An eating pattern characterised by skipped or delayed breakfast is associated with mood disorders among an Australian adult cohort.

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Keywords

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Abstract

Background: Meal timing may influence food choices, neurobiology and psychological states. Our exploratory study examined if time-of-day eating patterns were associated with mood disorders among adults.

Methods: During 2004-06 (age 26-36 years) and 2009-11 (follow-up, age 31-41 years), N=1304 participants reported 24-hour food and beverage intake. Time-of-day eating patterns were derived by principal components analysis. At follow-up, the Composite International Diagnostic Interview measured lifetime mood disorder. Log binomial and adjacent categories log-link regression were used to examine bidirectional associations between eating patterns and mood disorder. Covariates included sex, age, marital status, social support, education, work schedule, BMI, and smoking.

Results: Three patterns were derived at each time-point: Grazing (intake spread across the day), Traditional (highest intakes reflected breakfast, lunch and dinner), and Late (skipped/delayed breakfast with higher evening intakes). Compared to those in the lowest third of the respective pattern at baseline and follow-up, during the 5-year follow-up, those in the highest third of the Late pattern at both time-points had a higher prevalence of mood disorder (Prevalence ratio (PR)=2.04 95% Confidence Interval (CI):1.20, 3.48), and those in the highest third of the Traditional pattern at both time-points had a lower prevalence of first onset mood disorder (PR=0.31; 95% CI:0.11, 0.87). Participants who experienced a mood disorder during follow-up had a 1.07 higher relative risk of being in a higher Late pattern score category at follow-up than those without mood disorder (95% CI:1.00, 1.14).

Conclusions: Non-traditional eating patterns, particularly skipped or delayed breakfast, may be associated with mood disorders.

Introduction

Mood disorders, primarily depressive disorders, contribute more to worldwide disability than any other health condition (World Health Organization, 2017). Diet may influence mood disorders due to the physiological effects of nutrients on biochemical processes involved in mental health, such as hormones, neurotransmitter activity, and the gut-brain axis (Lang *et al.*, 2015). However, the frequency and timing of meals can also have hormonal, neurobiological and microbiome effects, thought to be related to circadian rhythms (Tahara and Shibata, 2013, Asher and Sassone-Corsi, 2015). Physical effects include possible influence on cardiometabolic conditions such as diabetes and obesity that are often comorbid with mood disorders (Stunkard *et al.*, 2003, Mattson, 2005, Lowden *et al.*, 2010).

Existing research on the relationship between food timing and mood has largely involved à priori defined dietary behaviours and cross-sectional analyses. For example, skipping breakfast has been consistently cross-sectionally associated with depressive symptoms and poorer mental well-being among both youth (Fulkerson *et al.*, 2004, Lien, 2007, O'Sullivan *et al.*, 2009, Lee *et al.*, 2017a), and adults (Smith, 1998, Begdache *et al.*, 2017, Lee *et al.*, 2017b, Kwak and Kim, 2018). These associations are often clinically significant, and robust to potential confounders including socioeconomic factors (Lee *et al.*, 2017b) and lifestyle practices such as diet quality, smoking, or alcohol consumption (Smith, 1998, O'Sullivan *et al.*, 2009, Kwak and Kim, 2018). Other eating behaviours are less well studied, but snacking between meals has been associated with depressive symptoms among adults (Furihata *et al.*, 2018), while snacking and meal skipping has been associated with higher levels of psychological problems in female adolescents (Farhangi *et al.*, 2018). To our knowledge only one prospective study has examined multiple eating behaviours. This study reported that having at least two out of three unhealthy eating practices of skipping breakfast, snacking after dinner, or eating dinner shortly before bed was associated with a higher incidence of depressive symptoms (Huang *et al.*, 2017).

Limitations of previous studies include examining discrete eating behaviours, using non-clinical measures of depression, or only considering concurrent mood. Cross-sectional analyses are unable to identify directionality of the relationship. Both high and low emotional states have been found to influence food consumption (Cardi *et al.*, 2015) meaning bidirectionality should be considered. Furthermore, despite the popularity of methods such as principal components analysis (PCA) to examine patterns of nutritional intake, it is rare for data-driven approaches to be used to determine time-of-day eating patterns. Two time-of-day eating patterns (a conventional pattern of three main meals, and a snack-dominant pattern), were derived using PCA in a 2011 cross-sectional study (Kim *et al.*, 2011). However, the outcome in that study was sleep duration, not mood.

There were two important rationales for this study. Firstly, empirical analysis of eating and drinking occasions would allow us to determine common eating patterns that explain variation in timing of food intake over the day. The term "eating patterns" refers to patterns related to the timing and relative size of meals/snacks as a proportion of daily intake, not the foods, nutrients, or energy consumed. Secondly, examining bidirectional associations between eating patterns and clinical diagnosis of depressive episodes over time could help us understand the relationship between eating patterns and mood disorders if one exists. In this study we aimed to determine if time-of-day eating patterns were longitudinally associated with mood disorders (dysthymia or depression) among an Australian cohort of young to middle-aged adults. We examined if eating pattern score predicted subsequent mood disorders, if tracking of pattern scores were associated with mood disorder over time, and if mood disorders predicted eating pattern scores.

Methods

Participants

In 1985, the Australian Department of Community Services and Health conducted the Australian Schools Health and Fitness Survey (ASHFS) of schoolchildren aged 7-15 years. A two-stage probability design derived a nationally representative sample. Of 121 schools approached, 109 schools participated (90.1% response rate). The student response rate was 67.6% (N=8498).

During 2001-02, ASHFS participants were traced and invited to participate in the Childhood Determinants of Adult Health (CDAH) study, resulting in enrolment of 5170 participants (61.0%) (Gall *et al.*, 2009). For the first follow-up 2004-06 (CDAH-1), n=2410 participants (aged 26-36 years) attended study clinics for physical measurements and completed questionnaires including a food frequency questionnaire (FFQ) and food habits questionnaire (FHQ). At the second follow-up 2009-11 (CDAH-2), n=1749 participants (aged 31-41 years) completed a mental health diagnostic interview, questionnaires, and the same FFQ and FHQ used in CDAH-1.

Ethical standards

All procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. The State Directors General of Education approved the ASHFS, and signed parental consent was required for all participants. The Southern

Tasmanian Health and Medical Ethics Committee approved the CDAH study protocol, and all participants gave informed written consent.

Measures

Eating occasions

At CDAH-1 and CDAH-2, participants were mailed questionnaires that were returned by post or collected at the CDAH-1 clinics. The FHQ included a meal pattern chart, which collected information on the types of meals and drinks consumed from 6am the previous day to 6am that morning (Smith *et al.*, 2010). The 24-hour period was divided into hourly periods (e.g. 6-7am) from 6am to 11pm, and an overnight period of 11pm-6am. For each time period, respondents were asked "Did you eat anything?" with responses of "No", "A snack", "A small meal" or "A large meal", and "Did you drink anything", with responses of "No", "Alcohol", "Water", or "Something else". Examples of meal types were given: snacks: a biscuit or piece of fruit; small meal: beans on toast, boiled egg and bread, breakfast cereal, a pie; large meal: meat and three vegetables or a large serving of fish and chips. Participants were instructed that they could fill in more than one type of drink for each period.

