Investigating the use of swap-based interventions to reduce the energy content of foods and drinks pre-ordered in online canteens

Sarah Breathnach

A thesis submitted for the degree of

Doctor of Philosophy in Behavioural Science & Health

University College London

2021

Declaration

I, Sarah Breathnach confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Acknowledgements

To Dr Phillippa Lally, Dr Dimitrios Koutoukidis and Dr Clare Llewellyn - Thank you for your unwavering support and mentorship throughout this process. I could not have asked for a better supervisory team. It's difficult to convey how grateful I am to you for sharing with me so generously your time and expertise. To Clare, thank you for taking me under your wing in the early days and believing in me and this project. It would not have been possible without your kindness and guidance. To Pippa and Dimitris, thank you for supporting me through all of the highs and lows and for answering my questions so thoughtfully morning, noon and night. The three of you have not only been my mentors and co-authors but great friends as well.

A big thank you to the sponsor of this research, The Behavioural Insights Team. In particular, I would like to thank Dr Alex Surtherland, Hazel Wright and Dr Giulia Tagliaferri for facilitating my PhD research at work and helping me to strike a balance between the two.

I would like to express my gratitude to Bupa UK for supporting this research. In particular, Dr Sarah Deedat and Juliet Hodges of Bupa's Behavioural Science team. I would also like to thank Mark Byrne and the catering team at Bupa for providing the menus and recipes, and for engaging so enthusiastically with the project.

Thank you to my upgrade examiner Professor Dame Theresa Marteau, my co-authors, and the anonymous reviewers on the publications that have contributed to this PhD. Thanks also to David Boniface for his statistical advice, Anna Kallianteri for her work on the nutritional analysis of the menus, Feargus Hosking-Jervis for his help setting up the pre-ordering website, and the participants for taking part in the research and sharing their views.

Thank you to my BSH colleagues at UCL, especially the Energy Balance group for their helpful advice and feedback on the project over the years. In particular, thank you to Dr Andrea Smith for being a stellar PhD buddy.

Thank you to my friends, especially the London crew for all of the laughs. You made the PhD journey all the sweeter.

To Mum, Dad and Séamus, thank you for your unconditional love and support, and to Bob for always keeping his promise.

BLANK PAGE

Abstract

The average adult in the UK consumes 200-300 calories beyond their Guideline Daily Amount. For working adults, more than one-third of calories are consumed in the workplace, making this an important environment for intervention. This thesis makes a contribution to the academic literature, by improving our understanding of how and when offering lower-energy alternatives ('swaps') is effective, and to public health by refining an intervention which could be delivered in workplace canteens.

Two scoping reviews were conducted (studies 1 & 2) and pointed towards the potential effectiveness of pre-ordering lunch and offering healthier swaps as strategies that may help to improve the healthfulness of food and drink choices. When offering lower-energy swaps for snacks and non-alcoholic drinks, studies 3 (n=449) and 4 (n=3,481) recruited samples of UK adults in employment to test the effect of different messages on the acceptance of swaps in an experimental online canteen. The results indicated that messages focusing on the lower-energy content of swaps offered may be an effective and acceptable approach. When highlighting the energy content of swaps offered, increasing the interpretability of this information, by providing physical activity calorie equivalent information (PACE) (i.e., the number of minutes walking required to expend the energy contained) further increased the acceptance of snack and drink swaps offered. In study 5, an online version of a real-world canteen was developed and the intervention (prompts to swaps accompanied by a PACE message) was due to be tested in a real-world trial with the healthcare organisation Bupa. However, due to Covid-19, it was tested qualitatively with employees (n=30) of this organisation across the full lunch menu to provide insights about the factors perceived to influence swap acceptance and the acceptability of the intervention. Swap acceptance was facilitated by the provision of PACE information, and swap similarity in terms of taste, texture, and expected satiety as well as the perception that alternatives provided meaningful energy savings. Overall, the intervention was viewed as an acceptable approach to help reduce energy intake in the workplace. Following refinements to the intervention, Study 6 tested the effect of offering lower-energy swaps with and without PACE messages on the energy of hypothetical lunches pre-ordered with a

representative online sample of working adults (n=2,150). Offering swaps with and without a PACE message was found to significantly reduce average energy ordered at lunch compared to when no swaps were offered, the PACE message was more acceptable, and there was no evidence of significant interactions between intervention efficacy and participant characteristics.

Offering lower-energy swaps in the workplace when employees pre-order is an acceptable and promising intervention to reduce the energy of foods and drinks ordered. Future work should replicate this research in real-world settings.

Impact statement

This thesis provides experimental evidence that nudging people with lower-energy alternatives when they choose lunch may be an effective and acceptable strategy to reduce energy ordered in workplace canteens. The association between excess energy intake and weight gain has been widely documented. Today, almost 40% of the world's population meet the criteria for overweight or obesity. Strategies to align energy-intake with public health recommendations are needed as part of the wider effort to stem the tide of obesity. The workplace is the second most common environment where food is consumed. Similar to online supermarkets, pre-ordering websites for canteens provide a platform for prompting users with lower-energy alternatives - platforms which may become increasingly popular with the post-Covid-19 return to the workplace, as companies consider measures to reduce social contact at lunchtime.

My review of the literature suggests that offering healthier alternatives to foods selected is a promising intervention. Over a series of studies, each building on the other, this thesis allowed me to go beyond previous literature and develop an experimental online canteen to demonstrate, for the first time, that offering lower-energy alternatives reduces average energy of pre-ordered lunches compared with when no swaps are offered by up to 66 kcal. The research also showed that accompanying alternatives with easily interpretable energy-information in the form of physical activity calorie equivalents (PACE), which is a label showing the amount of physical activity that would be required to expend the energy contained in a product, increases the acceptance of alternatives offered. Offering lower-energy alternatives both with and without PACE information also significantly increased the likelihood that lunches ordered would meet Public Health England's energy intake recommendation, by 10 and 5 percentage points respectively, compared with when no swaps were offered. If interested companies developed an automated way of offering swaps, this could be a relatively low-cost tool (over the long term) for helping employees to order lunches that are more in line with public health recommendations.

Given that adherence to behavioural interventions is moderated by perceived acceptability, the challenge is to develop interventions that are both effective and acceptable to employers and employees. This research shows that offering employees lower-energy alternatives when they pre-order their lunch at work is acceptable. Although acceptability ratings were in line with similar supermarket studies, this research is the first to indicate potential unintended harms from the use of PACE labelling, with 25% of participants reporting that this message would encourage them to count calories excessively. This should be investigated in future research. This thesis offers a range of practical recommendations to implementation scientists for enhancing the acceptability of an intervention of this nature and for increasing the likelihood that lower-energy alternatives will be accepted.

Future research will need to test the intervention in a real-world canteen, but my thesis provides a starting point for understanding how such an intervention may be designed.

Table of Contents

Chapter 1: Introduction & objectives 27

1.1 Obesity prevalence & consequences 27

1.2 The aetiology of obesity 28

1.3 Environmental factors 30

1.4 Choice architecture 33

1.5 Information-based interventions 35

1.5.1 Front of pack nutrition labelling 35

1.5.2 Evidence for front of pack nutrition labelling 37

1.5.3 Menu labelling 39

1.5.4 Messaging 41

1.6 Swaps 45

1.7 The workplace 47

1.8 Pre-ordering 48

1.9 Summary 50

1.10 Aim and objectives 51

Chapter 2: Swaps scoping review 53

2.1 Introduction 53

2.1.1 Review questions 54

2.2 Methods 54

2.2.1 Searching and inclusion criteria 54

2.2.2 Screening and data extraction 56

2.2.3 Analysis 56

2.3 Results 57

2.3.1 Setting 57

2.3.2 Participants 68
2.3.3 Comparators & outcomes 68
2.3.4 What are the characteristics of swap-based interventions? 69
2.3.5 What effect do swap-based interventions have on diet-related outcomes? 74
2.3.6 What study characteristics are associated with intervention efficacy? 81
2.3.7 How acceptable are swap-based interventions? 86
2.4 Discussion 88
2.4.1 Swaps acceptance rates 89
2.4.3 Intervention target 91
2.4.4 Participant characteristics 93
2.4.5 Intervention acceptability 93
2.4.6 Limitations of the current evidence & future research 94
Chapter 3: Pre-ordering scoping review *96*
3.1 Introduction 96
3.1.1 Review questions 96
3.2 Methods 97
3.2.1 Inclusion criteria 97
3.3 Results 97
3.3.1 Participants & setting 103
3.3.2 Comparators & outcomes 103
3.3.3 What are the characteristics of pre-ordering interventions? 105
3.3.4 What effect do pre-ordering interventions have on diet-related outcomes? 106
3.3.5 What study characteristics are associated with intervention efficacy? 109
3.3.6 How acceptable are pre-ordering interventions? 111
3.4 Discussion 112
3.4.1 Intervention target 112
3.4.2 Intervention characteristics 113
3.4.3 Participant characteristics 115

3.4.4 Intervention acceptability 116
3.4.5 Limitations 116
3.4.6 Conclusions & future research 117

Chapter 4: Health-based messages pilot RCT *119*

4.1 Introduction 119
4.1.1 Calorie-focused messages 120
4.1.2 Nutrient-focused messages 121
4.1.3 Health-focused messages 122
4.1.4 Aims 123

4.2 Methods 124
4.2.1 Design and setting 124
4.2.2 Participants 124
4.2.3 Randomisation & blinding 125
4.2.4 Online ordering task 126
4.2.5 Menu item selection 128
4.2.6 Swaps offered 129
4.2.7 Intervention 130
4.2.8 Post-trial survey 131
4.2.9 Outcome measures & statistical analysis 132
4.2.10 Sample size 136

4.3 Results 136
4.3.1 Estimate of effect size (a): Swap acceptance 139
4.3.2 Estimate of effect size (b): Energy ordered by product category and intervention 139
4.3.3 Estimate of effect size (c): Total energy ordered by intervention 143
4.3.4 Intervention acceptability 145
4.3.5 Subgroup outcome (a): Intervention effects and demographics 146
4.3.6 Subgroup outcome (b): Intervention acceptability and demographics 152

4.4 Discussion 155
4.4.1 Summary of findings 155

4.4.2 Findings in context 156
4.2.3 Strengths and limitations 158
4.2.4 Conclusion & future research 160

Chapter 5: Calorie-focused messages RCT *161*

5.1 Introduction 161
5.1.1 Vague calorie message 162
5.1.2 Numeric-calories message 162
5.1.3 Physical activity calorie equivalent (PACE) message 163
5.1.4 Other research questions 164
5.1.5 Aims 164

5.2 Methods 165
5.2.1 Design and setting 165
5.2.2 Participants 165
5.2.3 Randomisation & blinding 165
5.2.4 Online ordering task 166
5.2.5 Swaps offered 166
5.2.6 Interventions 166
5.2.7 Post-trial survey 169
5.2.8 Outcome measures & statistical analysis 170
5.2.9 Sample size 177

5.3 Results 177
5.3.1 Primary Outcome (a) Swap acceptance by product category 180
5.3.2 Primary Outcome (b) Energy ordered by product category 182
5.3.3 Secondary Outcome (a) The total energy (kcal) ordered 182
5.3.4 Secondary Outcome (b) At least one swap accepted 186
5.3.5 Acceptability & inadvertent harm: Outcome (a) acceptability 186
5.3.6 Acceptability & inadvertent harm: Outcome (b) calorie counting 188
5.3.7 Acceptability & inadvertent harm: Outcome (c) PACE messages 189
5.3.8 Exploratory Outcome (a) Subgroup analysis of the primary outcomes ... 190
5.3.9 Exploratory Outcome (b): Primary outcome (a) dietary restraint or price 201

5.3.10 Exploratory Outcome (c): Primary analysis (a) repeated for swap-type 203
5.3.11 Sensitivity analysis: Primary analysis (a) 205
5.4 Discussion 206
5.4.1 Summary of findings 206
5.4.2 Findings in context: Swap-acceptance 206
5.4.3 Findings in context: Energy ordered 208
5.4.4 Findings in context: Intervention acceptability & beliefs about future behaviours 209
5.4.5 Findings in context: Subgroup analyses 210
5.4.6 Findings in context: The potential influence of swap-type, dietary restraint and price 210
5.4.7 Strengths and limitations 211
5.4.8 Implications for future research 213
5.4.9 Conclusion 214
Chapter 6: Bupa Eats pilot feasability field trial protocol *215*
6.1 Background 215
6.2 Introduction 215
6.3 Study aims 216
6.4 Study design 217
6.5 Participant identification & recruitment 218
6.5.1 Study partner 218
6.5.2 Study setting 219
6.5.3 Study participants 220
6.6 Intervention 221
6.6.1 Procedure for control participants 224
6.6.1 Swap Criteria 229
6.6.2 Process for offering swaps by menu 231
6.7 Study procedures 233
6.7.1 Recruitment 233

6.7.2 Informed consent 234
6.7.3 Assignment of intervention 234
6.8 Data collection & management 235
6.9 Outcome measures and analysis 236
6.9.1. RCT 236
6.10 Ethical approval 242
6.11 Conclusion 242
Chapter 7: Bupa Eats think-aloud study *243*
7.1 Introduction 243
7.1.1 Aims 246
7.2 Methods 246
7.2.1 Design 246
7.2.2 Participants 247
7.2.3 Pre-ordering website 248
7.2.4 Swaps offered 250
7.2.5 Think-aloud script 251
7.2.6 Data collection 252
7.2.7 Reflexivity 253
7.2.8 Data analysis 254
7.3 Results 257
7.3.1 Intervention acceptability 260
7.3.2 Factors influencing swap acceptance 266
7.4 Discussion 270
7.4.1 Summary 270
7.4.2 Intervention acceptability 271
7.4.3. Factors potentially influencing swap acceptance 273
7.4.4 Strengths and limitations 275
7.4.5 Implications for future implementation of the intervention 276
7.4.6 Future research 278

7.4.7 Conclusion 278

Chapter 8: Online canteen RCT *280*

8.1 Introduction 280

8.1.1 Aims 281

8.2 Methods 282

8.2.1 Design and setting 282

8.2.2 Participants 282

8.2.3 Randomisation & blinding 283

8.2.4 Online ordering task 283

8.2.5 Swaps offered 284

8.2.6 Interventions 289

8.2.7 Post-trial survey 292

8.2.8 Outcome measures & statistical analysis 294

8.2.9 Sample size 300

8.3 Results 301

8.3.1 Primary outcome 304

8.3.2 Secondary outcomes 308

8.3.3 Exploratory outcomes 309

8.4 Discussion 316

8.4.1 Summary of findings 316

8.4.2 Findings in context: Energy ordered & swap acceptance 316

8.4.3 Finding in context: Intervention acceptability 317

8.4.4 Findings in context: Moderation analysis 318

8.4.5 Findings in context: Price & swap acceptance 318

8.4.6 Strengths and limitations 319

8.4.7 Conclusion 320

Chapter 9: General discussion *322*

9.1 Introduction 322

9.2 Summary of findings and contribution to the literature 323

9.2.1 Key findings from Study 1 324
9.2.2 Key findings from Study 2 325
9.2.3 Key findings from Study 3 326
9.2.4 Key findings from Study 4 328
9.2.5 Key findings from Study 5 329
9.2.6 Key findings from Study 6 330
9.3 Limitations 332
9.3.1 Hypothetical choice & self-report data 332
9.3.2 Generalisability of findings 334
9.3.3 Sample size and power 336
9.3.4 The role of theory 336
9.4 Implications for research and practice 339
9.5 Concluding remarks 345
References *346*

List of Tables

Table 1.1: Summary of FoPL formats used internationally. 36
Table 2.1: Description of studies testing swap-based interventions 59
Table 2.2: Criteria for swaps offered by study 71
Table 2.3: Standardised means (Cohen's d effect sizes) for change in dietary outcomes. 78
Table 3.1: Description of studies testing pre-ordering interventions 99
Table 3.2: Standardised means (Cohen's d effect sizes) for change in dietary outcomes. 107
Table 4.1: Summary of menus with examples of swaps offered for initially selected items in each category 127
Table 4.2: Study outcome measures and methods of statistical analysis employed. 134
Table 4.3: Baseline characteristics of participants, by trial arm. 138
Table 4.4: Number of participants offered and accepting a swap (proportions accepting in parentheses) for each product category by group. 139
Table 4.5: Mean change in energy (kcal) ordered before and after sweet **swaps** were offered for each group 141
Table 4.6: Mean change in energy (kcal) ordered before and after savoury **swaps** were offered for each group 142
Table 4.7: Mean change in energy (kcal) ordered before and after drink **swaps** were offered for each group 143
Table 4.8: Mean change in total energy (kcal) ordered before and after swaps were offered for each group 144
Table 5.1: Study outcome measures and methods of statistical analysis employed. 172
Table 5.2: Baseline characteristics of participants, by trial arm. 179
Table 5.3: Number of participants offered and accepting swaps for each product category by group. 180

Table 5.4: Means and effect sizes for total calories ordered controlling for initial calories selected (450 kcal) by intervention allocation 183
Table 5.5: Mean differences in energy ordered between groups from sweet snacks (n=3,085), savoury snacks (3,284) and drinks (n= 1,233) controlling for initial calories selected 185
Table 5.6: Ordinal logistic regression for acceptability ratings of offering swaps by intervention allocation (i.e., after exposure to the intervention). 187
Table 5.7: Ordinal logistic regression for Likert scale ratings of agreement with the statement "the calories message would make me want to count calories excessively" by intervention allocation (n= 2,061)..... 189
Table 5.8: Swap acceptance & gender……186
Table 5.9: Swap acceptance & age……188
Table 5.10: Swap acceptance & ethnicity……...190
Table 5.11: Swap acceptance & education …….. 192
Table 5.12: Swap acceptance & income……194
Table 5.13: The effect of score (out of 15) on the DIS scale (Dietary Restraint) on the likelihood that a sweet, savoury and drink swap is accepted. 201
Table 5.14a: Prices of initially selected items, swaps offered and price difference for those offered swaps only..... 202
Table 5.14b: The effect of price difference (i.e., cheaper swaps) on the likelihood that a sweet and savoury swap is accepted compared with control. 203
Table 5.15: The effect of swap-similarity on the likelihood that a sweet and savoury snack swap offered is accepted compared with control. 204
Table 5.16: Sensitivity analysis: The effect of message-type on the likelihood that a sweet, savoury and drink swap is accepted compared with control when the 274 ineligible participants are included in the model..... 205
Table 6.1: Bupa menu descriptions and regularity with which menu options change..... 219
Table 6.2: Criteria for swaps offered by menu..... 230

Table 7.1. Summary of data saturation check. Rows represent participant interviews. Columns represent themes identified. ..... **Error! Bookmark not defined.**
Table 7.2: Summary table of participant characteristics. 258
Table 7.3: Summary table of TFA themes with definitions and the sub-themes as facilitators and barriers to the acceptability of the pre-ordering+swaps website. 259
Table 7.4: Potential modifications to the intervention that could be made ahead of the online RCT testing potential effect of the swap-based intervention on energy ordered. 277
Table 8.1: Criteria for swaps offered by menu category 287
Table 8.3: Benjamini-Hochberg p-value threshold procedure 294
Table 8.4: Study outcome measures and methods of statistical analysis employed. 296
Table 8.5: Sample size estimates for the primary outcome (energy ordered) based on a range of energy-reductions with upper, middle, and lower bounds for required n 301
Table 8.6: Baseline characteristics of participants. Data are presented as mean ± standard deviation or n (%). 303
Table 8.7: Standardised effect sizes (Cohen's d) for differences in total energy ordered controlling for energy content of first item ordered (464 kcal) by intervention allocation (n=2,150). 305
Table 8.8: Standardised effect sizes for mean differences in energy ordered between groups for each menu controlling for energy content of the initial item ordered in each menu category. 307
Table 8.9: Number (%) of participants offered and accepting swaps within each menu by intervention group (n=1,424). 308
Table 8.10: Prices of initially selected items, swaps offered and price difference for those offered swaps only. 313
Table 8.11: Exploratory outcome (c). Swap acceptance by condition for each menu, with the Swaps only intervention as the reference category. 315

List of Figures

Figure 2.1: PRISMA inclusion flowchart.....58
Figure 3.1: PRISMA inclusion flowchart.....98
Figure 4.1: An example of the intervention 131
Figure 4.2: CONSORT flow diagram.....137
Figure 4.3: Mean change in energy (kcal) ordered before and after sweet swaps were offered for each group.....140
Figure 4.4: Mean change in energy (kcal) ordered before and after savoury swaps were offered for each group.....141
Figure 4.5: Mean change in energy (kcal) ordered before and after drink swaps were offered for each group.....142
Figure 4.6: Mean change in total energy (kcal) ordered before and after all 3 swaps were offered for each group.....144
Figure 4.7: Intervention acceptability……...145
Figure 4.8: Subgroup outcome (a) gender & swap acceptance.....147
Figure 4.9: Subgroup outcome (a) age & swap acceptance.....148
Figure 4.10: Subgroup outcome (a) ethnicity & swap acceptance.....149
Figure 4.11: Subgroup outcome (a) education & swap acceptance 150
Figure 4.12: Subgroup outcome (a) income & swap acceptance 151
Figure 4.13: Subgroup outcome (b) intervention acceptability & gender..152
Figure 4.14: Subgroup outcome (b) intervention acceptability & age 153
Figure 4.15: Subgroup outcome (b) intervention acceptability & ethnicity.153
Figure 4.16: Subgroup outcome (b) intervention acceptability & education 154
Figure 4.17: Subgroup outcome (b) intervention acceptability & income..154
Figure 5.1: An example of the intervention 167
Figure 5.2: Options presented to social media users during preliminary work.....168
Figure 5.3: CONSORT flow diagram.....178
Figure 5.4: Odds of a sweet, savoury or drink swap being accepted by group.....181

Figure 5.5: Means and 95% confidence intervals for final calories ordered adjusting for initial calories ordered 184
Figure 5.6: Intervention acceptability: Pre-ordering & swaps 187
Figure 5.7: Excessive calorie counting 188
Figure 5.8: Intervention acceptability: PACE message 190
Figure 5.9: Energy ordered & gender 192
Figure 5.10: Energy ordered & age 194
Figure 5.11: Energy ordered & ethnicity 196
Figure 5.12: Energy ordered & education 198
Figure 5.13: Energy ordered & income 200
Figure 6.1: Daily reminder email with instructions for pre-ordering participants 223
Figure 6.2: Designated study till point in Bupa Salford Quays 223
Figure 6.3: Daily reminder email with instructions for control participants. 224
Figure 6.4: Bupa Eats landing page 225
Figure 6.5: Menu overview 225
Figure 6.6: Main hot dishes menu 226
Figure 6.7: Swap offered for the Fisherman's pie 227
Figure 6.8: Selection of side dishes to accompany main meals 227
Figure 6.9: Drinks menu 228
Figure 6.10: Checkout 229
Figure 7.1: An example user journey 251
Figure 7.2: Coding tree for factors influencing swap acceptance. 256
Figure 7.3: Coding tree for factors influencing intervention acceptability guided by the Theoretical Framework of Acceptability 257
Figure 8.1: Flow diagram outlining the criteria for swaps offered for main dishes 286
Figure 8.2: An example of the intervention when selecting a savoury snack in which 1 swap is offered, by condition 290
Figure 8.3: Intervention example 291
Figure 8.4: CONSORT flow diagram 302

Figure 8.5: Means and 95% confidence intervals for total energy ordered (adjusted for energy content of first item ordered) 305
Figure 8.6: Means and 95% confidence intervals for energy ordered 306
Figure 8.7: Intervention acceptability 310
Figure 8.8: Interaction effect by gender, age, ethnicity, education, BMI, physical activity level, dietary restraint and hunger. 312
Figure 8.9: Interaction analysis for the effect of price difference on the likelihood of accepting a swap offered, by intervention group (swap alone versus swap+PACE). 314

List of Abbreviations

BH: Benjamini-Hochberg procedure
BMI: Body Mass Index
COM-B: Capability, Opportunity, Motivation, Behaviour model
DIS: Dietary Intent Scale
DSH: Data Safe Haven
ED: Energy Density
ES: Effect Size
FoPL: Front of Pack Labelling
HWL: Health Warning Label
IRR: Incidence Rate Ratio
IQR: Inter Quartile range
Kcal: Kilocalorie
Kj: Kilojoule
LS: Lower Salt Swaps
MDES: Minimum Detectable Effect Size
MJ: Megajoule
MTL: Multiple Traffic Light Label
MLS: Much Lower Salt Swaps
NLS: Nutrition for Life System
OR: Odds Ratio
PACE: Physical Activity Calorie Equivalent
PP: Percentage Point
RCT: Randomised Controlled Trial
REDCap: Research Electronic Data Capture
SFA: Saturated Fat
SCOT-PAQ: The Scottish Physical Activity Screening Questionnaire
SD: Standard Deviation
SES: Socioeconomic Status
SSB: Sugar Sweetened Beverage
TFA: Theoretical Framework of Acceptability
TIPPME: Typology of Interventions in Proximal Physical Micro-Environments
95% CI: 95% Confidence Interval

Note

Appendices can be found in Additional File 1.

BLANK PAGE

Chapter 1

Introduction

1.1 Obesity prevalence & consequences

Obesity is a complex, major public health problem characterised by excess body fat which can lead to adverse health consequences. At a population level, obesity is best estimated using Body Mass Index (BMI), an assessment of weight adjusted for height, which is used to classify weight status as: underweight (<18.5), healthy weight (≥18.5-24.9), overweight (25-29.9), and obesity (≥30), with the latter divided into subcategories of obesity severity (World Health Organisation, 2021a). Almost 40% of the world's population meet the criteria for overweight or obesity (World Health Organisation, 2021b), and in some countries obesity rates are above 50% (Ng et al., 2014). It is estimated that by 2050, about two-thirds of the world's population will have overweight or obesity (Bodirsky et al., 2020). Excess body fat is associated with an elevated risk of developing diseases, such as cardiovascular disease, type 2 diabetes and certain cancers, as well as mental health problems including depression and substance abuse (Abdelaal et al., 2017; Sarwer & Polonsky, 2016). An estimated 1 in 7 premature deaths in Europe could be prevented if individuals had a healthy BMI (Di Angelantonio et al., 2016). Alongside the heavy individual burden, there are significant socio-economic repercussions. Employers report reduced productivity, increased sick leave and medical claims (Ramasamy et al., 2019), while governments cite overweight and obesity as placing significant strain on healthcare systems (World Health Oraganisation, 2014). The UK government puts the National Health Service costs attributable to overweight and obesity at £6.1 billion per annum and this is expected

to rise to £9.7 billion by 2050 (National Health Service Digital, 2021). Reducing the burden of overweight and obesity is, therefore, a core objective of most governments and public health bodies worldwide.

1.2 The aetiology of obesity

The aetiology of obesity is multifactorial. Body weight and energy storage are determined by a combination of individual, social, and environmental factors which interact and exert their influence by altering the body's energy balance (Hill, 2006; Spiegelman & Flier, 2001). Energy balance refers to the relationship between energy consumed as calories present in food and drink, and energy expended as calories burned by the body either in its resting state, during digestion, or when physically active (Hall et al., 2012; Hill, 2006; Romieu et al., 2017; Spiegelman & Flier, 2001). To maintain a stable weight, a balance between the two is required. This can be achieved by regulating energy intake, energy expenditure, or both. If energy intake exceeds expenditure, weight is gained (Hill, 2006). Current evidence suggests that the average UK adult consumes 200-300 calories a day above the recommended energy intake (Public Health England, 2018a). Humans have an innate preference for energy dense foods, which is an evolutionary remnant, from a time when maximising energy was the priority (de Vries et al., 2020). However, individual factors such as genetics can make some individuals more susceptible to the influences of the environment than others, making energy balance more difficult to maintain. Twin and family studies estimate that 40-70% of variation in human body weight is attributable to genetic differences between people (Elks et al., 2012; Min et al., 2013; Robinson et al. 2017; Silventoinen et al., 2010), and genomic studies have identified hundreds of common genetic variants that are robustly associated with variation in BMI (Yengo et al., 2018). It is hypothesised that genetic factors that predispose to obesity make some individuals more susceptible to overeating in response to the increased environmental opportunity since the obesity epidemic began.

Social factors, such as income, education, social deprivation and ethnicity have also been identified as significantly influencing body weight (Devaux et al., 2011; Devaux

& Sassi, 2013; Drewnowsk, 2009; Gatineau & Mathrani, 2011; McLaren et al., 2007). Lower socio-economic status (SES), as measured by occupation, education, and/or income across the lifespan is associated with higher average BMI (Newton et al., 2017) and poorer general health outcomes (World Health Organisation, 2008). This is thought to be because our ability to practice health-promoting behaviours is affected by our access to resources which is influenced by SES (Williams et al., 2016); for instance, access to affordable nutritious foods such as fresh fruit and vegetables or, on the other side of the energy-balance equation, access to green spaces for enjoyable outdoor activities. It is important to note that the food and physical activity environments are not the same in deprived and affluent neighbourhoods. In the UK, Black and ethnic minorities are twice as likely to experience deprivation than their White counterparts (Social Metrics Commission, 2019), and public health data show that rates of childhood obesity are higher among Black and Asian children. It is possible that some of the variation in obesity rates may be explained by deprivation, especially given that children living in deprived areas are twice as likely to have obesity than those in less-deprived areas (Raleigh & Holmes, 2021). Other potential explanations for ethnic diversity in prevalence of obesity include differences in body composition and fat distribution due to genetic background (Fernandez & Shiver, 2004), lifestyle (Falconer et al., 2014), and cultural differences in body size norms (Kronenfeld et al., 2010).

While genetic and social factors undoubtedly play a role, a growing body of evidence points to the environment as a key driver of the two-fold rise in obesity that has been observed in over 70 countries since 1980 (Hall, 2018; The GBD 2015 Obesity Collaborators, 2017). The last several decades have brought considerable changes to food production, food sales, and the food environment more broadly. The food environment refers to *"the physical, economic, political and socio-cultural contexts in which people engage with the food system to make their decisions about acquiring, preparing and consuming food*" (European Public Health Alliance website, 2019). Recent reviews of the empirical evidence characterise the current food environment as 'obesogenic', meaning that it promotes a positive energy balance (Kirk et al., 2010; Swinburn et al. 1999; Swinburn et al., 2019). The next section outlines the ways in which the food environment has become obesogenic. The term energy-dense-

nutrient-poor will be used to describe foods that are referred to as unhealthy, unhealthful or less healthful in the literature.

1.3 Environmental factors

In the developed world, highly palatable, energy-dense-nutrient-poor food is widely available, inexpensive and convenient (Swinburn et al., 2011). Global food production has increased at such a rate that the amount of food produced today is sufficient to meet the nutritional needs of the population in 2050 (Berners-Lee et al., 2018). The link between food availability and food intake has been well documented in the literature. Empirical studies demonstrate that people will consume more energy when the amount of food available for consumption is increased (Steenhuis & Poelman, 2017), and epidemiological research shows that increases in the amount of food-energy available per capita are positively associated with increases in BMI globally (Vandevijvere et al., 2015).

