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Associations between childhood to adulthood socio-economic mobility and adult diet quality

Johanna E. Wilson[1], Dipti Sugumar[1], Sarah A. McNaughton[2], Seana L. Gall[1], Terence Dwyer[1,3,4], Alison J. Venn[1] and Kylie J. Smith[1]*

[1]*Menzies Institute for Medical Research, University of Tasmania, Hobart 7000, Australia*
[2]*Institute for Physical Activity and Nutrition Research (IPAN), School of Exercise and Nutrition Science, Deakin University, Burwood 3125, Australia*
[3]*The George Institute for Global Health, University of Oxford, Oxford, OX1 3QX, UK*
[4]*Murdoch Children's Research Institute, Melbourne 3052, Australia*

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Abstract

The impact of change in socio-economic status (SES) from childhood to adulthood (SES mobility) on adult diet is not well understood. This study examined associations between three SES mobility variables (area disadvantage, education, occupation) and adult diet quality. 1482 Australian participants reported childhood area-level SES in 1985 (aged 10–15 years) and retrospectively reported highest parental education and main occupation (until participant age 12) and own area-level SES, education, occupation and dietary intake in 2004–2006 (aged 26–36 years). A Dietary Guidelines Index (DGI) was calculated from food frequency and habit questionnaires. A higher score (range 0–100) indicated better diet quality. Sex-stratified linear regression models adjusted for confounders. Area-level SES mobility was not associated with diet quality. Compared with stable high (university) education, stable low (school only) was associated with lower DGI scores (males: $\beta = -5{\cdot}5$, 95 % CI: −8·9, −2·1; females: $\beta = -6{\cdot}3$, 95 % CI: −9·3, −3·4), as was downward educational mobility (participant's education lower than their parents) (males: $\beta = -5{\cdot}3$, 95 % CI: −8·5, −2·0; females: $\beta = -4{\cdot}5$, 95 % CI: −7·2, −1·7) and stable intermediate (vocational) education among males ($\beta = -3{\cdot}9$, 95 % CI: −7·0, −0·7). Compared with stable high (professional/managerial) occupation, stable low (manual/out of workforce) males ($\beta = -4{\cdot}9$, 95 % CI: −7·6, −2·2), and participants with downward occupation mobility (males: $\beta = -3{\cdot}2$, 95 % CI: −5·3, −1·1; females: $\beta = -2{\cdot}8$, 95 % CI: −4·8, −0·8) had lower DGI scores. In this cohort, intergenerational low education and occupation, and downward educational and occupational mobility, were associated with poor adult diet quality.

Key words: Socio-economic status: Cohort study: Nutrition: Childhood: Education

Diet quality among populations often follows a social gradient whereby lower socio-economic status (SES) is associated with poorer diet quality[1–4]. Poor diet quality and low SES have also been associated with obesity and other cardiovascular disease risk factors[5–7]. In the life course approach to understanding health outcomes, childhood factors, including socio-economic context, are thought to influence the development of health behaviours and pathways of disadvantage[8–10]. SES is commonly measured at the individual level by occupation or education (or parental occupation or education for children), the household level (e.g., household income), or by broader neighbourhood (area-level) socio-economic advantage or disadvantage[11–13].

Low childhood SES has been associated with poorer adult diet quality[8,9,14,15], but the association is not consistent, with several studies finding no association[16,17]. It is also understood that adult SES is associated with adult diet quality[11] and may be more important or at least have an attenuating effect on the relationship between childhood SES and adult diet quality[9,14,18]. Little is known about the effects of SES mobility and whether diet quality for those with the same attained adult SES varies depending on childhood SES, or if attained adult SES could account for some of the inconsistent associations between childhood SES and adult diet quality.

To our knowledge, only two studies have examined change in SES from childhood to adulthood, and adult dietary patterns. A 2004 UK study found that participants in the non-manual

Abbreviations: ASHFS, Australian Schools Health and Fitness Survey; CDAH, Childhood Determinants of Adult Health; DGI, dietary guideline index; MET, metabolic equivalent task; SEIFA, Socio-Economic Indexes for Areas; SES, socio-economic status.

* **Corresponding author:** Kylie J. Smith, email k.j.smith@utas.edu.au

occupation class in childhood (based on father's occupation) and in adulthood, or those who moved from the manual to non-manual class, were more likely to follow a healthy dietary pattern at age 43 than those who remained in the manual class at both time points[19]. A 2015 UK study of males 60–79 years of age found that compared with men in non-manual roles like their fathers, men in manual roles with fathers in a manual occupation, were less likely to be in the highest diet quality category or eat fruit and vegetables in older adulthood, but there were no significant differences among men who worked in a different class to their fathers[20]. It is noted that both these cohorts were youth in the mid-twentieth century, within socio-economic and dietary contexts that are substantially different to those of more recent decades.

There are gaps in our understanding of how different measures of SES and change in SES from childhood to adulthood in modern times, are associated with adult diet quality. Different SES measures may be associated with diet through different mechanisms, such as area-level (neighbourhood) SES potentially being related to income and access to resources[21], while education and occupation may capture more individual-level dimensions of self-efficacy, income, and peer/class influences[13,22]. Moreover, several studies have examined individual aspects of diet, whereas measuring outcomes with an overall food-based measure of diet quality is important as foods are eaten in combination, and these combinations may have synergistic effects on health[23,24]. The Childhood Determinants of Adult Health cohort offers an opportunity to examine associations between change in three different SES factors (area-level SES, education, and occupation) from childhood and adulthood, and an overall measure of adult diet quality. We hypothesised that stable high SES or increase in SES from childhood to adulthood for each SES factor, would be associated with better diet quality in adulthood compared with stable low SES or decrease in SES from childhood to adulthood.

Methods

Participants

The Childhood Determinants of Adult Health (CDAH) study is a follow-up of the 1985 Australian Schools Health and Fitness Survey (ASHFS)[25,26]. The ASHFS was a benchmark study of the health and fitness of a nationally representative sample of Australian schoolchildren aged between 7 and 15 years (*n* 8498). The study included a questionnaire completed by the participants aged 9–15 years, and a dietary survey comprising a 24-h food record, completed by participants aged 10–15 years. The CDAH follow-up study was developed to determine the impact of childhood factors on the development of adult health outcomes. During 2001–02, 6840 ASHFS participants (80 %) were traced and 5170 (61 %) enrolled in the CDAH study. During 2004–2006, 34 % (*n* 3992) of the original ASHFS participants completed at least one component of the first CDAH follow-up, which included socio-demographic and dietary questionnaires and study clinics held in cities and regional areas across Australia. The current study is restricted to participants who were 10–15 years of age in 1985, as this age group was eligible to complete both the baseline questionnaire and dietary survey (Fig. 1).

