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The effects of nutrition and health claims on the nutrient composition of single and subsequent meal servings

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ABSTRACT

Nutrition and health claims (NHCs) can help individuals make better food choices. While NHCs have been found to influence consumer perceptions and consumption, there has been less focus on how claims influence the nutritional composition of servings. There has also been little attention paid to longer term or compensatory effects of claims on subsequent food selection. This manuscript details two studies considering these matters. Study 1 (n = 60) was a within-subjects experiment to measure the impact of NHCs on food selection and nutritional composition at single meal servings. Participants served from three fake food buffet meal stations (breakfast, hot meal, snacks) with NHCs present or absent. Study 2 (n = 55) was a within-subjects experiment to examine the impact of NHCs on food selection and nutritional composition at a subsequent meal. Participants served from a fake food buffet breakfast with or without NHCs followed by a lunch without NHCs. In study 1, while results varied for different meals, the presence of claims was found to significantly reduce the amount of energy, fat, saturated fat, sugar, carbohydrates, and sodium, and increase the amount of protein in meals that were served. Results for fibre were mixed. In addition, NHCs increased the quantity of food served in the snacks condition. There was no evidence of claims at breakfast impacting the nutritional composition of subsequent lunch servings in study 2. Despite claims potentially increasing serving quantities, the nutritional composition of chosen servings was more encouraging and claims may help individuals to meet recommended nutritional daily guidelines. These findings have wider implications in terms of government policy, food reformulation, and the continuing debate around the use of nutrient profiling regulations for products carrying claims.

1. Introduction

Poor dietary habits can lead to multiple adverse health effects, with studies showing associations between diet and non-communicable diseases such as cardiovascular and respiratory diseases (Berthon & Wood, 2015; Dai et al., 2020; Lin et al., 2016; Micha et al., 2017; Scoditti, Massaro, Garbarino, & Toraldo, 2019). Dietary risk factors can cause a substantial burden. In 2017, a high intake of sodium was attributed to 3 million deaths and 70 million disability-adjusted life years (DALYs) and a low intake of fruits attributed to 2 million deaths and 65 million DALYs (Afshin et al., 2019). Meanwhile, aspects of a healthier and balanced diet such as intake of whole grains and fruit and vegetable consumption have been associated with a reduced risk of many diseases (Aune et al., 2016; Gan et al., 2015).

While food choice may be seen as an individual behaviour for most, there is increasing awareness of the factors which can shape our dietary decisions. Amongst others, environmental aspects such as school/work, cultural norms, socioeconomic status, and modelling by caregivers and peers can all affect our food choices (Larson & Story, 2009). At a wider level, these aspects, in conjunction with economic, developmental, medical and other factors can impact upon energy balance and overweight and obesity as outlined in the obesity systems map, which visualises potential influences on obesity across numerous levels

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Abbreviations

BMI	Body Mass Index
DALYs	Disability-Adjusted Life Years
NHCs	Nutrition and Health Claims

(Vandenbroeck, Goossens, & Clemens, 2007).

Nutrition labels have the potential to influence consumer food choices. This effect can be negative, causing confusion for consumers and encouraging behaviours such as overconsumption, or positive through educating the consumer to make healthier food choices (Koen, Blaauw, & Wentzel-Viljoen, 2016). Nutrition labels convey different types of information to the consumer (varying depending on the product and country) including ingredients, levels of macro- and micronutrients, allergy advice, serving or portion size, and percentage of recommended daily values (guideline amounts of nutrient intake recommended by governments in some countries). More recently, summary labels such as traffic light labelling, and the Nutri-score and health star rating systems have been placed on labels to guide consumers to make informed and healthier choices (Australian Government, 2020; Department of Health and Social Care, 2013; Julia, Etilé, & Hercberg, 2018). Nutrition and health claims have also been placed on foods to highlight health-relevant nutrients or beneficial effects. A nutrition claim states, suggests, or implies that a food has beneficial nutritional properties due to the energy it does or does not provide or the nutrients or other substances it does or does not contain. A health claim is a message conveyed in text or images that states, suggests, or implies that a relationship exists between a food category, a food or one of its constituents and health (European Commission, 2016).

Nutrition and Health Claims (NHCs) have been well researched. Studies broadly fall under two categories: consumer understanding of NHCs, and the impact of claims on perceptions, choices, and consumption of food. An earlier review of consumer understanding found that consumers are sceptical of claims, do not make distinctions between various types of claims, and prefer shorter and succinct claims (Wansink, Sonka, & Hasler, 2004; Williams, 2005). It has been suggested that information processing and cognitive models should be considered when examining consumer understanding (Leathwood, Richardson, Sträter, Todd, & van Trijp, 2007). The viewing of claims interacts with other biases and pre-existing cognitions, leading to individualised understanding for each consumer. Wider factors also thought to influence understanding include consumer variables such as beliefs, attitudes, relevance, familiarity, knowledge, and literacy as well as product characteristics such as food/drink category, wording, positioning, and ingredients (Grunert, Scholderer, & Rogeaux, 2011; Nocella & Kennedy, 2012; Todd, Guetterman, Sigge, & Joubert, 2021; Wills, genannt Bonsmann, Kolka, & Grunert, 2012). Research investigating the impact of claims on perceptions, choices, and consumption of food has used a range of methods. Surveys are often used to study perceptions and choices. These have found that claims influence healthiness perceptions and perceptions of other nutrients within foods (Annunziata, Vecchio, & Kraus, 2015; Bryła, 2020; Franco-Arellano, Vanderlee, Ahmed, Oh, & L'Abbé, 2020; Lähteenmäki et al., 2010). However, other survey studies have found little or no effect of claims on perceptions (Benson et al., 2018; Talati et al., 2016). The impact of claims on perceptions may also vary by country (Van Trijp & Van der Lans, 2007). Overall, a recent meta-analysis found claims negatively influence tastiness perceptions and positively influence healthfulness perceptions (Ikonen, Sotgiu, Aydinli, & Verlegh, 2020). For example, believing that a low-fat product also contains beneficial levels of other nutrients. Qualitative studies have also found that tastiness and healthiness perceptions of foods may be influenced by claims, with some individuals viewing these foods as less tasty and more healthy (Benson et al., 2019; Lando & Labiner-Wolfe, 2007).

Given their ability to manipulate variables such as the presence/absence, number, and types of claims, experiments are often used to understand the impact of claims on dietary choices and consumption (Kaur, Scarborough, & Rayner, 2017). Choice experiments involve providing participants with discrete choices to elicit their individual preferences (Mangham, Hanson, & McPake, 2009). de-Magistris and Lopéz-Galán (2016) assessed choice and willingness to pay for cheese carrying "reduced-fat" and "low salt" claims. They found that individuals were willing to pay extra for cheese with reduced-fat claims and cheese with both reduced-fat and low salt claims. However, this was not the case for cheese with only a low salt claim. Laboratory experiments invite participants to a laboratory to choose and/or consume foods with and without claims and compare any differences between conditions. Steenhuis and colleagues had females consume chocolate cake, which they had been primed either did or did not carry a (healthy) choices logo (Steenhuis et al., 2010). Overall, there was no significant difference in the amount of cake consumed between claim or no claim conditions. While results across experiments are mixed (potentially also influenced by the aforementioned consumer and product characteristics), overall it appears that the presence of NHCs does increase purchasing and/or consumption of foods. A systematic review and meta-analysis found that 20 of 31 experimental studies reported increases in purchasing and/or consumption and an overall odds ratio of 1.75 (CI 1.60–1.91) for being more likely to purchase or consume products with claims compared with products without claims (Kaur et al., 2017). The increased consumption and/or purchasing of foods associated with NHCs may be due to 'health halo' and/or 'magic bullet' effects. These are generalisations that consumers can make in judging products as healthier or attributing inappropriate health benefits to products (Roe, Levy, & Derby, 1999), based on the presence of a NHC. For example, an individual might consume more potato crisps (chips) labelled with a "low fat" claim believing they are healthier than potato crisps without such a claim. In reality, the nutrient profile may be less optimal and total overall intake may be higher for the potato crisps with a claim than those without a claim.