Changes in the availability of food-energy have been driven by a combination of economic and political factors (Hall, 2018). The sudden upturn in population weight that happened across all subgroups at the end of the 1970s in the USA coincided with a change to farming bills (Swinburn et al., 2018). Agricultural subsidies provided to American farmers following the Great Depression incentivised the farming of crops such as corn, sugar and flour at the expense of fruits, vegetables, and other grains (Field, 2004). Advancements in food technology led to the discovery that these heavily subsidized crops could be combined with flavour additives to create highly palatable, inexpensive products with long shelf-lives (Hall et al, 2019). This led to a rapid increase in food production and increase in portion sizes, accelerated marketing, availability and affordability of energy-dense-nutrient-poor foods. High volumes of these new ultra-processed foods (sometimes referred to as highly-processed foods) infiltrated the food system and affected the whole population simultaneously (Rodgers et al., 2018). These ultra-processed foods are typically low in dietary fibre, more energy dense and contain higher levels of sugar, salt and saturated fat than unprocessed foods (Monteiro et al., 2011; Moubarac et al., 2013). Although research into ultra-processed foods is in its infancy, preliminary experimental data have shown that they have appetitive

properties which drive increases in consumption (Hall et al., 2019). Today, more than half of UK diets are ultra-processed and consumption of these products is associated with weight gain (Rauber et al., 2020).

Cheap ingredients, large scale production, and long shelf-life mean that ultra-processed foods are often less expensive than fresh foods (Griffith, 2021). Price has been consistently found to influence food choice (Afshin et al., 2017). Kantar WorldPanel UK (2015) reported that price promotions increase the amount of food and drink people buy by around one-fifth. Research conducted in UK supermarkets indicates that although energy-dense-nutrient-poor foods are promoted no more frequently than healthier options (as judged by the product's nutrient profile score[1]), greater increases in sales are seen in energy-dense-nutrient-poor categories (e.g., cakes and pastries, crisps, cheese). Specifically, a 10% increase in price promotions was shown to correspond to a 35% sales increase for energy-dense-nutrient-poor products but only a 20% increase for foods with a superior nutrient profile (e.g., soup, bread, pasta) (Nakamura et al., 2015).

Increasing sales and high profitability of ultra-processed products has encouraged manufacturers to continue to focus on producing and marketing these products (National Food Strategy, 2021). As such, ultra-processed foods have become ubiquitous, being sold in supermarkets, corner shops and food-outlets. Over the last number of years, there has been a proliferation in fast-food outlets and restaurants globally (James, et al., 2017; Office for National Statistics, 2018). In the UK, there was a 34% rise in the number of fast-food outlets across the country between 2010 and 2018 (Office for National Statistics, 2018). Areas of deprivation have been the target, with some of the poorest areas in England being found to have almost five times the number of fast-food outlets than the most affluent neighbourhoods (Public Health England, 2018b). Proximity to food outlets selling energy-dense-nutrient-poor foods and drinks has been shown to increase the risk of overweight and obesity. Growing

[1] The nutrient profiling (NP) model assigns a score to products based on their energy density, saturated fat, sugar, sodium, fibre, and protein contents as well as an estimate of the fruit, vegetable, and nut contents. The NP provides a unified measure of healthiness across food and drink products. As the NP score increases, the healthiness of the product declines. NP cut-off points are used to categorise products as healthier and less-healthy products.

up in an area with a higher density of unhealthy food outlets is associated with overweight and obesity in later childhood (Lee et al., 2020). Prior to Covid-19, the eating out-of-home sector, which encompasses cafes, restaurants and pubs, experienced major growth, with over one quarter of adults eating out weekly (Public Health England, 2017). During Covid-19 lockdowns, consumption of out-of-home food in the UK did not cease, and was facilitated by delivery services which grew substantially (National Food Strategy, 2021). Observational research finds that the majority of main meals served in major restaurant chains in the UK do not meet dietary guidelines and almost half were found to contain excessive energy (≥1000 kcal) (Robinson et al., 2018). According to Public Health England (2018a), eating-out accounts for 20-25% of the average adult's energy intake.

Alongside increased availability and convenience, portion sizes of many popular energy-dense-nutrient-poor products have increased over the past decades (Benson, 2009; Matthiessen et al., 2003; McCrory et al., 2019; Nielsen & Popkin, 2003; Steenhuis et al., 2010). The introduction of super-sized meals, sharing size packets of crisps, and more recently, sharing pouches of chocolate are examples of these changes. Similar increases have been observed for sugar-sweetened beverages (SSBs) (Steenhuis et al., 2010), and research from across Australia, Canada, New Zealand and the Netherlands has found that average pack sizes of individually sold SSBs are larger than average recommended serving sizes (Poelman et al., 2016). These trends are concerning considering the evidence that increases in portion sizes are robustly linked to increases in energy consumption among children and adults (Hollands et al., 2015; Marteau et al., 2015; Zlatevska et al., 2014).

It is important to note that many of the factors that influence obesity risk are largely outside an individual's control (e.g., genetic predisposition, ethnicity, SES, the food and physical activity environment). However, there is also an element of individual choice. This is an important part of the equation because it is something that can be supported alongside government initiatives targeting the wider environment (e.g., sugar levies). As we await more radical changes to be made to the wider environment that will make it easier for the public to make healthy choices, researchers have focused on developing interventions that alter environments to steer individuals

towards better choices. These so-called 'choice architecture' interventions are discussed in the next section.

1.4 Choice architecture

Just as marketing practices such as product displays, placement, promotions, and advertising campaigns exploit our cognitive biases to maximize sales and profit and, consequently, calories consumed, these techniques can also be leveraged to promote healthier choices. This form of intervention is often referred to as 'choice architecture' and became popularised in 2008 by the book, '*Nudge: Improving decisions about health, wealth and happiness*' (Thaler & Sunstein, 2008). Choice architecture or 'nudges' are defined as interventions that change behaviours in predictable ways without restricting choice or significantly altering economic incentives. They also tend to target our automatic unconscious system rather than relying on conscious cognitive processing (Thaler & Sunstein, 2008). Positioning healthful foods (e.g., fruits and vegetables and other products with good nutrient profile scores) on more salient shelves, and making smaller side portions the default in a 'meal deal' are classic examples of effective healthy eating nudges (Giesen et al., 2013; Piernas et al., 2021). A systematic review and meta-analysis of studies (n=42) testing Nudge Theory strategies in influencing the dietary behaviour of adults reported that these interventions increased healthy choices by 15%. Healthy choices were defined as either increases in healthier products being selected (i.e., nutrient dense, lower calorie, lower salt, lower sugar, lower cholesterol, or lower fat products such as vegetables, fruits and whole grains) or reductions in energy consumed (Arno & Thomas, 2016).

Over the past decade, researchers and policymakers have spent considerable time testing the effect of making small changes to environments on subsequent health behaviours. Despite often being referred to as 'nudges', these interventions often fall slightly outside the scope of the original definition because they rely on reflective cognitive processes (as is the case with labelling interventions). In order to encompass the breadth of research and policy efforts in this area, the TIPPME (typology of interventions in proximal physical micro-environments) was developed. The typology

includes any intervention that attempts to alter people's behaviour by changing aspects of the micro-physical environment. Micro-environments include shops, schools, workplaces and restaurants. Under the TIPPME, interventions can fall into six categories: availability, positioning, functionality, presentation, size or information (Hollands et al., 2017).

A recent systematic review (n=75) examined the effect of nudges (as classified by the TIPPME) on purchasing and consumption in real-world environments. Just over half of interventions included in the review were information based (56%), 13% were positioning nudges, and the remaining 24% was a mixture of the other four categories for which little evidence was available. Information and positioning based nudges were both found to be effective overall, but the quality of evidence was low to moderate. The majority (81%) of studies were also conducted over short timeframes (<6 months) and often relied on non-randomised designs. There was some indication of stronger intervention effects among lower SES groups, however, the evidence was limited (Harbers et al., 2020).

Although this most recent review indicates that position and information-based nudges hold promise for changing dietary behaviours, this study was unable to report on the comparative effectiveness of these nudges due to data quality issues. Previous research comparing nudge-based interventions categorized nudges as being either 'cognitively', 'affectively' or 'behaviourally' oriented. Cognitively orientated nudges typically tried to change behaviour by making information salient through labelling or by altering the visibility of healthful and less healthful products. These interventions were found to have a small, significant effect on behaviour (d = 0.12, -64 kcal). Affectively orientated nudges attempted to make healthful/less healthful options more/less desirable using strategies such as vivid descriptions, images, and displays. These interventions had a slightly larger effect on behaviour (d= 0.24, -129 kcal). Finally, behaviourally oriented nudges altered the convenience of certain food to ensure that less/more healthful foods were harder/easier to obtain, or adjusted plate and portion sizes. These interventions had the largest effect on behaviour (d= 0.39, -209 kcal) (Cadario & Chandon, 2017). These findings indicate that a range of healthy

eating nudges can effectively alter dietary choices, but those that do not rely on conscious cognitive processing, may be most effective.

Behaviourally oriented nudges, however, have been criticised for failing to help individuals to develop the nutritional awareness and self-monitoring skills necessary to make good choices when the context is less favourable (Grüne-Yanoff & Hertwig, 2016). John and Stoker (2019) have argued that these approaches to behaviour change needn't be opposing and could be combined. The authors propose the need for interventions that encourage people to engage their reflective 'system 2' (which Kahneman (2011, p13) describes as a *"slower, more deliberate and effortful form of thinking"*), either before or after the nudge, or even when it takes place. Although this approach, which they term 'Nudge Plus', emphasizes the importance of building a 'thinking' component into nudges, it equally recognises our limited capacity for reflection, and the time constraints we face when making choices (John, 2018; John & Stoker, 2019). As such, it does not imply full deliberation and reflection, but rather involves promoting thoughts in easy, cost-effective ways. The next section focuses on the evidence for information-based interventions to encourage healthier choices.

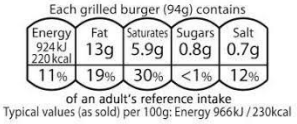
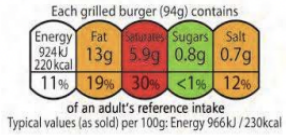
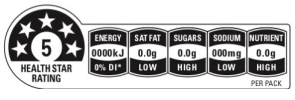
1.5 Information-based interventions

1.5.1 Front of pack nutrition labelling

Today, more than 30 countries have implemented front-of-pack nutrition labelling (FoPL) systems (Jones et al., 2019). These labels typically provide information about the energy and nutrient content of a product. However, different approaches have been taken to the presentation of this information (Goiana-da-Silva et al., 2019). Interpretive labels make an evaluation or recommendation about the product's nutritional quality based on an analysis of its nutrient profile, whereas non-interpretive labels present information about the product's nutritional content without making a judgement about its healthfulness. Labels can also either provide detailed information about specific nutrients, or they provide a summative evaluation of the product overall (World Health Organisation, 2019). In recognition of research which finds that consumers struggle to understand non-interpretive nutrition information (Roberto &

Khandpur, 2014), efforts have been made to enhance the interpretability of FoP nutrition information. Table 1 summarizes different FoPL formats used internationally.

Table 1.1: Summary of FoPL formats used internationally.

Name	Format	Description	Example
Non-interpretive			
Reference Intakes	Nutrient specific	Figures relating to the energy (kcal & kj), fat, saturated fat, sugar and salt content (in grams) of the product per portion are provided as a proportion of an adult's recommended daily intake.	
Interpretative			
Multiple Traffic Light (MTL)	Nutrient specific	Figures relating to the energy (kcal & kj), fat, saturated fat, sugar and salt content (in grams) of the product per portion are provided as a proportion of an adult's recommended daily intake. These figures are accompanied by red, yellow, and green markings to indicate high, medium or low levels of each nutrient.	
Nutri-score	Summative	Products are given one of five letters from A to E based on their nutrient profile score. These letters each have a corresponding colour ranging from dark green indicating the most healthful product through to dark red indicating the least healthful product.	
Health Star Rating	Nutrient specific and summative	Products are allocated a star rating between half a star for the least healthful products and 5 stars for the most healthful products based on	

		their nutrient profile score. Figures relating to the energy (kj), saturated fat, sodium, sugar, and nutrient content (in grams) of the product per pack/per 100g/per 100ml are provided. Percentage daily intake (%DI) information is only displayed on the energy icon of a 'per pack' or 'per [serve size]' representation. The words 'low' and 'high' are used within the nutrient icons (except for the energy icon) to highlight the content of individual nutrients.	
'High in' Warning Label	Nutrient specific	A black stop-sign shaped label that highlights high levels of individual nutrients such as fat, salt, sugar and energy. Up to 4 'High-in' labels can be displayed on a product, but foods that are naturally high in these nutrients (e.g., nuts) are exempt.	

1.5.2 Evidence for front of pack nutrition labelling

The rationale for providing nutrition labelling is that it will allow individuals to make healthier choices in-the-moment based on the information they are presented with, this will overtime improve nutrition knowledge which will prompt changes in purchasing behaviours at the individual-level which will, in turn, encourage reformulation at the industry-level (Crocker et al., 2020). Research shows that FoPLs can enhance adults' ability to interpret nutrition information and can improve nutrition knowledge more generally, both of which are associated with the selection of more healthful products (Hersey et al., 2013; Egnell et al., 2018). A large study conducted across 12 countries compared the impact of FoPL formats such as the Nutri-score, MTL, Health Star Rating, 'High in' warning label, and Reference Intakes on nutrition knowledge (Egnell

et al., 2018). The Nutri-score was found to improve nutrition knowledge the most followed by the MTL. The worst performing label was the Reference Intakes, a finding which is consistent with previous research (Hersey et al 2013; Crocker et al., 2020), and supports the argument that interpretive labels are superior to non-interpretive formats. However, the evidence-base is limited on the impact of FoPL on consumption behaviours (Crocker et al., 2020).

Evidence for the effect of FoPL on purchasing and consumption is mixed. A 2018 Cochrane review identified 6 experimental studies testing FoPL and found no significant effect of FoPL on energy consumption. However, only studies testing the effect of formats providing specific nutrient or energy information (e.g., MTL, Reference Intake etc.) were included, summative labels (e.g., the Nutri-score) were excluded, and all studies were considered to be of low-quality (Crockett et al., 2018). More recently, a systematic review and meta-analysis of studies testing the effect of FoPL on objectively measured purchasing behaviours was conducted. This review included studies published since the 2018 Cochrane review and those testing summative formats (e.g., Nutri-Score, Heath Star Rating, 'High in' warning labels). A total of 14 studies were identified. 'High-in' warning labels were found to be particularly effective, with products purchased (in real-life and in artificial settings) by those exposed to these labels containing significantly lower sugar, sodium and energy compared with when no FoPL was provided. Only salt purchased was significantly reduced among those exposed to MTL compared with no FoPL. No significant effect on purchasing for the Health Star Rating or the Nutri-score was observed, but few studies testing the Nutri-score were identified (Crocker et al., 2020). The authors noted that the evidence for the effect of nutrition information on consumption remains extremely limited and requires further investigation.

There is some evidence that FoPL has stimulated reformulation, reducing energy offered by retailers and increasing availability of more healthful products (Ni Mhurchu et al., 2017; Shangguan et al., 2019; van der Bend et al., 2020; Vyth et al., 2010). The introduction of the soft drinks industry sugar levy is another example of a government initiative that has prompted reformulation. This industry-level behaviour change was observed in the UK, with the sugar content of a number of products on the UK market

being significantly reduced ahead of the implementation of the industry levy. Research showed that in 2014, prior to the introduction of the levy, only 16% of soft drinks on the UK market were below the sugar threshold for the levy (i.e., contained 5 g/100 mL or less sugar), but by 2018, 63% of soft drinks were below the sugar threshold (Hashem et al., 2018). Small changes at industry-level can result in large-scale changes in population behaviour. Research has shown that the UK SSB levy was associated with a reduction of 50% in the total volume of SSBs (subject to the levy) sold between 2015 and 2018 and a corresponding 40% increase in low- and zero-sugar (< 5 g/100 ml) drink sales (Brandy et al., 2020). Recent reviews of the broader impact of the SSB levy indicate that sugar reductions correspond to energy reductions of between 5 kcal and 22 kcal per person per day. However, even if sustained, these reductions are not enough to alter the current trajectory of the obesity epidemic (Popkin & Ng, 2021). A suite of policy measures will, therefore, be necessary to effect meaningful change. Reformulation does however, ensure that benefits incurred are equitably distributed throughout the population, rather than only the most health conscious or educated benefitting.

1.5.3 Menu labelling

Positive industry engagement with voluntary FoPL schemes, coupled with research suggesting that consumers want access to nutritional information when eating out and believe it would influence their ordering behaviours (Bleich & Pollack, 2010; Diabetes UK, 2018; Lando & Labiner-Wolfe, 2007), has led to calls for menu labelling. Menu labelling legislation has now been introduced in a number of countries such as the USA, Canada, and Australia, and is due to be implemented in the UK from April 2022 (UK Government website, 2021). Unlike FoPL, the provision of energy information (in kj or kcal) has been the primary focus of menu labelling measures. A survey conducted in the USA ahead of the implementation of menu labelling legislation examined consumer preference for how calorie-disclosures on menus should be presented. The study found that consumers were divided, with 39% of respondents preferring energy information to be presented as a percentage of total energy intake, 35% preferring the number of calories to be displayed, and 26% favouring a physical activity calorie

equivalent [2] (Bleich & Pollack, 2010). Another survey study found that UK respondents viewed MTL labelling and calorie-disclosure as equally appealing. Respondents reported being more inclined to buy from eating establishments that provided MTL labelling (60%) and calorie labelling (59%) on menus, while 57% of respondents reported being more inclined to buy from eating establishments that offered a 'reduced calorie range' (Diabetes UK, 2018). Qualitative research from the USA found consumers were concerned that having information about multiple nutrients (as in the MTL) on menus might be overwhelming but viewed calorie disclosures as a useful heuristic indicating the healthfulness of a menu item (Lando & Labiner-Wolfe, 2007).

Several systematic reviews and meta-analyses have investigated the effect of menu labelling on consumer behaviour and have reported mixed results. An early systematic-review and meta-analysis of experimental (n=7) and quasi-experimental (n=7) studies found that menu labelling did not significantly reduce energy selected or consumed. The addition of interpretive information (n= 4) such as traffic light symbols to menus was, however, found to significantly reduce energy selected (-67 kcal) and consumed (-81kcal) (Sinclair et al., 2015). Another systematic review of studies conducted in real-world settings (n= 38) reported that while some positive effects were observed, the majority of studies found no effect overall of menu labelling on food choices (Fernandes et al., 2016). Other research has reported positive effects of menu labelling legislation. A Cochrane review found that calorie-labelling on menus reduced energy purchased by 47kcal (Crockett et al., 2018). A review of evidence from the USA reported that mandatory calorie disclosures on restaurant menus led to an average reduction of energy ordered of 27 kcal (Zlatevska et al., 2018). A more recent meta-analysis, found that menu labelling (n=23) reduced total calories purchased or consumed by 7% (Shangguan et al., 2019).

Although most studies reported positive effects of menu labelling, many concluded that the quality of evidence is mixed (Bleich et al., 2017; Crockett et al., 2018; Littlewood et al., 2016; Sinclair et al., 2015). A number of reviews have also suggested

[2] The time or distance walking (or another form of physical activity) needed to burn off the energy in the item is displayed.

that the effect of menu labelling may be context dependent, with positive effects being more frequently observed in canteens than restaurants (Bleich et al., 2017; Fernandes et al., 2016; VanEpps et al., 2016b). There are key differences between canteens and restaurants which might influence the effect of menu labelling. Firstly, in terms of population, most canteen studies were conducted in universities or hospitals. It is possible that customers in these settings have a higher education level than the general population in restaurants (Fernandes et al., 2016), and higher education may be associated with more healthful dietary choices (Sharma et al., 2011). Secondly, the nature of canteens is functional, customers may eat there on a daily basis and as a result may be more likely to opt for lower-energy options and use menu labelling (Jones, 2010). In contrast, restaurants (and take-aways) may be considered more of a treat. Customers may visit these establishments for pleasure and enjoyment (Bleich et al., 2017; Jones, 2010) and as a result, may be less inclined to worry about the healthfulness of their choices.

Taken together, these findings suggest that the provision of nutrition information (even in a basic form like energy content alone) may help to improve the healthfulness of choices made for both pre-packaged products and menu items, especially in canteen contexts. However, the mixed efficacy of nutrition labelling in its current form to influence consumer choice, has prompted researchers to test alternative information-based strategies for improving the healthfulness of dietary choices.

1.5.4 Messaging

a. Health warnings

Promising results from studies examining the use of health warnings on tobacco products (Brewer et al., 2016; Cantrell et al., 2013) has prompted researchers to test its application to energy-dense-nutrient-poor foods and drinks. In contrast to ‘High In’ warning labels used in Chile, the objective of health warning labels (HWLs) is to convey to the consumer the *harms* associated with consumption of a target product. This is communicated either via text for example, “*excess calories cause obesity which causes bowel cancer*” or text accompanied by a graphic image of an internal organ. A

systematic review and meta-analysis (n=9 studies) assessing the impact of HWLs on food and drink selection found that participants were 26% less likely to select a product high in energy or sugar when it displayed a HWL compared with when no label was present. A larger effect of image-and-text HWLs was reported compared with text-only, and there was evidence that these labels significantly reduce the likelihood that an energy dense snack will be selected compared with calorie-labelling (Clarke et al, 2020). However, current evidence is based almost exclusively on hypothetical choice studies in artificial settings. In terms of the public acceptability, two studies reported that the majority (73%, 63%) of participants agreed that text-only HWLs on SSBs were an acceptable policy measure in the USA (Roberto et al., 2016; VanEpps & Roberto, 2016c). In another study, image-and-text HWLs on energy-dense snacks were believed to be more acceptable on average than labels for alcohol, receiving an average acceptability score of 4 out of 7 among UK participants (Pechey et al., 2020). However, these labels have been regarded by respondents as less acceptable than labels depicting sugar or energy information (Mantzari et al., 2018). Content analysis of free-text comments provided by a subset of participants exposed to HWLs also found that the majority of comments expressed negative feelings towards the use of HWL on foods and alcoholic drinks (Pechey et al., 2020). Although there is evidence for the efficacy of health-warning labels on packaged goods, this form of messaging is unlikely to be applicable or acceptable in settings such as restaurants or canteens.

b. Social norms

Another strategy that might be more acceptable in restaurant and canteen environments is to provide people with information on the purchasing behaviours of their fellow patrons - so-called descriptive social norms. Descriptive social norms provide information on how popular a behaviour is in general, or among a similar social group (Cialdini, 2007). For example, "*the majority of our shoppers purchase low-fat milk*". Providing information about other peoples' eating habits has been shown to significantly influence both food choice and intake (Higgs et al., 2015). A systematic review and meta-analysis of studies (n=15) found that participants were significantly more likely to choose a high-energy product (standardised mean difference 0.41, 95% confidence interval 0.20 to 0.63) or low-energy product (mean difference -0.35, 95%

confidence interval -0.59 to -0.10) when they were led to believe that other people had also done so. The studies in this meta-analysis used a range of methods to convey the norms such written information about what other people usually eat or had been eating, and visual cues indicating target foods as popular choices. The quality of the evidence was also deemed to be good, with the reviewers noting that the studies were well designed with most including a suitable control (13 out of 15) or comparison condition (2 out of 15), and no evidence of demand awareness in any of the studies (Robinson et al., 2014). However, more recently, a study conducted in an experimental online supermarket found that messages highlighting the popularity of certain lower-energy products did not affect the likelihood that these products would be selected by shoppers relative to a message highlighting certain products as lower-calorie (Bunten et al., 2021). It has been suggested that norm messages may be strengthened by providing; (i) specific information regarding the product's degree of popularity (e.g., *90%* of our shoppers bought this product last week) (Bunten et al., 2021), or (ii) real-time information that changes regularly to prevent consumers from habituating to the messages (Haines et al., 2005). One study reported that when using norms messaging to encourage voting among students, similarity to other students moderated the relationship between the messages and intention to vote (Glynn et al., 2009). Providing information emphasizing one's similarity to the group who have engaged in the target behaviour (e.g., 150 of *your colleagues* bought this product last week) may also enhance the effect of social norms messages. Overall, incorporating this information into messages may be a challenge for certain providers, potentially limiting the applicability of norm-based information interventions.

c. Physical activity calorie equivalents

An alternative strategy is to focus on increasing the interpretability of nutrition information currently provided. The habitual nature of dietary choices means that we make choices quickly, and we often rely on heuristics when making these decisions (Grunert et al., 2012). This suggests that simplified information might lead to more healthful choices. Simplifying nutrition labelling by translating the concept of energy into a format that is familiar and easily understandable is what physical activity calorie

equivalents or 'PACE' labels attempt to do. PACE labels provide information on the amount of physical activity that would be required to burn off the calories contained in a given food or drink. For example, a 330ml can of a sugary soft drink containing 138 kcal would require the average person to brisk walk for about 26 minutes to burn it off (Royal Society for Public Health, 2016). These labels are hypothesised to enhance the effectiveness of simple calorie labels because physical activity information is easier for consumers to understand than abstract calories information (Blumenthal & Volpp, 2010; Fitch et al., 2009). PACE labels also have the benefit of highlighting to consumers the relationship between energy intake and energy expenditure and thus the importance of maintaining energy balance (Daley et al., 2020).

A recent systematic review and meta-analysis of 15 randomised controlled studies examining purchasing and consumption, reported a significant effect of the PACE labels. In terms of energy consumed, PACE labels on menus reduced calories consumed from food and drinks by 80 kcal compared with when other types of labelling or no labelling was provided. Further analysis indicated that PACE labelling was more effective than no labelling reducing energy ordered by 110kcal (95%CI -189 to -30, p=0.007) but not compared with calorie-only labelling (-51kcal, 95%CI −130.7 to 28.3, p=0.21). Compared with nutritional labelling, PACE message did however significantly reduce the amount of food (in grams) consumed by participants. However, study quality varied and most of the evidence is drawn from hypothetical choice studies (Daley et al., 2020). A study conducted in a real-world canteen suggested that PACE messaging may also promote exercise. PACE labels were found to increase self-reported physical activity by 13–26% and objective physical-activity by 6% compared with calorie-only labels (Deery et al., 2019).

While very little research has addressed the question of acceptability, one survey found that 63% of respondents (n=2,000) would support the introduction of activity equivalent calorie labelling (Royal Society for Public Health, 2016). PACE messaging has also gained popularity with companies. GPS phone application, CityMapper, makes energy balance salient to its users by providing information on calories burned when walking or cycling a journey. And online supermarket, Ocado, offered PACE information alongside prompts to swap to lower-energy alternatives as part of their

calorie-saver settings (Ocado, 2016). Evidence suggests that information is most likely to be effective if it is delivered at a decisive moment such as the point-of-choice (Hysong et al., 2006; Tang et al., 2014). Prompting consumers with alternatives or 'swaps' for energy-dense-nutrient-poor selections and accompanying swaps offered with PACE information is a potentially impactful way to intervene at the point-of-choice. This is a more actionable form of feedback than simple information provision because it encourages users to think (about whether they would like to swap), but prevents them from thinking 'too much' (about which options might be more healthful), ensuring they don't become overwhelmed and inert. The next section discusses the evidence for swap-based interventions.

1.6 Swaps

Just as a small positive energy balance that is sustained overtime will result in weight gain, small reductions that are made frequently can have a meaningful impact on weight in the long-term (Hills et al., 2013; Lean et al., 2006; Stroebele et al., 2009). Modelling studies suggest that an energy reduction of 50-100 kcal per-person per-day would be enough to offset weight gain at the population level (Hill et al., 2003). It has been argued that the use of a small-changes-approach may be more effective than asking people to make a major change to their behaviour (Lean et al, 2006; Rodearmel et al., 2007). In recognition of this, public health campaigns within the UK and internationally promote swaps as a means of encouraging more healthful choices at the population level (O'Hara et al., 2016; Stroebele et al., 2009; Wrieden & Levy, 2016). The 'Smart Swaps' initiative in the UK is part of an ongoing nationwide social marketing campaign called 'Change4Life'. The initiative encourages families with young children to make small changes by replacing some of their usual dairy, drinks and breakfast cereal purchases with lower-fat or lower-sugar alternatives. Those who register receive an information pack with swap suggestions. These suggestions are not personally tailored but instead are chosen based on the top five contributors to fat and sugar in the diet of children assessed from the National Diet and Nutrition Survey (Whitton et al., 2011). A quasi-experimental evaluation of the effectiveness of the campaign reported positive changes in purchasing behaviours. The study compared

267 families in England who had signed up to the Smart Swaps campaign with 135 families in Wales who registered for Change4Life materials but did not receive direct information on the Smart Swaps campaign. Smart Swap households were significantly more likely to purchase a lower-fat dairy product (58% vs 26%), a lower-sugar drink (32% vs 19%), and a lower-sugar cereal (24% vs 12%) compared with the control group. The majority (74%) of Smart Swap households also reported having made a swap suggested by the campaign over the 3 week study period (Wrieden & Levy, 2016).

Similar to Smart Swaps, the 'Swap It, Don't Stop It' initiative forms part of a wider mass media campaign in Australia to promote small changes to lifestyle behaviours. This campaign features an animated character who models behaviours demonstrating small changes (e.g., swapping large portions for smaller portions, fried food for fresh food, going for a walk with the family for watching television) that could be made to achieve a healthier lifestyle (O'Hara et al., 2011). Evaluations of the initiative found it to yield modest population awareness but a limited effect in terms of nudging behaviours (O'Hara et al., 2011). The evaluators concluded that the use of a mass media campaign may not be the best strategy to encourage swapping behaviours. Swap-based interventions may be better placed in micro-environments where swap suggestions can be tailored and presented at the point-of-choice.

Swap-based interventions have been tested in supermarket settings with promising results. An early real-world study tested the effect of providing shoppers with lower-saturated fat alternatives for items in their basket at the checkout when shopping online. The intervention provided initial evidence for the efficacy of tailored swap-based interventions, resulting in a 10% reduction in total saturated fat purchased (Huang et al., 2006). Other research testing a swap-based intervention delivered via a smartphone application found some evidence that this may also be an effective strategy for reducing salt purchased in real world supermarkets (Eyles et al., 2017). Swap-based interventions have been primarily tested in experimental online supermarket settings. Studies in these settings have reported significant reductions in the saturated fat (Koutoukidis et al., 2019) and salt content of online shopping baskets (Payne-Riches et al., 2019), but evidence on whether swap-based interventions

reduce the energy content of shopping baskets is mixed (Forwood et al., 2016; Bunten et al., 2021). Furthermore, this area of research has not yet been reviewed and therefore little is known about the type of swaps that are effective and how swaps should be presented.

