

particularly driven by changes in beverages and desserts, and the trends were similar in all restaurant types. The average reduction in sugar was smaller in common items compared to all items (0.30 g/year vs. 0.43 g/year). Changes for energy and other nutrients were sporadic and inconsistent across different restaurant types and food categories.

**Conclusion** From 2018 to 2020, sugar per serving declined in restaurant menu items, which could help to reduce sugar intake in the UK population. This may reflect a response to Public Health England's Sugar Reduction Strategy. In contrast, there was little change in other nutrients. Future policies addressing the overall nutritional quality of restaurant foods, rather than single nutrients, may help the restaurant sector to move towards offering healthier foods.

OP80

#### SOCIODEMOGRAPHIC DIFFERENCES IN SELF-REPORTED EXPOSURE TO HIGH FAT, SALT AND SUGAR FOOD AND DRINK ADVERTISING: A CROSS-SECTIONAL ANALYSIS OF 2019 UK PANEL DATA

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**Background** Obesity disproportionately affects socially disadvantaged groups. Differential exposure to advertising of high fat, salt and sugar (HFSS) foods and drinks has been proposed as one factor which may explain these social inequalities. This study explores sociodemographic differences in exposure to HFSS advertising and whether exposure is associated with body mass index.

**Methods** Adults recruited to the Kantar Fast Moving Consumer Goods panel for London and the North of England completed an online survey on their exposure to HFSS advertising in February 2019 (n=1552). We used logistic regression models to assess the association between self-reported exposure to HFSS advertising and sociodemographic characteristics: sex (male or female), age group (18–34 years, 35–44 years, 45–54 years, 55–64 years or ≥65 years), socioeconomic position (high, middle or low), children in the household (yes or no) and working status (full-time employee, part-time employee, self-employed, retired or not looking for work/unable to work). We further assessed associations stratified by product advertised (processed HFSS foods, sugary drinks, sugary cereals, sweet snacks, fast food or digital food delivery services) and advertising setting (traditional, digital, recreational, functional or transport). Lastly, we examined the association between self-reported advertising exposure and weight status.

**Results** Overall, 84.7% of participants reported exposure to HFSS advertising in the past 7 days. Participants in the middle

(vs high) socioeconomic group had higher odds of overall self-reported exposure (OR 1.48; 95% CI 1.06–2.07). Participants in the low (vs high) socioeconomic group had higher odds of reporting exposure to advertising for four of six product categories (ORs ranging from 1.36 to 1.67), traditional advertising (OR 1.44; 95% CI 1.00–2.08) and digital advertising (OR 1.50; 95% CI 1.06–2.14). Younger adults (18–34 years vs ≥65 years) had higher odds of reporting exposure to digital food delivery service advertising (OR 2.08; 95% CI 1.20–3.59), digital advertising (OR 3.93; 95% CI 2.18–7.08) and advertising across transport networks (OR 1.96, 95% CI 1.11–3.48). Advertising exposure was associated with increased odds of obesity for digital food delivery services (OR 1.40; 95% CI 1.05–1.88), digital advertising (OR 1.80; 95% CI 1.33–2.44) and advertising in recreational environments (OR 1.46; 95% CI 1.02–2.09).

**Conclusion** Exposure to HFSS advertising was prevalent, with adults in lower socioeconomic groups and younger adults more likely to report exposure. Several types of HFSS advertising were associated with increased odds of obesity. Restricting HFSS food and drink advertising may help to reduce sociodemographic differences in obesity.

OP81

#### ADJUSTMENT FOR ENERGY INTAKE IN NUTRITIONAL RESEARCH: A CAUSAL INFERENCE PERSPECTIVE

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**Background** Four modelling approaches are commonly used to adjust for overall energy intake when seeking to estimate the causal effect of an individual dietary component on an outcome; (1) the 'standard model' adjusts for total energy intake, (2) the 'energy partition model' adjusts for remaining energy intake, (3) the 'nutrient density model' examines the exposure as a proportion of total energy, and (4) the 'residual model' indirectly adjusts for total energy by using the residual from regressing the exposure nutrient on total energy intake. Unfortunately, it remains underappreciated that each approach evaluates a different causal effect estimand and only partially accounts for confounding by common causes of dietary intake and composition.

**Methods** Semi-parametric directed acyclic graphs and Monte Carlo simulations were used to identify the estimand implied by each approach and the correct interpretation of the model results. The performance of each model for estimating the corresponding target estimand was explored both in the absence and presence of confounding that acts through diet. An alternative approach based on the energy partition model that simultaneously adjusts for all competing dietary components, termed the 'all-components model', was also explored and compared with the four traditional approaches. This model involves using the weighted coefficients of different dietary components to estimate any desired causal effect estimand.

**Results** The 'standard model' and the mathematically identical 'residual model' both estimate *the average relative causal effect* (i.e. a 'substitution' effect) but provide biased estimates even in the absence of any confounding. The 'energy partition model', that adjusts for remaining energy intake, estimates *the*

*total causal effect* (i.e. an 'additive' effect) but only provides unbiased estimates in the absence of confounding or when all individual nutrients have equal effects on the outcome. The 'nutrient density model' does not target a causally meaningful estimand but can provide extremely biased estimates of the average relative causal effect of the exposure rescaled as a percentage of total energy intake. Accurate estimates of both the total and average relative causal effects were obtained with the 'all-components model'.