Seven time intervals were defined based on commonly-understood Australian meal windows to aid interpretability of results (Leech *et al.*, 2015): early (6am-9am), late morning (9am-12pm), midday (12pm-3pm), afternoon (3pm-6pm), evening (6pm-9pm), night (9pm-11pm), overnight (11pm-6am). To estimate the proportion of daily food intake consumed during each interval, 1 point was awarded for a snack, 3 points for a small meal, and 5 points for a large meal. Water was not awarded any points, but drinks of "Alcohol" or "Something else" were awarded one point, according to accepted methods of including beverages as eating occasions

(Kim *et al.*, 2011, Leech *et al.*, 2015). The number of points consumed during each interval by a participant were divided by their total points consumed that day to calculate the percentage distribution of daily intake across the seven time intervals. This distribution therefore reflected temporal distribution of daily intake, not nutritional or energy intake.

Participants reported the day of the week they completed the meal pattern chart for. Participants were categorised as weekday (Monday to Friday) or weekend (Saturday or Sunday) reporters.

Mood disorder

Mental health was assessed at CDAH-2 using the lifetime version of the Composite International Diagnostic Interview (CIDI) (World Health Organization, 1997). The computerised CIDI was administered by trained telephone interviewers to collect data on the lifetime prevalence of depressive symptoms, age of onset, and age of most recent recurrence. Symptoms were scored using DSM-IV criteria (American Psychiatric Association, 2000) to determine depressive episodes, or dysthymia. Participants, including those who had experienced a mood disorder prior to CDAH-1, were categorised as having a mood disorder only if they had experienced any episodes (first or recurrent) between CDAH-1 and CDAH-2. Sensitivity analyses excluded all participants who had their first mood disorder prior to CDAH-1.

Covariates

At CDAH-1 and CDAH-2, questionnaires collected data on age, marital status (married/living as married, single/separated/divorced), highest education (university, vocational, school), occupational status (professional, non-manual, manual, not in workforce), and current smoking status (never, ex-smoker, smoker). Total weekly minutes of leisure-time physical activity were measured using the validated International Physical Activity Questionnaire long form (Craig *et al.*, 2003), and converted to hours per week for interpretability. Parenting status (no children, have children) was determined using date of birth data for biological children reported at CDAH-2. Social support at CDAH-1 and CDAH-2 was measured using the Henderson Index of Perceived Social Support (potential range 15-75), with a higher score indicating higher self-perceived social support (Henderson *et al.*, 1978). At CDAH-2 only, participants reported the hours and minutes of usual sleep duration and the preferred amount of sleep they need to feel they have rested properly. Discrepancy of sleep preference was calculated as preferred minus usual sleep duration. At CDAH-2, participants reported their usual type of work schedule (regular daytime, evening/night/rotating, irregular (e.g. split shift, on call), not employed).

Dietary data were collected using a 127-item FFQ based on a validated FFQ developed for Australian populations (McLennan and Podger, 1998, Hodge *et al.*, 2000). Diet quality was calculated using a validated Dietary Guidelines Index (DGI) that reflects the 2013 Australian Dietary Guidelines (Wilson *et al.*, 2019). A higher score on the scale 0-100 indicated higher diet quality. At CDAH-2, participants were asked how many days per week they usually ate breakfast (range 0-7). Participants were categorised as never skip breakfast, sometimes skip (skip 1-3 days/week), or regularly skip (skip 4-7 days/week).

For CDAH-1 clinic participants, weight was measured to the nearest 0.1kg in light clothing using Heine portable digital scales (Heine, Dover, NH, USA), and height to the nearest 0.1cm with a Leicester stadiometer (Invicta, Leicester, UK). BMI was calculated as weight in kilograms divided by squared height in metres (kg/m^2). For CDAH-1 participants who did not attend clinics, and at CDAH-2, BMI was calculated from self-reported height and weight with a correction factor applied. The correction factor was determined based on discrepancies between the self-reported and measured height and weight of CDAH-1 clinic participants (Smith *et al.*, 2017).

Transition variables reflect change in circumstance between CDAH-1 and CDAH-2: parenting status (no children, first child born since CDAH-1, additional children born since CDAH-1, same number of children as CDAH-1); marital status (stayed living as married, became living as married, stayed living as single, became living as single); smoking (non-smoker, stopped smoking, started smoking, continued smoking); change in education level (advanced education, same level of education); and change in employment (remained employed, became employed, became unemployed, remained unemployed). For continuous variables (BMI, social support, DGI, and leisure-time physical activity), the transition variable was calculated by the value at CDAH-2 minus the value at CDAH-1.

Statistical analyses

All analyses were performed in Stata Version 15 (StataCorp, College Station, Texas, 2017). Time-of-day eating patterns were determined by PCA of the percentages of daily food intake consumed during each time interval (6-9am, 9am-12pm, 12-3pm, 3-6pm, 6-9pm, 9-11pm, 11pm-6am). The number of components were selected based on visual examination of the scree plot, and size of the eigenvalues. Orthogonal varimax rotation was applied to improve interpretability of the identified components. Bartlett's test of sphericity was used to test whether the variables were unrelated and therefore unsuitable for PCA. The Kaiser-Mayer-Olkin statistic for sampling adequacy was not generated due to singular correlation matrices arising from standardisation of the eating interval variables to sum to one for each participant.

Every participant received a score for each pattern and scores were categorised by tertiles into low, middle and high thirds. A tracking variable for change in pattern scores from CDAH-1 to CDAH-2 was created: consistently low (lowest third of pattern scores at both time-points), decreased (decrease from high or middle to a lower third), consistently middle (middle third at both time-points), increased (increase from low or middle to a higher third), or consistently high (highest third at both time-points). Tracking of pattern scores was determined by examining percent agreement of the categories and Cohen's Kappa coefficient for inter-rater reliability (Landis and Koch, 1977). At CDAH-2, percent agreement was also used to assess concordance of eating pattern score categories with reported frequency of eating breakfast.

Multiple imputation was performed to complete the 1985 ASHFS data for missing variables that predicted loss-to-follow-up. Inverse probability weighting on these variables was used in the regression analyses (motivated by Seaman *et al*., 2012). Firstly, we examined if eating patterns at CDAH-1 predicted risk of mood disorder during the follow-up period using log binomial regression to calculate relative risks (RR). Secondly, we examined if tracking of eating pattern scores from CDAH-1 to CDAH-2 was associated with prevalence of mood disorder during the intervening period using binomial logistic regression to calculate prevalence ratios (PR). Thirdly, to explore bidirectionality, we examined whether experiencing a mood disorder during follow-up predicted eating pattern category at CDAH-2. We used adjacent categories ordered log-link regression to calculate the relative risk (RR) for being in a higher adjacent score category for those who experienced a mood disorder during the follow-up period compared to those who did not (Blizzard *et al.*, 2013). Males and females were analysed together as there was no evidence of differences by sex in the estimates.

Minimally adjusted models (Model 1) adjusted for sex and age. Purposeful model building procedures were used to determine the fully adjusted models (Model 2) with adjustment for variables thought to be causally associated with the outcome and that changed the coefficient of the principal study factor by at least 10% (Greenland, 1989). Model 2 for the prediction of mood disorder based on CDAH-1 eating pattern adjusted for sex, age, social support, BMI and smoking at CDAH-1. Model 2 for the tracking analyses adjusted for sex, CDAH-2 age and work schedule, and transitions between CDAH-1 and CDAH-2 in social support, marital status, smoking, and BMI. Model 2, for the analysis of mood disorder predicting eating pattern at CDAH-2, adjusted for sex and CDAH-2 age, education, BMI, work schedule, parental status, smoking status and self-perceived social support. Model 3 further adjusted for eating pattern category at CDAH-1. Statistical significance was deemed if $p<0.05$.

Two PCA sensitivity analyses were conducted to check the robustness of the patterns by stratifying separately by: 1) sex, and 2) weekday/weekend. Two separate log binomial regression sensitivity analyses were conducted: 1) excluding weekend reporters; 2) excluding all participants who had experienced a mood disorder prior to CDAH-1.