Combining a swap-based intervention with other strategies such as information-based nudges may help to bolster its effect. For instance, online supermarket, Ocado, developed a feature which offered PACE information alongside prompts to swap (Ocado 2016). Although PACE information has been shown to improve the healthfulness of dietary choices (Daley et al., 2020), this combined strategy has yet to be empirically tested. Given that offering swaps has shown promise as an intervention within the supermarket setting, swap-based interventions could be applied to other micro-environments such as workplace canteens. The next section discusses why the workplace might be a good setting for such an intervention to be tested.

1.7 The workplace

After the home, the workplace is the most common environment where food is consumed (Liu et al., 2015). Prior to Covid-19, most working adults spent a large part of their day in the workplace (Quintiliani et al, 2010), ate at least one meal (Lassen, 2011), and employed adults in the UK consumed approximately one-third of their daily calories while at work (Vasiljevic et al., 2018). Across Europe, canteens are the preferred source of lunch at work, second only to bringing lunch from home (Corvo et al., 2020). Research with workplace canteens across the UK and USA reported that 90% of employees used the canteen at least once per week and almost half used it three or more times per week (Omnico, 2019). However, food served in canteens is often criticised by employees for being unhealthy (Czarniecka-Skubina et al., 2020; Sharma et al., 2016), and eating at work has been shown to be associated with an increased propensity to snack compared to when at home (Liu et al, 2015). These findings, coupled with the fact that workplaces are hubs where large numbers of people gather to eat, make this micro-environment a promising setting for an effective intervention to be delivered at scale (Whitehead, 2007).

A recent systematic review of studies (n=55) testing the effect of interventions to improve the healthfulness of dietary choices in workplace canteens reported positive outcomes. Of the 18 studies examining fruit and vegetable intake, 16 reported small (i.e., <1 serving/day < 80 g/day) to moderate (1-3 serving/day 80-240 g/day as moderate) increases. Of the 20 studies examining changes in energy and nutrient outcomes, 20 reported significant reductions in fat, saturated fat, and energy intake, and increases in fibre intake. Of the 20 studies reporting on health outcomes, 14 reported significant improvements such as reductions in BMI and positive changes in lipids. Most of these studies employed multiple-component interventions that focused on; (i) changing food quality or food quantity and, (ii) providing employees with educational or motivational information when making dietary choices. Finally, of the 24 studies that examined changes in sales, 13 reported significant increases in the sale of more healthful products. The majority of these studies employed pricing and labelling interventions at the point-of-choice (Naicker et al., 2021). In recent years, pre-ordering systems whereby food and drinks are ordered online ahead of time, have been introduced in workplace (Stites et al., 2015; Migliavada et al., 2021) and school (Miller et al., 2016; Wyse et al., 2019) canteens. Pre-ordering websites provide canteens with greater control over the design of the choice environment and, as such, could be promising vehicles for the delivery of healthy eating interventions in the workplace. The next section explores the concept of pre-ordering and why it might be an ideal forum to deliver a swap-based intervention.

1.8 Pre-ordering

Similar to an online supermarket setting, pre-ordering systems allow menu options to be displayed and manipulated to steer users towards more healthful choices. A 2016 study tested the effect of adding an information based nudge to a pre-ordering system for a school canteen. When pre-ordering, students selecting unbalanced meals received a pop-up message that read: "*Your meal does not look like a balanced meal*" accompanied by an image of a plate highlighting the missing food groups. Compared with pre-ordering alone, pre-ordering with the nudge increased fruits, vegetables and low-fat milk ordered by 8%, 15% and 13% respectively (Miller et al., 2016). Similar to

supermarket swaps, it is likely that this nudge was effective because of its timely delivery, helping students to change their behaviours at the point-of-choice.

In addition to pre-ordering being a vehicle for the delivery of healthy eating interventions, there is evidence that pre-ordering as an intervention itself, may help to foster more healthful dietary choices. When compared with orders placed in the moment, pre-ordering has been shown to increase the selection of fruits, vegetables and low-fat milk in schools (Miller et al., 2016), and reduce energy ordered by university students (VanEpps et al., 2016a), and employees in workplace settings in the USA (Stites et al., 2015; VanEpps et al., 2016a). Pre-ordering is understood to produce positive outcomes by restructuring the choice environment in ways that reduce or eliminate factors that have been shown to foster less healthful dietary choices. For instance, research shows that individuals are more likely to select less healthful products when they are hungry (Read & van Leeuwen, 1998). Pre-ordering in the morning enables users to make decisions for the future potentially in the absence of immediate hunger. Hunger also makes individuals more susceptible to tempting sensory cues such as the sight and smell of desirable foods (Bauer & Reisch, 2018; Loewenstein, 1996). Pre-ordering removes individuals from the canteen environment, eliminating sensory cues that make healthier choices difficult (Bauer & Reisch, 2018; Schelling, 1984). Research shows that individuals have a strong tendency to prioritise short-term 'wants' over longer term goals (Laibson, 1997; O'Donoghue & Rabin, 1999). Due to this, individuals might resolve that the immediate benefit - like the pleasure of drinking a sugary drink - outweighs the potential of a future desired outcome being achieved - like weight loss. Due to this phenomenon known as present bias, individuals are more likely to select less healthful items when they are for immediate consumption (Read & van Leeuwen, 1998). Pre-ordering acts as a commitment device because it binds the individual to their initial choices, reducing the likelihood that they will succumb to temptation in the moment (Schwartz et al., 2014). Commitment devices have been shown to help encourage a range of positive behaviours such as smoking cessation (Gine et al., 2010; Halpern et al., 2015), exercise (Prestwich et al., 2012; Royer et al., 2015) and weight management (Savani, 2018). Pre-commitment via pre-ordering is, therefore, a potentially effective way to mitigate food-related self-control issues, because it compels individuals to make a

decision for their future selves in the absence of stimuli such as hunger or food cues which may deplete self-control (Schwartz et al., 2014). Again, the research on pre-ordering interventions has not yet been reviewed and therefore little is known about the effect of the intervention or the characteristics of the intervention that are associated with effectiveness.

1.9 Summary

During the last half century, there has been a steady increase in obesity rates globally (Ritchie & Roser, 2017), and empirical evidence implicates the environment as a key driver of this trend (Hall, 2018). Reshaping the choice environment to steer individuals towards more healthful choices has proven to be an effective strategy for behaviour change (Arno & Thomas, 2016; Bucher, et al., 2016; Cadario & Chandon, 2017; Harbers et al., 2020; Vecchio & Cavallo, 2019). Modelling studies support a small-changes-approach to energy reduction, indicating that weight gain could be prevented at the population level by reducing energy intake by just 50 kcal (Hill et al., 2003). Given that prompting consumers with swaps has been shown to reduce the saturated fat (Koutoukidis et al., 2019), salt (Payne-Riches et al., 2019) and energy (Bunten et al., 2021) content of grocery baskets successfully in experimental online settings, offering lower-energy swaps may be a potential strategy for achieving small changes in energy intake in canteen settings. Similar to supermarkets, workplace canteens present a strong opportunity for intervention delivery because they provide access to large, diverse pools of people and because working adults in the UK consume over one third of daily energy in the workplace (Vasiljevic et al., 2018). Furthermore, the introduction of new technologies, such as pre-ordering systems for canteens, provide a unique opportunity for choice architecture to be applied. Integrating prompts to swap within pre-ordering websites might be an effective strategy to promote more healthful changes at scale.

However, there remain several unanswered questions to address before such an intervention can be designed and tested in the field. Firstly, it will be important to systematically examine what is already known about pre-ordering and swap-based interventions, particularly in relation to the characteristics of these interventions that are more or less likely to make them effective. Secondly, there is the question of what information should be provided with prompts to swap to maximise swap acceptance. Once these questions have been answered, the intervention will need to be tested to determine whether offering swaps when pre-ordering is an effective strategy to reduce energy ordered in canteen settings.

With this in mind, the work presented in this thesis set out to answer the initial questions in scoping reviews and online studies, and then design and test a pre-ordering system which offers swaps in a field trial with Bupa, a healthcare company. However, due to Covid-19 the trial had to be stopped before randomisation could be conducted. The trial protocol for this work will be presented alongside the two studies that were conducted in lieu of the field trial. These studies will go towards answering some of the key research questions that I intended to address in the field trial. The first of these studies will use a novel qualitative research method to provide insights about the perceived acceptability of the intervention among Bupa employees. The second study will use an online randomised controlled trial with a large sample of UK working adults to provide an estimate of the potential effect of offering lower-energy swaps on the energy of lunches pre-ordered. The next section formally outlines the aim and objectives of this PhD, following these changes.

1.10 Aim and objectives

The aim of this PhD thesis is to investigate the use of swap-based interventions to reduce the energy content of foods and drinks pre-ordered in online canteens.

The specific objectives of this PhD are as follows:

1. To determine what experimental evidence is available on the effect and acceptability of (i) pre-ordering and; (ii) swap-based interventions to improve the healthfulness of dietary choices made by adults. (Chapters 2 & 3).

2. To develop a pilot study that would allow me to explore the acceptability and potential effect of a range of messages, including a calorie, nutrient and health-focused message on the acceptance of lower-energy swaps offered for snacks and drinks with working adults in an experimental online canteen. (Chapter 4).
3. To test whether accompanying lower-energy swaps offered for snacks and drinks with calorie-focused messages (a vague calorie message, a numeric-calorie message and a PACE message) increases swap acceptance among working adults in an experimental online canteen. (Chapter 5).
4. To explore qualitatively with working adults (i) the acceptability of a workplace canteen intervention combining pre-ordering and prompts to swap to lower-energy alternatives with PACE messaging, and; (ii) the factors influencing the acceptance of lower-energy swaps offered. (Chapter 7).
5. To test the effect of offering lower-energy swaps with and without PACE messages on the energy of hypothetical lunches pre-ordered with working adults in an experimental online canteen. (Chapter 8).

Chapter 2

Swap-based interventions to improve the healthfulness of dietary choices: A scoping review of the experimental evidence

2.1 Introduction

Over the last decade, public health campaigns have promoted the idea of "healthier swaps" whereby consumers are encouraged to exchange their usual purchases for healthier alternatives (O'Hara et al., 2011; Stroebele et al. 2009; Wrieden & Levy, 2016). Healthier swaps in this context, typically refer to food or drinks that are lower in salt, fat, sugar or energy. In support of these public health campaigns, UK supermarket chain Ocado created a 'Switch and Save' setting on their website which offered lower-energy swaps to customers (Ocado, 2016). However, to have maximum impact, public health campaigns need to be underpinned by empirical evidence (Lhachimi et al., 2016), both in terms of efficacy and acceptability. Recently, experimental studies examining swap-based interventions have begun to emerge (e.g., Forwood et al., 2015; Koutoukidis et al., 2019; Payne-Riches et al., 2019).

Scoping reviews are particularly useful when examining nascent research because contrary to systematic reviews which tend to focus on a single outcome, scoping reviews allow for evidence to be mapped more broadly (Peters et al., 2015). The purpose of this scoping review is to: (i) determine what experimental evidence is available on the effect of swap-based interventions to improve the healthfulness of dietary choices; and (ii) map the existing evidence to highlight gaps in the literature and help inform the design of the intervention to be tested in this PhD.

2.1.1 Review questions

What experimental evidence is available on the efficacy and acceptability of swap-based interventions to improve the healthfulness of dietary choices?

Sub-questions:

I. What are the characteristics of swap-based interventions?
II. What effect do swap-based interventions have on diet-related outcomes?
III. What study characteristics are associated with intervention efficacy?
IV. How acceptable are swap-based interventions?

2.2 Methods

A study protocol was written and published in advance of the analysis of this review. It can be found on the OFS register website: https://osf.io/rsfjm/; DOI 10.17605/OSF.IO/RSFJM. The JBI methodological guidance for conducting scoping reviews was followed (Peters et al., 2015; 2020). A completed PRISMA checklist can be found in Appendix 2.1 of Additional File 1.

2.2.1 Searching and inclusion criteria

Five electronic databases (PsycINFO, Embase, MEDLINE, Global Health and Web of Science) were searched on the 13th of May 2021. Search terms relating to swaps, food and drink, were developed in consultation with an experienced librarian and validated methodological filters were used to identify randomised controlled trials (RCT) and quasi-experimental studies. Full search strategies for each database can be found in Appendix 2.2 of Additional File 1. Once all searches had been completed, records were downloaded to EndNote and checked for duplicates. Deduplication was conducted in accordance with guidance developed by AUHE Information Specialists at the University of Leeds (Library & Archive Service, 2018). Unique records were then uploaded to Rayyan, a web application for conducting systematic reviews (Ouzzani et al., 2016). Reference lists of included papers were also searched for relevant studies.

RCT and quasi-experimental studies were included when the recommendation to swap was tailored to specific food choice based on either a selected food/drink (when ordering online) or a food/drink potentially about to be ordered (e.g., the participant was considering a specific food product and used a smartphone app to identify potential swaps). Studies where non-tailored recommendations to swap were provided to everyone (e.g., public health campaigns or messaging on food products available), and studies offering smaller portions of the same food were excluded. The latter form of intervention was excluded for a number of reasons. Firstly, this scoping review is being undertaken to inform the design of swap-based interventions to be delivered in a canteen environment. The catering company I worked with as part of the preparation for the field trial described in Chapter 6 manages many canteens across the UK. They informed me that for pre-packaged items such as snacks, drinks and sandwiches, it would not be economical for them to introduce smaller versions of these items while also retaining the original larger versions (meaning that it would not be possible to offer these as swaps). This is because, in contrast to supermarkets, it is most cost effective to have a relatively limited range of popular items in their canteens. In terms of the hot dishes and deli food, they expressed concern about practically implementing half-portions as many of the menu options would be difficult to halve (e.g., it would be challenging to offer half a chicken thigh). Furthermore, from the perspective of the current research, ensuring that canteen staff knew exactly how to serve a half portion and execute this in a uniform manner presented potential implementation and (energy) measurement difficulties. Secondly, there is a wide body of literature on portion size interventions. Including this as a search term in the existing review would have substantially increased the scope of this review. Given that I did not intend to test the effect of offering smaller portion sizes due to the aforementioned practical reasons, the inclusion of such studies was deemed beyond the scope of the current review.

The term ‘more healthful’ was used to refer to studies that attempted to reduce the selection of target foods and/or drinks (e.g., items high in energy, salt, sugar) or increase the selection of target foods and/or drinks (e.g., fruit, vegetables, water). Only studies that provided evidence relating to the potential efficacy of a swap-based intervention in changing the selection of target foods and/or drinks were included. This is because the objective of this review was to map the empirical evidence for the

potential effectiveness of swap-based interventions for improving diets. Evidence for the acceptability of swap-based interventions was also collected but studies were not excluded if they did not report on this.

2.2.2 Screening and data extraction

Records were screened by two reviewers independently at both the title/abstract stage and the full-text stage using Rayyan (Ouzzani et al., 2016). Data were extracted using a predefined extraction form that was piloted with one study prior to the formal screening process (Appendix 2.3, Additional File 1). In these forms, intervention details were reported using the items from the TIDieR checklist (Hoffmann et al., 2014).

2.2.3 Analysis

Formal assessments of risk of bias (study quality) were conducted using the Cochrane Risk of Bias (RoB) measurement tool for randomised trials (Higgins et al., 2011). To assess each study, the tool provides researchers with a series of signalling questions across five key RoB domains. The domains are as follows: Risk of bias arising from; (i) the randomisation process; (ii) deviations from the intended interventions (*effect of assignment to intervention*); (iii) missing outcome data; (iv) measurement of the outcome and; (v) selection of the reported result. Based on the responses (yes, probably yes, probably no, no or, no information) provided by the researcher to these signalling questions, the tool's algorithm designates the study's RoB as 'high', 'some concerns', or 'low' within each domain. The signalling questions asked in each domain can be found in Additional File 1. For domain (iii) missing outcome data, a threshold of $\geq$80% completion for outcome data was set prior to the RoB assessment. This relatively high threshold was based on the fact that the vast majority of studies in this review are short online studies with no follow-up period reducing the likelihood of attrition.

Neither meta-analysis nor quantitative synthesis of outcome data were conducted. Data were charted and results relating to the research questions were tabulated and summarised. For ease of comparison between studies, standardised means (Cohen's

d) were calculated by dividing raw mean differences by the standard deviation reported. In studies where the standard deviation was not reported, standard Cochrane methods were used to estimate it based on reported mean, confidence intervals (or t-values), p-values and sample sizes using Review Manager version 5.4 (Review Manager, 2020) and corresponding 95% confidence intervals were calculated in RStudio 1.3 (RStudio Team, 2020). Cut-offs for effect sizes (Cohen's *d*) are as follows: small: *d*= 0.2; medium: *d*= 0.5; Large: *d*=0.8.

2.3 Results

After deduplication, 4,212 papers were put forward for title/abstract screening. Following title/abstract screening, 61 papers were put forward for full text-review. Of these papers, 54 were excluded. The reference lists of all 7 papers that met the criteria for inclusion were subsequently searched by hand (n=303 titles/abstracts), and 4 previously unidentified papers were put forward for full-text review, one of which was deemed eligible for inclusion. A total of 8 studies were included (Figure 2.1). Table 2.1 provides a summary of key information extracted from each paper. Full extraction tables can be found in Appendix 2.3, Additional File 1. Findings from these extractions are presented in accordance with (i) the setting in which food/drink selections were made (i.e., hypothetical or real-world), (ii) dietary outcome measured, and; (iii) descending sample size.

2.3.1 Setting

Of the 8 studies included, 4 were hypothetical choice experiments which took place in simulated online supermarkets (Bunten et al., 2021; Forwood et al., 2015; Koutoukidis et al., 2019; Payne-Riches et al., 2019). The remaining 4 studies took place in settings where participants were making actual food/drink selections. Of these 4 remaining studies, one was a real online supermarket (Huang et al., 2006), and three were made in physical supermarkets (Eyles et al., 2017; Winett etal., 1991; Dorsch et al, 2020).

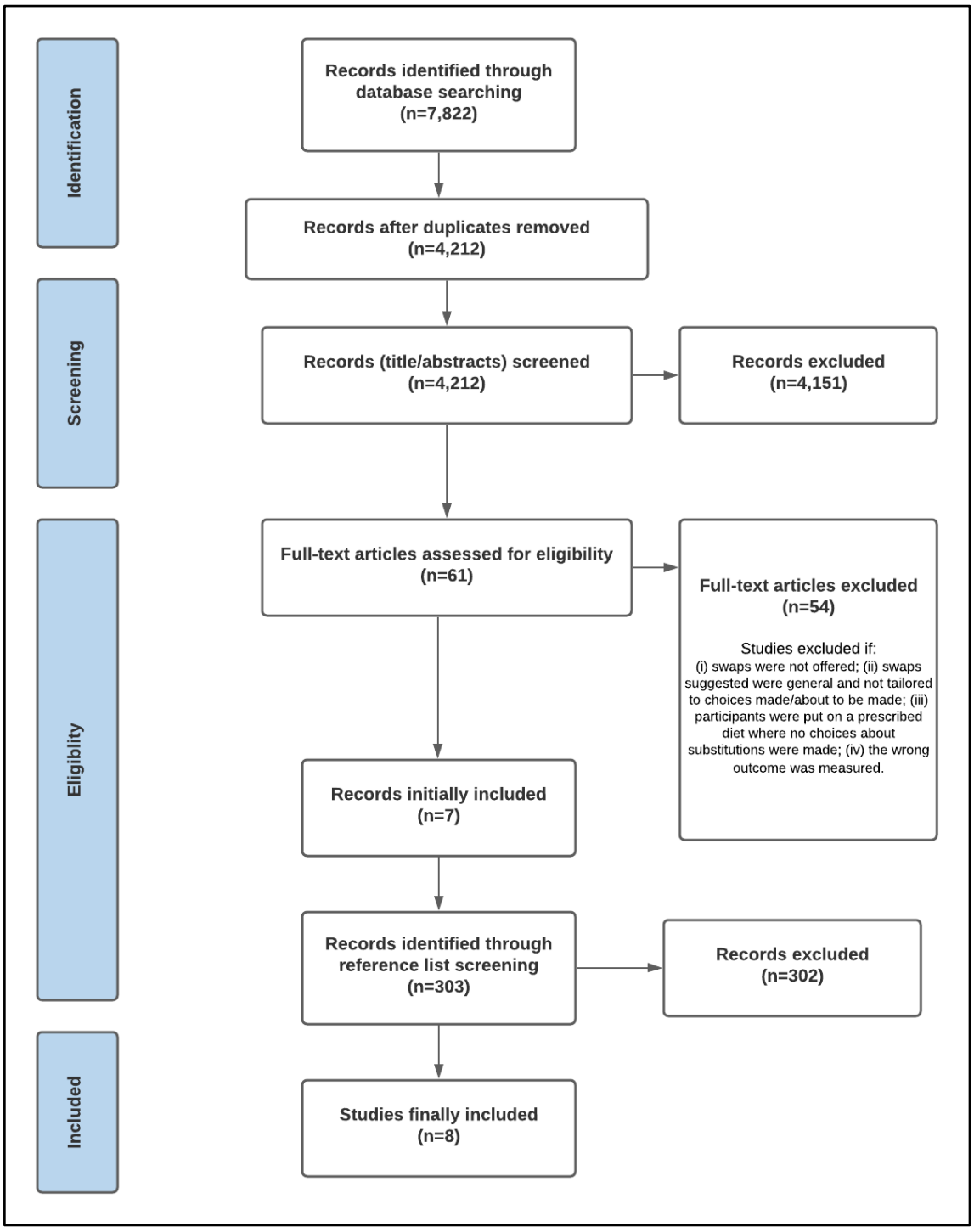


Figure 2.1: PRISMA Inclusion Flowchart

Table 2.1: Description of studies testing swap-based interventions

Title & authors (year)	Study design	Intervention details	Swap acceptance findings	Diet related findings	Acceptability findings
Hypothetical					
1. Prominent positioning and food swaps are effective interventions to reduce the saturated fat content of the shopping basket in an experimental online supermarket: a randomized controlled trial. Koutoukidis, D. A., Jebb, S. A., Ordóñez-Mena, J. M., Noreik, M., Tsiountsioura, M., Kennedy, S., ... & Piernas, C. (2019).	RCT 4 arms: (i) products within a category were displayed in ascending order of saturated fat (SFA) content (ii) swaps lower in SFA were offered for initial choices (iii) a combination of both interventions (iv) no intervention (control). n randomised = 1,240 n analysed = 1,088	Simulated online supermarket which either: (i) allowed products to be displayed according to **SFA** content or (ii) automatically offered similar lower SFA alternatives to participants for initially selected items or (iii) a combination of (i) and (ii). Only one lower SFA swap was offered for each selection and swaps were offered at the point-of-choice.	On average, 14% of swaps offered were accepted. Those offered swaps were offered a median of 7 (inter-quartile range (IQR) = 4) swaps. The percentage of participants who accepted at least one swap was 63% in the swaps group.	Compared with no intervention, offering an explicit swap with lower SFA (*n* = 279) reduced % energy from SFA by 2.0% (95% CI: -3.3 to -0.6). There were no significant differences between groups for other dietary outcomes assessed: Energy density = -7.91 kcal/100g (95% CI: -17.97 to 2.16); Sugar, % energy= -0.03% (95%CI: -1.25 to 1.19); Salt = 0g/100g (95%CI: -0.02 to 0.02)	Of those offered swaps, 76% 'strongly' or 'somewhat' agreed that swaps are a feature that they would like to see in their usual shopping with only 10% disagreeing, and the rest being indifferent to this feature.

Title & authors (year)	Study design	Intervention details	Swap acceptance findings	Diet related findings	Acceptability findings
2. Optimising swaps to reduce the salt content of food purchases in a virtual online supermarket: A randomised controlled trial. Panye-Riches, S., Aveyard, P., Piernas, C., Rayner, M., & Jebb, S. A. (2019).	RCT 2 arms: (i) Lower salt swaps (LS): participants were offered one swap for each initial selection that was slightly lower in salt (ii) Much lower salt swaps (MLS): participants were offered two swaps for each initial selection. The first was a lower-salt swap described above. The second was a swap much lower in salt. n randomised = 2,021 n analysed = 949	Simulated online supermarket which automatically offered lower-**salt** alternatives to participants for initially selected items. LS contained between 5% and 20% less salt (g/100g). Swaps offered were similar to the initially selected item meaning they were from the same food category and subcategory (based on supermarket categorisation) as initially selected items. MLS contained at least 21% less salt than the initially selected item and from the same food category, but not limited to the same subcategory (i.e.,	On average, 34% of swaps offered were accepted. In the LS group the average number of swaps accepted per participant was 0.34 (SD=28). In the MLS group it was 0.33 (SD=26). Mean difference = -0.01 (-0.04 to 0.03, p=0.62) The MLS group was offered almost twice as many swaps with 15.7 swaps compared with 8.4 in the LS group (Incidence Rate Ratio (IRR): 1.86, 95% CI: 1.79, 1.93, p< 0.001) and accepted a significantly higher number of offered swaps, 4.39 compared to 2.69 in the LS group (IRR 1.64, 95% CI: 1.53, 1.76 p< 0.001).	There was a significant reduction in the salt density of the final shopping basket in both intervention groups: LS (-0.04g/100g, 95% CI: -0.04 to -0.03, p< 0.001); MLS (-0.13g/100g, 95% CI: -0.14 to -0.11, p< 0.001); with a significantly greater reduction in the MLS group compared to the LS group (-0.09g/100g, 95% CI: -0.10 to -0.07, p< 0.001). Exploratory findings: There was a significantly larger decrease in total energy in the shopping basket post-swaps in the MLS group (-408 kcal (95% CI: -607 to -213, p< 0.001). There were very small changes in saturated fat and	70% of all participants 'strongly' or 'somewhat' agreed that this type of swap intervention is something they would like to see when they do their usual shopping and 7% somewhat or strongly disagreed. Increasing acceptability of the intervention was associated with a greater reduction in salt in the total shopping basket; -0.04g/100g (95% CI: -0.05 to -0.03, p< 0.001) greater reduction in salt with each increasing category of acceptance.

Title & authors (year)	Study design	Intervention details	Swap acceptance findings	Diet related findings	Acceptability findings
		out-of-category swaps).	In the MLS group, 68% of accepted swaps were MLS swaps. 30% of MLS swaps offered were out-of-category products.	sugar in the final basket, with a significant between group difference of -0.08 g/MJ (95% CI: -0.16 to -0.01 p= 0.023) for saturated fat; and -0.12 g/MJ (95% CI: 0.00 to -0.25 p= 0.043) for sugar.	
3. Offering within-category food swaps to reduce energy density of food purchases: a study using an experimental online supermarket. Forwood, S. E., Ahern, A. L., Marteau, T. M., & Jebb, S. A. (2015).	RCT 5 arms: (i) consented swaps at point-of-choice (ii) consented swaps at checkout (iii) imposed swaps at point-of-choice (iv) imposed swaps at checkout. (v) no swap control condition n randomised = 1,610 n analysed = 720	Simulated online supermarket with lower **energy** density (ED) swaps offered at different stages (at point-of-choice or at the checkout) during the shopping task. The inclusion of swaps within the site was framed as either something participants had consented to or as something imposed on participants. Each swap presented two lower ED options.	Median 1 (IQR 0-2) out of 4 swaps were accepted. More swaps were accepted when offered at point-of-choice than at checkout (Odds Ratio (OR) = 1.2, 95% CI: 1.11 to 1.35, p< 0.001). No differences were seen with consent.	Offering lower ED swaps did not significantly reduce the energy density (ED) of food purchases (-6 kcal/100g, 95%CI: -12 to 0.96, p= 0.094).	Ratings given to the overall shopping experience were significantly better for participants in the intervention groups than in the control group (effect size: 0.36, 95% CI: 0.08 to 0.63, p= 0.01), and significantly better for consented swaps than imposed swaps (effect size: 0.33, 95% CI: 0.02 to 0.63, p= 0.039.
4. A randomised experiment of	RCT	Simulated online supermarket. When	Participants were offered a mean of	Offering swaps reduced energy	Acceptability of the intervention was

Title & authors (year)	Study design	Intervention details	Swap acceptance findings	Diet related findings	Acceptability findings
health, cost and social norm message frames to encourage acceptance of swaps in a simulation online supermarket. Bunten, A., Porter, L., Sanders, J. G., Sallis, A., Payne Riches, S., Van Schaik, P., ... & Forwood, S. (2021).	3 arms: Swaps offered are accompanied by one of the following messages: (i) the health benefits: 'swap to save calories'. (ii) cost benefits: 'swap to save money'. (iii) social norms: 'swap to this product chosen by customers who buy similar groceries to you'. n randomised = 900 n analysed = 713	a target high-**energy** food was identified in the shopping basket at the checkout, one or two (if available) lower-energy swaps would be offered. A pop-up appeared which presented a thumbnail image of the originally chosen product on the left and the suggested alternative(s) displayed on the right. At the top of the pop-up window, one of the 3 messages was displayed.	3.17 swaps (SD = 1.50), and 12.91% of swaps were accepted (health = 14.31%, cost = 11.49%, social norms = 13.18%). With the health frame condition as a baseline, framing the benefits in terms of cost (p= 0.455) or social norms (p= 0.175) did not significantly increase the likelihood of accepting a swap.	(kcal) per product by -9.69 kcal (p= 0.017). The average total energy reduction of 30 kcal between original choices (M= 3623 kcal, SD= 748) and final purchases (M= 3595 kcal, SD= 749) was significant (p<0.001). The difference between original products and final purchases was not moderated by either the cost frame (p= 0.808) or the social norms frame (p= 0.949) relative to the health frame. A significant reduction in grams of saturated fat in the total basket was observed (MChange = -1.09g, SD = 5.52g, p<0.001), but there	relatively high, with participants' mean rating of the intervention being equivalent to stating that they would "somewhat like" to be offered swaps in real life.