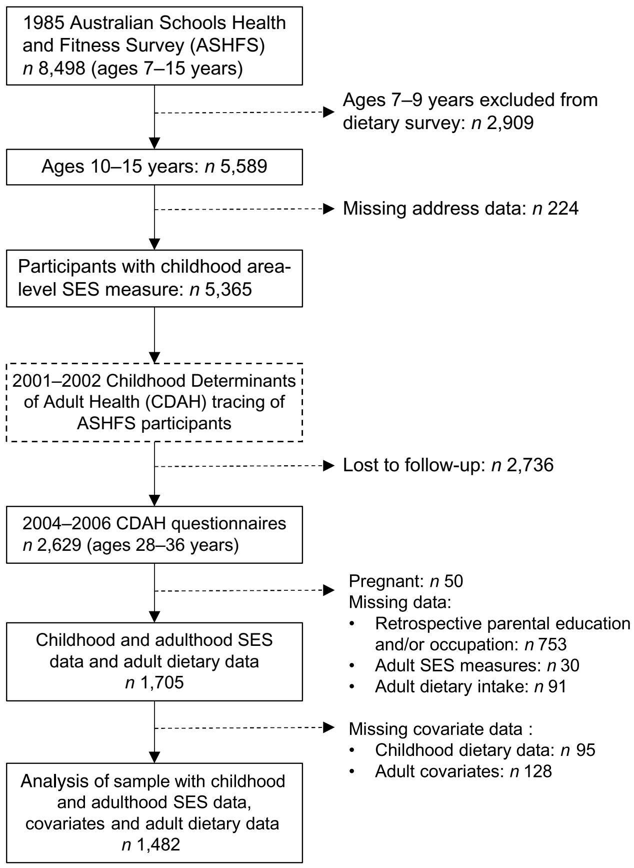

Fig. 1. Flow chart of the Childhood Determinants of Adult Health study population.

Ethical standards

This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving research study participants were approved by the Southern Tasmania Health and Medical Human Research Ethics Committee (approval H6020). Written informed consent was provided by parents for the ASHFS participants and by the participants for the CDAH study.

Childhood socio-economic status

Childhood SES was determined by three separate measures: area-level SES, parental education and parental occupation[6,9,27,28]. Area-level SES was based on residential postal code identified from town or suburb of residence reported by ASFHS participants. The postal codes were used to identify the 1981 Australian census Socio-Economic Indexes for Areas (SEIFA) Index of Relative Socio-economic Disadvantage[29,30] score quarter: high (lowest disadvantage), medium-high, medium-low and low (highest disadvantage). Parental occupation and education were reported retrospectively in questionnaires at the CDAH follow-up. Participants reported

Table 1. Definition of childhood to adulthood socio-economic status mobility categories

Mobility type	Childhood*	Adulthood
Area-level SES		
Stable high	High	High
Stable intermediate	Medium high or medium low	Medium high or medium low
Stable low	Low	Low
Upward mobility	Lower category than in adulthood	Higher category than in childhood
Downward mobility	Higher category than in adulthood	Lower category than in childhood
Education		
Stable high	University	University
Stable intermediate	Vocational	Vocational
Stable low	School	School
Upward mobility	Lower category than in adulthood	Higher category than in childhood
Downward mobility	Higher category than in adulthood	Lower category than in childhood
Occupation		
Stable high	Manager/professional	Manager/professional
Stable intermediate	Non-manual	Non-manual
Stable low	Manual/not in workforce	Manual/not in workforce
Upward mobility	Lower category than in adulthood	Higher category than in childhood
Downward mobility	Higher category than in adulthood	Lower category than in childhood

* Childhood education and occupational status was determined by highest level of either parent, reported retrospectively by the participant in adulthood.

their father's (biological father or male who lived with them and was like a father) and mother's (biological mother or female who lived with them and was like a mother) highest level of education and main occupation up to when the participant was 12 years old. Parental education was categorised into university, vocational or school only. Parental occupation was categorised as professional/managerial, non-manual, manual or not in the workforce. The highest level of education and occupation reported for either parent was used in this analysis.

Adult socio-economic status

At the CDAH follow-up, participants reported their residential address, their highest level of education and their main occupation. Adult area-level SES categories were determined using residential postal codes and the 2006 Australian census SEIFA Index of Relative Socio-economic Disadvantage score quarters[29]. Adult area-level SES, education and occupation were categorised to align with the childhood measures.

Socio-economic mobility

SES mobility was determined by change in the category of each SES factor from childhood to adulthood and categorised as stable high, stable intermediate, stable low, upward mobility or downward mobility (Table 1). The stable categories indicated the participant was in the same category at both time points, while upward mobility indicated a higher level in adulthood than in childhood, and downward mobility indicated a lower level in adulthood than in childhood. Area-level SES categories at baseline and follow-up were determined by the relevant SEIFA Index of Relative Socio-economic Disadvantage scores at each time point, meaning that a participant who remained in the same location may have area-level SES mobility from childhood to adulthood, due to differences between the 1981 and 2016 SEIFA Index of Relative Socio-economic Disadvantage rankings for that area.

Dietary guideline index

Diet quality in adulthood was the outcome measure in this study. Adult dietary intake was measured using a FFQ and a food habits questionnaire. The FFQ, derived from the Australian 1995 National Nutrition Survey and validated for use within Australian populations[31,32], asked participants to estimate their frequency of intake of 127 food and beverages over the previous year with nine options ranging from 'never or less than once per month', to 'six or more times a day'. Usual fruit and vegetable intake were determined by two questions about how many servings of fruit and vegetables they usually consumed each day and provided examples of serving sizes (five response options ranging from 'I don't eat fruit' or 'I don't eat vegetables' to '6 or more serves per day'). It was assumed that each reported frequency equalled one serve[33,34], and frequencies were equated to daily serves. For example, a report of consuming fresh fish once per week was equated to one seventh of a serve of fish per day. Participants also reported the type of milk they usually consumed (e.g. full fat, reduced fat and soya), whether they usually trimmed fat from meat, and the type of spread used for bread/crackers.