Results

The meal pattern chart at CDAH-1 was completed by 2853 participants, however 78 were excluded due to pregnancy. Of the remaining 2775 participants, 1435 completed the meal pattern chart at CDAH-2, with 39 participants excluded for pregnancy. Of the 1396 participants with meal data at both time points, 1374 also completed the CDAH-2 CIDI. PCA was performed separately on the CDAH-1 and CDAH-2 time-of-eating data for this group.

After exclusion of 70 participants missing covariate data, the final sample for regression analyses was n=1304 (**Figure 1)**. Participant characteristics are shown in **Table 1.**

Time-of-day eating patterns

Three similar patterns were obtained at both time-points, cumulatively explaining 65% (CDAH-1) and 64% (CDAH-2) of the variation in timing of daily food intake. Factor loadings, which indicate the strength of association between the variable and component, and scree plots are shown in **online supplementary Table S1** and **Figure S1** respectively.

Bartlett test of sphericity results for CDAH-1 and CDAH-2 were p<0.001. Sensitivity analyses of PCA on subgroups male, female, weekday, and weekend day produced the same three dominant patterns, with similar loadings to whole-of-group patterns (data not shown).

The mean percentages of daily intake consumed at each of the seven time intervals by those in the highest third of pattern scores, were examined to further describe and name the patterns as Grazing, Traditional, and Late (**Figure 2**). Those high on the Grazing pattern had intake spread across the day from 6am-6pm and consumed the highest average percentage of their daily food intake during the afternoon 3-6pm. The Traditional pattern was characterised as three main intakes, with the largest mean percentages reflecting breakfast, lunch and dinner times. The Late pattern was characterised by low intake during 6-9am, with slightly higher mean percentages of intake during the night and overnight periods than the other patterns.

There was evidence of tracking of participant scores for all patterns from CDAH-1 to CDAH-2, with participants more likely to be in the same score category at CDAH-2 than the two other score categories (**online supplementary Table S2**). For example, of the 33.4% of participants who were in the highest third of the Late pattern at CDAH-1, 16.0% were also in the highest third at CDAH-2, 8.6% in the middle third, and 8.8% in the lowest third.

Only the Late pattern was associated with skipping breakfast. Of the 426 participants in highest third of the Late pattern who had breakfast frequency data, 239 (56.1%) reported skipping breakfast at least once per week (**online supplementary Table S3**).

Associations between eating patterns and mood disorder

Time-of-day eating patterns at CDAH-1 were not significantly associated with mood disorder outcomes during the 5-year follow-up (**Table 2)**. A borderline significant increased risk for those in the highest compared to the lowest third of the Late pattern (RR= 1.33; 95% CI: 0.97, 1.83) was attenuated in Model 2 (RR= 1.13; 95% CI: 0.82, 1.55).

Associations between pattern score tracking categories from CDAH-1 to CDAH-2 and mood disorder during follow-up are also shown in **Table 2**. After adjustment, compared to those in the consistently low category of the Late pattern, there was a higher prevalence of mood disorder among those in the increased (PR=1.85; 95% CI: 1.11, 3.09) and consistently high (PR=2.04; 95% CI: 1.20, 3.48) categories. A significant trend for the Late pattern was observed, with higher pattern category associated with higher prevalence of mood disorder. Indications of higher prevalence of mood disorder among those in the consistently high category of the Grazing pattern and lower prevalence among those in the consistently high category of the Traditional pattern, were not statistically significant.

Results for the analysis of mood disorder predicting eating pattern scores are presented in **Table 3**. After adjustment for covariates, participants who experienced a mood disorder during the follow-up period had a 7% increased risk (RR=1.07; 95% CI: 1.00, 1.14) of being in a higher adjacent score category (e.g. high rather than middle, or middle rather than low), compared to participants who had not experienced a mood disorder during follow-up. Having a mood disorder during follow-up was not associated with the Grazing or Traditional patterns at CDAH-2.

Results of the sensitivity analyses are presented in the online supplementary **Tables S4 and S5**. Among participants who experienced their first mood disorder between CDAH-1 and CDAH-2, those in the consistently high category of the Late pattern had higher prevalence of mood disorder compared to those in the consistently low category (PR=2.84; 95% CI: 1.06, 7.58). For the Traditional pattern, compared to those in the lowest category at both time points, a lower prevalence of mood disorders during the follow-up period was observed among those in the consistently middle category (PR=0.34; 95% CI: 0.12, 0.99), and the consistently high category (PR=0.31; 95% CI: 0.11, 0.87). After excluding weekend reporters, compared to those in the lowest category of the Late pattern at both time-points, those in the increasing (PR=2.30; 95% CI: 1.01, 5.24) and consistently high categories (PR=3.46; 95% CI: 1.47, 8.14) had an increased prevalence of mood disorder during follow-up. Those who increased their Grazing pattern score category between follow-ups also had a higher prevalence of mood disorders during follow-up (PR=2.67; 95% CI: 1.19, 5.99) compared to those in the consistently low category.

Discussion

Three distinct time-of-day eating patterns were identified. The Traditional pattern described a conventional eating schedule of breakfast, lunch, and dinner, and the Grazing pattern had intake spread more evenly across the daytime hours. The Late pattern was characterised by low intake in the early morning (6-9am) but higher intakes late morning, indicating skipped or delayed breakfast, and proportionally more food consumed during the evening and night than the other patterns. High compared to low scores on the Late pattern at both time-points were associated with a higher likelihood of experiencing a mood disorder, and a nearly three times higher prevalence of first ever onset of a disorder during the intervening 5-year period. However, there was also weak evidence of bidirectionality, with mood disorder during follow-up associated with slightly increased risk of being in a higher Late pattern score category at CDAH-2. Participants who consistently scored in the middle or highest third of the Traditional pattern had a lower prevalence of first onset of mood disorder during the follow-up period. These results suggest that a more traditionally structured pattern of eating may be associated with better mental health.

Preference for a later-in-the-day style of eating could be a biological or social trait that is implicated in, or predisposes an individual to, poorer mental health. Chronotype characteristics relating to difference in preference for morning or evening activity may contribute to the observed associations. Evening chronotypes are more likely to skip or delay breakfast, consume higher intakes of food later in the day compared to morning types (Meule *et al.*, 2012, Roßbach *et al.*, 2018), and have a higher risk of major depressive disorder (Antypa *et al.*, 2016, Au and Reece, 2017). It is suggested that preference for evening activity may be a pre-existing trait of the individual rather than symptom of mood disorders (Drennan *et al.*, 1991, Hidalgo *et al.*, 2009). A later pattern of eating may precede onset of mood disorders, and contribute to "social jetlag" which has been associated with depressive symptoms (Levandovski *et al.*, 2011). Social jetlag refers to a discrepancy between biological and social or work schedules, where evening chronotypes are unable to fulfil their sleep timing preferences (Wittmann *et al.*, 2006). In our cohort, a larger mean discrepancy between preferred sleep and actual sleep times at CDAH-2 was reported by participants who experienced a mood disorder (46 minutes) than those with no mood disorder (33 minutes). However, the amount of reported usual sleep was very similar at 7 hours 22 minutes for those who had experienced a mood disorder compared to 7 hours 25 minutes for those who had not. Usual sleep duration and sleep preference were not included in our adjusted models as they did not have sufficient effect on the prevalence estimates after inclusion of other covariates.