Title & authors (year)	Study design	Intervention details	Swap acceptance findings	Diet related findings	Acceptability findings
				was no significant changes in grams of sugar (MChange = 0.14g, SD = 6.12g, p= 0.555) or grams of salt (MChange = 0.28g, SD = 6.89g, p= 0.281) in total baskets.	
Real-world					
1. The effects on saturated fat purchases of providing internet shoppers with purchase-specific dietary advice: a randomised trial. Huang, A., Barzi, F., Huxley, R., Denyer, G., Rohrlach, B., Jayne, K., & Neal, B. (2006).	RCT 2 arms: (i) Tailored advice: online shoppers were prompted to replace specific items in their shopping basket with alternatives lower in saturated fat. (ii) General dietary advice (control condition): online shoppers were directed to a web page with information about	A software program for a real-world online supermarket was developed that enabled swaps lower in **saturated fat** to be automatically offered to online shoppers. Swaps were presented with a side-by-side on-screen presentation of the original item and the suggested alternative lower in saturated fat for each eligible item in their basket. All swaps (and general dietary advice for	Not reported	The amount of saturated fat in the food purchased by those offered swaps was a mean of 0.66% (95% CI: 0.48 to 0.84, p= 0.001) lower than in the corresponding foods purchased by the control group.	Not reported

Title & authors (year)	Study design	Intervention details	Swap acceptance findings	Diet related findings	Acceptability findings
	how to choose a diet lower in saturated fat. n randomised = 497 n analysed = 456	control) were presented at once just before the checkout.			
2. Altering shoppers' supermarket purchases to fit nutritional guidelines: An interactive information system. Winett, Moore, Wagner, Hite, Leahy, Neubauer & Mundy, (1991).	RCT 2 arms: (i) experimental participants used the Nutrition for Life System (NLS) - a prototype interactive information system. Users could enter their intended food purchases into the NLS and receive a printed shopping list with suggested swaps lower in fat and/or higher in fibre. (ii) Control participants entered intended food purchase data but received	The NLS is a prototype interactive information system comprising a colour-monitor with built-in scanner and printer that was set-up in a kiosk in a real-world supermarket. Participants entered their intended food purchase data into the NLS during their main weekly shopping. Suggested substitutes for an item appeared next to the selected item on the printed shopping list. Participants also received praise for new purchases of **lower fat or higher fibre** products and	Not reported	During the intervention: The intervention group ordered: - 37% less high-fat meat than control ($p < 0.001$). - 62% more high-fibre grains/cereals ($p < 0.001$) - 20% less high-fat dairy ($p < 0.05$) These changes remained similar at follow-up.	NLS users reported high satisfaction with the NLS and use of the suggested strategies (purchase and meal changes). Store personnel and managers reported liking the NLS because the system did not disrupt store operations. It is unclear how these were measured

Title & authors (year)	Study design	Intervention details	Swap acceptance findings	Diet related findings	Acceptability findings
	no swaps and could not view intervention content. n randomised = 77 n analysed = 69	could watch videos about nutrition at the Kiosk. Shopping receipts were used to track purchases.			
3. A salt-reduction smartphone app supports lower-salt food purchases for people with cardiovascular disease: findings from the SaltSwitch randomised controlled trial. Eyles, H., McLean, R., Neal, B., Jiang, Y., Doughty, R. N., McLean, R., & Ni Mhurchu, C. (2017).	RCT 2 arms: (i) use of the SaltSwitch app. (ii) control group continued to shop as normal and were able to access usual care cardiac rehabilitation services for people with Cardiovascular Disease in New Zealand n randomised = 66 n analysed = 66	SaltSwitch enables users to make lower salt food choices by scanning the barcode of a packaged food using their smartphone camera to receive an immediate interpretive, traffic light nutrition label on screen, along with a list of lower **salt** alternatives to switch to. Intervention participants also received weekly reminder text messages to encourage them to use the app when grocery shopping. Shopping receipts	Not reported	Over the 4-week intervention, participants using the SaltSwitch app purchased significantly less salt (adjusted mean= 0.7g/MJ, 95% CI: 0.52 to 0.88) than those assigned to control (1.00g/MJ, 95% CI: 0.80 to 1.20). Group difference (-0.30g/MJ, 95% CI: -0.58 to -0.03, p= 0.03). There were no significant differences between groups for other nutrient outcomes assessed at 6 weeks: Energy	Of the 24 participants who responded to the (non-mandatory) question on intervention usability, 18 (75%) reported finding SaltSwitch very easy to use, and a further 4 found it somewhat easy to use. All 24 shoppers felt SaltSwitch was a good way to help shoppers to make lower salt food purchases.

Title & authors (year)	Study design	Intervention details	Swap acceptance findings	Diet related findings	Acceptability findings
		were used to track purchases.		density (kcal/g): adj mean difference =0.21 kcal/g, 95% CI: -0.097 to 0.51); Total fat (g/MJ): adj mean difference = 0.14, 95% CI: -1.7 to 2.0); Saturated fat (g/MJ): adj mean difference = 0.33, 95% CI: -0.7 to 1.4. Sugars (g/MJ): adj mean difference = 0.61 (95% CI: -2.6 to 3.8)	
4. Effects of a novel contextual just-in-time mobile app intervention (LowSalt4Life) on sodium intake in adults with hypertension: pilot randomized controlled trial.	RCT 3 arms: (i) App users: received push notifications and could search lower-salt alternatives for grocery products and menu items via the app.	The mobile app provided users with the ability to scan the universal product codes of grocery store items to find similar food options containing lower **sodium** contents. The app also had other features.	Not reported	Participants using the LowSalt4Life app had a greater reduction in their dietary sodium intake than control. The change in the estimated sodium intake by the 24-hour dietary recall and the food frequency questionnaire was -	In the survey of the 24 participants who used the app, 19 (79%) agreed that they found the app useful, 19 (79%) agreed that they used the information in the app in their daily life, 17 (71%) agreed that the information they received in the app was important to them, and 20 (83%)

Title & authors (year)	Study design	Intervention details	Swap acceptance findings	Diet related findings	Acceptability findings
Dorsch, M. P., Cornellier, M. L., Poggi, A. D., Bilgen, F., Chen, P., Wu, C., ... & Hummel, S. L. (2020).	(ii) Control group: no app. n randomised = 50 n analysed = 48			1553mg (SD= 1764) in the App group compared to -515mg (SD= 1081) in the No App group (P=0.01). The change in the Kawasaki-estimated 24-hour urinary sodium excretion calculated from spot urine was -462mg (SD=1220) in the app group vs -381mg (SD=1460) in the control group, p=0.03.	agreed the app was easy to use. Only 3 (13%) participants found the app confusing and 1 (4%) found the app difficult to understand.

2.3.2 Participants

Only studies recruiting adult participants were included in this review. The average age of participants ranged between 40 (SD=10) (Huang et al., 2006) and 65 (SD=7) (Eyles et al. 2017) years across studies. Between 17% (Eyles et al., 2017) and 88% (Huang et al., 2006) of participants were female across studies. In the 4 studies that reported ethnicity, between 80% (Dorsch et al., 2020) and 90% (Koutoukidis et al., 2019) of participants were White/Caucasian. Six studies reported BMI (in kg/m2, mean/SD format); average BMI ranged between 26.5 (SD=8) (Huang et al., 2006) and 28.5 (SD=4) (Eyles et al., 2017) across studies. Seven studies reported the education level of participants, between 35% (Forwood et al., 2016) and 66% (Koutoukidis et al., 2019) of participants in these studies had completed University education.

Five studies had inclusion criteria or recruitment settings that specifically targeted certain groups. In particular, 3 studies included participants with diet-related health conditions, such as hypertension (Dorsch et al,, 2020), high cholesterol (Payne-Riches et al., 2019) and cardiovascular disease (Eyles et al., 2017). The other 2 studies included customers of a specific supermarket (Winett et al., 1991; Huang et al, 2006). Of the 8 studies included, 4 were conducted in the UK, 2 in the USA, 1 in New Zealand, and 1 in Australia.

2.3.3 Comparators & outcomes

All 8 studies included were randomised controlled trials. In 6 of the 8 studies, swap-based interventions had a control (no swaps-intervention) comparator. In two studies the comparator was a variation of a swap-based intervention. In one study, the comparison was between groups offered swaps slightly lower in salt versus much lower in salt (Payne-Riches et al., 2019). In the other study, the comparison was between groups offered swaps accompanied by different messages, within which the health-based message was used as the control condition (Bunten et al., 2021).

In 7 of the 8 studies, the primary outcome was purchasing behaviour (real or hypothetical). In the real-world studies, this was measured objectively via checkout receipts or transaction data (Eyles et al., 2017; Huang et al., 2006; Winett et al., 1991). In the studies for which purchasing behaviour was the primary outcome, 2 studies

measured swap acceptance along with energy purchased (Bunten et al., 2021; Forwood et al., 2015). Two studies measured saturated fat (Huang et al., 2006; Koutoukidis et al., 2019), 2 studies measured salt (Eyles et al., 2017; Payne-Riches et al., 2019), and a final study measured purchasing of target foods (e.g., low in fat) as the primary outcome (Winett et al., 1991). In one study, the primary outcome was sodium[3] intake (Dorsch et al., 2020). This was measured both subjectively using dietary recall tools (Automated Self-Administered 24-hour dietary assessment tool and the Food Frequency Questionnaire, 2014) and objectively using the Kawasaki-estimated 24-hour urinary sodium excretion calculated from spot urine.

2.3.4 What are the characteristics of swap-based interventions?

a. Swaps offered

In all 8 studies, participants were offered swaps for grocery shopping items. Of these studies, lower-salt swaps were offered in 3 (Dorsch et al., 2020; Eyles et al., 2017; Payne-Riches et al., 2019), lower fat/saturated fat swaps were offered in 3 (Huang et al., 2006; Koutoukidis et al., 2019; Winett et al., 1991) and lower-energy swaps were offered in 2 (Bunten et al., 2021; Forwood et al., 2015) studies.

In all four simulated online supermarket studies, participants were offered "within-category" swaps, meaning that swaps offered were belonging to the same category as defined by the 'shelf' location commonly used by online supermarket retailers (Bunten et al., 2021; Forwood et al., 2015; Koutoukidis et al., 2019; Payne-Riches et al., 2019). In one of these studies 'out-of-category' swaps (i.e., swaps not from the same subcategory) were also offered (Payne-Riches et al., 2019). Swaps offered via the SaltSwitch app were from the same narrow product category (Eyles et al., 2017), but this was not defined. In one study, swaps offered were from the same food category according to the categorisations of the USDA (1989) (Winett et al., 1991). In some cases, the nature of swaps offered was not explicitly discussed but examples given (e.g., skim milk for whole milk) would indicate that swaps offered were within-category (Huang et al., 2006). Table 2 outlines the criteria for swaps offered by study.

[3] Salt is made of sodium (40%) and chloride (60%). It is the sodium component of salt that is detrimental to health when excessively consumed.

In the majority of studies, more than one alternative was presented to the participant if available (Bunten et al., 2020; Dorsch et al., 2020; Eyles et al., 2017; Forwood et al., 2015; Payne-Riches et al., 2019). This was particularly true of the SaltSwitch and LowSalt4Life apps, through which several alternatives could be presented (Dorsch et al., 2020; Eyles et al., 2017).

Table 2.2: Criteria for swaps offered by study

Study	**Dietary outcome**	**Swap Criteria**	
Hypothetical			
1. Koutoukidis et al., (2019).	Saturated fat	- 1 swap offered per product. - From the same category as the initially selected food. - 2 percentage points less SFA (i.e. 2 g less SFA per 100 g of product) and; - Between 60 and 140% of the weight and; - Between the same price and 200% of the price of the original product.	
2. Panye-Riches et al., (2019).	Salt	<u>Lower salt intervention (LS)</u> - 1 swap offered - From the same category and subcategory* - 5% and 20% less salt (g/100g)	<u>Much lower salt (MLS)</u> - 2 swaps offered - From the same category - At least 21% less salt
		- Between half and double the pack weight and price	
3. Forwood et al., (2015).	Energy	- 2 swaps offered per product if available. - From the same category as the initially selected food. - At least 100 kJ (24 kcal) /100 g lower in energy density and; - between 90 % and 110 % of the weight and; - between 90 % and 110 % of the price of the original product.	
4. Bunten et al., (2021).	Energy	- 2 swaps offered per product if available - From the same category as the initially selected food. - At least 100 kJ (24 kcal) /100 g lower in energy density and; - between 90 % and 110 % of the weight and; - cost less than the originally selected food by a maximum of 20% (no minimum difference limit was imposed).	

Study	Dietary outcome	Swap Criteria
Real-world		
1. Huang et al., (2006).	Saturated fat	- 1 swap offered per product. - Similar (but unspecific). - Lower in saturated fat by an unspecified amount - Food items that were not pre-packaged, such as some meat products, were excluded.
2. Winett et al., (1991).	Fat, fibre*	- 1 swap offered per product. - From the same food category. There were 13 categories. The placement of a food item in a category was based on food type and nutritional content, using standard sources e.g., USDA, 1989. - Lower in fat or higher in fibre by an unspecified amount based on a table look up procedure.
3. Eyles et al., (2017)	Salt	- Unspecified number of swaps offered per product. - From the same product category - Swap offered is based on the overall nutrient profile score & the health star rating. The algorithm adapts the results based on the amount of salt. No minimum reduction specified. - Uses the traffic light signals to provide information on alternatives.
4.Dorsch et al., (2020)	Salt	- Unspecified number of swaps offered per product. - Unspecified similarity - No minimum reduction specified. - Uses the using a traffic light signal red (≥480 mg/serving), yellow (≥120 mg/serving to <480 mg/serving), and green (<120 mg/serving) to show consumers, whether a product is high, medium, or low in sodium.

*The actual outcome was: choice of a food low in fat or high in fibre. Fat and fibre in grams was not reported.

b. Mode of intervention delivery

In 5 of the 8 studies, participants were automatically prompted with substitution suggestions when shopping online for groceries. In 2 studies, participants could actively search for information on potential alternatives via a dedicated smartphone application. In one of these studies, the only way for participants to gain this information was by using the app to scan the barcode of items they intended to purchase at the supermarket (Eyles et al., 2017). In the other, participants could scan items but also received push notifications reminding them about alternatives for frequently purchased high-sodium items while in supermarkets (Dorsch et al., 2020). In the final study, participants had to enter a list of their intended purchases into a dedicated computer at the supermarket and then received a printed version of their shopping list with suggested alternatives to items high in saturated fat/low in fibre, highlighted (Winett et al., 1991).

Among the studies conducted in online supermarket settings, swap-based interventions were automatically delivered almost immediately after food/drink selections were made. In two studies, one real-world (Huang et al., 2006) and one hypothetical (Bunten et al., 2021), consumers were prompted to swap at the checkout. In two simulated supermarket studies, swaps were offered at the point-of-choice (Koutoukidis et al., 2019; Payne-Riches et al., 2019). In the other simulated supermarket study, swaps were offered at either the point-of-choice or the checkout depending on the experimental condition (Forwood et al., 2015). This study reported that swaps were more likely to be accepted when offered at the point-of-choice compared to when offered at the checkout (OR 1.2, 95%CI: 1.11 to 1.35, $p < 0.001$).

c. Framing prompts to swaps

In almost all of the studies, participants were made aware of the reason why they were being offered alternatives, however, the way in which this information was delivered varied between studies. In the online supermarket setting, three studies informed participants at the outset that they might be offered lower-energy (Forwood et al., 2015), lower-saturated fat (Koutoukidis et al., 2019) or lower-salt (Payne-Riches et al., 2019) alternatives for their selected items but only one of these studies re-emphasized

this information when swaps were offered (Payne-Riches et al., 2019). In this study, each time a swap was presented, the percentage reduction in salt content was displayed beside the alternative (Payne-Riches et al., 2019). When swaps were offered in the real-world supermarket study (Huang et al., 2006), they were explicitly framed as "low-fat alternatives" but details on the specific amount of fat saved was not provided. Similarly, in the final supermarket study, some swaps offered were explicitly framed as lower-energy with participants being invited to "swap to save calories" (Bunten et al., 2021). This study compared the effect of framing swaps in terms of health (i.e., calories) against framing swaps as cheaper "swap to save money" or as popular "swap to this product chosen by customers who buy similar groceries to you". This study found that swap acceptance was not influenced by the specific swap frame used (health = 14.31%, cost = 11.49%, social norms = 13.18%, all $p > 0.170$).

In one real-world supermarket study, participants were directed to a custom designed kiosk in a supermarket with a sign that read "Nutrition for Life". This provided printed shopping lists with substitution suggestions in which lower fat and higher fibre items were indicated on shopping lists by assigning a red asterisk next to their names. Participants were also congratulated on their printout for buying lower fat items or higher fibre items and avoiding lower fibre and higher fat items (Winett et al., 1991). In both studies where swap suggestions were delivered via smartphone apps, swaps were explicitly framed as lower in salt and the exact salt content (plus other key nutrient content) of each alternative available was presented in the traffic light labelling system format for ease of interpretation (Dorsch et al., 2020; Eyles et al., 2017).

2.3.5 What effect do swap-based interventions have on diet-related outcomes?

Of the 8 studies included in this review, 7 reported a significant effect of the intervention on the primary dietary outcome. Two studies tested the effect of swap-based interventions on energy purchased (Bunten et al., 2021; Forwood et al., 2015). One of them reported a significant reduction (Bunten et al., 2021). Two studies measured saturated fat and both reported significant reductions (Huang et al., 2006; Koutoukidis et al., 2019). One study measured the purchasing of target foods such as lower-fat products and reported significant differences between those offered swaps and those who were not (Winett et al., 1991). All three studies measuring salt

purchased reported significant reductions (Dorsch et al., 2020; Eyles et al., 2017; Payne-Riches et al., 2019). Some studies reported on changes in multiple dietary outcomes as secondary measures. Of these studies, 3 measured energy (Eyles et al., 2017; Koutoukidis et al., 2019; Payne-Riches et al., 2019) and one reported significant reductions (Payne-Riches et al., 2019), 3 measured saturated fat purchased (Bunten et al., 2021; Eyles et al., 2017; Payne-Riches et al., 2019), and 1 reported significant reductions (Bunten et al., 2021). Two studies measured salt purchased (Bunten et al., 2021; Koutoukidis et al., 2019) and neither study reported evidence of significant changes. Four studies measured sugar purchased and none of these studies reported evidence of change (Bunten et al., 2021; Eyles et al., 2017; Koutoukidis et al., 2019; Payne-Riches et al., 2019). Table 2.3 provides a summary of standardised effect sizes for changes in dietary outcomes examined in this review. The effect of the swap-based interventions on the: (a) energy and energy density, (b) salt, (c) fat & saturated fat and, (d) sugar content of products selected are discussed below.

a. Energy and energy density

Reducing energy purchased was the primary dietary objective of 2 studies included in this review (Bunten et al., 2021; Forwood et al., 2015). Both of these were conducted in simulated supermarkets, only 1 reported a significant average energy reduction of the total basket of -30 kcal ($p<0.001$) between original choices (mean= 3623 kcal, SD= 748) and final purchases (mean= 3595 kcal, SD= 749) (Bunten et al., 2021). The other study reported a non-significant reduction of -6kcal/100g (95% CI: to -12 to 0.96, $p=0.094$) in the total energy density of the basket of foods purchased by participants after swaps were offered (Forwood et al., 2015).

Of the 3 other studies in which change in energy was examined, but was not the primary dietary outcome (Eyles et al., 2017; Koutoukidis et al., 2019; Payne-Riches et al., 2019), only one study reported a significant reduction in energy ordered between groups (Payne-Riches et al., 2019). The comparator group in this study, however, was not a control group but rather received a variation of a swap-based intervention. This study reported that offering swaps much lower in salt, resulted in a significantly larger decrease in total energy in shopping baskets after swaps were offered of -408 kcal

(95% CI: -606 to -210, p< 0.001) compared with when a swap slightly lower in salt was offered.

b. Salt

Reducing salt purchased or consumed was the primary objective of 3 studies included in this review. In two of these studies, participants could search for lower-salt alternatives via a smartphone application (Dorsch et al., 2020; Eyles et al., 2017). Both studies reported significant reductions in salt purchased. Those using the SaltSwitch app while grocery shopping purchased significantly less salt (-0.3g/MJ, 95% CI: -0.58 to -0.03, p=0.03) than the control group, equating to a reduction of ~0.7g per person per day during the 4-week intervention phase (Eyles et al., 2017). Similarly, those using the LowSalt4Life app consumed significantly less salt while using the app (Dorsch et al., 2020). The estimated change in sodium intake from baseline to the 8-week follow-up was -1.5g (SD 1.8g) in the app group compared to -0.5g (SD 1.1g) in the control group, an estimated difference in change between groups of -1g (SD=2.85, p=0.01). In the other study, participants completed a hypothetical supermarket shop online and were offered either one alternative slightly lower in salt or they were offered two alternatives, one slightly lower in salt and the other much lower in salt than the originally selected item. Those offered swaps much lower in salt ordered on average 0.9g/100g (95% CI: -0.10 to -0.07; p< 0.001) less salt than those offered swaps that were slightly lower in salt (Payne-Riches et al., 2019).

A further 2 studies measured changes in salt as a secondary outcome measure, but neither found evidence of significant differences between groups in salt purchased (Bunten et al., 2020; Koutoukidis et al., 2019).

c. Fat & saturated fat

Both studies measuring saturated fat reported significant reductions in saturated fat purchased. One of the studies conducted in a simulated online supermarket found that offering swaps reduced saturated fat purchased by 2.0% (95% CI: 0.6 to 3.3) compared with when swaps were not offered (Koutoukidis et al., 2019). The other real-world online supermarket study also reported a significant reduction of 0.66% (95%

CI: 0.48 to 0.84, p< 0.001) in saturated fat when swaps were offered compared with control (Huang et al., 2006).

In one study the primary objective was to reduce fat (i.e., not just saturated fat) and increase fibre purchased in supermarkets but this was measured by examining changes in the purchasing of target foods such as low and high fat products or high-fibre grains/cereals (Winett et al., 1991). This study reported significant reductions in the amount of high-fat meat (37%, p<0.001) and high-fat dairy (20%, p<0.05), and significant increases in the amount of high-fibre grains/cereals (62%, p<0.001) purchased by those offered swaps compared with control.

A further 3 studies reported on changes in fat as a secondary outcome measure. Bunten et al., (2021) aimed to reduce the total energy (in kcal) content of shopping baskets, but found a significant change in the saturated fat content in the total shopping basket after swaps were offered (mean change = -1.09g, SD = 5.52, p<0.001). Payne-Riches et al., (2019) aimed to reduce the salt content of shopping baskets, but also reported a small significant change in saturated fat in the final basket of those offered swaps much lower in salt (-0.08g/MJ (95% CI: -0.16 to -0.01, p= 0.023), but the comparator group was those offered slightly lower salt alternatives. There were no significant differences reported between intervention and control groups for total fat or saturated fat purchased among those using the SaltSwitch app (Eyles et al., 2017).

d. Sugar

No studies have yet aimed to reduce sugar intake by swaps, but four studies reported on sugar purchased as a secondary/exploratory outcome. Only one study found evidence of a significant change in sugar in the final basket of 0.12 g/MJ (95% CI: 0.00 to 0.25 p = 0.043), but this was between groups offered lower versus much lower salt alternatives (Payne-Riches et al., 2019).

Table 2.3: Standardised means (Cohen's d effect sizes) for change in dietary outcomes.

Author	n	Raw effect size	SD	Standardised mean (Cohen's *d* effect size)	95% CI
Energy					
Bunten et al., (2021)	713	-30 kcal	86	-0.35	-0.42 to -0.27*
Forwood et al., (2015)	720	-6kcal/100g	95	-0.06	-0.13 to 0.01
Eyles et al., (2017)	66	0.21 kcal/g	1.25	0.17	-0.07 to 0.41
Koutoukidis et al., (2019)	554	-7.9/100g	121	-0.07	-0.09 to 0.08
Payne-Riches et al., (2019)	947	-408 kcal	3105	-0.13	-0.19 to -0.07*
Salt					
Payne-Riches et al., (2019)	947	-0.09g/100g	0.31	-0.29	-0.35 to -0.22*
Eyles et al., (2017)	66	-0.3g/MJ	1.09	-0.28	-0.51 to -0.02 *
Dorsch et al., (2020)	48	-1.0g	2.9	-0.34	-0.66 to -0.07*
Bunten et al., (2021)	713	-0.28g	6.89	-0.04	-0.11 to 0.03
Koutoukidis et al., (2019)	554	0g/100		-	-
Saturated Fat					
Koutoukidis et al., (2019)	554	-2%	16.77	-0.12	-0.20 to -0.04*
Huang et al., (2006)	497	-0.66%	2.04	-0.32	-0.41 to -0.23*
Bunten et al., (2021)	713	-1.09g	5.52	-0.19	-0.27 to -0.13*

Payne-Riches et al., (2019)	947	-0.08g/MJ	1.18	-0.07	-0.13 to -0.006*
Eyles et al., (2017)	66	0.33g/MJ	4.35	0.08	-0.16 to 0.32
Sugar					
Payne-Riches et al., (2019)	476	0.12g/MJ	1.29	0.093	0.003 to 0.18*
Koutoukidis et al., (2019)	554	-0.03%	14.61	-0.002	-0.09 to 0.08
Bunten et al., (2021)	713	0.14g	6.12	0.02	-0.05 to 0.09
Eyles et al., (2017)	66	0.61g/MJ	12.97	0.05	-0.19 to 0.29

Note: Grey shading indicates when the analysis was the primary outcome. Methods for effect sizes (ES) calculations are described in section 2.2.3. ES cut-offs are as follows: small= 0.2; medium = 0.5; large=0.8. Winett et al.,(1991) did not report sufficient information for ES calculation. * $p<0.05$.

e. Swap acceptance

Of the 8 studies included in this review, only 4 studies, all of which were conducted in simulated online supermarkets, explicitly reported on swap acceptance (Bunten et al., 2021; Forwood et al., 2015; Koutoukidis et al., 2019; Payne-Riches et al., 2019). Swap acceptance rates reported in these studies ranged between 13% (Bunten, et al., 2021) and 34% (Payne-Riches et al., 2019). At the lower-end of this range was a study offering lower-energy swaps. Despite reporting an average acceptance rate of only 13%, a significant reduction in the average energy density of baskets from pre to post intervention was observed (Bunten et al., 2020). This was similar to the average acceptance rate of 14% reported in a study testing the effect of offering swaps lower in saturated fat (Koutoukidis et al., 2019). This study also reported a significant corresponding reduction in the saturated fat content of shopping baskets. In contrast, another study offering lower-energy swaps reported a higher average acceptance rate of 23% but did not find evidence of a corresponding reduction in the average energy

density of shopping baskets (6 kcal/100g, 95%CI: -12 to 0.96, p= 0.094) (Forwood et al., 2015).

The highest acceptance rates were reported in a study comparing swap acceptance in those offered very similar products with slightly less salt (LS) and those offered swaps much lower in salt (MLS), some of which were 'out-of-category' products (i.e., less similar products). This study also made clear to participants the reduction in salt offered by each swap offered. The study reported no difference in the proportion of swaps accepted out of those offered between these groups (LS= 34% vs MLS= 33%). However, those offered swaps much lower in salt were offered almost double the number of swaps that those in the LS group were offered. Consequently, this group accepted a significantly higher number of swaps offered, 4.39 compared to 2.69 in the LS group (IRR 1.64, 95% C.I. 1.53, 1.76 $p < 0.001$). Interestingly, the majority (68%) of swaps accepted by those in the MLS group were swaps that were much lower in salt than the originally selected item, 30% of which were out-of-category swaps, indicating that offering out-of-category swaps is acceptable to consumers in the context of salt reduction. The high acceptance rate of swaps offered that were much lower in salt resulted in salt-reductions in the MLS group that were almost twice the size of average reductions seen in the LS group (Payne-Riches et al., 2019).

There was some indication of differences in swap acceptance rates by product type. One study reported that lower-saturated fat alternatives for cheese, butter, and sweets and desserts may have been more acceptable than those for milk or meat (Koutoukidis et al., 2019). Another study reported that lower-energy swaps for pasta, rice & noodle, and continental & cooked meats yielded the highest acceptance rates, while swaps offered for raw meats and poultry had the lowest acceptance rates (Forwood et al., 2015).[4]

Among the other studies included in this review, swap acceptance is more difficult to quantify. In the real-world physical supermarket study, swap acceptance was not reported (Winett et al.,1991). Instead, purchasing of target food categories was measured. Many of these related to the categories in which swaps were offered. There

[4] In both studies all swaps offered were from within the same category as the initially selected item.

was evidence that the intervention group purchased significantly fewer foods in the high-fat meat and dairy categories and more foods in the high-fibre grains/cereals category. However, given that the intervention had multiple components it is difficult to draw a conclusion specifically regarding the swap acceptance rate. Neither of the smartphone app studies reported on swap acceptance rates or related outcomes (Dorsch et al., 2020; Eyles et al., 2017).

2.3.6 What study characteristics are associated with intervention efficacy?

a. Participant characteristics

Gender

Two studies reported some evidence of differences between men and women, with mixed findings. Forwood et al. (2015) found a significant main effect of gender on swap acceptance, reporting that female participants were more likely to accept lower-energy swaps (OR: 1.31, 95%CI: 1.06 to 1.61, p=0.012). Subgroup analysis by Koutoukidis et al., (2019) pointed to larger reductions in saturated fat among men (mean difference in % energy from SF: -3.27, 95% CI: -5.56 to -0.99) than women (mean difference in % energy from SF: -1.28, 95% CI: -2.92 to 0.35) in the intervention group compared with control. However, neither study conducted interaction analyses to examine the relationship between gender and intervention efficacy.

Two studies also reported no evidence of differences between men and women. Huang et al., (2006) reported no evidence of differential effects of the intervention according to gender (decrease in %SFA for intervention compared with control for men: 0.84%, 95% CI: 0.30 to 1.39 vs women: 0.64%, 95% CI: 0.45 to -0.82, p=0.44). Bunten et al., (2021) found no evidence of a main effect of gender on swap acceptance (b=0.06. SE= 0.14, p=0.652).

Age

Three studies reported differences between participants based on age, all of which pointed to potentially larger effects among older participants. A real-world online

supermarket study reported that older participants (≥40 years) in the intervention group had a larger decrease in the percentage of saturated fat purchased when compared with control than their younger counterparts in the intervention group (% SF decrease: 0.95%, 95% CI: 0.64 to 1.25 vs 0.47%, 95% CI: 0.27 to 0.66, p=0.03) (Huang et al., 2006). Similarly, subgroup analysis by Koutoukidis et al., (2019) pointed to larger reductions in saturated fat among those with the median age or above (mean difference in % energy from SF: -2.84, 95% CI: -4.77 to -0.91) than below the median age (mean difference in % energy from SF: -1.05, 95% CI: -2.88 to 0.79) in the intervention group compared with control. Bunten et al., (2021) reported a significant main effect of age (in years) on swap acceptance. Older participants were more likely to accept lower-energy swaps offered (b = 0.02, SE = 0.00, p < 0.001), and had a larger change in the total energy of baskets than their younger counterparts (b = 0.44, SE= 0.21, p=0.034).

One study by Forwood et al., (2015) reported no evidence of a significant main effect of age on swap acceptance (OR: 1.06, 95%CI: 0.95 to 1.17, p=0.280).

Ethnicity

Only one study examined differences based on ethnicity. Subgroup analysis by Koutoukidis et al., (2019) pointed to larger (but non-significant) reductions in saturated fat among non-white participants (mean difference in % energy from SF: -2.8, 95% CI: -7.38 to 1.78) than white participants (mean difference in % energy from SF:-1.89, 95% CI: -3.3 to -0.48) in the intervention group compared with control. Only the reduction for white participants was statistically significant.