While these studies have shown an effect of NHCs on purchasing and/or consumption, they have several limitations. Individual experiments typically examine only a few different foods and single or discrete food choices. To our knowledge, no study investigating the effects of nutrition and health claims has examined more than a few foods. Studies are also often limited to displaying only a few NHCs. Kaur et al. (2017) found that only 11 of 31 studies used both nutrition and health claims. These are noteworthy limitations given that in typical food choice situations individuals are faced with multiple types of foods and claims (Hieke et al., 2016). In addition, studies have typically investigated the impact of NHCs at a general purchasing or consumption level (that is, if claims increase or decrease purchasing or consumption). This does not provide detail as to whether these impacts might be beneficial or harmful. For example, at face value an increase in consumption may be viewed negatively, however, if this increase related to food(s) with a 'high in protein' claim this may help an individual to meet the Recommended Daily Allowance of protein. Another limitation is that while, to our knowledge, health halo and magic bullet effects have been studied, there have been no studies that have examined possible compensatory or longer-term effects of NHCs. There is evidence to suggest that individuals may compensate for their (earlier) food choices (Lenne et al., 2017). This is based on the compensatory health beliefs model, which posits that having made an unhealthy or indulgent (food) choice, individuals then compensate for this with a subsequent healthy (food) choice (Knäuper, Rabiau, Cohen, & Patriciu, 2004). Similarly, an individual might follow a healthy food choice with a subsequent unhealthy choice – known as the self-licensing effect (Huberts, Evers, & Ridder, 2012). Therefore, it is logical to expect a self-licensing effect from choosing or consuming foods with NHCs. For example, an individual who chooses a cereal labelled as "low fat" in the morning may then make

different food choices at lunch (such as choosing to eat a greater volume of food or more processed foods).

The purpose of the current two studies was to examine the impact of nutrition and health claims on food choice composition using a wide range of claims and foods, both at a single meal occasion and in terms of meal-to-meal compensation. Following on from previous research, we predicted that the presence of nutrition and health claims would lead to less optimal nutrient compositions of meals when compared to the absence of nutrition and health claims e.g. a greater amount of energy fat, and sugar served (study 1). In line with self-licensing effects, we hypothesised that individuals would compensate after choosing items with claims for breakfast by serving a lunch with a less optimal nutrient composition e.g. greater amount of energy, fat, and sugar served (study 2).

2. Study 1 – the effects of nutrition and health claims on nutrient composition at a single meal

This was a repeated measures experiment, conducted in Northern Ireland, to understand the impact of nutrition and health claims on meal composition.

2.1. Method

2.1.1. Participants

A total of 60 participants aged 18–64 years old from Northern Ireland were recruited through convenience sampling. This involved inviting staff and students within the university to participate via email, along with any other individuals that they felt may be interested. Individuals with an advanced knowledge of diet, nutrition, or food and those working or living alongside anyone working in these areas were excluded. To control for influences on food choices, those who never eat breakfast, those who were strictly limiting intake due to intolerances or health conditions, and individuals who were vegetarian, vegan, or pescatarian were also excluded. The mean age of the sample was 30.9 (*SD* = 9.7), with just over half (52%) male. Body Mass Index (BMI) was calculated using self-reported height and weight (weight in kilograms divided by square of height in metres). The World Health Organisation's BMI ranges were used to classify respondents as underweight (<18.50), normal weight (18.50–24.99), and overweight (>25). Two percent of the sample were underweight, 50% normal weight, and 48% had overweight or obesity.

2.1.2. Fake food buffet

The fake food buffet was used to examine food selection. This is a validated method used in nutrition research, consisting of lifelike polyvinyl chloride replicas of food (Bucher, van Der Horst, & Siegrist, 2012). Where replica foods were not available or suitable for certain types of foods, real foods were used. Three different food stations were used; breakfast, hot meal, and snacks (see supplementary materials figures S1.1 – S1.6). The breakfast station consisted of 21 different food and drink items, the 'hot' meal station consisted of 13 different food and drink items, while the snacks station consisted of 10 different food and drink items. Each station had a claims version, in which all products contained at least one NHC and a no claims version, in which none of the products had NHCs. Therefore, a 2 (claims, no claims) x 3 (breakfast, hot meal, snacks) within-group experimental design was used. Products selected for the buffet were foods and drinks commonly consumed by individuals on the island of Ireland. To control for branding, where possible claim and no-claims versions of a product within the same brand were used. Items were either contained within their packaging (e.g. milk) or placed in appropriate containers beside their packaging (e.g. chips). All 'best before', 'use by' or expiry dates were covered. For a list of the products with nutrition and health claims used in the buffets, see supplementary materials Table S1. Participants were free to choose from a range of plates (15 cm, 20 cm, 27 cm), bowls (13 cm × 6 cm, 16 cm × 7 cm), glasses (230 ml, 400 ml, 500 ml), and serving instruments (tongs, scoops, slicers/servers) at each station to serve their food. While most foods had multiple replicas of each item, multiplication cards (0.5x, 2x, 3x etc.) were also available to allow participants to indicate that they would serve more or less of a single item. Additional items such as cutlery were placed at each station to enhance authenticity of the buffet.

2.1.3. Measures and tasks

In addition to typical sociodemographic data such as gender and age, participants self-reported their weight and height. Body Mass Index (BMI) was calculated by dividing weight (kg) by height (m) squared.

Similar to other fake food buffet studies (Bucher, van der Horst, & Siegrist, 2011; Libotte, Siegrist, & Bucher, 2014), current appetite was measured at the beginning of each session by asking participants to rate their current hunger and thirst on two separate six-point scales (1 = not hungry at all, 6 = very hungry; 1 = not thirsty at all, 6 = very thirsty).

Participants rated their general liking of each item in the buffet on a scale from 1 (do not like at all) to 6 (like very much), as well as a 'never eaten before' option. Authenticity of the buffet was also measured on a six-point scale ranging from 1 (not realistic at all) to 6 (very realistic). These measures have been previously used in fake food buffet studies (Libotte et al., 2014; Mötteli, Keller, Siegrist, Barbey, & Bucher, 2016).

To assess if participants were aware of the claims on the packaging, individuals were asked to "write down two thoughts or things that you noticed about the buffet and materials that were used today in the study". Along with this awareness check, participants also completed some psychological items such as subjective and objective nutrition and health claim knowledge.

To prevent carryover effects from one meal serving to the next, 'spot the difference' puzzles were used as distractor tasks.

2.1.4. Procedure

Prior to full implementation, the experiment was piloted with five individuals leading to minor changes to the questionnaires and distractor tasks. Participants arrived at the testing room individually and were provided with written instructions outlining the experiment. Each participant was then led to a meal station and the cover was removed. The participant was instructed to act as though they were at home and to select a meal that they would eat from the station, using any bowls, plates or glasses available. The researcher then left the serving area and returned when the participant indicated they had finished their selections. The participant then left the serving area and completed a distraction task or questionnaire. Meanwhile, the researcher collected the foods and drinks chosen and covered the used meal station and uncovered the next station. The participant returned to the serving area and completed their second meal serving at the next station, using the same procedure. Finally, the participant completed their final meal serving. Participants returned approximately one week later to complete their second session consisting of their remaining three meal servings. Each session lasted approximately 30 min. In total, participants completed six conditions across the two sessions; breakfast no claims, breakfast claims, hot meal no claims, hot meal claims, snacks no claims, snacks claims (Fig. 1). To prevent order effects, Latin squares were used to randomise and counterbalance conditions within each session, such that participants completed a breakfast, hot meal, and snack serving in each session and alternated between claims and no claims version for each serving. For example, in their first session, a participant might serve from the hot meal station with claims, followed by the snacks station with no claims, followed by breakfast with claims. In their second session, they would then serve from the hot meal station with no claims, followed by the snacks station with claims, then breakfast with no claims.