There were indications of bidirectionality, as participants with mood disorders during follow-up were slightly more likely to be in a higher score category of the Late pattern at CDAH-2 compared to participants who had not experienced a mood disorder. Mood disorders may influence lifestyle and dietary behaviours, but this does not preclude the influence of chronobiology. Mood disorders and emotional stress may reduce capacity to adhere to morning or daytime work/life schedules, or what are considered favourable behaviours such as making healthy food choices (Lopresti *et al.*, 2013). Therefore, bidirectionality and the concept of social jetlag and chronobiology should be considered when exploring the nexus between diet, time-of-day eating patterns, and mood disorders.

Our results concerning the Late pattern complement existing literature reporting cross-sectional associations between skipping breakfast and depressive symptoms (Fulkerson *et al.*, 2004, Lien, 2007, O'Sullivan *et al.*, 2009, Lee *et al.*, 2017a, Lee *et al.*, 2017b, Kwak and Kim, 2018). However, 'breakfast' has often been poorly defined or not defined at all (Szajewska and Ruszczynski, 2010) making it difficult to determine whether associations are due to not eating a morning meal, or delaying first consumption until later in the morning. In the current study, the Late pattern is likely to reflect both skipped and delayed breakfast. Participants who scored highly on the Late pattern had greater intake during late morning (9am-12pm) compared to other patterns, and more than half of these participants reported they usually skipped breakfast at least once per week. Although this demonstrates the need for clarification around what constitutes breakfast, previous studies examining various concepts of 'skipping breakfast' have highlighted the physiological and hormonal mechanisms that could explain the associations between omitting or delaying breakfast and mood disorders. Skipping breakfast has been shown to be associated with poorer diet quality and obesity which may affect mood due to long-term nutritional imbalance as well as metabolic co-morbidities (Smith *et al.*, 2010, Szajewska and Ruszczynski, 2010, Horikawa *et al.*, 2011). Eating breakfast lowers cortisol levels so skipping or delaying this meal may affect mood due to higher levels of cortisol and immune system dysregulation (Witbracht *et al.*, 2015, Lee *et al.*, 2017b). Lower appetite for breakfast first thing in the morning could also indicate reduced levels of the appetite regulating hormone ghrelin. Ghrelin has been shown to have an anti-depressant effect in mice (Lutter *et al.*, 2008) and affect plasma cortisol (Kluge *et al.*, 2011). Proximity of the last eating occasion can influence the amount of food consumed at the following eating occasion, so higher intake at night may result in less subsequent hormonal drive to eat early the next day. People with night eating syndrome (NES), typified by >50% of daily calorie intake during the evening and waking at night to eat, have been shown to have lower ghrelin levels than controls during the early morning period to 9am (Allison *et al.*, 2005). We do not suggest that participants who scored high on the Late pattern meet criteria for NES, but later eating combined with skipping breakfast could be eating practices that warrant further attention.

Associations between the Grazing pattern and mood disorder only reached statistical significance in the sensitivity analyses excluding weekend reporters, with those who increased their score category between CDAH-1 and CDAH-2 having a 2.7 times higher prevalence of mood disorder during the follow-up period. The Grazing pattern's spread of food intake across daytime hours, could represent snacking type behaviour and varied eating schedules. Irregular meal schedules, including skipped meals, snacking, and delayed lunch, have been associated with unfavourable health outcomes including obesity, depressed mood, and hypertension (Gill and Panda, 2015, Furihata *et al.*, 2018, Leech *et al.*, 2019).

Consistently high scores on the Traditional pattern, characterised by distinct meal times, was associated with a non-statistically significant lower prevalence of mood disorder during follow-up. Furthermore, in the sensitivity analyses, high scores on the Traditional pattern at CDAH-1 was associated with a lower risk of first ever onset of mood disorder during follow-up. Structured and regular meal times may indicate healthier behaviours. In a previous study, healthier lifestyle behaviours were protective against mood disorders among the CDAH cohort (Gall *et al.*, 2016).

Limitations of this study include potential bias as the meal pattern chart was reliant on recall and only covered a single 24-hour period at each time-point which may not reflect usual eating patterns. However, there was evidence the pattern scores tracked from CDAH-1 to CDAH-2, indicating possible habituality of time-of-day eating. There was no guidance given to participants about entering multiple meal types in the same hourly period, or which time-period they should use when entering food or drink consumed on the hour (e.g. whether a drink at 7am should be entered as 6-7am or 7-8am). The 11pm-6am period meant there was no differentiation between overnight eating and an early breakfast. Bias from loss to follow-up between the nationally representative baseline youth sample and the adult surveys may limit the generalisability of our results. However, there was wide variation in the characteristics of participants in the adult sample and loss-to-follow-up was mitigated by inverse probability weighting. There is also the possibility of bias from misreporting of covariate measures, such as self-reported weight (mitigated by using a correction factor) and physical activity; or unmeasured confounding such as lifestyle (e.g. work schedule or sleep hours at CDAH-1) or psychological factors.

Strengths of the study include the use of the CIDI, which is considered the "gold-standard" measure for retrospective assessment of history of mental disorders in epidemiological studies (Steel *et al.*, 2014). Participant recollection may have resulted in some misreporting.

However, the time-related questions in the CIDI around the first and last occurrence of a disorder have shown good reliability (Wittchen, 1994). Although misreporting of snack and beverage intake is common in dietary surveys, primarily as under-reporting (Poslusna *et al.*, 2009), converting each individual's eating occasion to a proportion of their total intake may have helped address systematic misreporting by individuals, or variation in concepts of snack or meal sizes between participants. The assessment of BMI, overall diet quality, and physical activity as covariates in our models considered potential confounding or mediation from energy and nutritional aspects of diet. Diet quality and physical activity did not change the coefficients sufficiently to be included in our models, indicating they were not confounding measures. The sensitivity analyses on the PCA and regression analyses confirmed that the patterns and associations were robust to influence of factors such as sex, prior mood disorder, and differences between weekday and weekend eating practices. Another strength is the novel application of PCA to derive patterns that capture dietary behaviours, and in the case of the Late pattern, multiple behaviours of skipping breakfast and eating later into the evening. Furthermore, the longitudinal design builds on existing cross-sectional research.

Longitudinal studies that replicate the eating patterns observed in this study, or specifically examine clustering of several habits, may be useful in determining lifestyle and chronobiological influences on mood disorders. Repeat measures and more detailed information about timing and size of meals would help determine the nature of the relationship between eating patterns and mental health outcomes.

In conclusion, delaying or skipping breakfast and eating higher proportions of intake later in the day may be an unhealthy behaviour associated with higher likelihood of mood disorder among adults. Whereas more traditional eating patterns of main meals at breakfast, lunch and dinner may be associated with lower likelihood of mood disorder over time. These relationships may be bidirectional, and a pre-existing preference for certain eating patterns due to chronobiological traits of the individual should be considered.

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Conflicts of interest

None.

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Table 1. Participant characteristics by experience of mood disorder during follow-up (CDAH-1 to CDAH-2).