Education

Only one study reported significant differences between participants based on education. Subgroup analysis by Koutoukidis et al., (2019) pointed to larger reductions in saturated fat among participants with higher education (mean difference in % energy from SF: -2.06, 95% CI: -3.67 to -0.46) than participants who had none/secondary education (mean difference in % energy from SF: -1.57, 95% CI: -4.09 to 0.95) in the intervention group compared with control, but no interaction analysis was conducted.

However, three other studies reported no evidence of difference between participants based on education. Forwood et al., (2015) reported no evidence of a significant main effect of education on swap acceptance (OR: 1.03, 95%CI: 0.96 to 1.10, p=0.384). Bunten et al., (2021) also reported no evidence of a significant main effect of education level on swap acceptance (no formal education, b=-0.73, SE=0.39, p=0.63). Huang et al., (2006) reported no evidence of differential effects of the intervention according to education (decrease in %SFA for intervention compared with control for university education: 0.79%, 95% CI: 0.49 to 1.08 vs no university education: 0.61%, 95% CI: 0.39 to 0.82, p=0.21).

BMI

Two studies reported differences between participants based on BMI, with mixed results. Huang et al., (2006) reported a significant interaction between BMI and intervention. Participants with a higher BMI (≥25) in the intervention group had a larger decrease in the percentage of saturated fat purchased when compared with control than those with a lower BMI (<25) in the intervention group (Decrease in %SFA for intervention compared with control for BMI ≥25: 0.85%, 95% CI: 0.57 to 1.12 vs BMI <25: 0.47%, 95% CI: 0.28 to 0.67, p=0.02) (Huang et al., 2006). In contrast, subgroup analysis by Koutoukidis et al., (2019) pointed to larger reductions in saturated fat among participants with lower BMI (<30) (mean difference in % energy from SF:-2.14, 95% CI: -3.72 to -0.56) than participants with higher BMI (>30) (mean difference in % energy from SF: -1.83, 95% CI: -4.33 to 0.68) in the intervention group compared with control. No interaction analysis was conducted.

Two studies reported no evidence of difference between participants based on BMI. Bunten et al., (2021) reported no significant main effect of BMI (score) on swap acceptance (b= -0.00, SE=0.01, p=0.956). Similarly, Forwood et al. (2015) reported no evidence of a significant main effect of BMI category, overweight vs healthy BMI (OR: 0.95, 95%CI: 0.63 to 1.47, p=0.817) and obese vs health BMI (OR: 1.13, 95%CI: 0.75 to 1.74, p=0.584) on swap acceptance.

Income

Two studies reported differences between participants based on income, with mixed results. Subgroup analysis by Koutoukidis et al., (2019) pointed to larger reductions in saturated fat among participants with low-middle income (£25-39k) (mean difference in % energy from SF: -2.21 95% CI: -3.82 to -0.59) than participants with higher income (£40k) (mean difference in % energy from SF: -1.34, 95% CI: -3.8 to 1.13) in the intervention group compared with control. In contrast, Forwood et al. (2015) reported a significant main effect of income on swap acceptance and showed that less deprived participants (as indicated by higher IMD quintiles) were more likely to accept lower-energy swaps offered (OR: 1.11, 95%CI: 1.05 to 1.18, p=0.0004).

Two studies reported no evidence of difference between participants based on income. Bunten et al., (2021) reported no significant main effect of income category on swap acceptance. The trend indicated that swap acceptance might increase with increased income, but this trend stoped at the highest income band (40K +), and there was no interaction effect between message type (i.e., social norms or cost) and participants' incomes. Framing a swap offered as cheaper did not have a stronger effect on swap acceptance for those on a low income (this analysis was adequately powered). Huang et al., (2006) also reported no evidence of differential effects of the intervention according to income (decrease in %SFA for intervention compared with control for Below AUD$90,000: 0.65%, 95% CI: 0.36 to 0.94 vs Above AUD$90,000: 0.55%, 95% CI: 0.26 to 0.85, p=0.53).

Other characteristics

One study found that those who viewed health as an important factor when grocery shopping, accepted 13% (95%CI: 10 to 17, p < 0.001) more swaps than participants who did not. This was also associated with a 3% greater reduction in the salt content of final baskets (−0.03g/100g, 95%CI: -0.05, -0.02; p < 0.001). The same study reported that swap acceptance (B=0.06 95% CI: 0.03, 0.10, < 0.001) and salt reduction (-0.03, 95% CI: -0.04, -0.01, < 0.001) was also higher among participants who had previously been advised to reduce their salt intake or those living with someone who had been advised to do so (Payne-Riches et al., 2019).

b. Target outcome

It is difficult to ascertain whether the type of swap offered, for example, lower-salt or lower-energy or lower-saturated fat swaps influences swap acceptance and thus dietary outcomes. Overall, the largest effect-sizes were observed in the three studies offering lower-salt swaps (i.e., salt reduction was the primary objective). However, in all three of these studies, participants had a related diagnosis such as high-blood pressure (Payne-Riches et al., 2019), cardiovascular disease (Eyles et al., 2010) or hypertension (Dorsch et al., 2020) where standard care includes advice for reduction in sodium intake. It is possible that given their diagnoses, participants in these studies were more motivated to decrease their salt intake than those without health conditions who were offered lower-energy swaps, for instance. The finding that participants who reported previously being advised to reduce their salt intake (or who had a household member who had been so advised), accepted more swaps and reduced the salt in their final basket more than those who had not, supports this idea (Payne-Riches et al., 2019). However, another study examining self-reported attempts to lose weight found that having a health condition for which weight loss is recommended (e.g., cardiovascular disease) was only modestly associated with weight loss attempts (Piernas et al., 2016). It is, therefore, unclear as to whether those with health conditions are more motivated to engage in health promoting behaviours. Furthermore, in two of these studies, the intervention was delivered via a smartphone app in which users had to actively seek out swap information. Again, this may indicate that participants in receipt of these interventions were highly motivated to change their behaviour.

c. Price

In half of the studies, the price of swaps offered was constrained to prevent them being either significantly more expensive or cheaper than originally selected items (Bunten et al., 2021; Forwood et al., 2015; Koutoukidis et al., 2019; Payne-Riches et al., 2019).

Two studies offering swaps lower in saturated fat reported that there were no significant differences between control and intervention groups with respect to the average price of shopping baskets (Koutoukidis et al., 2019; Huang et al., 2006). This

indicates that offering swaps is a potentially effective strategy for reducing fat purchased in supermarket settings without increasing cost to the consumer.

One study asked participants to rate the importance of price on their purchasing decisions and reported no significant association between the importance attached to price and any of the outcomes such as swap acceptance (Payne-Riches et al., 2019). Another study tested the effect of making salient that the swap was cheaper than the originally selected item (Bunten et al., 2021). Highlighting this did not significantly increase swap acceptance relative to the health-benefit (i.e., calorie) framing. And there was no evidence of an interaction effect between this message and participants' income. It is likely that the minimum potential price difference between products of £0.01 was not sufficient to encourage participants to swap.

2.3.7 How acceptable are swap-based interventions?

Of the 8 studies included, 6 asked participants to report on aspects of the intervention related to acceptability. Studies in which swaps were offered to participants while shopping for groceries were generally well-received. In one study, 76% of those offered swaps lower in saturated fat (Koutoukidis et al., 2019), and 70% of those offered swaps lower in salt (Payne-Riches et al., 2019) agreed that this was a feature that they would like to see when doing their usual shop online. Similarly, the majority of participants offered lower-energy swaps agreed that they would "somewhat like" to be offered these swaps in real life (Bunten, et al., 2021). One online supermarket study found that when the inclusion of prompts to swap within the site was framed in the introductory message as something participants had consented to (i.e., "The website you are about to use is designed to help you buy food with fewer calories. It will suggest alternatives to your choices that have fewer calories per gram. *Please shop using the website and give us feedback*"), participants gave higher ratings for the overall shopping experience than those for whom the inclusion of swaps within the site was framed in the introductory message as something imposed on the participant (i.e., "The website you are about to use is designed to help you buy food with fewer calories. It will suggest alternatives to your choices that have fewer calories per gram. *Your task is to shop using the website and give us feedback.*") (Forwood et al., 2015). Those provided with swap suggestions for their intended purchases in the physical

supermarket study also reported high satisfaction with the program (Winett et al., 1991). Furthermore, supermarket staff reported liking the system because it did not disrupt store operations.

In both studies where participants could access suggested swaps via smartphone applications, acceptability ratings were also high. All SaltSwitch app users (n=24) agreed that SaltSwitch was a good way to help shoppers to make lower salt food purchases (Eyles et al., 2017) and 79% of LowSalt4Life app users reported using the app in their daily life (Dorsch et al., 2020). The majority SaltSwitch (75%) and LowSalt4Life (83%) app users also rated the apps as easy to use.

In some cases, acceptability coincided with intervention efficacy. One study reported that acceptability ratings for the intervention were significantly correlated with the number of swaps accepted (Forwood et al., 2015). Another study found that increasing acceptability of the intervention was associated with a greater reduction in salt in the total shopping basket in salt with each increasing category of acceptance (Payne-Riches et al., 2019). This study also provided evidence that even when healthier alternatives offered are slightly different to the original product (but achieved larger decreases in salt content), acceptability of the intervention was maintained. However, this may not be applicable to other types of swaps (e.g., lower-sugar swaps where fruit is offered for confectionaries).

2.3.8 Risk of Bias Assessment

Table 2.4 presents a summary of the RoB assessments. Of the 8 studies reviewed, 6 were judged to be at low risk of bias across all domains (Bunten et al., 2021; Eyles et al., 2017; Huang et al., 2006; Koutoukidis et al., (2019); Payne-Riches et al., 2019) 1 study was at high risk of bias in 1 domain, and two studies had some concerns in at least 1 domain.

Table 2.4: Risk of Bias within studies.

Study	Risk of Bias				
	(i)	(ii)	(iii)	(iv)	(v)
Bunten et al., (2021)					
Forwood et al., (2015)					
Payne-Riches et al., (2019)					
Eyles et al., (2017)					
Dorsch et al., (2020)					
Koutoukidis et al., (2019)					
Huang et al., (2006)					
Winett et al., (1991)					

Risk of bias legend: Risk of bias arising from;

(i) the randomisation process
(ii) deviations from the intended interventions (*effect of assignment to intervention*)
(iii) missing outcome data
(iv) measurement of the outcome
(v) selection of the reported result

2.4 Discussion

This scoping review retrieved 8 studies testing the effect of swap-based interventions on dietary outcomes. Interventions were tested in both hypothetical and real-world settings. In terms of the efficacy of swap-based interventions to change dietary choices, the direction of evidence is most clear for swap-based interventions as a strategy to reduce salt and saturated fat. It is less clear for energy reduction with only some studies reporting an effect, and no studies to my knowledge have tested the effect of offering lower-sugar swaps. There is some evidence that swap-based interventions are viewed as acceptable by recipients. Study quality was high overall, with most studies being judged to be of low risk of bias. One study was judged as being at high risk of bias overall given that there were some concerns in almost all

domains (Winett et al., 1991). While another had a high risk of bias in one domain only (Dorsch et al., 2019). Several gaps in the literature were identified and are discussed.

2.4.1 Swaps acceptance rates

Swap acceptance rates ranged between 13% and 34%. There were two gaps in the literature relating to swap acceptance identified in this review that potentially have important implications for the current body of work. These factors are discussed below.

Nature of swaps offered

The range of products for which swaps were offered in studies was relatively restricted. In all studies, participants were offered swaps while grocery shopping. In most of these studies participants were provided with a shopping list of generic items (e.g., bread, milk, meat etc.) to hypothetically purchase (Bunten et al., 2021; Forwood et al., 2015; Koutoukidis et al., 2019; Payne-Riches et al., 2019). In the remaining studies, items for which swaps were offered were based on participants' actual purchases, providing some evidence that swaps for grocery products that are lower in saturated fat are acceptable (Huang et al., 2006; Winett et al., 1991). In most of the online supermarket studies, swaps offered were ‘within-category’ (i.e., very similar) products. Although within-category swaps means that swap-similarity is high - a factor which might increase swap acceptance, it often means that swaps offered yield only small changes in dietary outcomes (Forwood et al., 2015). Forwood et al., (2015) suggested that offering slightly different “out-of-category” swaps might mean that larger reductions in target nutrients (or energy) can be achieved, but only if such swaps are acceptable to recipients. Payne-Riches et al., (2019) tested this by offering either within-category swaps that were slightly lower in salt or swaps that were much lower-in-salt, of which some were less similar alternatives (i.e., out-of-category). This study found that offering swaps much lower in salt, some of which were out-of-category swaps, reduced salt selected more than offering within-category swaps with slightly less salt. This indicates that consumers may be more inclined to accept swaps when the swap offered provides larger benefits (e.g., in this case larger salt reductions) even if this means they will receive a less similar alternative. It is, however, important to note that ‘less similar’ in the supermarket context where a vast range of products are available

typically refers to a product from a different subcategory (e.g. a pitta as a swap for a bagel) meaning that swaps offered are often still functionally the same. The impact of offering a less similar alternative outside of the salt reduction context (e.g., in an energy or fat reduction context) is also not yet known.

In contrast, in other contexts where swaps could be offered such as restaurants or canteens, the range of options which could be offered as swaps is likely to be far smaller. This means that it is likely that swaps offered would be more dissimilar or could even be an entirely different meal to the initial selection. Theory from economics would suggest that offering swaps that are as similar as possible to the initially selected item is likely to increase swap acceptance because offering swaps that are different in nature to first preference choices could potentially reduce utility, causing consumers to deem the expected health gain not worth the potential loss of utility from the enjoyment of the original product (Payne-Riches et al., 2019; Salvatore, 2008). Dissimilar swaps may also require participants to engage in more demanding 'system 2' decision making (which Kahneman (2011, p13) describes as a *"slower, more deliberate and effortful form of thinking"*) which could result in disengagement and, in turn, reduce the likelihood that swaps will be tried (Payne-Riches et al., 2019). It will be important to examine the extent to which swaps offered in other contexts such as canteens are acceptable to customers.

Framing of swaps

One study aiming to reduce the energy content of shopping baskets hypothetically purchased by a sample of the general population explored whether accompanying swaps offered with different messages would increase swap acceptance. The study found no benefit of framing swaps as cheaper or popular (i.e., descriptive social norms) beyond that which is reached with a health-benefit framing of 'lower-calorie'. One potential reason for the null effect was that it may have been obvious from the outset to consumers presented with the social norms and cost messages that swaps offered were intended to improve the healthfulness of their choices because some swaps offered had packaging that said "low fat" or "low calorie". Given that health was likely to be salient anyway, this may have reduced the size of any differences between groups. In addition, while this study framed the swap as 'cheaper', often alternatives

offered were not much lower in price than initially selected items, which may have reduced the impact of the messaging (Bunten et al., 2021). It has yet to be established whether offering significantly cheaper products motivates consumers to swap. However, without government subsidisation, offering healthier alternatives at significantly cheaper prices may present a challenge to organisations in real-world settings. The study did, however, report a descriptive trend in the data which suggested that swap acceptance rates were higher among those presented with the health-based 'lower-calorie' message. Given that this study found no evidence that social norms or cost-based messages increase swap acceptance beyond the effect of a health-based message emphasizing that the product is lower calorie, efforts could be made to test other health focused messages.

Although messaging was not manipulated in Payne-Riches et al., (2019) study, the finding that among those offered both types of swap, much-lower-salt swaps (68%) were accepted more than slightly-lower-salt swaps, it is possible that highlighting to consumers the percentage reduction in salt may have aided swap acceptance. Providing information to participants about the swap offered (such as the amount of salt that would be saved by swapping) may increase the likelihood that a swap is accepted.

2.4.3 Intervention target

Studies included in this review tested the effect of swap-based interventions to change a range of dietary outcomes; most often swaps offered were lower in salt, saturated fat or energy. Generally, offering swaps successfully reduced the purchasing of the target nutrient.

In three of the studies, intervention recipients were those at risk of cardiovascular disease and salt-reduction was the target outcome. Although salt-reduction is a relevant dietary change for these specific participants, it may be less so for the general population. Indeed, evidence showed that those who had been advised to reduce their salt intake were more likely to accept lower-salt swaps than those who had not received this advice (Payne-Riches et al., 2019).

When targeting the general population, there is debate around which dietary change (e.g., sugar reduction, energy reduction etc.) should be the focus of intervention, not only with respect to public health but also public perception (i.e., how acceptable and motivating the public find it) (Gonzalez-Nahm et al., 2020). In circumstances where swaps offered cannot be easily tailored to the individual (e.g., for some it may be most beneficial to offer lower salt while for others lower-sugar may be better), the question of whether the focus of swap-based interventions should be on targeting energy or specific nutrients or on overall diet quality remains. It may be the case that swaps should be offered only if they have an overall superior nutrient profile. However, this may be difficult to achieve in settings like canteens, where the range of options is limited. This may also be difficult to explain to consumers who are not familiar with the nutrient profiling model. Swaps offered that focus on one familiar metric such as a single nutrient or energy may be easier for people to understand and monitor their behaviour on. Some research indicates that reducing energy has favourable health effects among people with healthy weight, overweight, or obesity (Dorling et al., 2021; Wing, 2021). With high levels of obesity in the UK, current public health campaigns focus on encouraging energy reduction meaning that the general public might be receptive to prompts to swap to lower-energy alternatives (Action on Sugar, 2020). Participants in qualitative studies have also indicated that they use calorie information as a signal to judge the overall healthfulness[5] of a meal (Lando & Labiner-Wolfe, 2007). The extent to which offering lower-energy swaps effectively reduces energy purchased is not entirely clear from the current evidence but should be explored further given the positive evidence reported by Bunten and colleagues (2021).

Another approach for intervention with the general population would be to think of outcomes in terms of increasing the number of healthful foods purchased such as fruits and vegetables and decreasing the amount of less healthful products purchased such as sugar sweetened beverages (SSBs). Only one study has taken this approach (Winett et al., 1991) and reported significant increases in more healthful product categories. Two studies in this review pointed to differences in acceptance rates across product categories (Koutoukidis et al., 2019; Forwood et al., 2015). However,

[5] In this study, healthful meals were defined as "*having 1/3 or less of a day's calories in a 2000 calorie diet. Also 1/3 or less of the Daily Value for saturated fat and cholesterol, less than 1/2 of the Daily Value for sodium and 7 grams or less of saturated plus trans-fat*.".

there is very little data on swap acceptance rates for specific food groups. None of the studies included in this review reported on the effect of offering swaps for drinks. SSBs provide little to no nutritional value and their frequent consumption is associated with increased risk of a range of health problems including type 2 diabetes and obesity (Malik, 2010). Investigating the acceptance of swaps offered for SSBs should, therefore, be a priority going forward. Similarly, understanding the extent to which people are willing to accept fruits and vegetables as swaps for less healthful items would be beneficial given that people eat foods not nutrients. This may also be beneficial for groups with specific health conditions. For instance, research finds that following a diet rich in fruits, vegetables, and low-fat dairy products is as effective in reducing blood pressure as reducing sodium intake from a high to an intermediate level. Furthermore, combining salt reductions with fruit and vegetable rich diets reduces blood pressure beyond either approach alone (Sacks et al., 2001).

2.4.4 Participant characteristics

Studies analysing intervention effects by demographic characteristics suggest that offering swaps may be slightly more effective older participants. While the results for gender, education, ethnicity, BMI and income are more mixed or lacking. Overall the analyses by participant characteristics point to very few clear differences between groups. Although these analyses were exploratory in nature (most were not powered to detect interaction effects), they indicate that swap-based interventions work well across the population. This is reassuring considering concerns that dietary interventions involving individual decision making exacerbate health inequalities (Adams et al., 2016). Studies should continue to monitor the impact of swap-based interventions according to demographic characteristics, especially when framing is the subject of investigation.

2.4.5 Intervention acceptability

Although swap-based interventions were generally rated highly with respect to acceptability, all studies were conducted in supermarket settings. As a result, little is known about the acceptability of these interventions in other contexts such as restaurants and canteens where suggested substitutions would be offered for menu

items rather than groceries. Intervention acceptability has been described as "*a necessary but not sufficient condition for effectiveness of an intervention*" (Sekhon et al., 2017). Evidence from a systematic and narrative review examining public acceptability of Government led health-based interventions supported this, reporting that intervention acceptability was importantly influenced by the perceived intrusiveness of the intervention (Diepeveen et al., 2013). This echoes the finding by Forwood and colleagues (2015) that participants find being offered swaps more acceptable when it is framed as something that they have consented to rather than something that is imposed. Previous research has also found that interventions that were classified as providing information (e.g., labels, education campaigns) were viewed as most acceptable, followed by those classified as guiding choices, followed by those restricting or limiting choice (e.g. taxes) which were viewed as least acceptable (Branson et al., 2012; Diepeveen et al., 2013). Sekhon and colleagues (2017) suggest the degree to which a recipient understands an intervention and why it is being offered influences perceived intervention acceptability. Swap-based interventions do not limit or restrict choices but rather seek to guide choices. It is possible that providing information alongside swaps offered may bolster acceptability. Considering that two studies in this review reported an association between swap acceptance and intervention acceptability, a deeper exploration of the factors influencing acceptability of swap-based interventions and how this may be enhanced is warranted.

2.4.6 Limitations of the current evidence & future research

Swap acceptance rates range between studies, with interventions offering lower-energy swaps to the general population at the lower end of the spectrum. The question of how swap acceptance rates can be maximised remains. Further examination of how different framing may be leveraged to increase swap acceptance and intervention acceptability is warranted.

Studies testing swap-based interventions have focused on measuring a variety of different outcomes including changes in salt, saturated fat and energy purchased. Sugar reduction has never been the primary target (i.e. the primary outcome) of a swap intervention. Moreover, within these outcomes there is diversity with respect to

how they are measured. For instance, among the studies testing changes in salt, one study measured the difference in the change in salt density (g/100g) of the final shopping basket between groups (Payne-Riches et al., 2019), while another measured change in estimated sodium intake by a 24-hour dietary recall tool (Dorsch et al., 2020). This makes direct comparisons a challenge. To minimise this issue, outcomes were standardised using effect sizes. While almost all of the studies reviewed provide evidence for the ability of swap-based interventions to alter people's purchasing behaviours, only a limited number of studies (n=8) were identified making it difficult to draw firm conclusions regarding the efficacy of swap-based interventions. Furthermore, all studies were conducted in supermarket settings (be it real or simulated). It, therefore, remains unclear as to how swap-based interventions translate (both in terms of swap acceptance and intervention acceptability) into other food environments such as take-aways or canteens. Like online supermarket websites, online pre-ordering websites for canteens provide a unique opportunity for swap-based interventions to be tested and if effective, implemented at scale. Preliminary experimental research is needed to provide important initial data on whether a swap-based intervention would potentially be effective and/or acceptable in a canteen pre-ordering setting. The next chapter presents a scoping review of the current literature on pre-ordering interventions to provide important context about the setting in which I intend to apply a swap-based intervention.

Chapter 3

Online pre-ordering interventions to improve the healthfulness of dietary choices made by adults: A scoping review of the experimental evidence

3.1 Introduction

The studies outlined in Chapter 2 pointed to the potential of swap-based interventions to improve dietary choices made by adults. The aim of this scoping review is to assess what experimental evidence is available on the effect of pre-ordering on the dietary choices of adults. To my knowledge, no review has done this to date. This review will help to inform the design of a combined pre-ordering and swap-based intervention to be tested in this PhD by aiming to identify aspects of pre-ordering interventions that are associated with intervention efficacy and acceptability.

3.1.1 Review questions

What experimental evidence is available on the efficacy of online pre-ordering interventions to improve the healthfulness of dietary choices made by adults?

Sub-questions:

I. What are the characteristics of these pre-ordering interventions?
II. What diet-related outcomes have been evaluated in these studies?
III. What study characteristics are associated with intervention efficacy?
IV. What experimental evidence is available on the acceptability of these interventions?

3.2 Methods

Ahead of the analysis of this review, a study protocol was written and published on the OFS register website: osf.io/wy3rq; DOI: 10.17605/OSF.IO/7NPCV. Chapter 2 outlined the methodology used for the scoping review on swap-based interventions. A completed PRISMA checklist can be found in Appendix 3.1, Additional File 1. An identical procedure was followed for this review with changes only in the (i) inclusion criteria and (ii) search terms. Searchers were conducted on the 25th of June 2021. Full search strategies for each database can be found in Appendix 3.2, Additional File 1. The inclusion criteria is detailed below.

3.2.1 Inclusion criteria

This review considered studies that tested the effectiveness of implementing a pre-ordering system to improve the healthfulness of dietary choices in adults (18 years of age or older). The word 'pre-order' was used to refer to the ordering of foods and/or drinks a minimum of 30 minutes in advance of consumption from a pre-prepared food provider (e.g., restaurants, canteens, caterers). Studies testing the effect of ordering groceries online from supermarkets were excluded. The term 'more healthful' was used to refer to studies that attempted to (i) reduce the selection of target foods and/or drinks (e.g. items high in energy, salt, or sugar) or (ii) increase the selection of target foods and/or drinks (e.g. fruit, vegetables, water).

To be included, studies had to test a pre-ordering intervention (i.e., experimentally manipulate pre-ordering) and provide evidence relating to its potential efficacy in changing the selection of target foods and/or drinks. A secondary objective of this review was to map the evidence for the acceptability of the intervention. No restrictions to intervention duration or mode of delivery were applied.

3.3 Results

The titles and abstracts of 101 unique papers were screened. Of these papers, 7 proceeded to the full-text screening stage and 2 were deemed eligible for inclusion. The reference lists of both papers were examined, but no further relevant studies were identified. Two published papers, representing 3 studies, were included in the final

review (Figure 3.1). A summary of key information extracted from these studies can be found in Table 3.1 (see Appendix 3.3, Additional file 1 for full extraction tables).

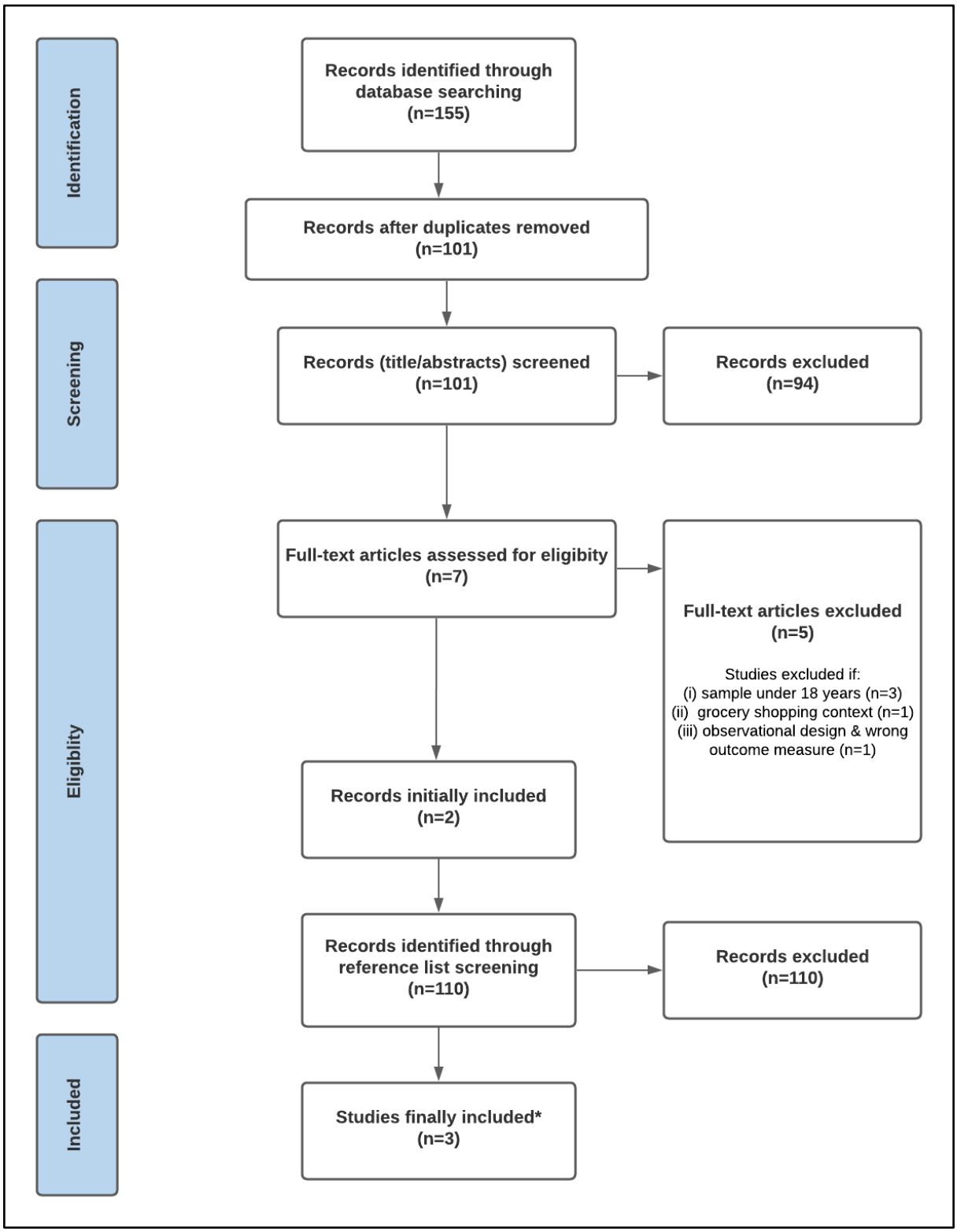


Figure 3.1: PRISMA Inclusion Flowchart. * NOTE: Records refer to publications. Two relevant records were identified. One of these publications contained two relevant studies, hence n=3 studies.