Diet in childhood, measured by a 24-h food record, was used as a covariate in this study. The children were shown by trained data collectors how to measure and record their food and drink intake in a booklet using provided circles, rulers, and metric cups and spoons. The 24-h period started after a practice exercise and each student was interviewed upon booklet collection to check the entries. The survey design and collection and processing of food record data were coordinated by the Department of Community Services and Health, with assistance from the Dietitians Association of Australia[35]. The gram weight and energy (kJ) content of each consumed item were converted to equivalent proportions of standard serves[33] of food and beverage items. For example, 125 ml of milk was equated to 0·5 standard servings (250 ml) of dairy.

Diet quality in childhood and adulthood was assessed using a validated age- and sex-specific dietary guideline index

(DGI)[34,36] based on the 2013 Australian Dietary Guidelines[33]. The daily serves of foods derived from the 24-h food record or FFQ were used to calculate scores for eight DGI components with the following maximum scores (minimum scores were zero): variety of core foods (10 points); vegetables (10 points), fruit (10 points), cereals/grains (10 points), dairy or alternatives (10 points), lean meats or alternatives (10 points), water (10 points) and limiting discretionary foods high in added salt, sugars, saturated fats or alcohol (20 points). The ninth component, to replace foods high in saturated fat with unsaturated fat (10 points), was calculated in childhood as energy from unsaturated fats/oils as proportion of total fats/oils, and for adulthood using the responses to the food habits questionnaire questions about trimming fat from meat and type of spread used. The DGI components and scoring matrix are outlined in the online supplementary material (online Supplementary Table S1). Partial scores were given when a component was partially achieved, for example five points were given for consuming one of the recommended two serves of fruit. The sum of component scores gave an overall score with possible range 0–100. Higher scores indicate stronger adherence to the dietary guidelines and better diet quality.

Covariates

Language spoken at home was reported at ASHFS and was used as a measure of cultural diversity, categorised as English, European languages (primarily Italian and Greek) and other languages (primarily Vietnamese, Arabic or Chinese). Other covariates were adulthood measures, including age (in years) at CDAH follow-up. Marital status (living as single, living as married) was self-reported in the questionnaire. Metabolic equivalent task (MET) minutes of physical activity based on self-reported duration and intensity of weekly physical activity was determined using the validated International Physical Activity Questionnaire long form[37]. Total weekly MET minutes were divided by 60 for total weekly MET hours of physical activity. Residential remoteness (major city, inner regional and outer regional/remote) was determined by participant address and the Accessibility/Remoteness Index of Australia[38]. BMI, calculated as weight in kilograms divided by squared height in metres, was measured at study clinics with participants in light clothing and no shoes. Height was measured to the nearest 0·1 cm using a Leicester stadiometer (Invicta, Leicester, UK), and weight was measured to the nearest 0·1 kg using a Heine portable scale (Heine, Dover, NH, USA). For participants who did not attend a study clinic, self-reported height and weight were used with a correction factor based on discrepancies between the self-reported and measured height and weight of clinic participants[39]. An estimate of usual energy intake per day in megajoules (MJ) during the previous 12 months was derived from the FFQ[40].

Statistical analysis

Participants were included in the analysis if they had childhood and adulthood data for all three SES variables of interest (area-level SES, education and occupation), dietary data and covariate measures and were not pregnant at the CDAH follow-up (as dietary intake may not represent usual intake). Linear regression was used to determine whether SES mobility was associated with diet quality in adulthood. Supplementary analyses also used linear regression to determine associations between childhood SES factors and adult diet quality and adulthood SES factors and adult diet quality. The beta-coefficients represent difference in the DGI score compared with the reference group. The analyses were stratified by sex, as interactions were observed for adult education and sex (vocational education and sex: $P = 0{\cdot}081$) and adult occupation and sex (not in labour force: $P = 0{\cdot}007$). The DGI scores were confirmed to be normally distributed by visual inspection of sex-stratified histograms and Shapiro–Wilk test results ($P > 0{\cdot}05$).

Covariates were selected a priori based on empirical evidence of associations with diet quality. Model 1 was unadjusted, and model 2 adjusted for childhood diet quality[16,17], language spoken at home and adult measures of age, marital status, remoteness area, BMI, physical activity MET hours per week, daily energy intake and SES (area-level SES models adjusted for adult education, whereas the education and occupation models adjusted for adult area-level SES)[34,36,41]. Adult education and adult occupation were not used as covariates in the same model due to collinearity (Spearman rank correlation coefficients for males: 0·42; females: 0·48, both $P < 0{\cdot}001$).

An approach motivated by Seaman *et al.*[42] was applied to account for loss-to-follow-up. First, multiple imputation of chained equations with fifty estimations was used to complete (where necessary) data on ASHFS variables that predicted loss-to-follow-up: sex, childhood age, language spoken at home, area-level SES, academic performance reported by the school (excellent, above average, average, below average and poor) and type of school (government, Catholic or independent). Second, inverse probability weighting was used to weight the sample in the regression analyses according to these variables, to reflect the original cohort of 5589 participants (10–15 years of age). Imputed values were used for the weighting of the models but not as values of dependent or independent variables in the models. All analyses were conducted using STATA 16.1 (2019, StataCorp).

Supplementary analyses examined participant distribution in two-way contingency tables of each combination of the SES measures in childhood and adulthood (e.g. education and area-level SES) and between the SES mobility measures.

Results

In 1985, 5365 of the 5589 eligible ASHFS participants aged 10–15 years completed the questionnaire field for town or suburb of residence. At the CDAH follow-up, 2629 of these participants (aged 28–36 years) completed the socio-demographic and lifestyle questionnaire (Fig. 1). Participants were excluded from the analysis for the following reasons: missing retrospective data on parental education or occupation (*n* 753), missing adult SES data (*n* 30), did not complete the adult dietary questionnaire or were missing dietary data required to calculate DGI (*n* 91), pregnant at CDAH follow-up (*n* 50), missing childhood dietary data (*n* 95) or missing adult covariate data (n 128). This left 1482 participants for the analysis (27 % of the 5589 eligible baseline participants; 46 % male). The childhood characteristics that were associated with loss-to-follow-up and used in the stratification and inverse probability weighting of the regression analyses are shown in Supplementary Table S2 for all eligible participants and those included in the analysis. There was greater loss-to-follow-up among participants who were male, resided in a low area-level SES area, spoke a language other than English at home and had below-average academic performance. The mean childhood DGI score was slightly higher among the analysis population than the eligible population. The majority of participants reported speaking only English at home (analysis population: 88 % of males, 90 % of females).