	CDAH-1 (2004-2006)				CDAH-2 (2009-2011)			
	No mood disorder		Mood disorder		No mood disorder		Mood disorder	
	% or mean (SD)	n	% or mean (SD)	n	% or mean (SD)	n	% or mean (SD)	n
Sex								
Female	58.4	631	70.4	157	–	–	–	–
Male	41.6	450	29.6	66	–	–	–	–
Age (years)	31.6(2.7)	1081	31.5(2.6)	223	36.6(2.6)	1081	36.5(2.5)	223
Living as married								
No	27.3	295	34.1	76	16.0	173	31.4	70
Yes	72.7	786	65.9	147	84.0	908	68.6	153
Parental status								
No children	51.9	561	54.3	121	27.9	302	39.5	88
≥ 1 child	48.1	520	45.7	102	72.1	779	60.5	135
Smoking status								
Never	60.6	655	50.2	112	62.3	674	52.0	116
Ex-Smoker	20.3	219	20.6	46	24.5	265	28.7	64
Current smoker	19.1	207	29.1	65	13.1	142	19.3	43
Highest education								
University	47.6	515	47.1	105	49.7	537	52.5	117
Vocational	28.0	303	24.2	54	30.3	328	26.9	60
School	24.3	263	28.7	64	20.0	216	20.6	46
Occupation								
Professional	55.9	596	53.4	117	58.6	631	55.7	123
Non-manual	18.1	193	20.5	45	17.7	191	19.0	42
Manual	13.3	142	11.0	24	13.1	141	11.3	25
Not working	12.7	136	15.1	33	10.6	114	14.0	31
BMI (kg/m^2)	25.2(4.7)	1081	26.0(5.4)	223	25.7(5.0)	1081	27.0(6.1)	223
Leisure-time physical activity (hrs/wk)	2.8(3.3)	1016	2.4(3.2)	204	2.8(3.1)	1004	2.4(3.1)	208
Social support[a]	62.5(7.1)	1081	59.0(8.2)	223	62.1(7.6)	1081	57.0(9.9)	223
Diet quality[b]	56.0(11.1)	1049	56.7(11.5)	222	56.9(11.2)	1008	57.5(11.2)	211
Usual sleep (hrs:mins)	–	–	–	–	7:25(1:00)	1076	7:22(1:06)	221
Sleep discrepancy (hrs:mins)[c]	–	–	–	–	0:33 (1:04)	1068	0:46(1:17)	219
Work schedule								
Regular day	–	–	–	–	64.1	693	56.4	127
Irregular hours	–	–	–	–	21.0	227	22.7	51
Night/Evening/ Rotating	–	–	–	–	5.2	56	6.2	14
Not employed	–	–	–	–	9.7	105	13.8	31

CDAH: Childhood Determinants of Adult Health study; SD, Standard deviation; BMI, body mass index

[a]Henderson Index of Perceived Social Support, possible score range 15-75. A higher score indicates higher self-perceived social support.

[b]Dietary Guidelines Index, possible score range 0-100 A higher score indicates greater compliance with the 2013 Australian Dietary Guidelines.

[c]Discrepancy between preferred and usual minutes of sleep per night.

Table 2. Associations between time-of-day eating pattern category at CDAH-1 or tracking of eating pattern category from CDAH-1 to CDAH-2, with mood disorder during follow-up between CDAH-1 and CDAH-2.

	Mood events		Model 1[a,b]		Model 2[c,d]	
	%	(n/N)	RR/PR	95% CI	RR/PR	95% CI
CDAH-1 patterns predicting mood disorders during follow-up						
Grazing						
Low	16.5	(72/437)	Reference		Reference	
Middle	16.7	(73/437)	0.94	(0.69, 1.29)	0.92	(0.67, 1.24)
High	18.1	(78/430)	1.03	(0.75, 1.40)	0.92	(0.68, 1.25)
Trend				*p*=0.862		*p*=0.612
Traditional						
Low	18.7	(83/444)	Reference		Reference	
Middle	17.0	(73/429)	0.89	(0.66, 1.21)	0.98	(0.71, 1.35)
High	15.5	(67/431)	0.84	(0.61, 1.15)	1.01	(0.72, 1.41)
Trend				*p*=0.262		*p*=0.969
Late						
Low	15.0	(65/434)	Reference		Reference	
Middle	17.1	(74/434)	1.11	(0.81, 1.54)	1.11	(0.81, 1.53)
High	19.3	(84/436)	1.33	(0.97, 1.83)	1.13	(0.82, 1.55)
Trend				*p*=0.076		*p*=0.473
Tracking category CDAH-1 to CDAH-2 and association with mood disorder during follow-up						
Grazing						
Consistently low	15.1	(29/192)	Reference		Reference	
Decreased	18.0	(72/400)	1.12	(0.73, 1.71)	1.22	(0.81, 1.83)
Consistently middle	17.2	(27/157)	1.18	(0.71, 1.99)	1.35	(0.82, 2.23)
Increased	17.5	(67/383)	1.22	(0.79, 1.89)	1.38	(0.92, 2.08)
Consistently high	16.3	(28/172)	1.11	(0.66, 1.86)	1.14	(0.70, 1.86)
Trend				*p*=0.535		*p*=0.321
Traditional						
Consistently low	21.1	(37/175)	Reference		Reference	
Decreased	16.1	(63/392)	0.72	(0.49, 1.06)	0.76	(0.52, 1.10)
Consistently middle	16.7	(28/168)	0.77	(0.48, 1.25)	0.95	(0.59, 1.54)
Increased	17.9	(73/407)	0.79	(0.54, 1.15)	0.83	(0.57, 1.19)
Consistently high	13.6	(22/162)	0.61	(0.37, 1.01)	0.64	(0.39, 1.06)
Trend				*p*=0.209		*p*=0.284
Late						
Consistently low	10.6	(19/180)	Reference		Reference	
Decreased	15.2	(56/369)	1.51	(0.89, 2.56)	1.28	(0.75, 2.21)
Consistently middle	12.3	(21/171)	1.27	(0.67, 2.38)	1.20	(0.64, 2.24)
Increased	20.0	(75/375)	**2.13**	**(1.28, 3.53)**	**1.85**	**(1.11, 3.09)**
Consistently high	24.9	(52/209)	**2.69**	**(1.60, 4.55)**	**2.04**	**(1.20, 3.48)**
Trend				***p*<0.001**		***p*<0.001**

CDAH: Childhood Determinants of Adult Health study; RR, relative risk; PR, Prevalence ratio; CI, confidence interval

Statistically significant (p<0.05) results are highlighted in bold.

[a]Prediction analysis models adjusted for sex and age at CDAH-1.

[b]Tracking analysis models adjusted for sex and age at CDAH-2.
[c]Prediction analysis models adjusted for sex and CDAH-1 age, BMI, social support, and smoking status.
[c]Tracking analysis models adjusted for sex, age, and work schedule at CDAH-2, and change from CDAH-1 to CDAH-2 in social support, smoking, marital status, and BMI

Table 3. Relative risk of being in a higher score category of CDAH-2 eating pattern for participants who experienced a mood disorder during follow-up between CDAH-1 and CDAH-2, compared to participants who did not experience a mood disorder during follow-up.

	Model 1[a]		Model 2[b]		Model 3[c]	
CDAH-2 pattern	RR	95% CI	RR	95% CI	RR	95% CI
Grazing	1.04	(0.98, 1.12)	1.02	(0.95, 1.10)	1.03	(0.97, 1.10)
Traditional	0.95	(0.88, 1.03)	0.99	(0.91, 1.07)	0.99	(0.92, 1.07)
Late	**1.12**	**(1.06, 1.19)**	**1.08**	**(1.01, 1.15)**	**1.07**	**(1.00, 1.14)**

CDAH: Childhood Determinants of Adult Health study; RR: relative risk; CI: confidence interval.

Statistically significant (p<0.05) results are highlighted in bold.

[a]Model 1: Adjusted for sex and CDAH-2 age.

[b]Model 2: Adjusted for sex and CDAH-2 age, BMI, education level, work schedule, parenting status, smoking status, and social support.

[c]Model 3: Model 2 plus additional adjustment for eating pattern category at CDAH-1.

Figure 1. Childhood Determinants of Adult Health (CDAH) study participant flow chart and related analyses.