Table 3.1: Description of studies testing pre-ordering interventions. NOTE: n analysed refers to the n for the primary analysis

Title & authors (year)	Trial design	Intervention details	Efficacy findings	Acceptability findings
Trial 2 from Advance ordering for healthier eating? Field experiments on the relationship between the meal order–consumption time delay and meal content. VanEpps, E. M., Downs, J. S., & Loewenstein, G. (2016a).	RCT (crossover design) 2 arms: (i) advanced ordering: participants could order lunch before 10:00 A.M. (ii) lunchtime ordering: participants could order lunch after 11:00 A.M. Setting: Company Canteen n randomised = 507 n analysed = 296	Participants could order up to 3 lunches per week via the pre-ordering system and were given a $3 discount on pre-ordered lunches during the trial's 4 week duration. Those in the advance-ordering condition had to pick up orders at least 60 min after placing them (delay ranged from 61 to 363 min), whereas those in the lunchtime-ordering condition could receive their orders sooner (delay ranged from 30 to 179 min).	(i) Orders placed in advance were more likely to include a meal from the under-500 kcal list than orders placed at lunchtime (60% vs. 53%; p= 0.05). (ii) Orders placed in advance had marginally fewer calories (Mean = 568 kcal, SE = 15) than those placed at lunchtime (Mean = 598 kcal, SE = 14), but this difference was not statistically significant (p= 0.086). (iii) There were no interactions between the timing restriction and any demographic variable (gender, age, ethnicity, dieting status, BMI).	Not reported

Title & authors (year)	Trial design	Intervention details	Efficacy findings	Acceptability findings
Trial 3 from Advance ordering for healthier eating? Field experiments on the relationship between the meal order–consumption time delay and meal content. VanEpps, E. M., Downs, J. S., & Loewenstein, G. (2016a).	RCT 2 arms: (i) Advance ordering (80 -170 min time delay) (ii) Order for immediate collection (no time delay). Setting: Catered lunch in a University n randomised = 212 n analysed =195	Completion of an order form for a once-off catered lunch either 80 - 170 minutes in advance of receipt or immediately before receipt of the order.	(i) Participants who placed orders in advance ordered significantly fewer calories (Mean = 890 kcal) than those who placed orders at lunchtime (Mean = 999 kcal; p<0.01) (mean difference= -109, SE= 37, p<0.01). (ii) Ordering in advance had no effect on energy from sandwiches (advance: Mean = 455 kcal calories; lunchtime: Mean = 459 kcal calories; p= 0.76) or energy from condiments (29 vs. 37 kcal; p= 0.24) but reduced energy from drinks (35 vs. 60 kcal; p< 0.01). There was evidence of a trend in reduction of energy from side dishes (160 vs. 176 kcal; p= 0.053) and energy from cookies and fruits (212 vs. 267 kcal; p= 0.056).	There was no difference in meal satisfaction ratings between those who ordered in advance (Mean = 4.10) and those who ordered at lunchtime (Mean = 4.28; p=0.33).

Title & authors (year)	Trial design	Intervention details	Efficacy findings	Acceptability findings
			(iii) Male participants ordered more energy than female participants (981 vs. 893 kcal; p< 0.05); there were no effects of other demographics, nor did any demographic interact significantly with order timing. (iv) Participants who ordered in advance rated themselves as significantly less hungry when placing their orders (3.46 vs. 4.89; t(190) = 7.23, p<0.001), and greater hunger predicted more energy ordered. Analysis did not reveal significant mediation through hunger (b = -25 kcal; 95% CI: -70 to 14).	

Title & authors (year)	Trial design	Intervention details	Efficacy findings	Acceptability findings
Pre-ordering lunch at work. Results of the: what to eat for lunch trial. Stites, S. D., Singletary, S. B., Menasha, A., Cooblall, C., Hantula, D., Axelrod, S., ... & Phipps, E. J. (2015).	A pilot randomised waitlist-controlled trial. 2 arms: (i) Treatment: 4 weeks baseline (no intervention), 4 weeks full intervention, 4 weeks partial intervention. (ii) Delayed treatment: 8 weeks baseline (no intervention), 4 weeks full intervention, 4 weeks partial intervention. Setting: Hospital Canteen n randomised = 28 n analysed =26	The online pre-ordering system was designed to allow employees to order their lunches at least 45 mins in advance of mealtime. The website displayed the nutrient content of the food choices. There were 3 trial phases: • Baseline: participants selected their lunches as usual from the canteen. • Full-Intervention: participants received mindful eating training, were encouraged to pre-order their lunches, and were provided financial incentives (vouchers) to use on lunch purchases. •Partial Intervention: participants were encouraged to pre-order their lunches but did not receive financial incentives.	On average, the treatment group purchased lunches with -145 kcal (95% CI= -254 to -35, p=0.01) and -8.9 grams of fat (95% CI= -15.2 to -2.6, p= 0.005) less than the waitlist control. Energy in purchased meals reduced by an average of 115 kcal (95% CI = -147 to -83, p< 0.001) and 5.4 grams of fat (95% CI = -7.5 to -3.8, p< 0.001) per lunch in the partial - intervention phase compared to the baseline phase. Energy in meals reduced by an average of 71 kcal (95%CI: -97 to -63) and 3.8 grams of fat (95%CI: -4.8 to -3.2) per lunch in the partial-intervention compared to the full-intervention phase.	Most participants (92%) said they would use a pre-ordering system if offered in the future. Problems with pre-ordering identified in open-ended responses were categorized as: problems related to food pick-up at the hospital cafeteria (n = 6); difficulty remembering to pre-order (n = 4); food on website did not reflect what was in the hospital cafeteria (n = 4); participant forgot vouchers or website address (n = 2); and difficulty remembering to order side dishes (n = 1).

3.3.1 Participants & setting

The average age of participants ranged between 25 (SD=9) (VanEpps et al., 2016a [trial 3]) and 45 (SD=11) years (Stites et al., 2015) across studies. Between 42% (VanEpps et al., 2016a [trial 3]) and 89% (Stites et al., 2015) of participants were female across studies. Between 27% (VanEpps et al., 2016a [trial 3]) and 84% (VanEpps et al., 2016a [trial 2]) were white/Caucasian. In the 2 studies reporting BMI, participants had an average BMI of 26 (SD=9) (VanEpps et al., 2016a [trial 2]) and 33 (SD=9) (Stites et al., 2015). One trial restricted recruitment to people with overweight and obesity (Stites et al., 2015). All studies were conducted in the USA.

The sample sizes of the 3 studies were 296, 195 (VanEpps et al., 2016a [studies 2 & 3) and 26 (Stites et al., 2015). In trial 2 by VanEpps et al., (2016a), 506 participants consented to participate and were randomised but only 296 (58%) completed at least one pre-order. The authors confirmed that random assignment (condition) did not predict likelihood of placing an order. In trial 3 by VanEpps et al., (2016a), 92% (n=195) of the randomised sample were analysed. The remaining 8% did not complete their lunch order or did not collect their order, but again random assignment (condition) did not predict dropout. In the pilot trial by Stites et al., (2015), 28 participants registered for the trial and were randomised, two participants in each group withdrew due to reasons unrelated to the trial. Three new participants registered after randomisation and so were allocated to the delayed treatment group. Data from 26 participants were analysed. No trial reported a power calculation.

All studies included in this review were conducted in real-world settings. In two studies, lunches were ordered from workplace canteens over a period of 4 weeks (VanEpps et al., 2016a [trial 2]; Stites et al., 2015). In the other trial, a catering company was hired to fulfil one-off lunch orders made by university students (VanEpps et al., 2016a [trial 3]).

3.3.2 Comparators & outcomes

All trials employed a randomised design. One trial was a one-off experiment in which the average energy content of lunches ordered by participants that were randomly

allocated to pre-order their lunch ahead of consumption was compared with those who were randomly assigned to order their lunch for immediate consumption (VanEpps et al, 2016a [trial 3]).

The other two studies were conducted over longer timeframes. In one of these studies, participants could order 3 lunches per week for a period of 4 weeks (VanEpps et al., 2016a; [trial 2]) and two variations of pre-ordering were compared: orders placed far in advance of lunchtime and closer to lunchtime. Participants were randomly assigned to one condition for the first two weeks and then were switched to the other condition for the final two weeks of the trial. The average energy content of lunches ordered in the advanced ordering condition was compared with orders placed in the lunchtime ordering condition.

In the third trial, all participants could pre-order their lunch from the canteen for a period of 8 weeks but were randomly allocated to one of two conditions: treatment or delayed treatment (Stites et al., 2015). In the treatment condition, baseline data were collected for a period of 4 weeks after which participants received the full intervention for 4 weeks, and the partial intervention for a further 4 weeks. In the delayed condition, baseline data were collected for 8 weeks after which participants received the full and partial interventions for 4 weeks each (please see Table 3.1 for intervention details). To examine the effect of the full intervention, the energy and fat content of lunches ordered by the treatment group and the delayed treatment group during the same period of time was compared (i.e., the delayed treatment group was in the baseline phase when the treatment group was in the full intervention phase). Baseline data for each individual was used to statistically control for individual-level differences in energy and fat purchased. To examine the longitudinal effect of the intervention, the average energy ordered by participants during the partial-intervention phase was compared with energy ordered during the baseline period in a pre-post comparison including all trial participants. To examine the effect of the financial incentives over and above pre-ordering alone, the average energy ordered by participants during the full-intervention phase with the average energy ordered by participants during partial-intervention phase.

3.3.3 What are the characteristics of pre-ordering interventions?

a. Mode of intervention delivery & menu presentation

Menu presentation varied across studies. In one trial, both groups placed their orders online via a pre-ordering website designed for their workplace canteen (VanEpps et al., 2016a [trial 2]). This meant that neither group (i.e., those ordering far in advance nor those ordering closer to lunchtime) could physically see the foods when making their selections. Menu options were presented with a brief written description and no images were displayed. No specific nutritional information was published on the website but 8 of the 13 menu options were labelled as containing <500 kcal. No energy information was published for the other menu items which ranged in energy content from 560 kcal to 960 kcal.

In another trial, only the pre-ordering group placed their orders online via the pre-ordering website designed for their workplace canteen (Stites et al., 2015). A written description of menu items along with information on their energy and fat content was published on the website. No images were displayed. In contrast to trial 1, the control group placed their orders in the canteen, meaning that they could physically see menu options when making their selections. However, the canteen did not display the energy or fat content of the majority of foods available.

In the third trial, all orders were placed by completing a written order form (VanEpps et al., 2016a [trial 3]). Orders were fulfilled by a catering company that had been hired for the day. This form provided a brief written description of each menu item without nutritional information, however the lowest energy sandwich on the menu was described as a “healthy option”. Neither the pre-ordering group nor the control group could see the foods or drinks available when making their selections.

b. Order timings and payment

In one trial, pre-ordering participants were able to place their lunch order at any time during the day, but orders could only be collected during canteen lunch hours (11 am to 3 pm, Monday to Friday) and a minimum of 45 minutes after the order had been

placed (Stites et al., 2015). Participants in the control group ordered their lunch as usual from the canteen and received it almost immediately after ordering. All participants had to pay for their meals but sometimes received unspecified discounts when pre-ordering to encourage use of the system.

In the second trial, both groups pre-ordered online but the time delay between ordering and collection was varied such that participants were randomly assigned to order far in advance of lunchtime (i.e., before 10 am) or closer to lunchtime (i.e., after 11 am) (VanEpps et al., 2016a [trial 2]). When placing an order, participants could select a collection time between the hours of 11 am and 2 pm. Those in the 'far in advance' condition were required to allow at least 60 minutes between order and collection. In this group, the time delay ranged between 61 and 363 minutes. Those in the 'closer to lunchtime' condition could collect their orders sooner. In this group, the time delay ranged between 30 and 179 minutes. Similar to the previous trial, participants purchased lunches with their own money but were provided with a $3 discount on up to three lunches per week ordered via the pre-ordering website.

In the third trial, university students completed their written lunch order form either at the beginning (pre-ordering condition) or at the end (control) of a lecture (VanEpps et al., 2016a [trial 3]). In the pre-ordering condition, the time delay between order and collection ranged from 80 to 170 minutes, depending on the lecture. Those in the control condition received their lunch a few minutes after it had been placed. Lunch orders were supplied by a catering company that had set-up a collection point outside the lecture theatre. Lunch orders were supplied for free, in exchange for trial participation.

3.3.4 What effect do pre-ordering interventions have on diet-related outcomes?

Two of the three studies included in this review reported a significant effect of pre-ordering on energy ordered. Alongside energy ordered, two studies examined the effect of pre-ordering on grams of fat contained in lunches ordered (VanEpps et al., 2016a [trial 2]; Stites et al., 2015) with one reporting significant reductions (Stites et al., 2015).

Table 3.2: Standardised means (Cohen's d effect sizes) for change in dietary outcomes.

Author	**n**	**Raw effect size**	**SD**	**Standardised mean (Cohen's d)**	**95% CI for effect size**
Energy (kcal)					
VanEpps [trial 2]	225	-30 kcal	262	-0.11	-0.24 to 0.02+
VanEpps [trial 3]	195	-109 kcal	517	-0.21	-0.35 to -0.07*
Stites	26	-145kcal	270	-0.54	-0.94 to -0.11*
Fat & saturated fat					
VanEpps [trial 2] (fat grams)	296	-0.12g	14.9	-0.008	-0.12 to 0.11
VanEpps [trial 2] (saturated fat grams)	296	-0.22g	5.5	-0.04	-0.15 to 0.07
Stites (Fat grams)	26	-8.9g	15.6	-0.57	-0.69 to -0.45 *
Other nutrients					
VanEpps [trial 2]					
Carbohydrates (grams)	296	2.5g	35.8	0.07	-0.04 to 0.18
Protein (grams)	296	0.08g	9.9	0.008	-0.11 to 0.12
Sodium (milligrams)	296	51.29mg	823.5	0.06	-0.05 to 0.17
Fibre (grams)	296	0.29g	3.3	0.09	-0.02 to 0.20

NOTE: The n is smaller for VanEpps [trial 2] because the model reported includes covariates, those missing this data are excluded hence the lower n (225 v 296). Including the full n did not materially change the findings. Methods for effect sizes (ES) calculations are described in Chapter 2, section 2.2.3. ES cut-offs are as follows: small= 0.2; medium = 0.5; large=0.8. + Indicates p=0.05, * indicates p <0.05.

a. Energy

One trial assessing the short-term (one-off) impact of pre-ordering on energy ordered, reported that those who pre-ordered a single lunch, ordered 109 kcal (SE= 37, p<0.01) fewer calories (mean = 890 kcal) than those who placed orders in-the-moment for immediate consumption (mean = 999 kcal; p<0.01) (VanEpps et al., 2016a [trial 3]). When examining orders by menu item, pre-ordering significantly reduced the energy content of drinks ordered (35 vs. 60 kcal; p< 0.01) but did not significantly reduce the energy content of other meal components such as sandwiches, snacks or side-dishes.

The other two studies investigated the medium-term impact of pre-ordering on energy ordered in workplace canteens. In one trial, participants could pre-order for a period of 8 weeks (Stites et al., 2015). During the first 4 weeks, participants received discounts on pre-ordered meals and attended a mindful eating training session. The average energy content of lunches pre-ordered during this period was -145 kcal less (95% CI= -254 to -35, p=0.01) than orders placed in the canteen at lunchtime. During the second 4-weeks of the trial, participants were encouraged to continue pre-ordering but stopped receiving discounts. This phase was designed to simulate real-life in which pre-ordering would be a standard service offered by the canteen. Pre-ordering lunch during this period was associated with lower energy lunches (-115 kcal, 95% CI= -147 to -83, p< 0.001) compared with baseline where lunch was ordered in the canteen.

In the other medium-term trial, the effect of two different types of pre-ordering on menu selection was investigated (VanEpps et al., 2016a [trial 2]). The results indicated that orders placed far in advance of consumption (i.e., mean = 168 min, SD = 53 min ahead of time), were marginally significantly more likely to be a ‘low-calorie’ menu option (i.e., <500kcal) (60% vs. 53%; p= 0.05) than orders placed closer to lunchtime (i.e., mean = 42 min, SD = 20 min ahead of time). Orders placed far in advance contained slightly less energy on average (mean = 568, SE = 15) than those placed closer to lunchtime (mean = 598 calories, SE = 14; p= 0.086), but this difference was not statistically significant.

b. Fat

Two studies reported on the effect of the intervention on the fat content of lunches ordered with one of these studies reporting a significant reduction (Stites et al., 2015). This trial reported that when pre-ordering was financially incentivised via discounts, those who pre-ordered purchased lunches with 8.9 grams less fat (95% CI= -15.2 to -2.6, p= 0.005) than those who ordered at lunchtime. This effect was largely sustained when financial incentives were removed, with pre-ordering lunch during this period associated with lower fat lunches (-5.4g, 95% CI= -7.5 to -3.8, p <0.001) compared with baseline when lunch was ordered in the canteen. The other trial found no significant difference in fat ordered between those ordering far in advance and those ordering closer to lunchtime (mean difference = -0.14g, p=0.89) (VanEpps et al., 2016a [trial 2]).

c. Other nutrients

One trial investigated the effect of pre-ordering on other nutrients contained in lunches ordered and reported no significant effect of the intervention on the carbohydrate, protein, fibre, or sodium content of lunches ordered far in advance compared with lunches ordered closer to lunchtime (VanEpps et al., 2016a [trial 2]).

3.3.5 What study characteristics are associated with intervention efficacy?

a. Time delay

The two trials by VanEpps et al., (2016a) aimed to investigate the effect of time delay between order placement and collection on the energy content of lunches ordered. In trial 2, both groups pre-ordered but the time delay was varied such that for one group, orders were placed far in advance of lunchtime (at least 60 minutes ahead of time) and for the other group orders were placed closer to lunch time (at least 30 minutes ahead of time). Those ordering far in advance (60%) were marginally significantly more likely to order a lunch from the lower-calorie section (i.e., <500kcal) than those ordering closer to lunchtime (53%), but this was associated with only a small non-

significant reduction in energy ordered (-30 kcal). It is important to note that in this study there was overlap in time delay for participants in the two groups which is likely to have reduced the difference in energy ordered between groups. In trial 3, the authors removed the shorter time-delay such that participants were randomised to either order and receive their food immediately or order in advance (by at least 80 minutes). To ensure that time-delay was the main mechanism being manipulated, participants in the immediate consumption group were not able to see the food when ordering (i.e., sensory cues were eliminated). This trial found a significant effect of time-delay such that those ordering in advance ordered 106 kcal fewer calories than those ordering for immediate consumption. Taken together, these findings might indicate that modifying the size of the time delay between order placement and collection when pre-ordering may increase the effect of the intervention. Stites et al., (2015), did not directly manipulate the effect of time delay but those in the pre-ordering condition had to place orders at least 45 minutes in advance of collection. This trial reported a slightly larger effect size than VanEpps et al (2016a), however comparisons were between those pre-ordering online and those ordering in-the-moment from the canteen. As such, those ordering in-the-moment were potentially exposed to sensory cues such as the sight and smell of tempting foods which may have increased energy ordered in this condition.

b. Participant characteristics

Two studies examined interactions between participant characteristics and intervention efficacy. One trial conducted over a 4-week period comparing two forms of pre-ordering (far in advance and closer to lunchtime) found no evidence of differences according to demographic variables including gender, age, ethnicity, dieting status or BMI (VanEpps et al., 2016a [trial 2]). Similarly, the other trial comparing one-off orders placed in advance with orders made for immediate consumption reported no evidence of significant interactions between demographic variables and intervention efficacy (VanEpps et al., 2016a [trial 3]). One trial found that higher self-reported hunger ratings were associated with more calories ordered, and participants in the pre-ordering condition rated themselves as less hungry at the point of ordering. However, mediation analysis found no evidence of significant mediation through hunger (VanEpps et al., 2016a [trial 3]).

3.3.6 How acceptable are pre-ordering interventions?

Two studies reported on acceptability-related measures. One trial examined the effect of pre-ordering on meal satisfaction and found no difference in satisfaction between those who pre-ordered (mean= 4.10) and those who ordered in-the-moment (mean= 4.28; p= 0.33) (VanEpps et al., 2016a [trial 3]). The other trials asked participants to report any problems they experienced while pre-ordering (Stites et al., 2015). Participants cited issues such as difficulties collecting pre-orders, remembering to pre-order, and online menus not matching the canteen menu. Despite these issues, 92% of participants reported that they would use a pre-ordering system if it was offered by the canteen in the future.

3.3.7 Risk of Bias Assessment

Table 3.3 presents a summary of the RoB assessments. Of the 3 studies reviewed, no study was judged to be at low risk of bias across all domains. One study has a high risk of bias in 1 domain, and all three studies had some concerns in at least 1 domain.

Table 3.3 Risk of Bias Assessment

Study	**Risk of Bias**					
	(i)	**(ii)**	**(iii)**	**(iv)**	**(v)**	**(vi)**
Stites et al., (2015)						N/A
VanEpps et al., 2016a, Trial 2*						
VanEpps et al., 2016a, Trial 3						N/A

*The Crossover design version of the RoB tool was used to analyse this study. There is an additional domain for crossover trials which has been added as domain (vi)

Risk of bias legend: Risk of bias arising from;

(i) the randomisation process
(ii) deviations from the intended interventions (*effect of assignment to intervention*)
(iii) missing outcome data
(iv) measurement of the outcome
(v) selection of the reported result
(vi) carryover effects

3.4 Discussion

Only three studies testing the effect of pre-ordering interventions on dietary outcomes in adults were identified. All three studies were conducted in real-world settings and point to pre-ordering as a potentially effective strategy for reducing the energy content of food and drinks pre-ordered. However, there remains considerable knowledge gaps surrounding this type of intervention which are summarised in this section. Studies were judged to be of mixed quality. Van Epps et al., 2016a [study 3] had a low risk overall. The study by Stites et al., 2015 was judged to have highest risk of bias of the three studies while Van Epps et al., (2016a) [Study 2] was assessed as having "some concerns".

3.4.1 Intervention target

To date, pre-ordering studies have mainly focused on reducing the energy content of lunches ordered. Two of the three studies reported significant reductions in the total energy of lunches pre-ordered. One trial targeted saturated fat alongside energy.

Although reducing the energy (and fat) content of lunches ordered by adults was the primary target of the studies included in this review, other research has examined the effect of pre-ordering interventions on the broader healthfulness of foods and drinks purchased with children in school canteens. One such trial reported that among students aged 9 to 13 years, pre-ordering increased fruit selection by 27.7%, vegetable selection by 15.8%, and selection of low-fat milk by 16.3% compared to when orders were placed in the canteen as usual (Miller et al., 2016). This trial also reported that combining pre-ordering with a reminder message of nutritional recommendations significantly enhanced this effect, with students in this group increasing their selection of fruits, vegetables, and low-fat milk by 8%, 15% and 13% respectively compared with pre-ordering alone. Other studies conducted in school canteens in which pre-ordering systems are in place have tested ways to enhance the effectiveness of pre-ordering. One such trial redesigned the school canteen's pre-ordering website in accordance with evidence-based healthy eating nudges. Availability of more healthful options was increased, menu items were classified into green, amber, and red categories according to their nutritional value and assigned a

traffic light label, menu items were re-ordered such that more healthful options were presented first, and messages providing positive reinforcement were displayed when more healthful options were selected. Students (aged 5-12 years) using the enhanced pre-order website ordered significantly less energy, saturated fat, and salt than students who used the standard pre-ordering system (Delaney et al., 2017). Whether these findings in children translate to adults is unclear, so research should examine strategies to enhance the effectiveness of pre-ordering with adults in workplace canteens.

3.4.2 Intervention characteristics

Pre-ordering has been identified as a potentially effective strategy for improving the healthfulness of food and drinks purchases, because it requires individuals to make decisions in advance when they are likely to be less hungry and without being exposed to the sight and smell of tempting foods, which theory suggests depletes self-control (Schwartz et al., 2014). The time delay between ordering and collection, the absence of food cues and pre-commitment are, therefore, the three key mechanisms thought to drive the effect of pre-ordering. The combined findings from the two studies examining time delay suggest that a larger time delay between ordering and collection may strengthen the efficacy of the intervention. This finding aligns with the results from a non-randomised study (VanEpps et al, 2016a [study 1] that was not included in this review which examined the association between time of order placement and the energy content of purchases made. The study reported that for every 1-hour delay between order placement and collection the energy content of lunches ordered decreased by approximately 38 kcal (p= 0.015). This finding aligns with economic theories of dynamic inconsistency and hyperbolic discounting which suggest that individual preferences change based on how far in the future the outcome will be experienced, and this is thought to be caused by our tendency to prioritize current benefits over future costs (Ainslie 1975; Read and Van Leeuwen 1998). For example, a person wanting to lose weight might decide at breakfast to have a salad for lunch, but when lunchtime comes around, they opt for the immediate pleasure of a tasty high-energy food despite of the potentially negative future impact it will have on their weight. It is this ‘present-bias' which is thought to underlie a myriad of sub-optimal behaviours such as unhealthy eating, smoking and not saving for a pension (Thaler,

1981). Given that time delay was not randomly assigned in the aforementioned study, these findings cannot be interpreted as causal evidence of the effect of greater time-delays. It is possible that people who order their lunch earlier are also inclined to order less energy (e.g., they may be consciously using pre-ordering as a commitment device). Nevertheless, the findings of the studies reviewed here, suggest that time-delays (even small ones ~30 mins) between order placement and collection might encourage lower-energy food choices, and that increasing the time delay between order and collection may help to maximise potential energy reductions yielded.

Temporal construal theory (Trope & Liberman, 2003) provides one explanation for why the time delay is important. It suggests that pre-ordering may help to promote healthier dietary choices by eliciting decisions at timepoints when people are most likely to be guided by goals such as health. According to this theory, we hold different cognitive representations for present and future events. Decisions around present events are thought to be guided by concrete low-level factors like the subjective experience of the event, such as taste or satiation, while choices for future events are guided by more abstract, high-level representations, like the goal of eating a healthier diet. When integrated with the multiple-selves model (Kivetz & Tyler, 2007), temporal construal theory can help to explain why pre-ordering might be effective. The multiple selves model holds that we have both a pragmatic version of ourselves which prioritises tangible benefits (e.g., taste) and an idealistic self which is more likely to engage in health-promoting behaviours. Research has shown that during future decision-making activities the idealistic self is activated (Trope & Liberman, 2003). This finding indicates that when pre-ordering, people may be less guided by concrete details relevant to the consumption experience, like taste, and more likely to behave in ways that are consistent with their idealistic self (i.e., I'm a healthy person who eats healthy foods).

With respect to the presence of food cues, only one trial compared choices made when pre-ordering with choices made in the canteen environment (Stites et al., 2015). This trial reported slightly larger but overall similar energy reductions to one of the other studies in which all participants made their choices in the absence of food cues (VanEpps et al, 2016a [trial 2]). Evolutionary theory may help to explain why we might make less healthful choices in the presence of sensory cues. Due to our innate preference for energy-dense foods, reward pathways in the brain are stimulated by

these foods. The reward system is responsible for our cravings of energy dense foods and motivates our behaviours to satisfy these cravings by obtaining such foods. Food cues activate the brain's reward pathways which, in turn, trigger cravings. This causes us to focus our attention on unhealthy but rewarding foods, and this attention bias towards the rewarding stimuli is elevated when in a hungry state (Appelhans et al. 2016). Hunger is an example of a 'hot state' and empirical evidence shows that individuals are more likely to make impulsive, less healthful choices when in a 'hot state' (Loewenstein, 1996; Loewenstein, 2000; Cameron et al. 2014). Furthermore, when in a cold state, individuals also find it difficult to imagine being tempted in a 'hot state' and, as a result have been shown to vastly underestimate their susceptibility to reward cues when hungry (e.g., energy-dense nutrient poor foods) (Appelhans et al. 2016; Wilson & Gilbert, 2003). Pre-ordering is thought to improve dietary choices by enabling people to make choices when they might be potentially less hungry, and in the absence of sensory cues such as the sight and smell of tempting foods. Further research is needed to examine the role that sensory cues play in the context of pre-ordering.

Finally, pre-ordering is thought to be effective, because it commits individuals to the choices they made when less hungry (assuming they had breakfast) and in the absence of food cues. When an individual pre-commits, they are less likely to change their order because the pre-committed choices may start to be viewed as the 'default', and there is evidence that individuals have a strong tendency to stick with the default (Just & Price, 2013). Studies reported in this review did not examine changes made to pre-orders upon collection. However, one observational study not included in this review (because it did not measure dietary outcomes), reported that more last-minute additions were made to pre-ordered lunches by females. The authors found that while female patrons were more likely to make last-minute additions to their pre-orders, they were less likely to add high-energy items such as desserts and sides than male patrons (Migliavada et al., 2021). Future research should examine the extent to which alterations are made to pre-orders in real-world environments.

3.4.3 Participant characteristics

Two of the three studies included in this review examined the interaction between demographic variables and intervention efficacy (VanEpps et al., 2016a [trial 2 and trial 3]). No evidence of differential effects of the intervention by participant characteristics were reported. One trial exclusively recruited participants with overweight or obesity who also received mindfulness eating training. It is possible that the magnitude of energy reductions observed in this trial were a result of these participants being particularly motivated or willing to try new strategies to change their eating behaviours in order to lose weight. Evidence in support of this idea comes from a study examining self-reported weight loss attempts which found that overweight or obesity was the biggest predictor of weight loss attempts (Piernas et al., 2016). However, energy reductions observed in this trial were similar to those reported in trial 2 by VanEpps and colleagues (2016a) in which recruitment was not limited to those with high BMI or those receiving any training. In terms of the effect of hunger, only one trial in this review measured hunger and the authors noted that it is possible that the hunger scale did not capture the urge to eat. Further research is required to examine the mechanisms underlying pre-ordering.

3.4.4 Intervention acceptability

Very little research has examined the acceptability of pre-ordering as a strategy for improving the healthfulness of dietary choices. Initial findings are, however, positive, indicating that pre-ordering is not detrimental to meal satisfaction (VanEpps et al., 2016a), and that future uptake of pre-ordering services may be high (Stites et al., 2015). Issues experienced by pre-ordering system users were briefly explored qualitatively by Stites et al., (2015) and highlighted structural barriers such as remembering to pre-order and issues with order collection. Identifying and addressing barriers to pre-ordering will be important in research going forward given that such factors influence intervention engagement which is likely to have downstream effects for intervention efficacy.

3.4.5 Limitations

As this is a scoping review, no synthesis of the results was conducted meaning that the question of the effect of pre-ordering on energy purchased cannot be

comprehensively answered. Effect sizes were, however, calculated to make studies more easily comparable. Given that this review was being used to inform the design of the intervention for this thesis, I felt it was more important to provide a broader descriptive overview of the evidence and trends across studies relating to the research questions outlined rather than focusing on answering one primary research question, which is usually the case with systematic reviews. Finally, only a very small number of studies (n=3) were identified making it very difficult to make concrete judgements regarding the potential efficacy of pre-ordering as an intervention. Although selection bias can occur if the scoping review does not identify all available data on a topic, efforts were made to minimize this risk, by consulting with a trained librarian and searching five key databases considered to be most relevant to the topic of pre-ordering. It is important to note that there is a broader literature which examines concepts related to pre-ordering such as present bias and pre-commitment that has not been included in the current review. These concepts were not discussed in detail due to the lack of opportunity to conduct the planned study on pre-ordering but have been briefly touched on in the general introduction and section 3.4.2 of this chapter.

3.4.6 Conclusions & future research

Very few studies have tested the effect of pre-ordering interventions on dietary choices in adults. Among the few that have, the primary focus has been on measuring changes in the energy (and fat) content of lunches purchased. While these studies, all of which were conducted in real-world settings, point to the promise of pre-ordering as a strategy for reducing the energy and fat content of lunches ordered, further research is necessary to confirm the effect of pre-ordering on energy ordered within canteen environments and to explore the intervention's impact on wider dietary outcomes such as the purchasing of whole foods (e.g., fruits and vegetables). Deeper examination into the hypothesized mechanisms of change such as time-delays and the presence of food-cues may help to enhance intervention efficacy. Similarly, studies investigating the effect of accompanying pre-ordering with other interventions are warranted with adults, considering the positive findings emerging from studies conducted in school canteens with children. This was one of the aims of the pilot field trial outlined in the protocol presented in Chapter 6. A deeper examination of the acceptability of pre-

ordering as a strategy for improving the healthfulness of food choices in workplace canteens is also warranted. A detailed qualitative examination of the facilitators and barriers to the use of such a system for a workplace canteen could provide important insights for the successful implementation of pre-ordering in environments where the healthfulness of dietary behaviours could be improved. This question of acceptability is addressed in depth in Chapter 7. The next chapter describes the development of an experimental pre-ordering website for a canteen which is used to explore potential messaging to accompany swaps offered.