The mean (SD) age of participants at follow-up was 32·9 (1·8) years for both sexes (Table 2). In adulthood, the majority of participants were married or living as married, resided in major cities and worked in a managerial/professional or non-manual role. The mean (SD) adult DGI score was 51·1 (10·6) for males and 58·4 (11·3) for females. A greater percentage of participants resided in the extremes of high or low SES areas in adulthood (males: high = 32·7 %, low = 15·2 %; females: high = 33·5 %, low = 14·4 %) compared with childhood (males: high = 23·7 %, low = 7·8 %; females: high = 27·1 %, low = 6·6 %). A greater percentage of participants had attained university-level education (males: 36·0 %; females: 44·2 %) compared with their parents (males: 25·2 %; females: 23·9 %). The percentage of participants not in the workforce was higher in adulthood (males: 3·7 %; females: 22·1 %) compared with the percentage of parents not in the workforce (males: 0·4 %; females: 1·5 %).

These differences between childhood and adulthood SES are reflected in the SES mobility categories, particularly for area-level SES where around 65 % of males and females had either upward or downward mobility (Table 3). Participants were considerably more likely to have upward (both males and females = 37 %) than downward educational mobility (males = 17 %; females = 18 %). In comparison, participants were more likely to have downward occupation mobility (males = 25 %; females = 35 %) than upward mobility (males = 22 %; females = 25 %).

After covariate adjustment, there were no associations between area-level SES mobility and DGI score for males or females. The covariate with the largest attenuating effect was attained education followed by childhood DGI score. Compared with those with stable high education, a lower adult DGI score was associated with stable-intermediate education among males only (β = –3·9; 95 % CI: −7·0, −0·7) and for both sexes: stable-low education (males: β = –5·5; 95 % CI: −8·9, −2·1; females: β = –6·3; 95 % CI: −9·3, −3·4) and downward mobility (males: β = –5·3; 95 % CI: −8·5, −2·0; females: β = –4·5; 95 % CI: −7·2, −1·7). Compared with those with stable high occupation, a lower adult DGI score was associated with stable low occupation among males only (β = –4·9; 95 % CI: −7·6, −2·2) and downward mobility among both sexes (males: β = –3·2; 95 % CI: −5·3, −1·1; females: β = –2·8; 95 % CI: −4·8, −0·8). Childhood DGI score was the covariate with the largest attenuating effect on the associations between occupation mobility and education mobility and adult diet quality.

Results of supplementary analyses to separately examine the associations between childhood SES factors and adult DGI score and adult SES factors and adult DGI score are shown in Supplementary Table S3. After covariate adjustment, there was no association between childhood area-level SES or parental education or parental occupation and adult DGI score for either sex. In adulthood, for males only, compared with high adulthood area-level SES, low adult area-level SES was associated with a lower adult DGI score (β = –3·1; 95 % CI: −5·8, −0·5). Among both sexes, there was a significant linear trend of lower attained education level associated with lower DGI score. Compared with those with university education, lower DGI scores were observed for those with vocational education (males: β = –4·8; 95 % CI: −6·7, −2·9; females: β = –2·2; 95 % CI: −4·2, −0·2) or school education only (males: β = –6·4; 95 % CI: −8·6, −4·1; females: β = –6·4; 95 % CI: −8·4, −4·4). Compared with those in managerial/professional roles, males in manual roles had lower DGI scores (β = –3·9; 95 % CI: −5·8, −2·1), as did females in non-manual roles (β = –2·7; 95 % CI: −4·8, −0·7).

Contingency tables of the distribution of participants across the SES measures in childhood (online Supplementary Table S4) and adulthood (online Supplementary Table S5) and across the SES mobility measures (online Supplementary Table S6) are shown in supplementary material. Supplementary Table S6 shows that highest proportions of each sex with upward mobility in one measure and downward mobility for another was for upward area-level SES mobility and downward occupational mobility among females (11 %) and upward educational mobility and downward area-level SES mobility for males (10 %).

Discussion

This study aimed to examine associations between childhood to adulthood SES mobility and adult diet quality. We found that education and occupational mobility, but not area-level SES mobility, were associated with diet quality. Participants with upward educational and occupational mobility had similar adult diet quality to those with high SES at both time points, while those with downward mobility had poorer diet quality.

The results highlight the importance of educational attainment. Compared with university-educated participants with a university-educated parent, participants and their parents who only completed school had the poorest diet quality (around six DGI points lower), followed by those who had a lower education than their highest educated parent (downward mobility) (four to five points lower). Six points roughly equates to eating three fewer serves of vegetables per day. Those with upward educational mobility had DGI scores only one to three points lower than those with stable university education. The results are consistent with a 2010 CDAH study that found that the participant's education attainment attenuated the positive association between parental education and a healthy lifestyle score (derived from: BMI, smoking, physical activity and intake of alcohol, salt, skim milk, fish, meat, fruit/vegetables and use of low fat spread)[6]. Our results are also consistent with studies that have reported that educational attainment attenuates associations between childhood SES measures and cardiovascular risk

Table 2. Characteristics of the childhood determinants of adult health study participants
(Numbers and percentages; mean values and standard deviations)

	Males (*n* 678)		Females (*n* 804)	
Characteristic	*n*	%	*n*	%
Childhood variables				
Area-level SES quarter*				
High	161	23·7	218	27·1
Medium-high	192	28·3	241	30·0
Medium-low	272	40·1	292	36·3
Low	53	7·8	53	6·6
Parent highest level of education†				
University	171	25·2	192	23·9
Vocational	221	32·6	282	35·1
School only	286	42·2	330	41·0
Parent highest occupation†				
Manager/Professional	373	55·0	434	54·0
Non-manual	132	19·5	155	19·3
Manual	170	25·1	203	25·2
Not in workforce	3	0·4	12	1·5
Language spoken at home‡				
English	600	88·5	726	90·3
European languages	66	9·7	57	7·1
Other languages	12	1·8	21	2·6
Dietary Guidelines Index score, mean§				
Mean	46·7		44·0	
SD	12·2		11·7	
Adult variables				
Age years				
Mean	32·9		32·9	
SD	1·8		1·8	
Marital status				
Single	190	28·0	196	24·4
Married/living as married	488	72·0	608	75·6
Residential remoteness‖				
Major city	490	72·3	575	71·5
Inner regional	116	17·1	143	17·8
Outer regional/remote	72	10·6	86	10·7
Area-level SES quarter*				
High	222	32·7	269	33·5
Medium-high	190	28·0	220	27·4
Medium-low	163	24·0	199	24·8
Low	103	15·2	116	14·4
Education				
University	244	36·0	355	44·2
Vocational	257	37·9	206	25·6
School only	177	26·1	243	30·2
Occupation				
Manager/Professional	400	59·0	379	47·1
Non-manual	43	6·3	205	25·5
Manual	210	31·0	42	5·2
Not in workforce	25	3·7	178	22·1
Dietary Guideline Index score‡				
Mean	51·1		58·4	
SD	10·6		11·3	
BMI				
Mean	26·7		25·1	
SD	4·3		5·2	
Physical activity – MET hours per week¶				
Mean	63·8		51·9	
SD	47·6		36·1	
Energy intake – MJ per day**				
Mean	11·8		8·9	
SD	4·2		3·2	