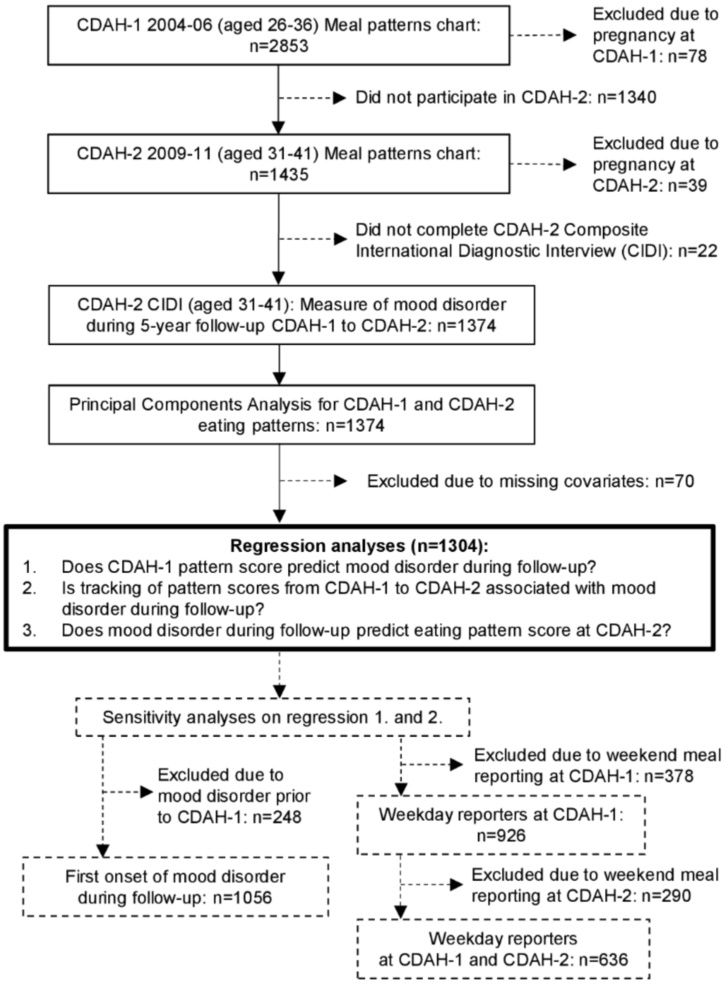
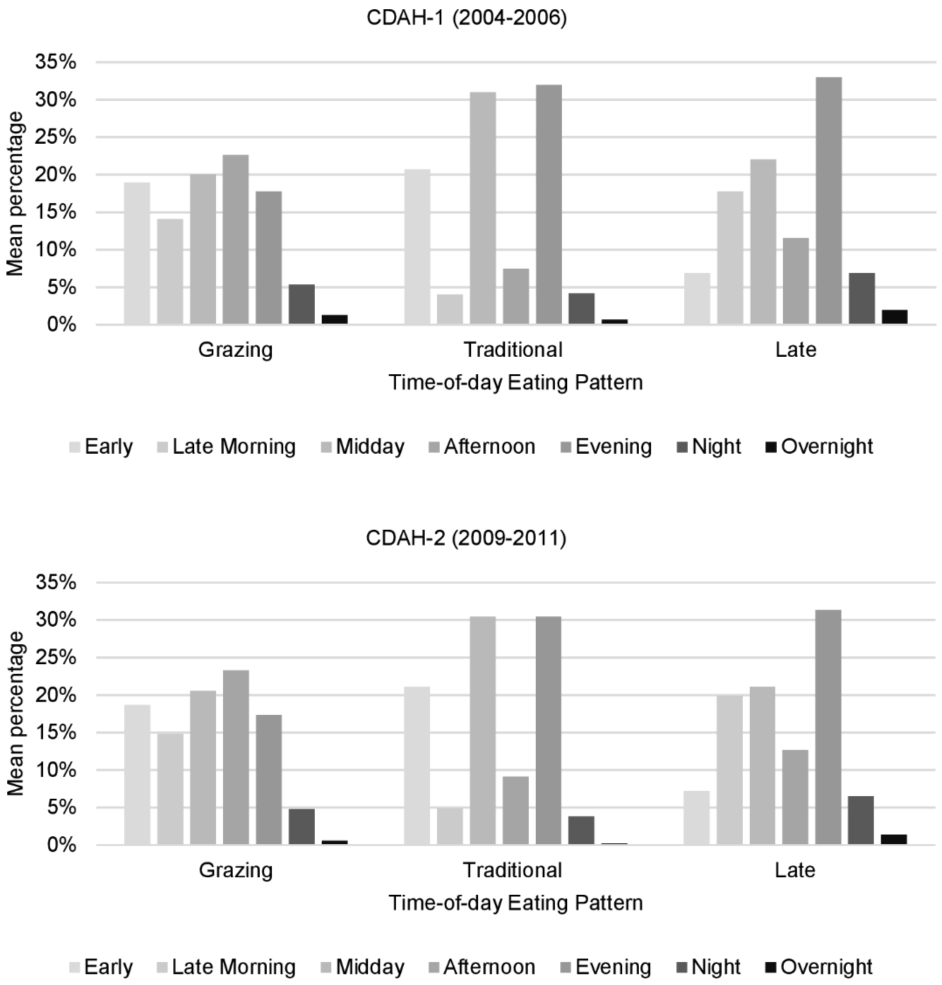


Figure 2. Mean percentage of daily intake by eating interval* among participants scoring in highest third of each time-of-day eating pattern at CDAH-1 and CDAH-2.



* Early (6am-9am), late morning (9am-12pm), midday (12pm-3pm), afternoon (3pm-6pm), evening (6pm-9pm), night (9pm-11pm), overnight (11pm-6am).

Online Supplementary Material for:

An eating pattern characterised by skipped or delayed breakfast is associated with mood disorders among an Australian adult cohort

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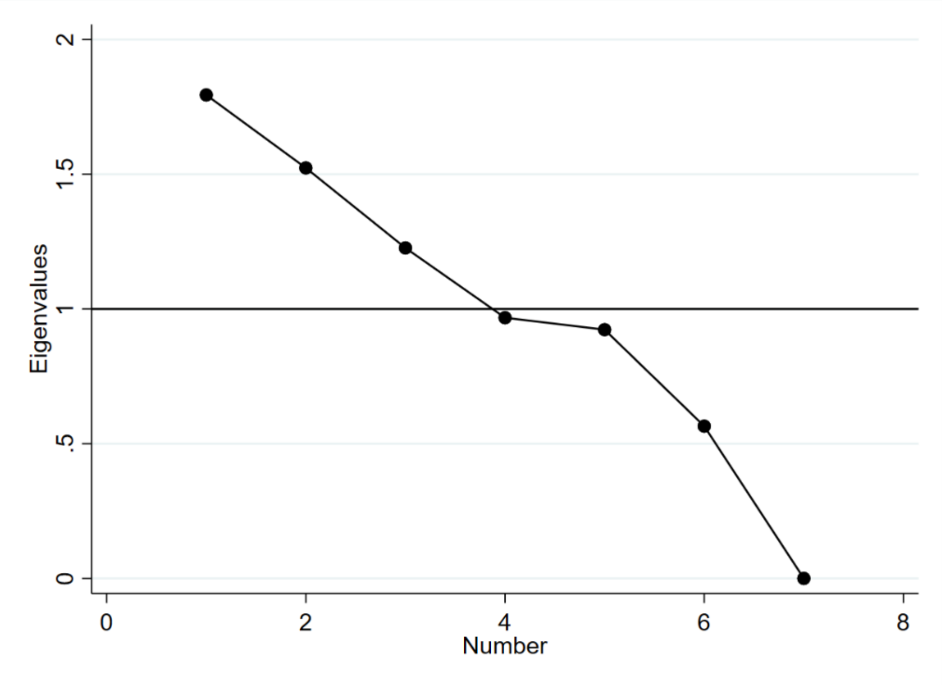
Supplementary Table S1. Time-of-day eating pattern factor loadings generated by principal components analyses of percentage of daily food consumed during each interval at CDAH-1 and CDAH-2 (n=1374)