Chapter 4

The effect of health-based messages on the acceptance of swaps to reduce the energy content of snacks and drinks pre-ordered in an experimental online canteen: a pilot randomised controlled trial

4.1 Introduction

The studies reviewed in Chapters 2 and 3 point to the potential effectiveness of pre-ordering and offering swaps as strategies to improve the healthfulness of dietary choices made by adults. When offering swaps for food and drinks, the messaging and framing around the prompt are likely to influence consumer choice (Forwood et al., 2015), but little research has examined this. Given the lack of research examining the effect of messages on the acceptance of lower-energy swaps, some key information needs to be gathered before a full-scale trial can be conducted. Firstly, it is not yet known what effect sizes may be yielded from accompanying swaps offered with messages.[6] This information is essential for producing accurate sample size calculations. Indications of potential effect size are also important as proof-of-concept and from an intervention design perspective. If the trend of results points to the potential efficacy of a particular message, but the potential effect size is very small, efforts can be made to enhance the potential efficacy of the message before testing it in the next study. Secondly, little is known about the acceptability of offering swaps within the context of a canteen environment, and even less is known about how messages may influence intervention acceptability. This is important given that intervention acceptability is thought to be associated with intervention efficacy (Sekhon

[6] Please note this study was conducted in 2017, prior to Bunten et al. (2021)'s study examining the effect of messages on swap acceptance.

et al., 2017). Thirdly, the extent to which there are differences in the effect and acceptability of messages according to demographic characteristics is not yet known. Should substantial differences between subgroups emerge (e.g., a backfire effect in a certain group), this would need to be taken into account when developing the full-scale study. A pilot study allows for such questions to be addressed in advance of a full-scale study, thereby improving its quality.

As the focus of this PhD is on reducing energy ordered in online canteen settings, the simplest message to present when offering lower-energy swaps might be one that highlights to the consumer that the swap offered is '*lower in calories'*. However, there was uncertainty around whether a calorie-focused message would be acceptable and effective. Qualitative research with expert stakeholders reported a belief among some experts that interventions should focus on overall diet quality rather than calories as calorie-focused messages may not be appropriate for all populations. For instance, it may trigger unhealthy thoughts and behaviours in vulnerable individuals such as those with or susceptible to eating disorders, or it may not resonate with people from cultures where eating is more culturally based (Gonzalez-Nahm et al., 2020). With this in mind, I decided to develop this pilot study to test three health-focused messages: a calorie-focused message, a nutrients-focused message and a health-focused message. A more detailed rationale for testing these individual messages is outlined in the following sections.

4.1.1 Calorie-focused messages

Calorie disclosures are the most common type of nutritional information provided on menus, meaning that this information would not be out of place when offering swaps in an online canteen. Research suggests that consumers want energy (calorie) information when ordering (Bleich & Pollack, 2010), and there is some evidence that calorie disclosures on menus reduce energy ordered compared with when no information is provided (Crockett et al., 2018; Shangguan et al., 2019; Zlatevska et al., 2018). A Cochrane review of studies (n=3) reported an average energy reduction of 47 kcal (MD -47 kcal, 95% CI -78 to -15, N = 1,877) in energy purchased when calorie information was present compared with when no information was provided (Crockett et al., 2018). In the UK, energy reduction has become the focus of public health

campaigns targeting obesity (Public Health England, 2018c). These campaigns, which have received extensive media coverage, are likely to have resulted in an increase in public awareness around the need for excess calories to be cut from our diets. Similar to the Sugar Reduction Programme launched in 2017, the 2018 Calorie Reduction Programme aims to encourage changes in the purchasing behaviours of the public by increasing awareness as well as prompting changes at the industry level (Public Health England, 2018a). Framing swaps as lower-calorie may thus be motivating to consumers in light of this public health advice. Measures of this kind have, however, been met with some resistance, with critics arguing that public health nutrition policies should focus on healthy eating rather than calorie counting (Fernandes et al., 2019). Other sorts of health messages such as those that highlight a swap as being healthier or lower in sugar or saturated fat may offer an alternative to calorie-focused messages, however, little is known about how health-based messages are received in this context.

4.1.2 Nutrient-focused messages

Approximately 40 countries globally have introduced a tax on sugar sweetened beverages (SSBs), and heath taxes on products high in sodium, saturated fat and trans-fat have been trialled in countries like Denmark, Hungry and Finland (Holt, 2011; Wright et al., 2017). If well communicated, these taxes can help signal to consumers that certain products are unhealthful because of their nutrient content (Cornelsen & Carreido, 2015). In recent years, countries such as the UK, USA, Mexico and South Africa, have made efforts to explicitly frame SSB taxes as public health measures to reduce sugar intake (Cornelsen et al., 2020). Research has shown that the introduction of the soft drinks industry levy in the UK was associated with an increase in public awareness of the link between sugary drinks consumption and obesity (Pell et al., 2019), and an experimental study (n=2,002) testing the effect of a message highlighting the exact sugar content of SSBs was found to reduce the likelihood that SSBs would be purchased by 9 percentage points on average compared with when no message was provided (Control= 49.2%, 95% CI: 47% to 51% v Sugar= 40.5%, 95% CI: 38% to 43%) (Mantzari et al., 2018). However, the sugar content message did not significantly decrease the odds of SSB selection when compared with a basic calorie label (43.5%, 95% CI: 41% to 46%). Alongside taxes, FoPL schemes have

been shown to increase public awareness about the link between high levels of specific nutrients and obesity and related diseases (Correa et al., 2019). Research testing Chilean 'High in' labels which highlight high levels of energy and individual nutrients such as fat, salt and sugar have found these labels to be effective in promoting healthier choices. One study (n=1,182) found the hypothetical baskets of consumers exposed to 'High in' labels contained fewer calories (about 11 kcals per 100g, $p<0.009$), less sugar (0.9g per 100g, $p<0.001$) and less saturated fat (0.3g per 100g, $p<0.001$) than the baskets of consumers shown products with no labels [7] (Machín et al., 2018). Taken together, these findings suggest that messages highlighting a swap as lower in specific nutrients such as sugar or saturated fat may increase swap acceptance compared with when no information is provided.

4.1.3 Health-focused messages

Despite the promising evidence for nutrient specific messaging, qualitative research indicates that consumers may find multiple macronutrient information on menus confusing (Lando & Labiner-Wolfe, 2007). The evidence that consumers spend an average of 35 seconds looking at products before making a purchase (Gurnert et al., 2010), has prompted governments to support the introduction of simplified summary labelling (Chantal et al., 2017). Health symbols (e.g., Green Tick or Keyhole) have been introduced in several countries to help consumers quickly identify healthier products (Mørk, et al., 2017). Health symbols provide no nutritional information and are only displayed on products deemed to be the most healthful options (i.e., contain less fat, sugars and salt, more fibre and wholegrain) within a product category. The Heart Foundation Green Tick symbol is used in Australia and New Zealand (Williams & Mummery, 2013), and has been shown to increase the purchasing of more healthful products compared with when no label is present. One study (n=11,981) found that those presented with the Green Tick symbol had significantly healthier baskets as defined by lower Food Standards Agency scores than those presented with no information (Ducrot et al., 2016). Qualitative research supports the idea that simple cues identifying more healthful menu options may be effective, with this form of information being viewed favourably by consumers especially when having to make choices in a hurry (Lando & Labiner-Wolfe, 2007). Other research has found that

[7] No confidence intervals were provided

health-orientated messages, emphasizing that consuming certain foods helps people to ‘maintain good health’, ‘manage their weight’, and ‘stay energised’, significantly increased the likelihood that healthier meals would be selected (OR: 1.83, 95% CI: 1.21 to 2.77, n=198) compared with when no information was provided (Trudel-Guy et al., 2019). Given that swaps encourage people to switch to a ‘healthier’ product, these findings might suggest that a message highlighting a swap as healthier may be effective in increasing swap acceptance.

There is, however, some evidence that labelling foods as ‘healthy’ may have adverse effects on food selection. Research has shown that foods that are viewed as healthy are perceived by consumers as less tasty (Raghunathan et al., 2006; Trendel & Werle, 2016). This may be important given the finding that taste is a key determinant of dietary choice (Kourouniotis et al., 2016). Research in a restaurant setting found that labelling menu items as healthy did not increase selection of lower-fat foods (Horgen & Brownell, 2002). Labelling foods as healthy may also result in ‘licensing effects’ whereby foods perceived to be healthy are over-consumed (Khan & Dhar, 2006). One study (n=99) found that female participants consumed 35% more when a snack was perceived to be healthy than when it was viewed as unhealthy (Provencher et al., 2009).

4.1.4 Aims

Research indicates that providing nutrition information at the point-of-sale effectively promotes more healthful choices in supermarkets (Chan et al., 2021). However, it is not yet known what effect different health-based messages might have on people’s motivation to accept a lower-energy swap offered. The aims of this pilot study were to (i) generate estimates of effect sizes for the potential effect of different health-based messages on swap acceptance and energy ordered to inform the design of future full-scale studies; (ii) examine the acceptability in principle of offering swaps accompanied by different health-based messages in the context of an online workplace canteen and; (iii) check that there is no evidence of substantial differences in intervention effects between demographic groups that would need to be accounted for in future studies.

4.2 Methods [8]

4.2.1 Design and setting

This was an ethically approved (ref no.: 12861/001) 4-arm pilot randomised controlled trial. The study was conducted in a simulated online canteen developed using REDCap (Research Electronic Data Capture)[9]. REDCap is a secure, web-based application designed to support data capture for research studies, providing: (i) an intuitive interface for validated data entry; (ii) audit trails for tracking data manipulation and export procedures; (iii) automated export procedures for seamless data downloads to common statistical packages; and (iv) procedures for importing data from external sources (Harris et al., 2009). The simulated online canteen was designed based on a custom-made experimental online supermarket platform, used in previous studies (Forwood et al., 2015; Koutoukidis et al., 2019). The simulated online canteen was a website that allowed employees to hypothetically pre-order their sweet snacks (n= 17), savoury snacks (n= 9), and non-alcoholic drinks (n= 25) for the workday. For this study, the menu was restricted to snacks and drinks only, because many of these are standard items sold across workplaces whereas hot-food menus tend to vary by organisation. The process for selecting these menu items is described in section 4.2.5.

Participants were randomised to one of the four trial arms. During the experiment, participants were asked to select 3 items (one sweet snack, one savoury snack, and one drink) from the menu that they would like to consume during their working day. Data were collected via the online canteen and from pre-and post-trial questionnaires developed using REDCap.

4.2.2 Participants

Participants were recruited through an online participant sourcing platform called Prolific Academic (Palan & Schitter, 2018) in August 2019. Prolific Academic pre-

[8] Some aspects of the methods section are reproduced from a published paper with permission from Breathnach et al., (2021).

[9] The study was initially developed using the purpose built online supermarket platform used in previous studies (e.g., Forwood et al. 2015; Koutoukidis et al., 2019). However, due to GDPR issues I was unable to collect data through the platform and so REDCap was employed.

screened panel members for eligibility and sent invitations to a random subsample of a pool of 8,123. As the platform did not record invitation and response rates, this information was not available. As this is a preliminary study to inform the pilot field trial that I intended to conduct with a real-world workplace canteen in the UK, the target population of the intervention was adults working in the UK. To be eligible, panel members had to live in the UK, speak English fluently, be in full- or part-time employment and aged between 18 and 65 years. The age and employment criteria were used to help ensure that a sample similar to the target population of the planned intervention would be recruited. The target population of the planned intervention was employees of a UK healthcare company (Bupa Healthcare UK); Bupa Healthcare UK (henceforth Bupa) had agreed to take part in a pilot field trial as part of this PhD research testing a swap-based intervention for a pre-ordering system. However, due to Covid-19 this field trial could not be completed. Those following any restricted diet such as a vegan, dairy-free, sugar-free, or gluten-free diet were not eligible as this would influence the appropriateness of swaps offered. Panel members who were deemed eligible could access the study via a link on their Prolific Academic dashboard. The link directed interested panel members to a website where they could read the information sheet and provide consent electronically by ticking a box.

4.2.3 Randomisation & blinding

Randomisation was performed using SmartSurvey, a survey design platform. This platform has functionality which allows researchers to randomly display different information to each respondent. Before creating the randomisation page in SmartSurvey, four separate versions of the online canteen (i.e., one for each condition) were created, each with their own unique REDCap link. Participants were then randomly assigned to condition using the '*question randomisation'* functionality which allows researchers to randomly display different information to respondents. To do this, a new page on SmartSurvey containing four different 'questions' was created. All four 'questions' contained identical descriptive text which read "*Please click here to view the menus. This link will open in a new window.*" The word '*here'* was hyperlinked and contained a different link to the online canteen (i.e., one link for each condition). The platform then automatically randomised participants (1:1:1:1) to receive one of the four links by randomly assigning a number to each participant. This

number (1 through 4) corresponded to the link they were presented with. Allocation concealment was achieved, as participants were recruited by Prolific Academic and were directed to SmartSurvey for automatic randomisation.

I was not blinded to intervention allocation, but I was not able to manipulate any study parameters following the initial study set up, as all study procedures took place in the online platform. Although I was not blinded to intervention allocation during the analysis, the code and analyses were checked by a researcher blind to intervention allocation. Participants were not aware of the purpose of the study, however, due to the nature of the intervention, it was not possible to blind participants to the intervention. Participants were only aware of the trial arm that they were exposed to and were unaware of the other trial arms until the end of the study when they were debriefed.

4.2.4 Online ordering task

Following randomisation, participants were redirected to REDCap where they completed a short demographic survey. The survey collected information on gender, age, ethnicity, education, and income. Eligibility questions regarding employment status and dietary restrictions were also included to ensure participants met the eligibility criteria at the time the task was completed (i.e., to account for any changes in status not updated in Prolific Academic's system). After completing this questionnaire, participants were directed to the online canteen which presented the following vignette: "We'd like you to imagine that you arrive at work on Monday morning to receive this email… *Hi Team, we've set-up a new online ordering system for the canteen. Please login to your account and choose your drink and snacks for today. The canteen will have your order ready for collection. Thank you, The Canteen Manager".* After reading this, participants were asked to select a sweet snack, a savoury snack, and a drink from the menus that they would like to consume during their working day and were reminded to make selections that were in keeping with what they would usually purchase. The order in which participants selected snacks and drinks was fixed such that sweet snacks were selected first, then savoury snacks and finally, drinks. Ideally, the order in which products were presented would have been randomised, however this was not possible in REDcap without advanced

programming which I did not have access to when this study was being developed. As this limitation applies to both this study and the next study, it is discussed in the general discussion (Chapter 9). Table 4.1 provides a summary of each menu, for complete menus please see Appendix 4.1, Additional File 1. Participants were offered swaps to alternative products from those originally presented if a suitable swap was available.

Table 4.1: Summary of menus with examples of swaps offered for initially selected items in each category. The proportion of swaps available, means and range of energy content (in kcal) by menu is also provided.

Menu	**Type of items offered**	**Example of initially selected item**	**Example of swap offered**	**% Swaps available**	**Mean (range) energy kcal***
Sweet (n=17)	1.Chocolate bar 2.Biscuit 3.Muffin 4.Flapjack 5.Cereal bar 6.Fruit	1.Cadbury Dairy Milk (240 kcal) 2. Cadbury Dairy Milk Buttons (160 kcal)	1.Cadbury Dairy Milk Buttons (160 kcal) 2. Apple & grape snack pack (45 kcal)	94% (16/17)	195 kcal (45-393 Kcal)
Savoury (n=9)	1.Crisps 2.Nuts/trail-mix 3.Vegetable snack	1.Kettle Chips Salt and Vinegar (204 kcal) 2. Popchips Salt & Vinegar (95 kcal)	1. Popchips Salt & Vinegar (95 kcal) 2. Carrot sticks (17 kcal)	89% (8/9)	157 kcal (17-250 Kcal)
Drinks (n=25)	1.Carbonated Soft Drink 2.Still & Juice Drink 3.Fruit Juice (100%) 4.Sports & Energy Drink 5.Water	1. Oasis Summer Fruits (86 kcal) 2. Oasis Summer Fruits Zero (17 kcal)	1. Oasis Summer Fruits Zero (17 kcal) 2. No swap offered	48% (12/25)	76 kcal (0-237 kcal)

Note: * Refers to the mean (range) energy (in kcal) content of all menu items.

4.2.5 Menu item selection

Menu items were selected by searching through the sweet snack, savoury snack and non-alcoholic drinks sections of the websites of three major UK retailers; Tesco, Sainsbury's, and Waitrose. Products higher in energy and saturated fat/sugar were identified and were paired with alternatives that were sufficiently lower in energy and saturated fat/sugar to meet the thresholds outlined below in section 4.2.6. The decision regarding suitable alternatives (i.e., swaps) was based on (a) flavour and food-type (e.g., offering cheese flavour crisps for cheese flavour crisps as opposed to nuts). This is described in detail in the next section. An item was selected as a menu option for the study if it met the following criteria:

1. Is widely available in the UK (in at least one of the three aforementioned retailers).
2. Is commonly consumed in the UK. Marketing data on most commonly purchased snacks in the UK from YouGov (2019) and Statista (2019) helped inform the choice of sweet and savoury snacks respectively. Data from the British Soft Drinks Association (2019) informed the choice of non-alcoholic drinks. Based on their 2019 Annual Report, a mixture of carbonated drinks; still and fruit drinks which refer to drinks containing 1% to 99% juice, still flavoured waters, iced teas and non-fruit drinks; fruit juice which is 100% pure juice; water and sports and energy drinks were selected.
3. Is available individually packaged (i.e., not part of a multipack) and as a single serving portion (i.e., not sharing size).

A very low in energy item was also included on each menu. For sweet snacks, this was chopped ready-to-eat fruit. For savoury snacks, this was carrot sticks and for drinks this was still water. The decision to include these items was based on the rationale that (a) these items are almost always available in supermarkets and canteens and so their exclusion would reduce the external validity of the study and (b) to maximise the number of swaps that could be offered. Including a very low-energy item on each menu meant that a swap could be offered to those initially selecting a ‘medium-energy’ item (i.e., a swap item).

Following the product search, 17 sweet snacks, 9 savoury snacks and 25 non-alcoholic drinks met these criteria and were included as menu options. There were considerably fewer savoury snack options than sweet snack options because there were very few savoury snacks that matched the flavour profile of high-energy items, met the previously stated criteria, and met the energy and saturated fat/sugar threshold described in the next section. A database of nutrient information was manually created by searching supermarket websites for products and recording the energy, sugar and saturated fat information for each item based on the food labels provided online.

4.2.6 Swaps offered

Participants were offered swaps based on their initial selection. High-energy and saturated fat/sugar items were identified and paired with lower energy and saturated fat/sugar items. To qualify as a swap, items did not have to be the same or a similar weight, but had to be:

- ≥ 50 kcal lower per item than the originally selected item and;
    - ≥0.5g less saturated fat per item than the originally selected snack or;
    - ≥0.5g less sugar per item than the originally selected drink.

The calorie threshold was based on evidence from modelling studies that have identified a 50 kcal reduction in energy per-person per-day as being clinically relevant (Hill et al, 2003). The 50 kcal reduction represents a 2.5% energy reduction compared with the 2000 kcal recommended intake. For consistency, sugar and saturated fat threshold were set at ≥0.5g, as this is approximately 2.5% of the recommended intake for each of those nutrients. This meant that all swaps offered contained at least ≥50kcal fewer calories. All swaps offered for *snacks* had to also contain ≥0.5g of saturated fat (but not ≥0.5g less of sugar) than the initially selected item. All swaps offered for drinks also had to contain ≥0.5g of sugar (but not saturated fat). These reductions are small because the main focus was on lowering energy. I wanted, however, to ensure that when framing lower-energy swaps as “lower-sugar” this was a truthful statement, even if only by a small amount. Where no product met the criteria, no swap was offered.

Where possible, swaps offered were as close in nature to the originally selected item (e.g., a packet of Dairy Milk Buttons 30g was the swap offered for a Dairy Milk Bar 45g). In cases where this was not possible, swaps judged by me to be relatively close in flavour and texture to the original item were offered (e.g., a Nakd Bar Peanut Delight 35g was offered as the swap for a Snickers 48g). Swaps offered for drinks were almost always the diet or zero version of the originally selected drink. Where diet or zero equivalents were unavailable or did not meet the criteria, swaps judged to be relatively close in flavour to the original item were offered (e.g., Volvic touch of fruit lemon and lime Sugar-free 500ml was offered as the swap for Juicy Water Lemons and Limes 420ml).

Participants initially selecting items lowest in energy or saturated fat/sugar (i.e., swap items) were offered dissimilar swaps, once these swaps potentially yielded a ≥ 50kcal energy reduction. For sweet snacks, this was chopped ready-to-eat fruit and for savoury snacks this was carrot sticks. For drinks, no swaps were offered for the lowest energy/sugar items because many of these were already very low or zero-calorie drinks and so swaps offered would not meet the ≥50 kcal threshold. Table 4.1 summarizes the three menus and provides examples of swaps offered for initially selected items in each category. A lower-energy alternative existed for 63% of products (92% of snacks and 48% of drinks). Participants were prompted with swaps at the point-of-choice rather than at the checkout given that previous research has shown that this is the most effective point of intervention (Forwood, et al., 2015). Participants could decline or accept the swap by clicking either "*No, I will stick with my choice*" or "*Yes, I would like to swap*".

4.2.7 Intervention

Participants were randomly allocated to receive one of the following messages when swaps were offered as shown in Figure 4.1:

- Control: "How about a swap?"
- Calories: *"How about a swap? This has fewer calories."*
- Nutrients: For drinks: "*How about a swap? This has less sugar".* For snacks: "*How about a swap? This has less saturated fat".*
- Healthier: "*How about a swap? This is healthier"*

Figure 4.1: An example of the intervention when selecting a Cadbury Dairy Milk bar. (top left) the control condition; (top right) the calories message; (bottom left) the nutrients message for snacks; (bottom right) the healthier message.

The price of each item was presented beneath the image of the item. Prices were standardised across menus. All snacks were priced at £0.80, and all drinks were priced at £1.00.

4.2.8 Post-trial survey

Once participants had made their three selections and had accepted or declined any swaps offered, they were asked if they had been offered a swap (yes or no), this was used as an attention check. Participants were then presented with a question about the acceptability of the intervention. They were first asked to imagine that their workplace had a canteen and their employer had implemented an online ordering system like the one they had just used. They were then asked to indicate the extent to

which they agreed with the following statement: *"I would find being offered swaps for my food choices acceptable"*. Responses were on a scale from 1 (strongly disagree) to 5 (strongly agree). Participants were then debriefed and reimbursed with £0.50 for their participation in line with Prolific Academic's guidelines.

4.2.9 Outcome measures & statistical analysis

Outcome measures were separated into three categories relating to the research aims previously outlined; (i) effect-size estimation; (ii) intervention acceptability and (iii) subgroup analyses. Table 4.2 presents the study outcomes and corresponding methods of statistical analyses employed.

A decision was made a priori to analyse the three product categories separately because previous research has pointed to variation in average swap acceptance by the type of product (Koutoukidis et al., 2019). As this outcome examines swap acceptance, only those offered a swap (in each product category) were included in the analyses.

For the analysis of energy content, only those offered swaps were included so that the effect of the messages on energy ordered could be examined. For the subgroup analyses, descriptive statistics were presented for each subgroup given that the intention of this analysis was to identify any major differences between groups in swap acceptance and intervention acceptability. The boundaries for dichotomising age, income and education were based on a previous similar study examining a swap-based intervention (Koutoukidis et al., 2019), to facilitate comparison.

Initially, inferential statistics were conducted to examine potential efficacy, however, upon further research and consultation with my supervisors I decided to remove them. This decision is in line with CONSORT guidance on pilot trials which recommends against conducting hypothesis testing in pilot trials which are not powered to do so. Given that this is a pilot trial and had sample of (n=450), no tests for statistical significance were conducted. Instead, the focus was on reporting descriptive statistics (means and percentages) across the different groups, in order to calculate power for study 4 reported in the next chapter. Standardised effect sizes reported for means are Cohen's *d*. This was calculated using the mean change in energy (and standard

deviation for change) before and after swaps were offered for each group and the sample size in each group. Data were managed in Stata (version 16) (Stata Corp, 2019).

Table 4.2: Study outcome measures and methods of statistical analysis employed.

Outcome measure	**Statistical analysis**
Effect-size estimation	
(a) Acceptance of swaps offered between groups separately for each of the three categories (i) sweet snacks (ii) savoury snacks and; (iii) drinks for each of the 4 intervention groups.	● Among those offered swaps in each category, the proportion (n and %) of swaps accepted for (i) sweet snacks; (ii) savoury snacks and; (iii) drinks in each of the 4 intervention groups.
(b) The energy (kcal) of products ordered between groups for those offered swaps separately in each of the three categories (i) sweet snacks (ii) savoury snacks (iii) drinks for each of the 4 intervention groups.	● Among those offered swaps in each category, the mean and standard deviation of the change in energy ordered following the swap offered for (i) sweet snacks (ii) savoury snacks and; (iii) drinks in each of the 4 intervention groups.
(c) The difference in the total energy (kcal) of products finally ordered between intervention groups and control across the three product categories combined.	● Among those offered swaps, the mean and standard deviation of the change in total energy ordered following the swaps offered in each of the 4 intervention groups.
Intervention acceptability	
(a) The difference in acceptability ratings (Likert scale: 1 strongly disagree to 5 strongly agree) of the intervention between intervention groups and control.	● The proportion of participants in each group agreeing (rating of 4 or 5) and disagreeing (1 or 2) with the statement: "*I would find being offered swaps for my food choices in my workplace canteen acceptable."*

Subgroup analyses	
(a) Subgroup analysis of swap acceptance between intervention groups and control for each of the three categories (i) sweet snacks (ii) savoury snacks and; (iii) drinks.	● Among those offered swaps, the proportion (n and %) of swaps accepted for each of the following subgroups: gender (male and female), age (below median and median or above), ethnicity (white and non-white), education (up to and including college/A-levels completed and undergraduate or higher), and income (below £25K and £25K or above per year).
(b) Subgroup analysis of intervention acceptability ratings between intervention groups and control.	● The proportion (n and %) of participants in each group rating the intervention as acceptable (i.e., 4 or 5 on the Likert scale) and unacceptable (i.e., 1 or 2 on the Likert scale) for each of the following subgroups: gender (male and female), age (below median and median or above), ethnicity (white and non-white), education (up to and including college/A-levels completed and undergraduate or higher), and income (below £25K and £25K and above per year).

4.2.10 Sample size

Sample size targets were based on a previous study testing a swap-based intervention and recommendations from the literature on pilot trial design. Although 8 studies testing swap-based interventions were identified in the scoping review reported in Chapter 2, when this pilot was designed, only one study was similar enough to this pilot in terms of design to be used as a source of reference for the sample size calculations. This study by Forwood et al., (2015) tested the effect of offering lower-energy swaps on the energy density of shopping baskets. In this study, the control group ordered their shopping online as usual and were prompted with swaps. The authors based their sample size calculations on a small expected effect size (d=0.2). In contrast, the current study offers swaps to all participants with only the message accompanying swaps offered being manipulated. As such, effect sizes in this pilot study are expected to be very small, in the region of (≤0.1). Whitehead et al. (2016) recommends a sample size of 75 per group for a pilot trial in which the expected standard effect sizes are very small (≤0.1). This target (n=75 per group, n=300 total) was inflated by 50% so that the sample sizes in the subgroup analyses would be larger and therefore provide greater power to observe major differences between subgroups, should they exist. This gave a target sample size of 450.

4.3 Results

Out of the 8,123 participants deemed eligible by Prolific Academic (of whom an unknown subsample was invited) 483 (6%) participants consented to take part in the study and were randomised to one of four groups. Although filters were applied by Prolific Academic to prevent the inclusion of participants not meeting the eligibility criteria, responses to the pre-screener questions revealed that 29 participants did not meet the inclusion criteria with proportions not differing between groups. This was monitored during the data collection process. The ineligible participants self-reported as unemployed or not in paid work (n=24) or as having dietary restrictions (n=5). A further 5 (4.7%) participants were excluded due to incomplete responses. This left a final sample of 449 participants (Figure 4.2).[10]

Participants were on average 33.7 years old (SD= 10.2). Half (50%) of the sample was female, 83% identified as white, and 62% had completed some form of third-level education.

[10] One participant was excluded after recruitment had been closed due to a note they provided post-study on their dietary requirements.

Almost half (46%) of the sample had an annual salary before tax in excess of £25,000. Average completion time for the study was 4 minutes 5 seconds (SD= 1 minute 13 seconds) and attention checks confirmed high-levels of engagement with the task (Appendix 4.2, Additional File 1).