Participants' food choices were weighed (out of view) and the weight of each food and drink item chosen was entered into a spreadsheet, which calculated nutrient and other values for that meal. A conversion factor was used for all fake food so that the nutritional value of the

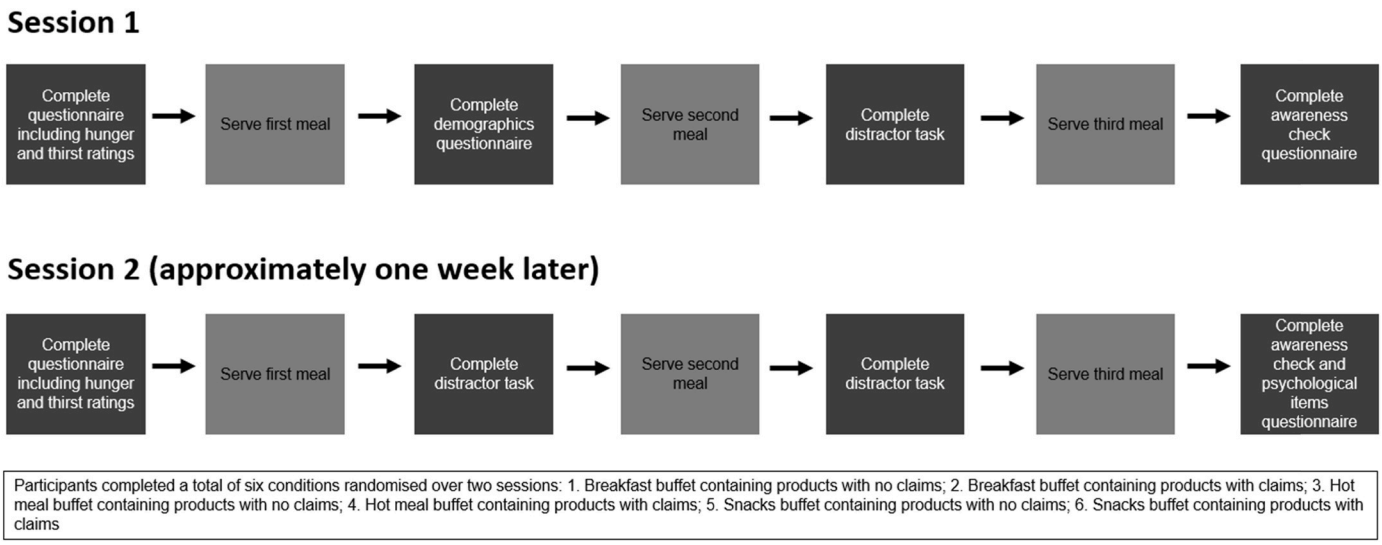

Fig. 1. Outline of procedure for study 1.

equivalent real food weight could be calculated. For example, a replica chicken breast may be the same size as a real size chicken breast, but the replica may weigh only 50g with an equivalent real chicken breast weighing 150g. Therefore, the individual's chicken selection would be multiplied by a factor of 3.

Participants were paid a total honorarium of £40 for time and travel costs. Ethical approval was obtained from the Queen's University Belfast School of Biological Sciences Research Ethics Committee (approval 10/16/BensonT). All participants provided informed written consent.

2.1.5. Data analysis

Data were analysed using R Studio and the nlme package (Pinheiro, Bates, DebRoy, Sarkar, & R Core Team, 2020). Mixed effects models were developed with each dietary component served for each meal as the outcome variable (e.g. breakfast fat, hot meal sugar etc.). Assumptions such as normality of residuals, linearity and homoscedasticity were checked. For each model, the presence or absence of claims, age, gender, BMI, hunger, and thirst were entered as fixed effects, with subject entered as a random effect. Maximum likelihood estimation was used. The maximal model was initially estimated and multiple iterations of this model were then tested using stepwise model selection. To identify the best fitting model, each iteration was compared using the BIC value.

2.2. Results

2.2.1. Participants' perceptions of buffet

Participants indicated that they felt the fake foods present in the study were realistic (M = 4.63, SD = 1.03, scale 1 = not realistic at all, 6 = very realistic) and overall liking for the foods contained in the buffets was good (M = 4.11, SD = 0.50, 1 = do not like at all, 6 = like very much). Only two participants specifically mentioned NHCs in the open-ended awareness check. There were many comments regarding the large variety of foods available at the buffet(s), but participants also noted the lack of fruit and vegetables available.

Below, the mixed effects models and predictors of nutrient components served for each meal are examined. Standard estimate plots show effect sizes. These are the standardized estimates, which show how much the outcome changes if the predictor changes by one standard deviation. Given the focus of the study, only conditions or results where claims were significant in the final model are examined.

2.2.2. Energy (kJ) served

Meals served from the hot meal buffet contained the most energy (kJ) (M = 5548, SD = 2446), followed by those from the breakfast buffet (M = 4336, SD = 1530), with those from the snacks buffet containing least kJ (M = 3796, SD = 1993). Gender, alongside claims was a significant predictor for the amount of energy in meals served in the hot meal condition (Fig. 2a). Being female as well as the presence of claims predicted a decrease in the amount of energy in meals that were served. Furthermore, the significant interaction between gender and claim shows that the presence of claims affected males more than females in terms of a reduction in the amount of energy in meals that were served (Fig. 2b). Claims, alongside BMI, were also a significant predictor of the amount of energy in meals served from the breakfast buffet (Fig. 2c). Specifically, the presence of claims was predictive of a decrease in the amount of energy in meals served, while a higher BMI predicted a greater amount of energy in breakfast meals served. The interaction between claims and BMI was also significant in the final model (Fig. 2d). In the absence of claims, there was an increase in energy served in meals for those with a higher BMI and a slight decrease in energy served in meals selected for those with a higher BMI when claims were present.

2.2.3. Fat (g) served

The greatest amount of fat (g) was served for meals in the hot meal condition ($M = 36.21$, $SD = 20.57$), followed by the breakfast buffet ($M = 32.02$, $SD = 16.83$). Least fat was served for meals in the snacks condition ($M = 30.29$, $SD = 17.21$). The presence of claims led to a reduction in the amount of fat (g) in meals served in the hot meal condition (Fig. 3a). Being female was also a predictor of a reduced amount of fat in meals served (Fig. 3b). Claims did not significantly predict the amount of fat served for meals in the breakfast or snack conditions.

2.2.4. Protein (g) served

The greatest amount of protein (g) was served for meals in the hot meal conditions ($M = 71.85$, $SD = 30$, followed by breakfast conditions ($M = 48.99$, $SD = 18.24$) and snack conditions ($M = 23.54$, $SD = 13.99$). Claims did not appear to influence the amount of protein served for meals in the hot meal and breakfast conditions, however, the presence of claims predicted an increase in the amount of protein served for meals in the snack condition ($\beta = 1.03$, $p<.001$).