**Conclusion** Only the 'all-components model' produces unbiased estimates of different causal effects. Lack of awareness of the estimand differences and accuracy of the different modelling approaches may explain some of the apparent heterogeneity among existing nutritional studies. Serious questions may be raised regarding the validity of meta-analyses where different strategies returning different estimands have been inappropriately pooled.

#### OP82 PERFORMANCE OF SUBSTITUTION MODELS IN NUTRITIONAL EPIDEMIOLOGY

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**Background** Dietary guidelines often recommend substituting certain nutrients or foods with healthier alternatives, based on the available evidence from nutritional epidemiology. The effects of food substitutions can be examined by conducting isocaloric dietary interventions, but experimental studies are often not practical or sufficiently generalisable. Therefore, nutritional epidemiology is highly reliant on observational data, in which food substitutions can be explored using mathematical modelling. The two modelling approaches commonly used for estimating substitution effects are known as (1) the 'leave-one-out' model, in which total energy intake and all dietary components are included as covariates, excluding the nutrient(s) that the exposure should be substituted with; and (2) the energy partition model, in which all dietary components are included as covariates, without further adjustment for total energy intake. It remains underappreciated that these approaches do not perform equally well for estimating substitution effects, and that there is limited evidence on whether they produce unbiased estimates.

**Methods** Semi-parametric directed acyclic graphs and Monte Carlo data simulations were used to explore the performance of the two approaches for estimating the following estimands: 1) the average relative causal effect (i.e. the joint effect of increasing intake of the exposure and decreasing the intake of all other nutrients, while keeping total energy intake constant), 2) the relative effect of increasing the exposure nutrient and decreasing the intake of one other nutrient, and 3) the relative effect of increasing the exposure nutrient and decreasing the intake of a combination of other nutrients. The approaches were explored both in the absence and presence of confounding that acts through diet.

**Results** The 'leave-one-out' model produced a biased estimate of the average relative causal effect even in the absence of any confounding. It robustly estimated substituting the exposure with another specific nutrient regardless of whether confounding was present but produced biased estimates of

substituting the exposure for a combination of other nutrients even in the absence of confounding. The energy partition model robustly estimated all three estimands of interest, producing unbiased estimates regardless of whether confounding was present or not.

**Conclusion** Only the energy partition model produces unbiased estimates of different substitution effects in the context of nutritional epidemiology. It performs equally well even in the presence of confounding that acts through diet. Substitution analyses using the 'leave-one-out' approach might not be robust and any existing studies using this model might suffer from bias.

#### OP83 DEVELOPING A MEASURE OF DIETARY QUALITY FOR THE UK BIOBANK

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**Background** The UK Biobank (UKB) has assessed diet among participants using a food frequency questionnaire (FFQ). Studies of UKB have tended to examine the association of intake of single foods with health outcomes. We used the FFQ data to develop a diet quality score that could be used to examine the relationship of dietary patterns with markers of cardiometabolic health.

**Methods** We applied principal components analysis to the FFQ data for participants from the Foodscapes section of UKB (n=52,345). The first component was transformed using Fisher-Yates normal scores, mapping it onto a Normal distribution with a mean of 0 and a standard deviation of 1. The median value was used to categorise diet as healthy or unhealthy. We examined the relationship of the diet scores with markers of cardiometabolic health (blood pressure, serum lipids, BMI) in linear regression analyses, adjusting for confounding factors identified in a Directed Acyclic Graph: sex, age, ethnicity, educational attainment, smoking, Index of Multiple Deprivation.

**Results** Of the 52,345 potential participants, 33,149 (63%) had complete dietary data. Just under half (45%) were men. The average age was 56.2 years (SD=8.2). Most (84%) were white and almost half had a college/university degree (49.5%). The first component explained 14% of the variation in the diet data. It was characterised by high consumption of beef, any type of meat, white bread and low fibre cereals, and low intake of fresh/dried fruit, salad and cooked vegetables and was defined as an 'unhealthy diet score'. Coefficients were multiplied by -1, so a positive value of the score indicated a healthy diet. A higher score, indicative of healthier diet, was associated with lower systolic and diastolic blood pressure ( $\beta$  -0.81, 95% CI -1.0, -0.62;  $\beta$  -0.61, 95% CI -0.72, -0.05), lower BMI ( $\beta$  -0.67, 95% CI -0.73, -0.62) and with healthier lipid profile (lower levels of cholesterol  $\beta$  -0.05, 95% CI -0.06, -0.04, triglycerides  $\beta$  -0.05, 95% CI -0.06, -0.03, and higher HDL cholesterol  $\beta$  0.01, 95% CI 0.0, 0.01). Participants with healthier diet scores (>1) were less likely to be current smokers and more likely to be physically active (>1/day vigorous activity) (both  $P < 0.001$ ).