	CDAH-1*			CDAH-2*		
Eating interval	Grazing	Traditional	Late	Grazing	Traditional	Late
Early 6-9am	–	–	-0.69	–	–	-0.74
Late morning 9am-12pm	–	-0.67	–	–	-0.61	–
Midday 12-3pm	–	0.69	–	–	0.75	–
Afternoon 3-6pm	0.65	–	–	0.67	–	–
Evening 6-9pm	-0.73	–	–	-0.72	–	–
Night 9-11pm	–	–	0.49	–	–	0.51
Overnight 11pm-6am	–	–	0.47	–	–	0.32
Eigenvalue	1.68	1.53	1.33	1.68	1.46	1.37
Variance explained†	0.24	0.22	0.19	0.24	0.21	0.20

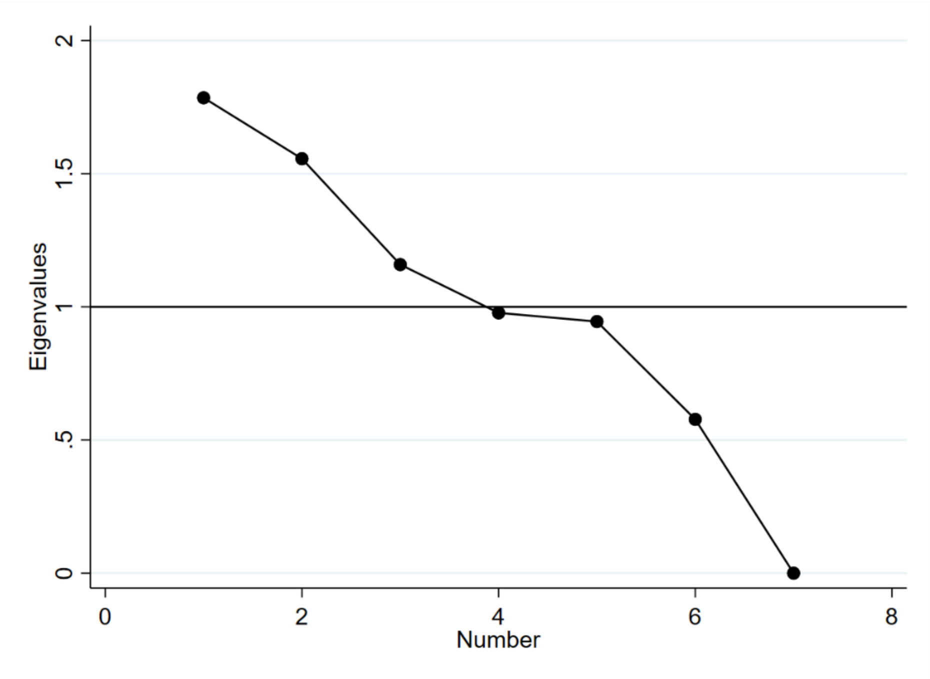
CDAH: Childhood Determinants of Adult Health study.

*Only factor loadings >|0.3| are shown for clarity. Loadings are for varimax rotated components
†Proportion of common variance (total of 1.00), explained by component.

Supplementary Figure S1. Principal components analysis (PCA) scree plots for time-of-day eating patterns for n= 1374 participants at CDAH-1 (2004-06) and CDAH-2 (2009-11)



S1a. Scree plot of eigenvalues after PCA on eating-time intervals at CDAH-1



S1b. Scree plot of eigenvalues after PCA on eating-time intervals at CDAH-2

CDAH: Childhood Determinants of Adult Health study

Supplementary Table S2. Percent agreement of low, middle and high score categories of time-of-day eating patterns at CDAH-1 (2004-2006) and CDAH-2 (2009-2011).

Pattern and score category at CDAH-1	Score category at CDAH-2						
	Lowest		Middle		Highest		Cohen's Kappa[a]
	%	(n)	%	n	%	n	
Grazing[b]							0.099
Lowest	14.7	(192)	9.9	(129)	8.9	(116)	
Middle	10.9	(142)	12.0	(157)	10.6	(138)	
Highest	8.2	(107)	11.6	(151)	13.2	(172)	
Traditional[c]							0.081
Lowest	13.4	(175)	10.1	(131)	10.6	(138)	
Middle	9.4	(123)	12.9	(168)	10.6	(138)	
Highest	10.1	(132)	10.5	(137)	12.4	(162)	
Late[d]							0.144
Lowest	13.8	(180)	11.6	(151)	7.9	(103)	
Middle	10.9	(142)	13.1	(171)	9.3	(121)	
Highest	8.8	(115)	8.6	(112)	16.0	(209)	

CDAH: Childhood Determinants of Adult Health study.

[a]Possible range -1 to +1. < 0: no agreement; 0–0.20: slight; 0.21–0.40: fair; 0.41–0.60: moderate; 0.61–0.80: substantial; 0.81–1: almost perfect agreement.

[b]Grazing pattern: intake spread across the day, highest in the afternoon.

[c]Traditional pattern: highest proportions of intake reflect breakfast, lunch and dinner times.

[d]Late pattern: skipped/delayed breakfast and higher intakes during the evening.

Supplementary Table S3. Percent agreement of low, middle and high score categories of time-of-day eating patterns and weekly frequency of skipping breakfast at CDAH-2 (2009-2011) among n=1284 participants.

	Usual breakfast skipping frequency per week at CDAH-2						
Score category at CDAH-2	Never (n=875) %	(n)	1-3 days (n=235) %	(n)	4-7 days (n=174) %	(n)	Cohen's Kappa[a]
Grazing[b]							-0.110
Lowest	21.9	(281)	5.8	(74)	5.8	(75)	
Middle	24.2	(311)	6.4	(82)	3.3	(42)	
Highest	22.0	(283)	6.2	(79)	4.4	(57)	
Traditional[c]							-0.032
Lowest	20.6	(265)	6.1	(78)	6.1	(78)	
Middle	24.8	(319)	5.8	(74)	3.0	(38)	
Highest	22.7	(291)	6.5	(83)	4.5	(58)	
Late[d]							0.144
Lowest	27.7	(356)	5.1	(65)	0.8	(10)	
Middle	25.9	(332)	5.0	(64)	2.4	(31)	
Highest	14.6	(187)	8.3	(106)	10.4	(133)	

CDAH: Childhood Determinants of Adult Health study.

[a]Possible range -1 to +1. < 0: no agreement; 0–0.20: slight; 0.21–0.40: fair; 0.41–0.60: moderate; 0.61–0.80: substantial; 0.81–1: almost perfect agreement.

[b]Grazing pattern: intake spread across the day, highest in the afternoon.

[c]Traditional pattern: highest proportions of intake reflect breakfast, lunch and dinner times.

[d]Late pattern: skipped/delayed breakfast and higher intakes during the evening.

Supplementary Table S4. Sensitivity analyses: Associations between time-of-day eating pattern category at CDAH-1 or tracking of eating pattern category from CDAH-1 to CDAH-2, with first onset of mood disorder during follow-up between CDAH-1 and CDAH-2 (n=1056).