2.2.5. Sugar (g) served

As might be expected, the greatest amount of sugar was found in selections served from the snacks buffets ($M = 62.45$, $SD = 35$). Meals from breakfast conditions contained the second highest levels of sugar ($M = 52.32$, $SD = 27.30$), followed by those from the hot meal

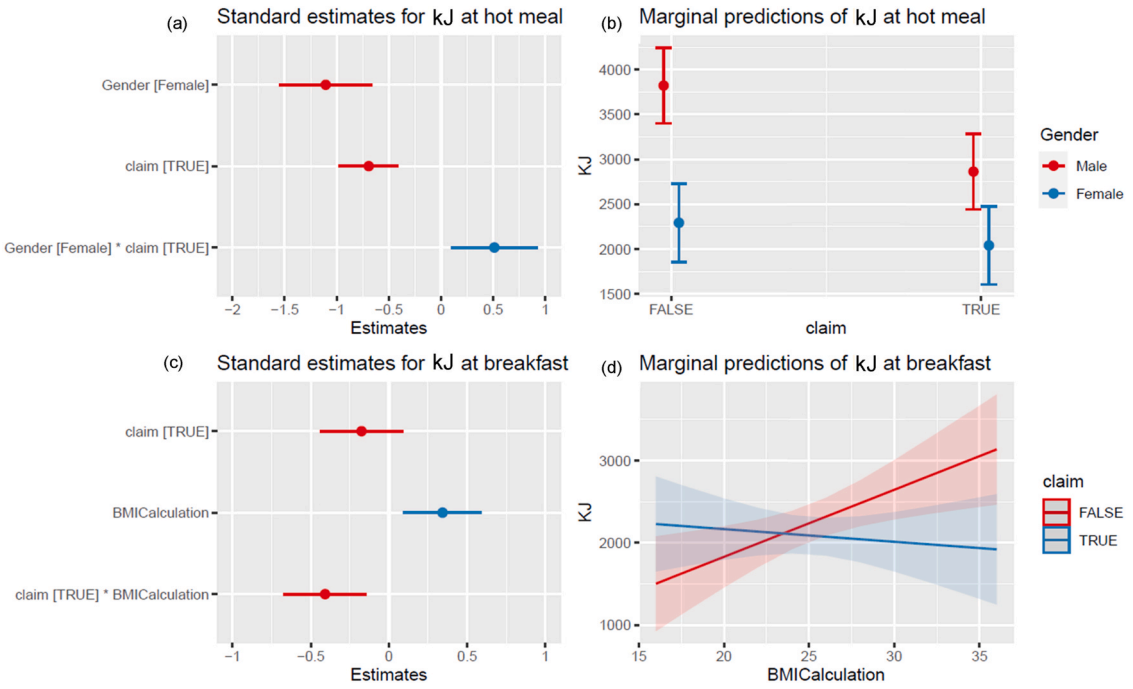

Fig. 2. Standard estimates and marginal predictions for kJ at hot meal (a), (b), and breakfast (c), (d).

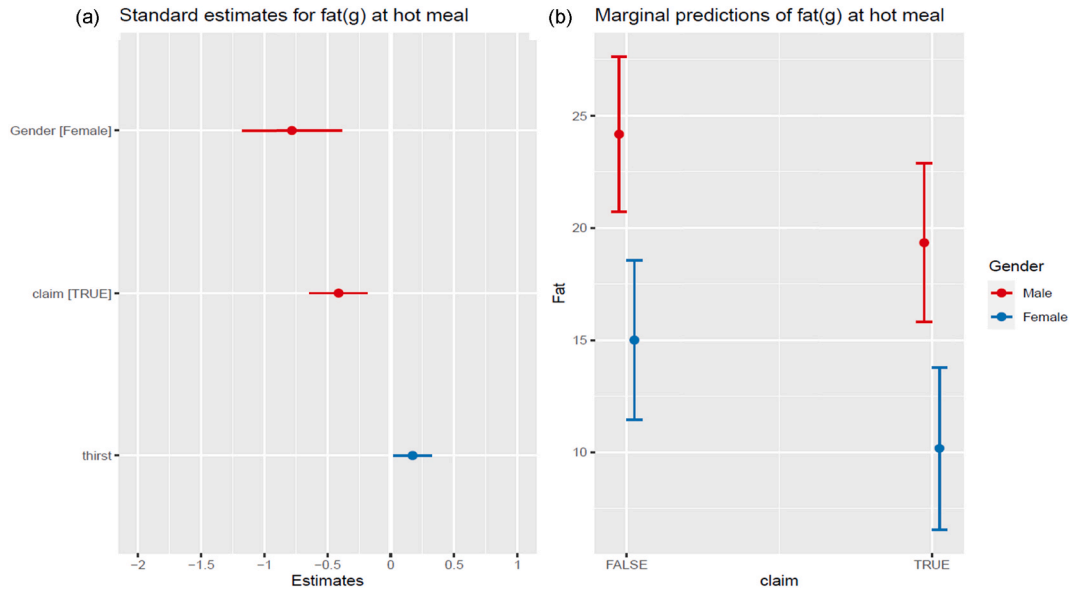

Fig. 3. Standard estimates (a) and marginal predictions (b) for fat at hot meal.

conditions ($M = 34.33$, $SD = 21.16$). The presence of claims predicted a reduction in the amount of sugar (g) served for meals in the snacks condition (Fig. 4a). Being female was also a predictor of a reduced amount of sugar served (Fig. 4b). Claims did not significantly predict the amount of sugar served for meals in the breakfast or hot meal conditions.

2.2.6. *Saturated fat (g) served*

As with fat served, most saturated fat was served in meals from the hot meal conditions ($M = 12.49$, $SD = 10.48$), followed by the breakfast ($M = 10.66$, $SD = 5.94$) and snacks ($M = 7.21$, $SD = 3.88$) conditions. While the presence of claims did not appear to affect the amount of saturated fat served in meals for breakfast, there were effects for both the snacks and hot meal conditions. Claims predicted a lower amount of saturated fat served for selections in the snacks condition ($\beta = -0.63$, $p < 0.001$). Claims, alongside thirst and being female, also predicted a lower amount of saturated fat served for meals in the hot meal condition (Fig. 5a). There was also a significant interaction between claims and thirst in this condition. In the presence of claims, there was an increase in the amount of saturated fat served in meals for those with a higher level of thirst and a slight decrease in the amount of saturated fat served in meals for those with a higher level of thirst when claims were absent (Fig. 5b).

2.2.7. *Carbohydrates (g) served*

Meals served from the hot meal buffets contained the greatest number of carbohydrates (g) ($M = 171.24$, $SD = 86$). Meals served from the breakfast buffets contained slightly more carbohydrates ($M = 132.44$, $SD = 57$) than those served from the snack buffets ($M = 131.23$,

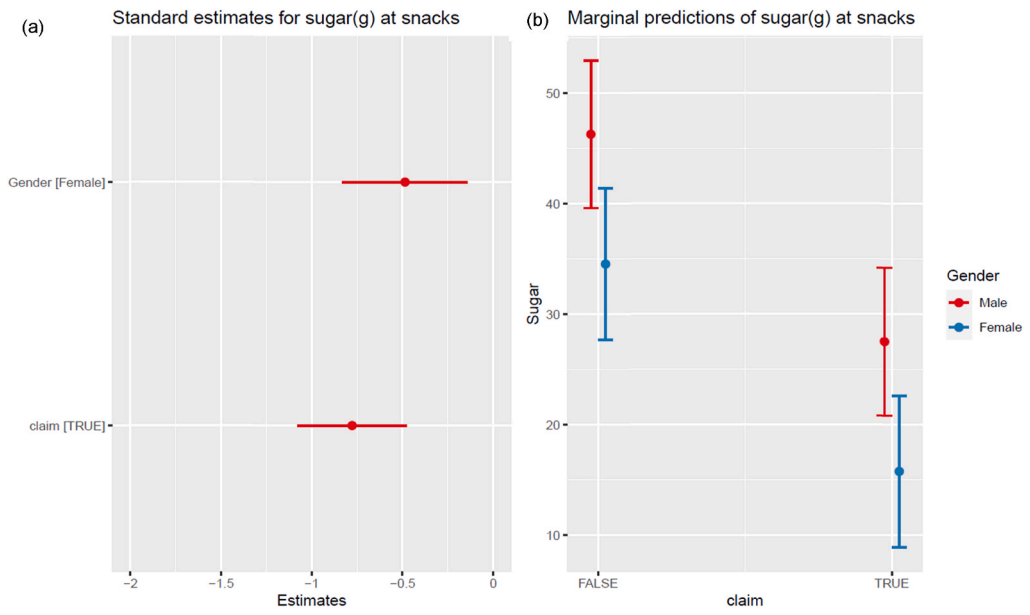

Fig. 4. Standard estimates (a) and marginal predictions (b) for sugar at snacks.