SES, socio-economic status; MET, metabolic equivalent of task.
* Area-level SES quarter defined using the SEIFA index, a measure of area disadvantage based on Australian census data: 1981 census for childhood, 2006 census for adulthood.
† Data collected retrospectively in adulthood – participants were asked to report their mother and father's education and main occupation up until they were 12 years old. The highest level of either parents was used.
‡ Other languages were primarily Vietnamese, Chinese and Arabic.
§ Dietary Guideline Index. A higher score on the range 0–100 indicates greater adherence to the 2013 Australian Dietary Guidelines and therefore better diet quality.
‖ Determined according to the Accessibility and Remoteness Index of Australia.
¶ Metabolic equivalents of task hours per week, measured by the International Physical Activity Questionnaire.
** Daily energy intake (MJ) estimated from the FFQ.

Table 3. Mean differences in the adult dietary guideline index score, by socio-economic status mobility
(Numbers and percentages; coefficient values and 95 % confidence intervals)

	Males (*n* 678)							Females (*n* 804)						
			Model 1†		Model 2‡				Model 1†		Model 2‡			
SES factor	*n*	%	β§	95 % CI	β^c	95 % CI	*n*	%	β§	95 % CI	β^c	95 % CI		
Area level mobility‖														
Stable high	84	12·4		Reference		Reference	115	14·3		Reference		Reference		
Stable intermediate	141	20·8	–2·1	–5·1, 0·9	–0·4	–3·3, 2·4	150	18·7	–1·4	–4·1, 1·2	1·4	–1·2, 4·0		
Stable low	16	2·4	–6·7	–14·3, 1·0	–3·9	–10·9, 3·1	9	1·1	–4·6	–10·2, 1·0	–2·8	–9·0, 3·5		
Upward mobility	235	34·7	–1·2	–3·6, 1·3	0·0	–2·4, 2·4	267	33·2	–0·4	–2·7, 2·0	1·2	–1·1, 3·5		
Downward mobility	202	29·8	–2·5	–5·1, 0·2	–1·1	–3·7, 1·4	263	32·7	–2·2	–4·5, 0·1	0·2	–2·2, 2·5		
Education mobility¶														
Stable high	93	13·7		Reference		Reference	130	16·2		Reference		Reference		
Stable intermediate	105	15·5	–5·3	–8·5, –2·1**	–3·9	–7·0, –0·7*	96	11·9	–1·9	–5·0, 1·3	–1·6	–4·9, 1·6		
Stable low	111	16·4	–8·0	–11·2, –4·8***	–5·5	–8·9, –2·1**	139	17·3	–7·5	–10·3, –4·7***	–6·3	–9·3, –3·4***		
Upward mobility	253	37·3	–3·9	–6·8, –1·0**	–2·8	–5·8, 0·1	298	37·1	–1·2	–3·6, 1·1	–0·8	–3·1, 1·6		
Downward mobility	116	17·1	–6·1	–9·5, –2·7***	–5·3	–8·5, –2·0**	141	17·5	–4·7	–7·5, –1·9**	–4·5	–7·2, –1·7**		
Occupation mobility [e]														
Stable high	261	38·5		Reference		Reference	246	30·6		Reference		Reference		
Stable intermediate	15	2·2	–0·3	–6·5, 5·9	–1·3	–7·8, 5·2	49	6·1	–0·5	–4·1, 3·1	0·0	–3·5, 3·5		
Stable low	83	12·2	–6·0	–8·8, –3·2***	–4·9	–7·6, –2·2***	26	3·2	–1·1	–5·7, 3·5	–0·3	–5·0, 4·3		
Upward mobility	149	22·0	–1·6	–3·7, 0·5	–1·1	–3·2, 1·0	202	25·1	–1·8	–3·9, 0·3	–1·3	–3·5, 0·9		
Downward mobility	170	25·1	–3·5	–5·6, –1·3**	–3·2	–5·3, –1·1**	281	35·0	–3·5	–5·6, –1·5**	–2·8	–4·8, –0·8**		

SES, socio-economic status.
* $P < 0·05$.
** $P < 0·010$.
*** $P < 0·001$.
† Model 1 – unadjusted.
‡ Model 2 – adjusted for childhood DGI score, language spoken at home, adult age, marital status, area of residence (major city, inner regional and outer regional/remote), physical activity (metabolic equivalents of task hours per week), BMI, usual daily energy intake and adult SES factors as follows: area-level SES mobility adjusted for adult education level but not adult occupation due to collinearity between adult occupation and adult education. Education and occupation mobility models adjusted for adult area-level SES.
§ The beta coefficients represent the difference in the Dietary Guideline Index (DGI) score compared with the reference group. The DGI was based on the 2013 Australian Dietary Guidelines. A higher score indicates greater adherence to the guidelines (potential range 0–100).
‖ Area-level SES quarter defined using the SEIFA index, a measure of area disadvantage based on Australian census data: 1981 census for childhood, 2006 census for adulthood.
¶ Childhood data collected retrospectively in adulthood – participants asked about life growing up until the age of 12. The highest level of either parent was used.

factors including obesity, smoking, unhealthy dietary practices and poor diet quality[9,14,18,27].

The mechanisms whereby a higher level of education is associated with better diet quality may relate to several factors, including peer/social influence or higher income to support better dietary variety and choices[43,44]. A 2012 review indicated that the social gradient of diet quality may be explained by the higher costs of nutritious food[45]. Higher education, particularly at the tertiary level, may help equip individuals with the health literacy and skills to seek out, interpret and apply information about healthy diets[46,47]. Nutritional knowledge has been shown to have a slight mediating effect between education level and diet quality[48–50], highlighting the importance of strategies to both improve formal education opportunities and implement health education campaigns, particularly targeted to those from socio-economically disadvantaged backgrounds. These strategies could be complemented by government policies such as providing adequate welfare payments or subsidising healthy foods to support affordability of nutritious diets[44,51,52].