	Mood events		Model 1[a,b]		Model 2[c,d]	
	%	(n/N)	RR/PR	95% CI	RR/PR	95% CI
CDAH-1 patterns predicting mood disorders during follow-up						
Grazing						
Low	7.4	(26/353)	Reference		Reference	
Middle	6.6	(24/362)	0.73	(0.42, 1.26)	0.74	(0.43, 1.27)
High	7.0	(24/341)	0.89	(0.50, 1.56)	0.86	(0.49, 1.52)
Trend				*p*=0.683		*p*=0.615
Traditional						
Low	8.5	(30/353)	Reference		Reference	
Middle	6.5	(22/340)	0.76	(0.44, 1.33)	0.81	(0.46, 1.43)
High	6.1	(22/363)	0.79	(0.45, 1.38)	0.90	(0.50, 1.62)
Trend				*p*=0.398		*p*=0.698
Late						
Low	7.0	(26/372)	Reference		Reference	
Middle	6.7	(23/344)	1.00	(0.56, 1.77)	1.01	(0.57, 1.78)
High	7.4	(25/340)	1.21	(0.69, 2.13)	1.06	(0.61, 1.85)
Trend				*p*=0.523		*p*=0.845
Tracking categories CDAH-1 to CDAH-2 and association with mood disorder onset during follow-up						
Grazing						
Consistently low	6.3	(10/159)	Reference		Reference	
Decreased	8.0	(26/325)	1.14	(0.55, 2.37)	1.15	(0.55, 2.40)
Consistently middle	6.2	(8/130)	0.80	(0.31, 2.05)	0.78	(0.30, 2.04)
Increased	8.1	(25/307)	1.16	(0.55, 2.44)	1.19	(0.56, 2.53)
Consistently high	3.7	(5/135)	0.55	(0.18, 1.73)	0.54	(0.18, 1.60)
Trend				*p*=0.457		*p*=0.451
Traditional						
Consistently low	11.6	(16/138)	Reference		Reference	
Decreased	6.8	(22/323)	0.58	(0.31, 1.11)	0.62	(0.32, 1.23)
Consistently middle	3.8	(5/131)	**0.28**	**(0.10, 0.83)**	**0.34**	**(0.12, 0.99)**
Increased	8.0	(26/326)	0.62	(0.33, 1.17)	0.63	(0.34, 1.16)
Consistently high	3.6	(5/138)	**0.30**	**(0.11, 0.83)**	**0.31**	**(0.11, 0.87)**
Trend				*p*=0.068		*p*=0.054
Late						
Consistently low	3.8	(6/159)	Reference		Reference	
Decreased	6.6	(20/304)	1.80	(0.66, 4.86)	1.60	(0.59, 4.32)
Consistently middle	3.6	(5/138)	1.23	(0.35, 4.26)	1.15	(0.33, 3.98)
Increased	8.6	(26/301)	**2.61**	**(1.00, 6.82)**	2.32	(0.89, 6.07)
Consistently high	11.0	(17/154)	**3.73**	**(1.37, 10.15)**	**2.84**	**(1.06, 7.58)**
Trend				***p*=0.002**		***p*=0.011**

CDAH: Childhood Determinants of Adult Health study; RR, relative risk; PR, prevalence ratio; CI, confidence interval. Statistically significant (p<0.05) results are highlighted in bold.

[a]Prediction analysis models adjusted for sex and age at CDAH-1.

[b]Tracking analysis models adjusted for sex and age at CDAH-2.

[c]Prediction analysis models adjusted for sex and CDAH-1 age, BMI, social support, and smoking status.

[d]Tracking analysis models adjusted for sex, age, and work schedule at CDAH-2, and change from CDAH-1 to CDAH-2 in social support, smoking, marital status, and BMI.

Supplementary Table S5. Sensitivity analyses: associations between time-of-day eating pattern category for weekday reporters only at CDAH-1 or tracking of pattern categories from CDAH-1 to CDAH-2, and mood disorder during follow-up between CDAH-1 and CDAH-2.

	Mood events		Model 1[a,b]		Model 2[c,d]	
	%	(n/N)	RR/PR	95% CI	RR/PR	95% CI
CDAH-1 patterns predicting mood disorders during follow-up (n=926)						
Grazing						
Low	17.1	(55/321)	Reference		Reference	
Middle	17.5	(58/331)	0.93	(0.65, 1.33)	0.88	(0.62, 1.25)
High	16.4	(45/274)	0.89	(0.61, 1.30)	0.78	(0.53, 1.15)
Trend				*p*=0.545		*p*=0.206
Traditional						
Low	20.2	(58/287)	Reference		Reference	
Middle	15.0	(51/341)	0.71	(0.49, 1.03)	0.77	(0.52, 1.14)
High	16.4	(49/298)	0.82	(0.57, 1.19)	0.97	(0.66, 1.43)
Trend				*p*=0.292		*p*=0.798
Late						
Low	15.3	(50/327)	Reference		Reference	
Middle	16.9	(54/320)	1.03	(0.71, 1.51)	1.01	(0.70, 1.46)
High	19.4	(54/279)	1.25	(0.85, 1.84)	1.06	(0.72, 1.56)
Trend				*p*=0.256		*p*=0.764
Tracking categories CDAH-1 to CDAH-2 and association with mood disorder during follow-up (n=636)						
Grazing						
Consistently low	7.7	(8/104)	Reference		Reference	
Decreased	14.4	(25/174)	1.81	(0.80, 4.09)	1.86	(0.82, 4.23)
Consistently middle	13.8	(13/94)	1.92	(0.78, 4.71)	2.21	(0.88, 5.53)
Increased	17.5	(33/189)	**2.65**	**(1.18, 5.96)**	**2.67**	**(1.19, 5.99)**
Consistently high	10.7	(8/75)	1.45	(0.52, 4.04)	1.42	(0.51, 3.92)
Trend				*p*=0.096		*p*=0.083
Traditional						
Consistently low	12.5	(10/80)	Reference		Reference	
Decreased	15.1	(28/186)	1.23	(0.60, 2.52)	1.24	(0.60, 2.55)
Consistently middle	11.9	(12/101)	1.05	(0.44, 2.52)	1.19	(0.49, 2.91)
Increased	14.0	(26/186)	1.27	(0.61, 2.64)	1.13	(0.51, 2.52)
Consistently high	13.3	(11/83)	1.20	(0.53, 2.75)	1.23	(0.54, 2.79)
Trend				*p*=0.682		*p*=0.888
Late						
Consistently low	8.3	(8/96)	Reference		Reference	
Decreased	13.7	(24/175)	2.14	(0.95, 4.84)	1.86	(0.81, 4.31)
Consistently middle	8.6	(8/93)	1.15	(0.41, 3.19)	1.09	(0.39, 3.05)
Increased	14.2	(26/183)	**2.53**	**(1.12, 5.67)**	**2.30**	**(1.01, 5.24)**
Consistently high	23.6	(21/89)	**4.34**	**(1.94, 9.72)**	**3.46**	**(1.47, 8.14)**
Trend				***p*=0.001**		***p*=0.002**

CDAH: Childhood Determinants of Adult Health study; RR, relative risk; PR, prevalence ratio; CI, confidence interval. Statistically significant (p<0.05) results are highlighted in bold.

[a]Prediction analysis models adjusted for sex and age at CDAH-1.

[b]Tracking analysis models adjusted for sex and age at CDAH-2.

[c]Prediction analysis models adjusted for sex and CDAH-1 age, BMI, social support, and smoking status.

[d]Tracking analysis models adjusted for sex, age, and work schedule at CDAH-2, and change from CDAH-1 to CDAH-2 in social support, smoking, marital status, and BMI.