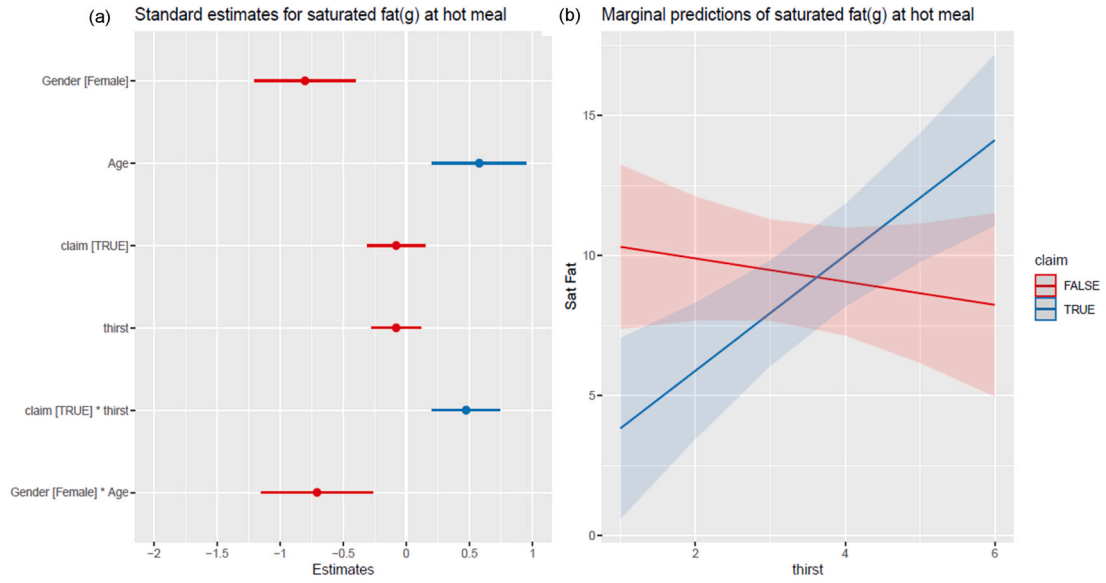

Fig. 5. Standard estimates (a) and marginal predictions (b) for saturated fat(g) at hot meal.

SD = 74). Claims and female gender predicted lower amounts of carbohydrates for meals served in the hot meal condition (Fig. 6a). The interaction between claims and gender was also significant. The presence of claims affected males more than females in terms of a reduction in the amount of carbohydrates served in meals (Fig. 6b). There was no apparent effect of claims for the snacks or breakfast conditions.

2.2.8. Sodium (mg) served

Following the trends of most other dietary components, most sodium (mg) was served in meals in the hot meal conditions ($M = 1920$, $SD = 944$). A mean of 1711 mg ($SD = 1033$) of sodium was served in the breakfast conditions, and a mean of 612 mg ($SD = 404$) was served in the snacks conditions. In the hot meal condition, being female and the presence of claims was associated with less sodium served (Fig. 7a and b). There was no effect of claims on the amount of sodium served in meals in the snacks or breakfast conditions.

2.2.9. Fibre (g) served

As expected, the greatest amount of fibre (g) was served in meals from the breakfast buffets ($M = 11.08$, $SD = 6.35$). This was followed by meals from the snacks conditions ($M = 8.03$, $SD = 5.28$) and hot meals conditions ($M = 7.78$, $SD = 3.77$). Claims predicted a reduction in the amount of fibre served in selections in the snacks condition ($\beta = 0.70$, $p < 0.001$). However, in the hot meal condition, claims (alongside hunger) predicted an increase in the amount of fibre served in meals (Fig. 8a). Age predicted a decrease in the amount of fibre in meals served, while the age × claim interaction was also significant. There was a greater reduction in the amount of fibre in meals served as age increased when claims were present, compared to when claims were absent (Fig. 8b). There was no effect of claims on amount of fibre served in breakfast meals.

2.2.10. Quantity of food (g) served

The presence of claims was associated with a higher quantity of food

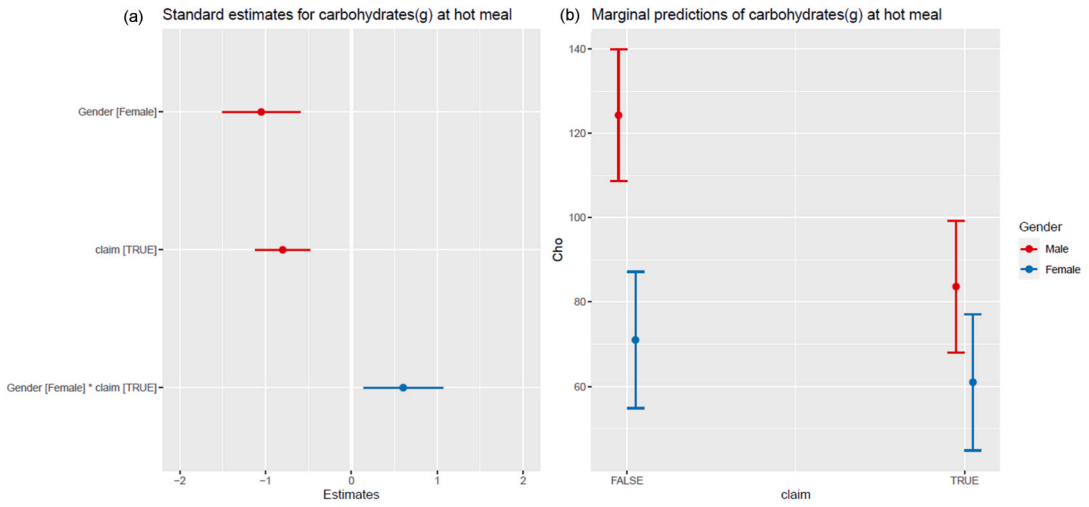

Fig. 6. Standard estimates (a) and marginal predictions (b) for carbohydrates(g) at hot meal.

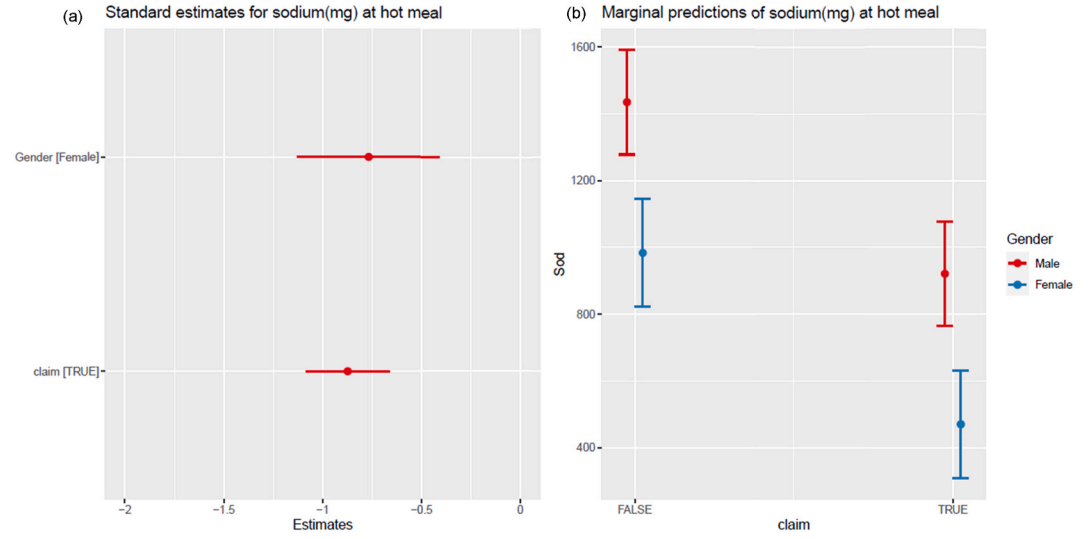

Fig. 7. Standard estimates (a) and marginal predictions (b) for sodium(mg) at hot meal.