There were some sex differences in the association between occupational mobility and diet quality. Males who were out of the workforce or in manual work and had parents in the same category had DGI scores around five points lower than those with stable managerial/professional occupational status, but there was no significant difference for females in the same categories. Females may be more likely than men to be stay-at-home parents which was not differentiated from being out of the workforce in the questionnaire, reflecting the limitations of using point-in-time occupation status to assess SES among women who may have less linear career paths than men[53]. Among both sexes, compared with stable managerial/professional occupation, downward occupational mobility was associated with slightly poorer diet quality (around three points lower), while those with stable non-manual or upward mobility had similar diet quality. Our results are consistent with studies using childhood data from the mid-20th century, which found that compared with stable high (non-manual) occupational status in childhood and adulthood, stable low (manual) status was associated with poorer diet quality[19,20], while upward mobility was associated with diet quality closer to the stable high group[19].

Mechanisms whereby occupation is associated with diet quality may relate to similar factors as education, e.g. income potential, social and peer influence and capacity for implementing nutritional knowledge[11]. However, occupational status as measured in this current study may not be a good indicator of income. The parental measure is the highest occupation level of either parent while the participant's occupational status does not account for a partner's occupation. This, and that the participant may be younger and at an earlier career stage than their parents, would also partly account for the high number of participants with downward occupational mobility. Participants out of the workforce as stay-at-home parents could also contribute to apparent downward mobility among the population, particularly among females. The correlation between education and occupation level in adulthood indicates that they are not independent of each other, although they may have independent but synergistic effects[54]. If using only one measure as an indicator of SES, education could be a more reliable measure than occupation as it is often completed in young adulthood and is a more enduring indicator of socio-economic circumstance and career opportunity than point-in-time occupation[13,53].

There were no associations between area-level SES mobility and diet quality for either sex. This may relate to discrepancies between area-level and individual SES, evidenced in the supplementary analysis by high proportions of participants with contrasting mobility (e.g. upward education mobility and downward area-level SES). A 2000 Canadian study showed poor agreement between area-level SES, also determined by SES of census areas, and individual-level SES determined by parental occupation and a score based on income and education required for the occupation[55]. Examining area-level SES in relation to diet quality or as a covariate may be appropriate depending on how the area-level measure is defined and how it relates to the local food environment and opportunities to make healthy food choices.

In the supplementary cross-sectional analyses, low compared with high adulthood area-level SES was associated with lower adult diet quality among males, consistent with two cross-sectional Australian studies from 2016 and 2017, where area-level SES was also determined by the SEIFA index, although these studies also found similar associations among women[3,56]. Among both sexes, there were significant linear trends for higher adult educational attainment and better adult diet quality equating to around seven DGI points difference between participants with a university education and those with school only. The differing associations between adult occupation categories and diet quality for males and females could relate to manual and non-manual gender role differences and social influences within these occupational contexts[57]. The limited significant results and smaller effect sizes related to the childhood SES factors compared with the adult analyses suggest that the results observed in the SES mobility analyses are likely to be largely influenced by the adult circumstances.

There are several limitations of this study, including the large loss-to-follow-up from the original nationally representative sample of Australian schoolchildren aged 10–15 years. Although the baseline sample was representative of schoolchildren at the time, the current Australian population is much more culturally and ethnically diverse than in 1985, which limits the generalisability of results. Moreover, the analysis population comprised only 27 % of the baseline eligible population. Of note is that 753 participants were excluded as they did not retrospectively report their parents' occupation or education. This could have introduced bias and unmeasured confounding related to specific characteristics of the remaining study population. However, the study population did have diversity of characteristics and inverse probability weighting on variables that predicted loss-to-follow-up was applied to weight the sample to reflect the original population.

The retrospective measures of parental education and occupation may also have introduced error. However, validation studies for retrospective measures of childhood SES have shown good agreement for parental education[58] and moderate agreement for father's occupation, with misclassifications mainly arising from participants reporting a higher occupational level than reported by their mother in childhood[59]. Categorising SES factors into broad categories is a previously used method[6,9,18], but other approaches may be more precise, such as by relating specific occupations to a census derived socio-economic occupational index[27]. However, this study was a secondary analysis using available data, and specific occupation and family/household income were not measured at baseline or follow-up, so more nuanced indexes or detailed outcomes were not able to be derived. Effects of unmeasured confounding should also be considered, such as lack of measures at both time points for number of people living in the household. Dietary intake was measured using a non-quantitative FFQ, and assumptions were made to equate frequency to daily serves, which is likely to have introduced some bias, although the method has been validated[34,36,40]. Although childhood diet was used as a covariate in the adjusted models, the dietary measure in childhood was a single 24-h food record intended as a snapshot of Australian schoolchildren's diet and may not reflect usual intake. Analysis of the change in diet quality from childhood to adulthood was not appropriate due to the different dietary measurement methods used at each time point. However, adjustment for childhood diet is a strength of the study as childhood DGI did have an attenuating effect on the associations between the SES mobility variables and adult diet quality, consistent with previous studies reporting associations between child and adult diet quality[10,17].

Another strength of the study is the separate examination of the three SES factors, rather than using a composite measure, to highlight how different dimensions of SES associate with diet quality potentially reflecting different mechanisms. Few cohorts exist with adequate measures to address this research question. The differing results between the three SES factors in both the primary and supplementary analyses highlight that SES measures are not interchangeable and should be selected and interpreted based on plausible mechanisms of how they may affect the health outcome of interest[22]. Any further work in developing a combined measure or index of SES mobility should consider these differences of effect. The use of the validated Dietary Guidelines Index derived from evidence-based dietary guidelines helps facilitate interpretation and comparability of results as the index is food-based and structured around core components of healthy eating that are commonly outlined in national dietary guidelines worldwide[60].

In summary, educational and occupational SES mobility was associated with adult diet quality. Improvement in SES from childhood to adulthood, particularly education status, may lead to diet quality outcomes similar to those with high SES at both time points. However, it is noted that the overall mean DGI scores among the cohort were low, indicating that there is plenty of room for improvement in the diets of Australian adults, even for those with the highest SES. Improving diet quality at the population level could be furthered by supporting educational attainment to help improve health literacy and employment potential among younger populations and implementing government policies to enhance affordability of nutritious foods, particularly for those with the greatest economic disadvantage.

