated inflammatory markers (Lane et al., 2022b). Chronic inflammation is a key contributor to depression, potentially altering neurotransmitter metabolism, impairing neuroplasticity, and dysregulating the hypothalamic–pituitary–adrenal axis (Forbes et al., 2021). Beyond inflammation, a Mediterranean-style diet may improve insulin sensitivity and vascular function (Bruna-Mejias et al., 2025; Tuttolomondo et al., 2019), thereby reducing the risk of metabolic and cardiovascular dysfunction, which are themselves linked to depression (CiteBerk et al., 2023; Kim et al., 2023; Yang et al., 2024). It may also support gut barrier integrity and a healthy gut microbiome, indirectly influencing brain health through the gut–brain axis (Marx et al., 2021). Conversely, UPFs are often nutrient-poor and contain additives (e.g., emulsifiers); these UPF constituents can disrupt the gut microbiota and compromise gut barrier integrity, insulin sensitivity, and vascular function (Juul et al., 2021; Whelan et al., 2024). Future research is needed to further explore the potential mechanisms of action. In addition, in exploratory sub-group analysis, we observed some sex differences in which dietary exposures were associated with risk of psychological distress. Further research is needed to explore these potential sex differences.

This study has several strengths. Firstly, the large cohort of Australian adults and the diverse population result in a wide range of dietary patterns. The observed associations were supported by supplementary and sensitivity analyses, as well as adjustment for important confounders. In addition to exploring diet at singular time points, we also explored change in diet over time, rather than diet measured at a single time point, a limitation of many previous studies (Altun et al., 2019; Lane et al., 2022a; Yin et al., 2021). Given the changing dietary landscape and the increasing prevalence of mental disorders, understanding how dietary patterns change over time and how these changes relate to mental disorders is critical to understanding whether diet could represent an appropriate population-level target to reduce the burden of mental disorders.

In addition to these strengths, this study also has several limitations. Although potential confounders were adjusted for, given its observational design, we cannot rule out residual confounding. Especially considering that key lifestyle factors, including BMI, smoking, alcohol intake, and physical activity, were not included in the primary adjusted model due to their potential role as mediators in the relationship between diet and psychological distress. However, these variables may also act as confounders. As such, excluding them from the primary model may have resulted in residual confounding, and the estimates should be interpreted with caution. Results were broadly consistent in sensitivity analyses that included these factors. Birthplace may not fully capture cultural dietary backgrounds or migration-related changes in diet, and grouping Northern European migrants with Australian- and New Zealand-born participants may obscure heterogeneity within this category. The dietary data were self-reported and subsequently subject to recall error and bias to over- or under-reporting.

While FFQs have been used to adequately categorise foods for the Mediterranean-style diet or UPFs (Khandpur et al., 2021; Trichopoulou et al., 2003), the FFQ used was not specifically designed to assess this dietary pattern, nor food processing, which may have resulted in some misclassification. Additionally, there was a change in the dietary questionnaire between baseline and follow-up; the dietary pattern changes observed in this study may reflect changes in the questionnaire rather than the underlying diet. In addition, the FFQ performance at estimating energy-adjusted nutrients is poorer for people born in southern Europe compared to Australian-born participants (Bassett et al., 2016). Furthermore, the Mediterranean-style diet score was derived using cohort- and sex-specific medians at each time point (Trichopoulou et al., 2003). This approach means that changes in score may be influenced not only by individual-level dietary change but also by shifts in the distribution of dietary intake within the cohort over time. Together, these factors limit the extent to which change scores can be interpreted as reflecting true within-person dietary change. However, if the observed dietary changes were due solely to the change in questionnaire, we would expect the changes to occur consistently for both the Southern European-born and the Australian, New Zealand and Northern European-born participants, which is not consistent with our findings.

Psychological distress was not assessed at baseline; therefore, antidepressant use was used as a proxy for psychological distress at baseline (Gardarsdottir et al., 2009; Skelton et al., 2021). Medication use is an imperfect proxy for psychological distress, as antidepressants may be prescribed for other conditions in addition to psychological distress, and many people with psychological distress may not take antidepressant medication. This limitation may have led to misclassification, and reverse causality remains a possibility. Additionally, there was substantial attrition from the original cohort to the analytic sample. Although comparison of included and excluded participants suggests broadly similar characteristics, participation in follow-up dietary and psychological distress assessments is unlikely to be random. As such, selection bias cannot be excluded and may have influenced the observed associations. Therefore, the results should be interpreted with caution.

Finally, the Mediterranean-style diet and the UPF dietary pattern capture conceptually distinct, and sometimes opposing, dimensions of diet quality. Although these patterns are correlated to some extent, they do not measure opposite ends of the same construct. As a result, individuals may score highly on one pattern without scoring low on the

other (and vice versa), depending on their specific food choices. This conceptual distinction may introduce some degree of misclassification in the representation of overall diet quality in the current study.

5. Conclusion

The current study demonstrated that changes in dietary habits over time are associated with psychological distress risk, highlighting the potential mental health benefits of maintaining or improving adherence to a Mediterranean-style diet. Findings among participants of southern European origin suggest partial preservation of traditional dietary practices even within a non-Mediterranean food environment. This dietary resilience may help buffer against psychological distress, and offer important insights for future policy and research. Public health strategies could focus on supporting culturally anchored dietary guidance and identifying factors that promote the retention of healthful, traditional eating patterns following migration.

CRediT authorship contribution statement

Sarah Gauci: Writing – review & editing, Writing – original draft, Project administration, Conceptualization. **Deborah N. Ashtree:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation, Conceptualization. **Allison M. Hodge:** Writing – review & editing, Conceptualization. **Melissa M. Lane:** Writing – review & editing, Conceptualization. **Monica Dinu:** Writing – review & editing, Conceptualization. **Priscila Machado:** Writing – review & editing, Conceptualization. **Rebecca Orr:** Writing – review & editing, Conceptualization. **Wolfgang Marx:** Writing – review & editing, Conceptualization. **Adrienne O'Neil:** Writing – review & editing, Supervision, Conceptualization.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) used ChatGPT to edit the manuscript to improve readability. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

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Declaration of competing interest

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Appendix A. Supplementary data

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