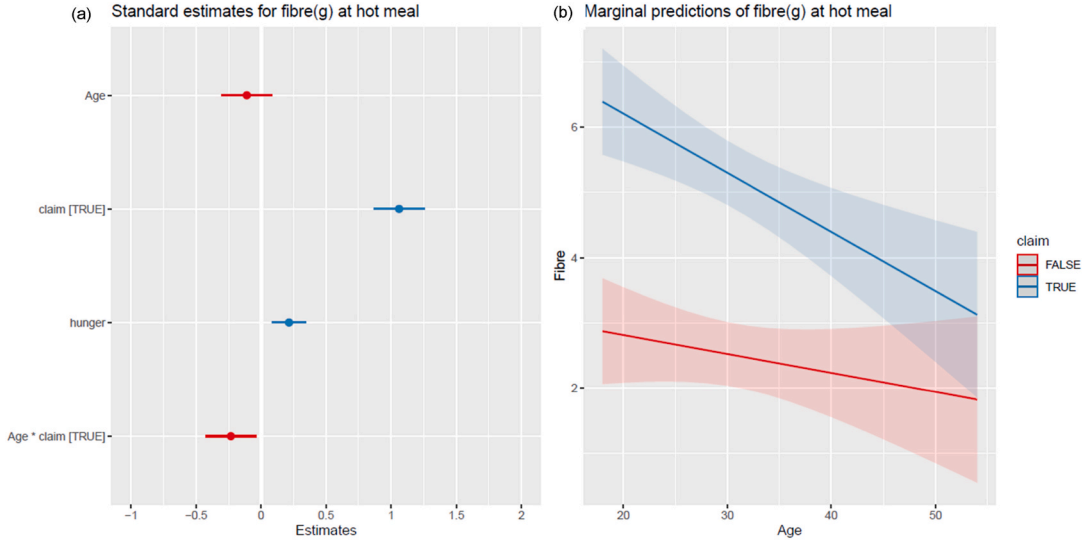

Fig. 8. Standard estimates (a) and marginal predictions (b) for fibre(g) at hot meal.

and drinks served in the snacks condition ($\beta = 0.32$, $p < 0.001$). However, there was no effect of claims on the quantity served in the hot meal or breakfast conditions.

2.3. Discussion

Study one examined the impact of nutrition and health claims on the nutrient composition of single meal servings. The greatest amount of each dietary component was served in meals selected in the hot meal condition, with the exception of sugar and fibre. As might be expected given the products typically associated with these meals such as chocolate and cereal, sugar was served in the highest amount in food selections in the snacks condition and fibre was served in the highest amount in meals in the breakfast condition. Claims significantly predicted the amount of energy, fat, protein, sugar, saturated fat, carbohydrates, sodium, and fibre in meals served. However, this varied depending on the type of meal. Hot meal servings were more likely to be affected by claims, followed by snack servings. For breakfast, claims were only significantly predictive of the amount of energy in meals served.

3. Study 2 – the effects of nutrition and health claims on nutrient composition at a subsequent meal

This was a repeated measures experiment, conducted in the Republic of Ireland. While study 1 examined the impact of nutrition and health claims on food selection at single eating occasions, the current study examined the impact of nutrition and health claims on meal-to-meal compensation.

3.1. Method

3.1.1. Participants

Convenience sampling was used to recruit fifty-five individuals (mean age = 37.9, *SD* = 14.7) from the Republic of Ireland to take part in the study. Word-of-mouth and email were used to recruit individuals from the college and local community. The same inclusion and exclusion criteria as study 1 were used. The majority of the sample were female (78%). Fifty six percent of the sample had overweight or obesity, 42% were of normal weight, with the BMI of the remaining 4% unknown.

3.1.2. Fake food buffet

Similar to study 1, a mixture of real and fake foods was used for the buffet. Two different meal stations were used – breakfast and lunch (see supplementary materials Figures S2.1 – S2.14). The breakfast station had two versions – one with nutrition and health claims and one without nutrition and health claims. Breakfast was selected as the meal to be manipulated as breakfast products such as cereal, milk, and yoghurt have been found to commonly have nutrition and health claims (Davidović et al., 2021; Sussman, McMahon, & Neale, 2019). For a list of the products with nutrition and health claims used in the breakfast buffet, see supplementary materials Table S2. As the focus was meal-to-meal compensation and the manipulation of breakfast nutrition and health claims, only one version of the lunch station was used with no nutrition and health claims present. Given their potential impact on health, there was a focus on products with claims relating to fat and sugar. Following feedback from participants in study 1, fruits and vegetables were added to the buffets. The breakfast station consisted of 30 different food and drink items and the lunch station consisted of 47 different food and drink items. Items were either left in their packaging (e.g. milk) or placed in appropriate containers beside their packaging (e.g. chips). As with study 1, participants were free to use a range of serving tools and crockery.

3.1.3. Measures and tasks

To prevent carryover effects, participants completed short questionnaires between conditions. As with study 1, data relating to BMI, appetite, and perceptions of the buffet were collected.

The awareness check in study 1 used an open-ended format to ask participants what they had noticed about the buffet. Only two participants mentioned nutrition and health claims, perhaps due to the vague nature of the check. To make the awareness check more focused specifically on nutrition and health claims, it was changed for the current study. Participants were presented with four pairs of product images of the same food (one with nutrition and/or health claims and one without nutrition or health claims) and asked to correctly identify which product they had seen in that session. Therefore, participants could score a minimum of 0 (did not correctly identify products available) to 4 (correctly identified products available).

3.1.4. Procedure

Upon arrival, participants were provided with written instructions outlining the study. After completing an initial questionnaire, participants served themselves from the breakfast station (see Fig. 9 for outline of procedure). To control for effects of special occasions on portion size, for example holidays or eating out, individuals were asked to imagine that this was a typical day. Participants were informed that they could use any bowl, plate, or glass. To encourage examination and awareness of the nutrition and health claims, participants were also told that they were free to examine any product packaging. Participants served their meal in the absence of the researcher. The served breakfast was then collected and moved to the lunch station. The lunch station was uncovered and participants were asked to imagine that they had eaten the breakfast served and to now select the lunch they would subsequently have later that day. The selected breakfast remained close to the lunch station for reference. The researcher again exited the serving area and returned when the participant indicated they had finished serving. Both meals were collected by the researcher and the participant completed a final questionnaire, which included the awareness check and perceptions of food used in the buffet such as their healthiness and the believability of NHCs. Participants returned approximately one week later to complete their second session, with the presence of nutrition and health claims in the breakfast station alternated. For example, if a participant completed breakfast containing products with claims followed by lunch in their first session, their second session consisted of breakfast containing products with no claims followed by lunch. Each session lasted approximately 30 min. The order of presentation was counterbalanced and randomised, with half of the sample selecting from the breakfast containing products with no claims condition on their first session and half selecting from the breakfast containing products with claims condition on their first session.

Participants received an honorarium of €40 for time and travel costs. Ethical approval was obtained from the Queen's University Belfast School of Biological Sciences Research Ethics Committee (approval 04/17/BensonT). All participants provided informed written consent.