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K. J. S. and S. A. M. conceived and designed the study. J. E. W. undertook the data analyses. J. E. W. composed the draft manuscript and coordinated revisions of the manuscript. K. J. S. and S. A. M. provided subject matter expertise and editing. A. J. V. and T. D. were involved in conceptualisation of the CDAH study and data acquisition. All authors reviewed and commented on the draft manuscript and approved the final manuscript.

There are no conflicts of interest.

Supplementary material

For supplementary material/s referred to in this article, please visit https://doi.org/10.1017/S0007114521003317

References

1. Orr CJ, Keyserling TC, Ammerman AS, *et al.* (2019) Diet quality trends among adults with diabetes by socioeconomic status in the US: 1999–2014. *BMC Endocr Disord* **19**, 54.
2. Darmon N & Drewnowski A (2008) Does social class predict diet quality? *Am J Clin Nutr* **87**, 1107–1117.
3. Backholer K, Spencer E, Gearon E, *et al.* (2016) The association between socio-economic position and diet quality in Australian adults. *Public Health Nutr* **19**, 477–485.
4. Lewis M & Lee AJ (2021) Dietary inequity? A systematic scoping review of dietary intake in low socio-economic groups compared with high socio-economic groups in Australia. *Public Health Nutr* **24**, 393–411.
5. de Mestral C & Stringhini S (2017) Socioeconomic status and cardiovascular disease: an update. *Curr Cardiol Rep* **19**, 115.
6. Gall SL, Abbott-Chapman J, Patton GC, *et al.* (2010) Intergenerational educational mobility is associated with cardiovascular disease risk behaviours in a cohort of young Australian adults: the Childhood Determinants of Adult Health (CDAH) study. *BMC Public Health* **10**, 55.
7. Savelieva K, Pulkki-Råback L, Jokela M, *et al.* (2017) Intergenerational transmission of socioeconomic position and ideal cardiovascular health: 32-year follow-up study. *Health Psychol* **36**, 270–279.
8. Lynch JW, Kaplan GA & Salonen JT (1997) Why do poor people behave poorly? Variation in adult health behaviours and psychosocial characteristics by stages of the socioeconomic lifecourse. *Soc Sci Med* **44**, 809–819.

9. Faught EL, McLaren L, Kirkpatrick SI, *et al.* (2019) Socioeconomic disadvantage across the life course is associated with diet quality in young adulthood. *Nutrients* **11**, 242.
10. Mikkilä V, Räsänen L, Raitakari O, *et al.* (2005) Consistent dietary patterns identified from childhood to adulthood: the cardiovascular risk in Young Finns Study. *Br J Nutr* **93**, 923–931.
11. Vlismas K, Stavrinos V & Panagiotakos DB (2009) Socio-economic status, dietary habits and health-related outcomes in various parts of the world: a review. *Cent Eur J Public Health* **17**, 55–63.
12. Krieger N, Williams DR & Moss NE (1997) Measuring social class in US public health research: concepts, methodologies, and guidelines. *Annu Rev Public Health* **18**, 341–378.
13. Galobardes B, Lynch J & Smith GD (2007) Measuring socioeconomic position in health research. *Br Med Bull* **81**, 21–37.
14. Puolakka E, Pahkala K, Laitinen TT, *et al.* (2018) Childhood socioeconomic status and lifetime health behaviors: the Young Finns Study. *Int J Cardiol* **258**, 289–294.
15. Hare-Bruun H, Togo P, Andersen LB, *et al.* (2011) Adult food intake patterns are related to adult and childhood socioeconomic status. *J Nutr* **141**, 928–934.
16. Mikkilä V, Räsänen L, Raitakari OT, *et al.* (2004) Longitudinal changes in diet from childhood into adulthood with respect to risk of cardiovascular diseases: the Cardiovascular Risk in Young Finns Study. *Eur J Clin Nutr* **58**, 1038–1045.
17. Maynard M, Gunnell D, Ness AR, *et al.* (2006) What influences diet in early old age? Prospective and cross-sectional analyses of the Boyd Orr cohort. *Eur J Public Health* **16**, 315–323.
18. Watts AW, Mason SM, Loth K, *et al.* (2016) Socioeconomic differences in overweight and weight-related behaviors across adolescence and young adulthood: 10-year longitudinal findings from Project EAT. *Prev Med* **87**, 194–199.
19. Mishra G, Prynne C, Paul A, *et al.* (2004) The impact of inter-generational social and regional circumstances on dietary intake patterns of British adults: results from the 1946 British Birth Cohort. *Public Health Nutr* **7**, 737–744.
20. Atkins JL, Ramsay SE, Whincup PH, *et al.* (2015) Diet quality in older age: the influence of childhood and adult socio-economic circumstances. *Br J Nutr* **113**, 1441–1452.
21. Thornton LE, Crawford D & Ball K (2010) Neighbourhood-socioeconomic variation in women's diet: the role of nutrition environments. *Eur J Clin Nutr* **64**, 1423–1432.
22. Braveman PA, Cubbin C, Egerter S, *et al.* (2005) Socioeconomic status in health research: one size does not fit all. *JAMA* **294**, 2879–2888.
23. Ocké MC (2013) Evaluation of methodologies for assessing the overall diet: dietary quality scores and dietary pattern analysis. *Proc Nutr Soc* **72**, 191–199.
24. McNaughton SA (2020) Dietary patterns. In *Present Knowledge in Nutrition: Clinical and Applied Topics in Nutrition*, vol. 2, pp. 235–248 [BP Marriott, DF Birt, VA Stallings, *et al.*, editors]. Cambridge, MA: Academic Press.
25. Gall SL, Jose K, Smith K, *et al.* (2009) The childhood determinants of adult health study: a profile of a cohort study to examine the childhood influences on adult cardiovascular health. *Australas Epidemiol* **16**, 35.
26. Dwyer T & Gibbons L (1994) The Australian Schools Health and Fitness Survey. Physical fitness related to blood pressure but not lipoproteins. *Circulation* **89**, 1539–1544.
27. McKenzie SK, Carter KN, Blakely T, *et al.* (2011) Effects of childhood socioeconomic position on subjective health and health behaviours in adulthood: how much is mediated by adult socioeconomic position? *BMC Public Health* **11**, 269.
28. Galobardes B, Lynch JW & Davey Smith G (2004) Childhood socioeconomic circumstances and cause-specific mortality in adulthood: systematic review and interpretation. *Epidemiol Rev* **26**, 7–21.
29. Australian Bureau of Statistics (2020) Socio-Economic Indexes for Areas. https://www.abs.gov.au/websitedbs/censushome.nsf/home/seifa (accessed November 2020).
30. Australian Bureau of Statistics (2011) *Information Paper: Measures of Socioeconomic Status. Report no. 1244.0.55.001*. Canberra: Australian Bureau of Statistics.
31. McLennan W & Podger AS (1998) *National Nutrition Survey Users' Guide, 1995. Report no. 4801.0*. Canberra: Australian Bureau of Statistics.
32. Hodge A, Patterson AJ, Brown WJ, *et al.* (2000) The Anti Cancer Council of Victoria FFQ: relative validity of nutrient intakes compared with weighed food records in young to middle-aged women in a study of iron supplementation. *Aust N Z J Public Health* **24**, 576–583.
33. National Health and Medical Research Council (2013) *Eat for Health: Australian Dietary Guidelines*. Canberra: National Health and Medical Research Council.
34. McNaughton SA, Ball K, Crawford D, *et al.* (2008) An index of diet and eating patterns is a valid measure of diet quality in an Australian population. *J Nutr* **138**, 86–93.
35. English R, Cashel K, Lewis J, *et al.* (1988) *National Dietary Survey of Schoolchildren (aged 10–15 years): 1985. Report no. 1 – Foods Consumed*. Canberra: Australian Government Publishing Services.
36. Wilson JE, Blizzard L, Gall SL, *et al.* (2019) An age-and sex-specific dietary guidelines index is a valid measure of diet quality in an Australian cohort during youth and adulthood. *Nutr Res* **65**, 43–53.
37. Craig CL, Marshall AL, Sjöström M, *et al.* (2003) International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc* **35**, 1381–1395.
38. Australian Bureau of Statistics (2016) The Australian Statistical Geography Standard (ASGS) Remoteness Structure. https://www.abs.gov.au/websitedbs/d3310114.nsf/home/remoteness+structure (accessed November 2020).
39. Smith KJ, Gall SL, McNaughton SA, *et al.* (2017) Lifestyle behaviours associated with 5-year weight gain in a prospective cohort of Australian adults aged 26–36 years at baseline. *BMC Public Health* **17**, 54.
40. Goode JP, Smith KJ, Kilpatrick M, *et al.* (2021) Retrospectively estimating energy intake and misreporting from a qualitative food frequency questionnaire: an example using Australian cohort and national survey data. *Front Nutr* **8**, 624305.
41. Collins CE, Young AF & Hodge A (2008) Diet quality is associated with higher nutrient intake and self-rated health in mid-aged women. *J Am Coll Nutr* **27**, 146–157.
42. Seaman SR, White IR, Copas AJ, *et al.* (2012) Combining multiple imputation and inverse-probability weighting. *Biom* **68**, 129–137.
43. Darmon N & Drewnowski A (2015) Contribution of food prices and diet cost to socioeconomic disparities in diet quality and health: a systematic review and analysis. *Nutr Rev* **73**, 643–660.
44. Lewis M, McNaughton SA, Rychetnik L, *et al.* (2020) A systematic scoping review of the habitual dietary costs in low socioeconomic groups compared to high socioeconomic groups in Australia. *Nutr J* **19**, 1–12.
45. Monsivais P, Aggarwal A & Drewnowski A (2012) Are socioeconomic disparities in diet quality explained by diet cost? *J Epidemiol Community Health* **66**, 530–535.
46. Martin LT, Ruder T, Escarce JJ, *et al.* (2009) Developing predictive models of health literacy. *J Gen Intern Med* **24**, 1211.
47. Clouston SA, Manganello JA & Richards M (2017) A life course approach to health literacy: the role of gender, educational

attainment and lifetime cognitive capability. *Age Ageing* **46**, 493–499.
48. McLeod ER, Campbell KJ & Hesketh KD (2011) Nutrition knowledge: a mediator between socioeconomic position and diet quality in Australian first-time mothers. *J Am Diet Assoc* **111**, 696–704.
49. Deroover K, Bucher T, Vandelanotte C, *et al.* (2020) Practical nutrition knowledge mediates the relationship between sociodemographic characteristics and diet quality in adults: a cross-sectional analysis. *Am J Health Promot* **34**, 59–62.
50. Beydoun MA & Wang Y (2008) Do nutrition knowledge and beliefs modify the association of socio-economic factors and diet quality among US adults? *Prev Med* **46**, 145–153.
51. Cobiac LJ, Tam K, Veerman L, *et al.* (2017) Taxes and subsidies for improving diet and population health in Australia: a cost-effectiveness modelling study. *PLoS Med* **14**, e1002232.
52. Lewis M & Lee AJ (2020) Affording health during the COVID-19 pandemic and associated economic downturn. *Aust N Z J Public Health* **44**, 519–520.
53. Shavers VL (2007) Measurement of socioeconomic status in health disparities research. *J Natl Med Assoc* **99**, 1013–1023.
54. Galobardes B, Morabia A & Bernstein MS (2001) Diet and socioeconomic position: does the use of different indicators matter? *Int J Epidemiol* **30**, 334–340.
55. Demissie K, Hanley JA, Menzies D, *et al.* (2000) Agreement in measuring socio-economic status: area-based *v.* individual measures. *Chronic Dis Can* **21**, 1–7.
56. Livingstone KM, Olstad DL, Leech RM, *et al.* (2017) Socioeconomic inequities in diet quality and nutrient intakes among Australian adults: findings from a nationally representative cross-sectional study. *Nutrients* **9**, 1092.
57. Maguire ER & Monsivais P (2015) Socio-economic dietary inequalities in UK adults: an updated picture of key food groups and nutrients from national surveillance data. *Br J Nutr* **113**, 181–189.
58. Krieger N, Okamoto A & Selby JV (1998) Adult female twins' recall of childhood social class and father's education: a validation study for public health research. *Am J Epidemiol* **147**, 704–708.
59. Batty GD, Lawlor DA, Macintyre S, *et al.* (2005) Accuracy of adults' recall of childhood social class: findings from the Aberdeen children of the 1950's study. *J Epidemiol Community Health* **59**, 898–903.
60. Herforth A, Arimond M, Álvarez-Sánchez C, *et al.* (2019) A global review of food-based dietary guidelines. *Adv Nutr* **10**, 590–605.

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