3.1.5. Data analysis

As with study 1, data were analysed using R Studio and the nlme package (Pinheiro, Bates, DebRoy, Sarkar, & Core Team, 2020). Two types of mixed models were used. To understand the impact of nutrition and health claims on meal-to-meal compensation, each dietary component of the lunch meal serving (fat, sugar etc.) was used as the outcome variable for separate models. While not a focus of study 2, the impact of nutrition and health claims on breakfast only was also examined, with each dietary component of the breakfast meal serving used as the outcome variable for separate models. For all models, presence/absence of claims at breakfast, age, gender, BMI, hunger, and thirst were entered as fixed effects, with subject entered as a random effect. Maximum likelihood estimation was used. After the initial maximal model estimation, multiple iterations of this model were then tested using stepwise model selection. BIC values were used to compare each iteration to identify the best fitting model. Assumptions such as normality of residuals, linearity and homoscedasticity were checked for each model.

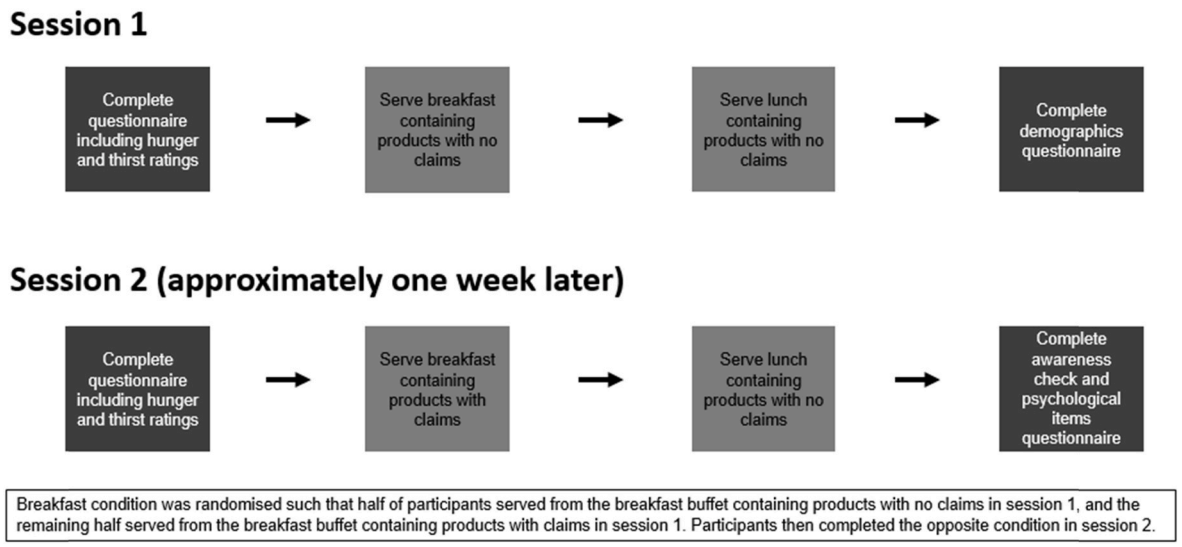

Fig. 9. Outline of example of procedure for study 2.

3.2. Results

3.2.1. Participants' perceptions of buffet

Participants indicated that they felt the fake foods present in the study were realistic (M = 4.50, SD = 1.27, scale 1 = not realistic at all, 6 = very realistic) and overall liking for the buffet was moderate (M = 3.71, SD = 0.61, 1 = do not like at all, 6 = like very much). Participants had a mean score of 2.24 (SD = 0.98, possible range 0–4) for the manipulation check and identification of products available at the buffet. Only four participants identified all four correct products that were available at the buffet.

Below, the mixed effects models and predictors of dietary components served for each meal are examined. Standard estimate plots show effect sizes. These are the standardized estimates, which show how much the outcome changes if the predictor changes by one standard deviation. Given the focus of the study, only conditions or results where claims were significant in the final model are examined.

3.2.2. Meal serving compensation

With the exception of sugar, participants served greater amounts of each dietary component for meals from the lunch buffet compared to the breakfast buffet (results not shown). Overall, the presence of claims at breakfast was not predictive of the amount of any dietary component served in meals at lunch.

3.2.3. Serving at single eating occasion

While the focus of study 2 was to understand the effects of claims on meal-to-meal compensation, analysis to understand the impact of claims on a single eating occasion (breakfast) similar to study 1, was also possible.

The presence of claims significantly predicted the amount of sodium served in breakfast meals (Fig. 10a). Gender was also a significant predictor. Specifically, the presence of claims or being female predicted a lower amount of sodium served in meals (Fig. 10b).

While claims were not a significant predictor of the amount of protein served for breakfast meals, a claims × gender interaction was significant (Fig. 11a). The presence of claims affected males more than females in terms of amount of protein served for breakfast meals when claims were present (Fig. 11b).

3.3. Discussion

Study 2 found no evidence of meal-to-meal compensation. The presence of claims at one meal (breakfast) did not affect the nutrient composition of a subsequent meal (lunch). While not a focus of this study, following on from study 1, there was further evidence that claims predicted nutrient composition at a single meal (breakfast).

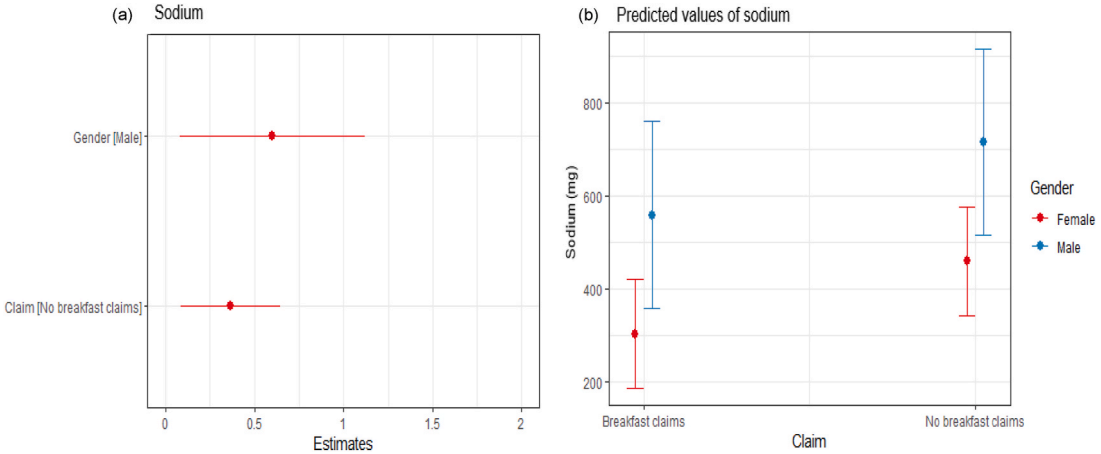

Fig. 10. Standard estimates (a) and marginal predictions (b) for sodium(mg) at breakfast.

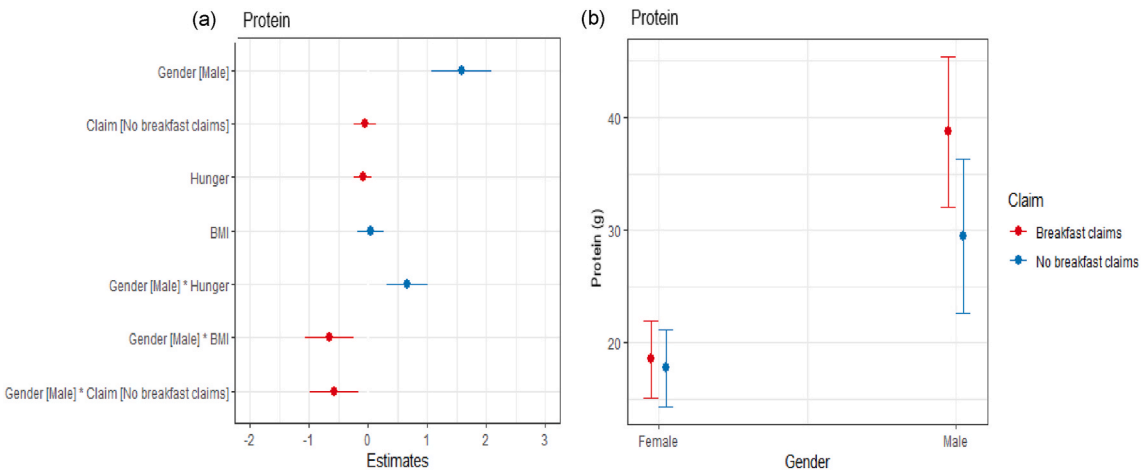

Fig. 11. Standard estimates (a) and marginal predictions (b) for protein(g) at breakfast.

4. General discussion

Nutrition and health claims are one potential tool helping individuals to make healthier food choices and avoid diseases such as those associated with overweight and obesity. While NHCs have been extensively studied, the effects of multiple simultaneous NHCs and different foods on food choice, the detailed impact of NHCs on meal composition, and the potential compensatory or self-licensing effects of claims have received little or no attention to date.

The current studies found that claims influence food servings. While the level of effect varied for different meals, overall NHCs showed evidence of reducing servings of energy, fat, saturated fat, sugar, carbohydrates, and sodium, and increasing servings of protein in meals. Results for fibre were mixed. These findings are in line with previous research showing that NHCs influenced consumption, purchasing, and portion size selection (Brown, Rollo, de Vlieger, Collins, & Bucher, 2018; Kaur et al., 2017). However, to our knowledge, the current results are the first to provide further details on the nutrient composition of foods chosen in the presence of claims. This is important, as it helps to understand whether claims may have a positive or negative effect on diet. Within the UK, there is evidence of the population not currently meeting the recommended daily intake for fibre and exceeding government daily recommended intakes of energy, free sugars, salt, and saturated fat (Public Health England, 2018; 2020b; 2020a). Similarly, within Ireland, adults do not meet the recommended intake for fibre and exceed the recommended intake for salt (Irish Universities Nutrition Alliance, 2011). Therefore, the reduction in energy, fat, saturated fat, and sodium, and the increase in protein and fibre influenced by claims demonstrated in the current studies are an encouraging finding. NHCs may be useful in the UK and Ireland as a tool to help individuals meet government recommended intake guidelines.

The presence of nutrition and health claims did not lead to less optimal nutrient compositions of meals when compared to the absence of nutrition and health claims as predicted. This may be due to the fact that although a sizeable portion of foods carrying claims have been found to be of poor nutritional quality (Pivk Kupirovič et al., 2019), overall foods with NHCs have a marginally improved nutritional profile compared to those without (Kaur et al., 2016). For example, foods carrying health claims have lower levels of energy, sugar, saturated fat, and sodium, and higher levels of fibre (Kaur et al., 2016). Therefore, if participants served their habitual portion size (their 'ideal' portion (Wilkinson et al., 2012)), as has been suggested often happens at specific mealtimes such as breakfast (Brunstrom & Shakeshaft, 2009), then they effectively improved the nutrition quality of their meals by substituting non-claims versions with claims versions where necessary. Indeed, despite the presence of claims significantly increasing the quantity of food and drink served in the snacks condition, claims in the snacks condition also lowered the amounts of sugar and saturated fat and increased the amounts of protein served. This suggests that a health halo effect which increases the portion size selected does not automatically lead to less optimal meal quality as the nutrient profiles of foods with NHC play an important role. It is also noteworthy that few participants were aware of the claims in the present studies, highlighting the often automatic and habitual nature of food choice decisions. These findings have wider implications for serving settings. The promotion and increased availability of healthier products or substitution of less healthy products may lead to improved food choices. Furthermore, this adds to the long-running debate as to whether only foods with a regulated or pre-defined nutrient profile should be eligible to carry NHCs. The present studies suggest that the current overall nutrient composition of products with NHCs may be adequate in leading to healthier servings. That is, if individuals switch to products with NHCs now, they could benefit from the improved nutritional profile over products without NHCs. Recent modelling has suggested that the introduction of nutrient profiling regulations for products which carry claims may adversely lead to less healthy diets and additional deaths (Kaur, Scarborough, & Rayner, 2019). Extensive further research should be conducted and considered prior to any implementation of nutrient profiling to regulate products.

In study 2, items chosen from a 'claims only' breakfast did not appear to influence a lunch serving through compensation. This did not support our self-licensing prediction. Similar to the study 1 findings, participants may have served their habitual portion size at lunch regardless of the presence or absence of claims at breakfast. This is supported by the manipulation checks for both studies, which found limited evidence that participants were aware of the NHCs. However, this does not rule out direct effects of claims as participants may have processed the labels at a subconscious level as proposed in other research (Grunert & Wills, 2007). The lack of findings relating to meal-to-meal compensation may be explained by the fact that although participants were asked to imagine they were serving lunch to be consumed later that day, they served this meal immediately after serving their breakfast meal. In addition, the participant's breakfast serving was placed beside them as a reminder while serving their lunch meal, which would not be the case in a real-life setting. This may have influenced the amount and types of food served, therefore biasing the results. Meals were also served rather than consumed, therefore while serving their lunch participants were not using cues such as their level of hunger following breakfast consumption. There is a paucity of research regarding the potential longer-term self-licensing effects of NHCs over a period of time or subsequent meals. Given that previous research (and the current studies) has found that claims can influence consumption/selection at a single eating

occasion, this remains an interesting area for future research.

While the results showed that the presence of claims predicted an improved nutrient composition of servings, some limitations need to be addressed. The varying selection of foods across the buffets was not controlled for in the current studies. For example, the buffets in study 1 did not contain fruit and vegetables, while those in study 2 did. Future studies should compare the effects of NHCs across different food selections and nutrient profiles. As a consequence of the fake food buffet method, individuals served but did not consume food in the current studies. Therefore, the current findings may not apply to the nutrient composition that would actually be consumed by participants. While individuals typically eat all of their meals (plate-clean)(Fay et al., 2011) and therefore those meals selected by participants would likely have been fully consumed, this limitation is particularly relevant as products bearing claims may look, taste, and feel differently to their non-claim counterparts. For example, 'high in protein' products are often denser in texture and may subsequently influence satiety. The use of fake foods and a laboratory setting also meant that several other factors known to influence food choice such as smells, price, and branding were not examined (Chen & Antonelli, 2020). While we attempted for the experiments to be ecologically valid by asking participants to imagine that they were at home, we acknowledge that a buffet setting is not typical for the home environment. However, the fake food buffet method also brought several benefits. The layout of the buffets could be reset to be exactly the same for each participant with no variation in look such as sizes or colours of foods. There was also minimal food waste and no cooking time required for the buffets, which also allowed for a wider range of foods and claims than previous studies to be used. With regards to statistical power, sample size calculations were based upon pre-planned analyses that were later found to be inappropriate for the data collected. For mixed models, power analyses should not be conducted after data has been collected (Kumle, Võ, & Draschkow, 2021). Therefore, the statistical power of the present studies is unknown and is a limitation that could be addressed in future similar research.

5. Conclusions

NHCs are one potential tool in helping individuals to make healthier food choices and improve diets. The findings from the current studies suggest that while individuals may not consciously notice nutrition and health claims, the selection and serving of products with claims may lead to healthier meal compositions and consequently healthier diets. This has wider implications in terms of reformulation, the substitution of non-claims products with claims products and their availability to consumers.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author upon reasonable request.

Declarations of interest

None.

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Authors' contributions

TBe, TBu, AMcC, EM, and MD conceptualised and designed the study. TBe and SF conducted the data collection and cleaned the data. Alongside RO, TBe and SF analysed the data. TBe created the first draft of the manuscript. All authors provided input on subsequent drafts of the manuscript. All authors have read and approved the final manuscript.

Ethical statement

Ethical approval for both studies contained in this manuscript was obtained from the Queen's University Belfast School of Biological Sciences Research Ethics Committee. All participants provided informed written consent.

Declaration of competing interest

The authors declare that there are no conflicts of interest.

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Not applicable.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appet.2022.106105.

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