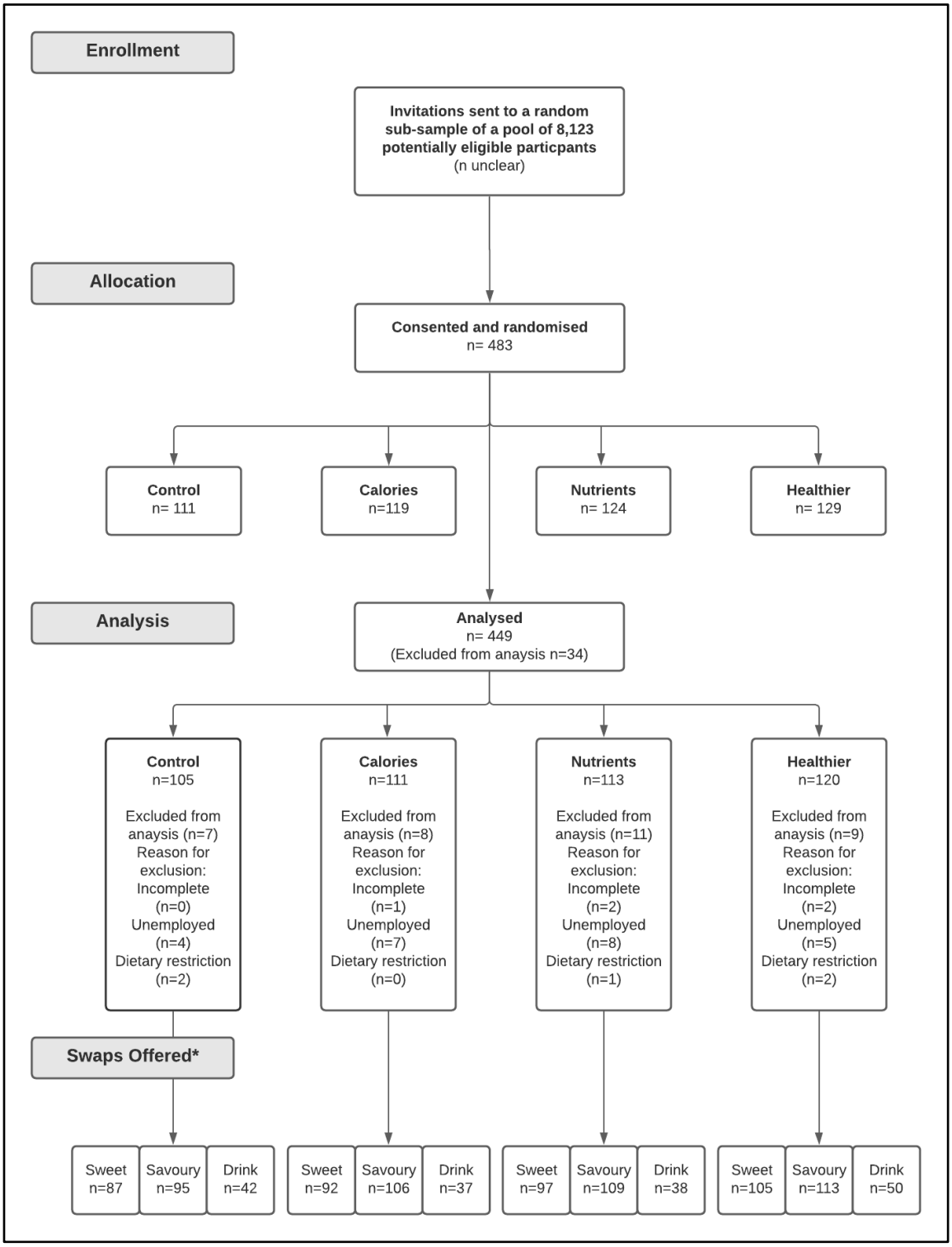


Figure 4.2: CONSORT flow diagram. *Note: The swaps offered section above provides a breakdown of the number of participants in each group that were offered swaps for their initial selections in each product category.

Table 4.3: Baseline characteristics of participants, by trial arm.

	Control (n = 105)	**Calories (n = 111)**	**Nutrients (n = 113)**	**Healthier (n = 120)**	**Total (n = 449)**
Age, *years*, mean ± SD	33.8 ± 10.5	33.1 ± 9.9	34.7 ± 10.0	33.1 ± 10.2	33.7 ± 10.2
Gender, *female*, n (%)	55 (52.4)	52 (46.9)	50 (44.3)	66 (55.0)	223 (49.7)
Other	0	0	0	1 (<1%)	1 (<1%)
Ethnic group, n (%)					
White	88 (83.8)	95 (85.6)	86 (71.6)	102 (85.3)	371 (82.6)
Mixed/Other	5 (4.8)	2 (1.8)	8 (7.1)	4 (3.3)	19 (4.2)
Asian/Black	12 (11.5)	14 (12.6)	19 (16.8)	14 (11.7)	59 (15.1)
Education, n (%)					
None-Secondary	12 (11.5)	13 (11.5)	10 (8.8)	15 (12.5)	50 (11.1)
College / A-level	28 (26.7)	31 (27.9)	21 (18.6)	41 (34.2)	121 (26.9)
Undergraduate	40 (38.1)	43 (38.7)	53 (46.9)	50 (41.7)	186 (41.4)
Graduate & higher	24 (23.8)	24 (21.6)	29 (25.6)	14 (11.7)	92 (20.5)
Income, n (%)					
Below £15.5K	28 (26.7)	12 (10.8)	23 (30.4)	28 (23.3)	91 (20.3)
£15.5K - £24,999K	25 (23.8)	43 (38.7)	27 (23.9)	46 (38.3)	141 (31.4)
£25K - £39,999K	30 (28.6)	33 (29.7)	43 (38.1)	31 (25.8)	137 (30.5)
£40K or Above	18 (17.1)	21 (18.9)	18 (15.9)	13 (10.8)	70 (15.6)
Prefer not to say	4 (3.8)	2 (1.8)	2 (1.8)	2 (1.7)	10 (2.2)

4.3.1 Estimate of effect size (a): Swap acceptance

Almost all (99%) participants were offered at least one lower-energy swap across their 3 food and drink selections. Overall, 21% (200 out of 971) of swaps were accepted. Table 4.4 shows the percentage acceptance rate of swaps by group. Across all comparisons, the calorie-based message yielded the largest indication of potential effect sizes. For sweet snacks, the calories group had a 5.5 percentage point higher acceptance rate than control while the nutrients and healthier groups had a 4.4 and 3.6 percentage points respectively higher acceptance rate than control. For savoury snacks, the calories group had a 9.9 percentage points higher acceptance rate than control while the nutrients and healthier groups had a 6.5 and 8.4 percentage points respectively higher acceptance rate than control. Finally for drinks, the calories group had a 18.1 percentage point higher acceptance rate than control while the nutrients and healthier groups had a 1.5 and 9.7 percentage points respectively higher acceptance rate than control.

Table 4.4: Number of participants offered and accepting a swap (proportions accepting in parentheses) for each product category by group.

	Control (n = 105)	**Calories (n = 111)**	**Nutrients (n = 113)**	**Healthier (n = 120)**	**Total (n=449)**
Sweet snacks					
Swaps offered n	87	92	97	105	381
Swaps accepted n (%)	15 (17.3%)	21 (22.8%)	21(21.7%)	22 (20.9%)	79(20.7%)
Savoury snacks					
Swaps offered n	95	106	109	113	423
Swaps accepted n (%)	13 (13.7%)	25 (23.6%)	22(20.2%)	25 (22.1%)	85(20.1%)
Drinks					
Swaps offered n	42	37	38	50	167
Swaps accepted n (%)	6 (14.3%)	12 (32.4%)	6 (15.8%)	12 (24.0%)	36(21.6%)

Note: Proportions accepting swaps in parentheses. Fewer swaps were offered for drinks because a lower-energy alternative only existed for 48% of drinks on offer.

4.3.2 Estimate of effect size (b): Energy ordered by product category and intervention

Effect sizes were small for all intervention groups but for both the savoury snacks and the drinks, the calorie message yielded the largest indication of potential effect sizes. For sweet snacks, the nutrients message yielded the largest indication of potential effect size (Figures 4.3-4.5 and Table 4.5-4.7).

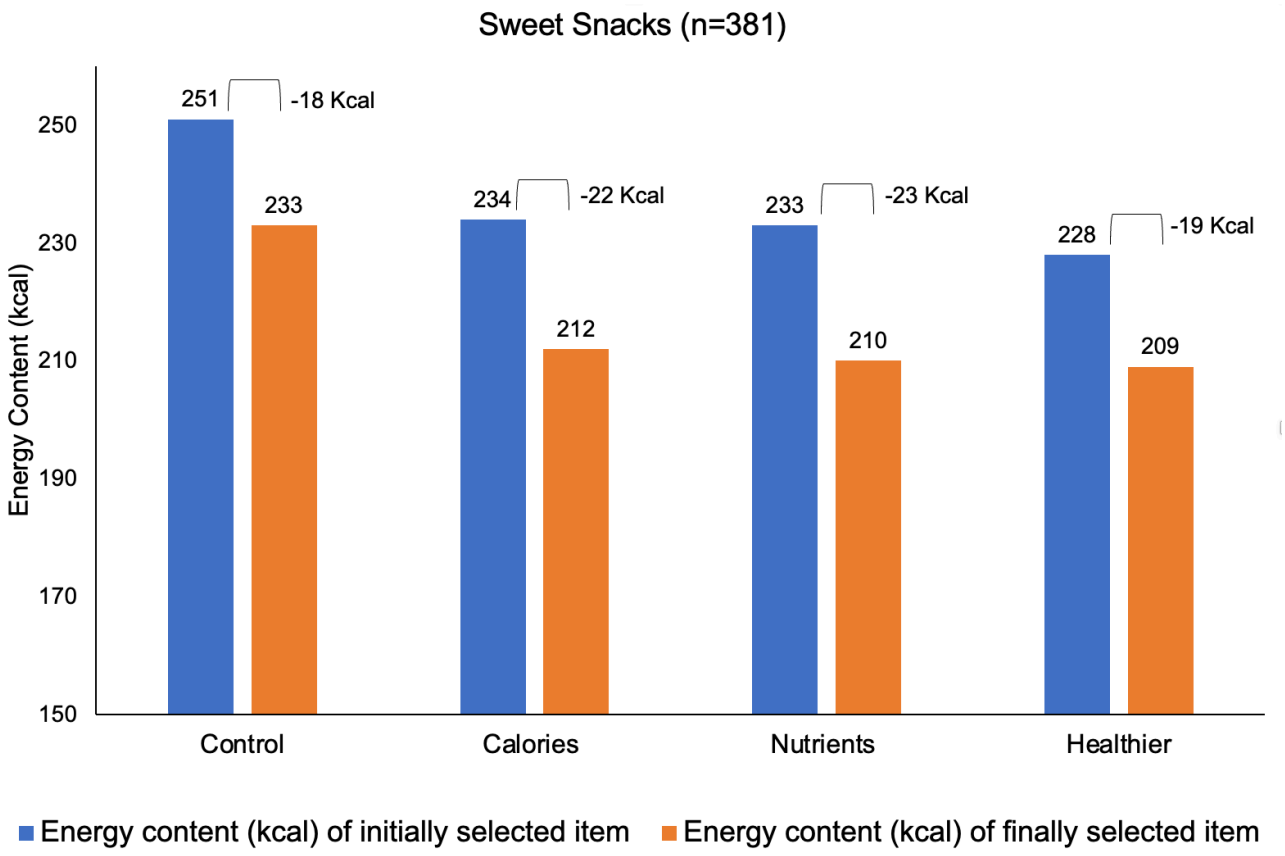


Figure 4.3: Mean change in energy (kcal) ordered before and after **sweet swaps** were offered for each group.

Table 4.5: Mean change in energy (kcal) ordered before and after **sweet swaps** were offered for each group, with Cohen's d effect sizes for mean between group differences in energy ordered.

Group (n)	Mean Change kcal ± SD	Group (n)	Mean Change kcal ± SD	Mean Difference (kcal)	Effect Size *(d)*
Calories (n=92)	22 ± 44	Control (n=87)	18 ± 43	4	0.09
Nutrients (n=97)	23 ± 49	Control (n=87)	18 ± 43	5	0.11
Healthier (n=105)	19 ± 40	Control (n=87)	18 ± 43	1	0.02
Calories (n=92)	22 ± 44	Nutrients (n=97)	23 ± 49	1	0.02
Calories (n=92)	22 ± 44	Healthier (n=105)	19 ± 40	3	0.07
Healthier (n=105)	19 ± 40	Nutrients (n=97)	23 ± 49	4	0.9

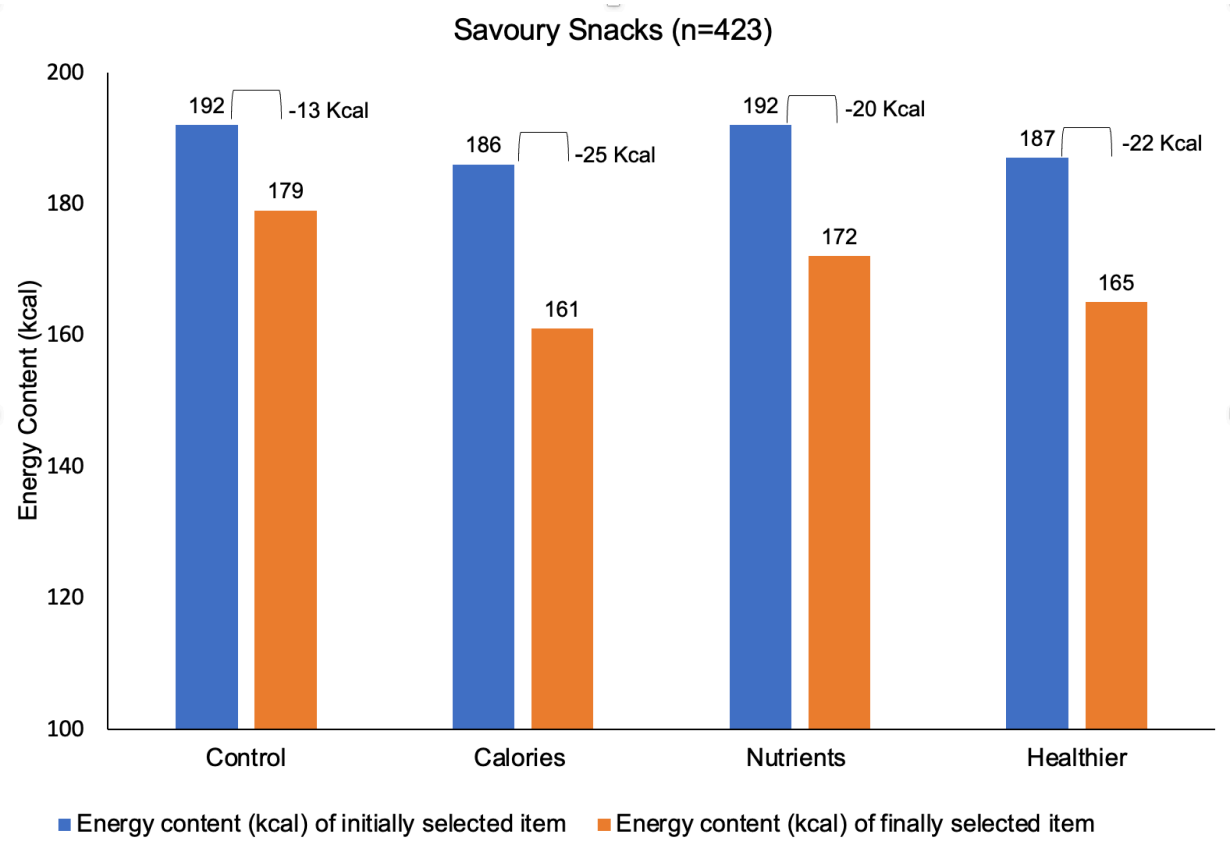


Figure 4.4: Mean change in energy (kcal) ordered before and after **savoury swaps** were offered for each group.

Table 4.6: Mean change in energy (kcal) ordered before and after **savoury swaps** were offered for each group, with Cohen's d effect sizes for mean between group differences in energy ordered.

Group (n)	Mean Change kcal ± SD	Group (n)	Mean Change kcal ± SD	Mean Difference (kcal)	Effect Size (*d*)
Calories (n=106)	25 ± 46	Control (n=95)	13 ± 35	12	0.29
Nutrients (n=109)	20 ± 41	Control (n=95)	13 ± 35	7	0.18
Healthier (n=113)	22 ± 43	Control (n=95)	13 ± 35	9	0.23
Calories (n=106)	25 ± 46	Nutrients (n=109)	20 ± 41	5	0.11
Calories (n=106)	25 ± 46	Healthier (n=113)	22 ± 43	3	0.07
Healthier (n=113)	22 ± 43	Nutrients (n=109)	20 ± 41	2	0.05

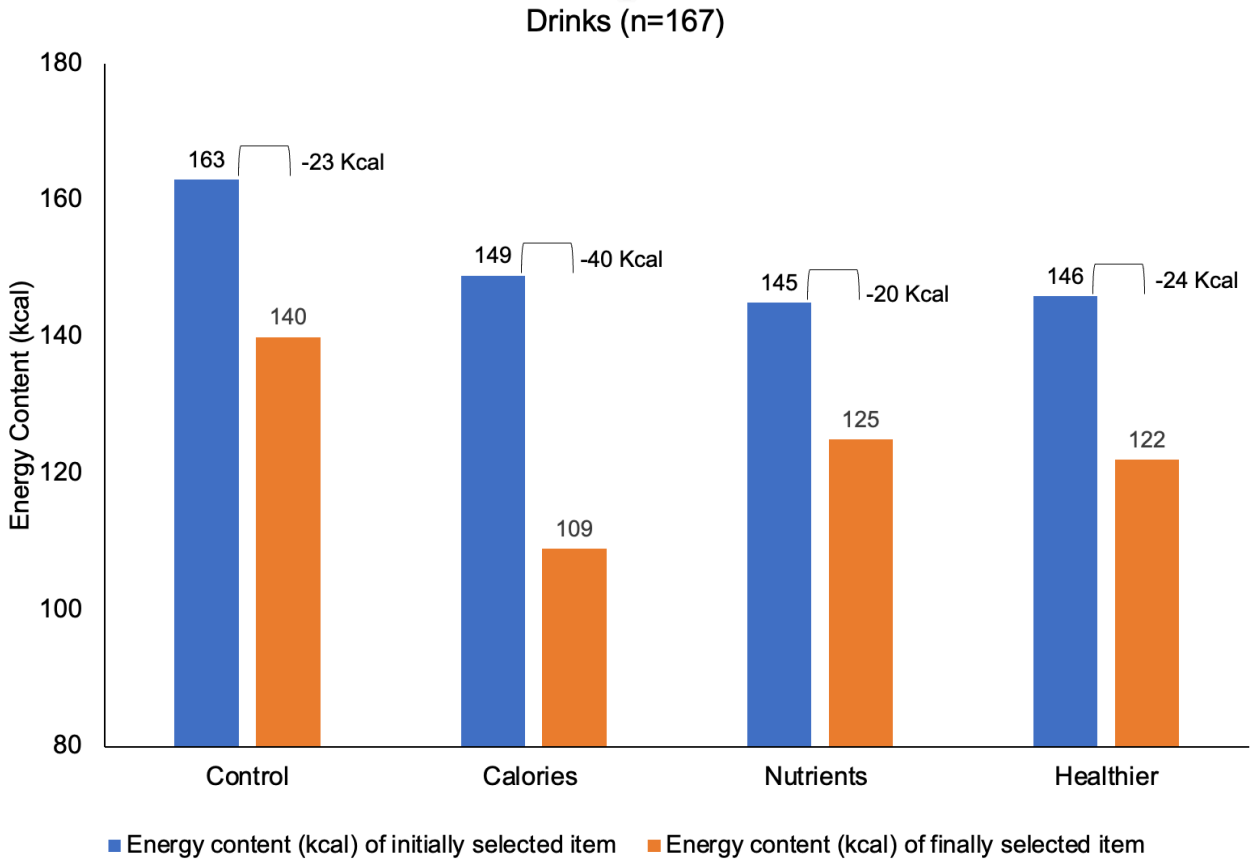


Figure 4.5: Mean change in energy (kcal) ordered before and after **drink swaps** were offered for each group.

Table 4.7: Mean change in energy (kcal) ordered before and after **drink swaps** were offered for each group, with Cohen's d effect sizes for mean between group differences in energy ordered.

Group (n)	Mean Change kcal ± SD	Group (n)	Mean Change kcal ± SD	Mean Difference (kcal)	Effect Size (*d*)
Calories (n=37)	40 ± 65	Control (n=42)	23 ± 61	17	0.27
Nutrients (n=38)	20 ± 51	Control (n=42)	23 ± 61	3	0.05
Healthier (n=50)	24 ± 46	Control (n=42)	23 ± 61	1	0.02
Calories (n=37)	40 ± 65	Nutrients (n=38)	20 ± 51	20	0.34
Calories (n=37)	40 ± 65	Healthier (n=50)	24 ± 46	16	0.28
Healthier (n=50)	24 ± 46	Nutrients (n=38)	20 ± 51	4	0.08

Note: Mean change was calculated by subtracting the mean energy content of the drinks finally selected (i.e., after swaps were offered) from the mean energy content of drinks initially selected for each group. Mean between group difference (Kcal) was calculated by subtracting mean change scores for each group from one another.

4.3.3 Estimate of effect size (c): Total energy ordered by intervention

Considering all food and drink types together, the calorie-based message yielded the largest indication of potential effect sizes, reducing total energy ordered by 19 kcal compared with control (Table 4.8). The nutrients (-10 kcal) and healthier messages (-11 kcal) also seemed to indicate a, yet smaller, energy reduction. The 4 participants who were not offered any swaps (i.e., because they selected the lowest-energy item in each product category) were excluded from this analysis. Figure 4.6 shows the mean change in total energy for each group.

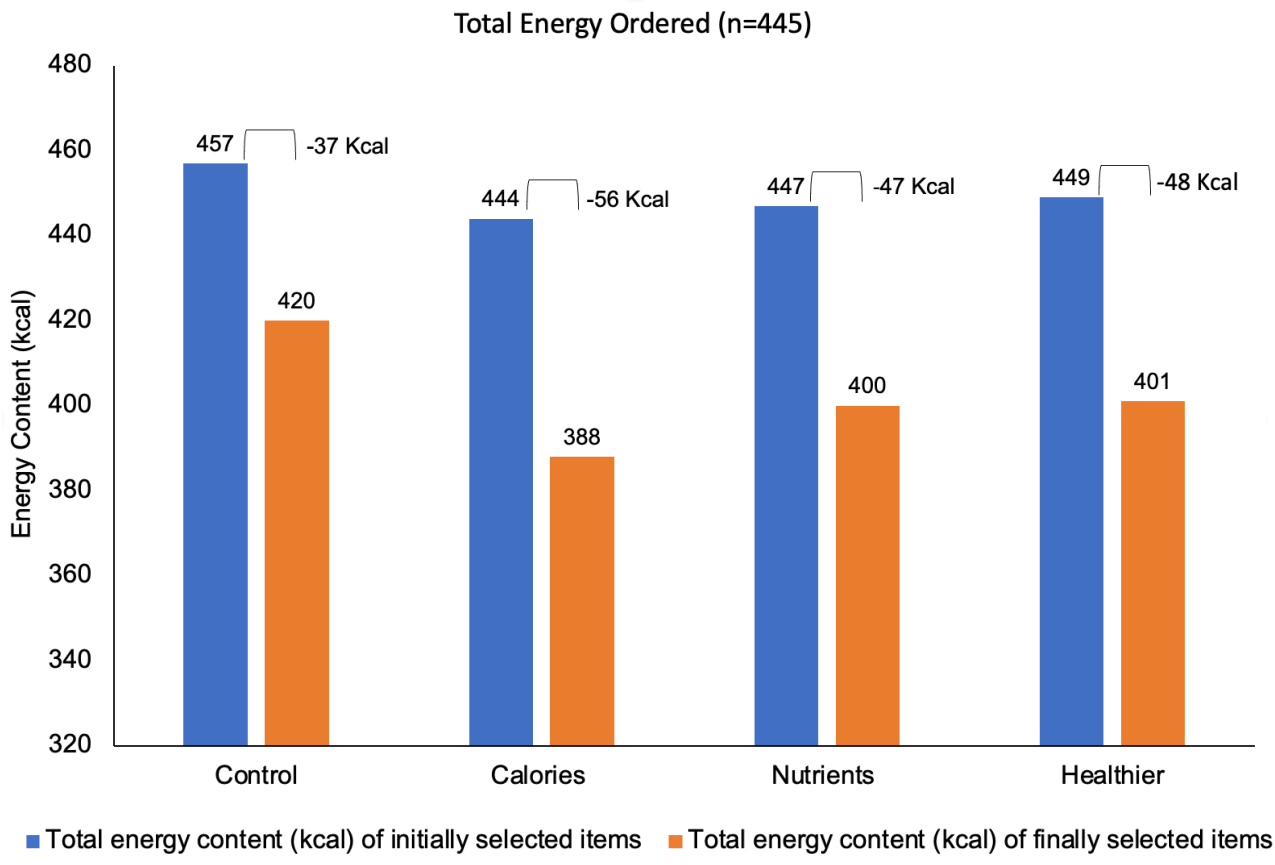


Figure 4.6: Mean change in total energy (kcal) ordered before and after **all 3 swaps** were offered for each group.

Table 4.8: Mean change in **total energy** (kcal) ordered before and after swaps were offered for each group, with mean difference in change between intervention groups and Cohen's d effect sizes for these between group comparisons.

Group (n)	Mean Change kcal ± SD	Group (n)	Mean Change kcal ± SD	Mean Differences (kcal)	Effect Size (*d*)
Calories (n=109)	56 ± 76	Control (n=103)	37 ± 75	19	0.25
Nutrients (n=113)	47 ± 66	Control (n=103)	37 ± 75	10	0.14
Healthier (n=120)	48 ± 62	Control (n=103)	37 ± 75	11	0.16
Calories (n=109)	56 ± 76	Nutrients (n=113)	47 ± 66	9	0.13
Calories (n=109)	56 ± 76	Healthier (n=120)	48 ± 62	8	0.11
Healthier (n=120)	48 ± 62	Nutrients (n=113)	47 ± 66	1	0.02

Note: Mean change was calculated by subtracting the mean energy content of savoury snacks finally selected (i.e., after swaps were offered) from the mean energy content of savoury snacks initially selected for each group. Mean between group difference (Kcal) was calculated by subtracting mean change scores for each group from one another.

4.3.4 Intervention acceptability

On average, 65% of participants agreed that it would be acceptable for their employer to prompt them with swaps when pre-ordering their lunch. The proportion of participants reporting the intervention as acceptable differed across groups, with the lowest ratings in the control group and the highest ratings in the calorie message group. All messages increased the proportion of participants rating the intervention as acceptable. While the majority of participants rated the intervention as acceptable, a quarter of participants (25%) in the control group felt that it would be unacceptable for their employer to offer them lower-calorie swaps for their food choices. A slightly lower proportion of participants in the intervention groups rated the intervention as unacceptable than the control group (Figure 4.7).

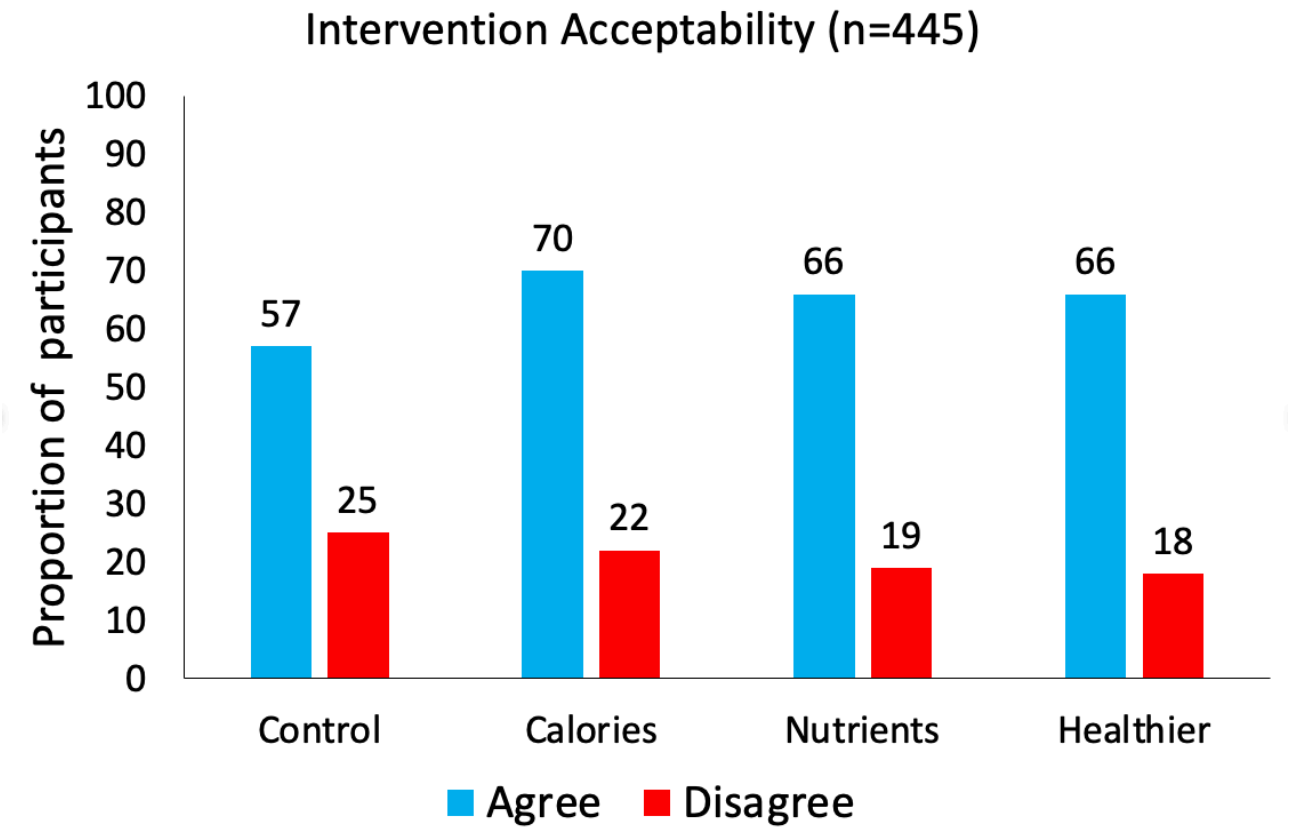


Figure 4.7: Proportion of participants in each group agreeing (ratings of 4 or 5) and disagreeing (ratings of 1 or 2) with the statement: "I would find being offered swaps for my food choices in my workplace canteen acceptable".

4.3.5 Subgroup outcome (a): Intervention effects and demographic variables

When swap acceptance was examined by subgroup, the overall pattern of results aligned with the main analysis (Figures 4.8 - 4.12). Across almost all subgroups, a higher proportion of swaps were accepted by participants who were exposed to the calorie-focused message than those exposed to the control message in all product categories. The three exceptions to this were as follows: Among those exposed to the calorie-focused message, a lower proportion of swaps offered for sweet snacks were accepted by male participants (i.e., 6% less than males in the control group), those with less formal education (6%), and those earning below £25,000 per year (2%) compared with their control group counterparts.

Although across most subgroups a higher proportion of swaps were accepted by participants that were exposed to the nutrient-focused message, there were eight instances in which acceptance rates were lower in the nutrient-focused message group than in the control group. For sweet snacks, non-white participants and those with less formal education accepted fewer swaps than their control group counterparts (3% and 21% respectively). For savoury snacks, non-white participants and those above the median age accepted fewer swaps (5% and 1% respectively) than their control group counterparts. For drinks, male participants, white participants, those who have not completed third-level education, and those earning above £25,000 per year accepted fewer swaps (6%, 4%, 11% and 4% respectively) than their control group counterparts.

Finally, across most subgroups a higher proportion of swaps were accepted by participants that were exposed to the health-focused message. There were, however, six instances in which acceptance rates were lower in the health-focused message group than in the control group. For sweet snacks, male participants, those above the median age, non-white participants, those who have not completed third-level education, and those earning above £25,000 per year accepted fewer swaps (11%, 3%, 4% 8% and 7% respectively) than their control group counterparts. For drinks, those earning above £25,000 per year accepted fewer swaps (4%) than their control group counterparts.

Overall, the calories message might be more effective in women, those over the median age of 32 years, non-white participants and those earning £25,000 and above.

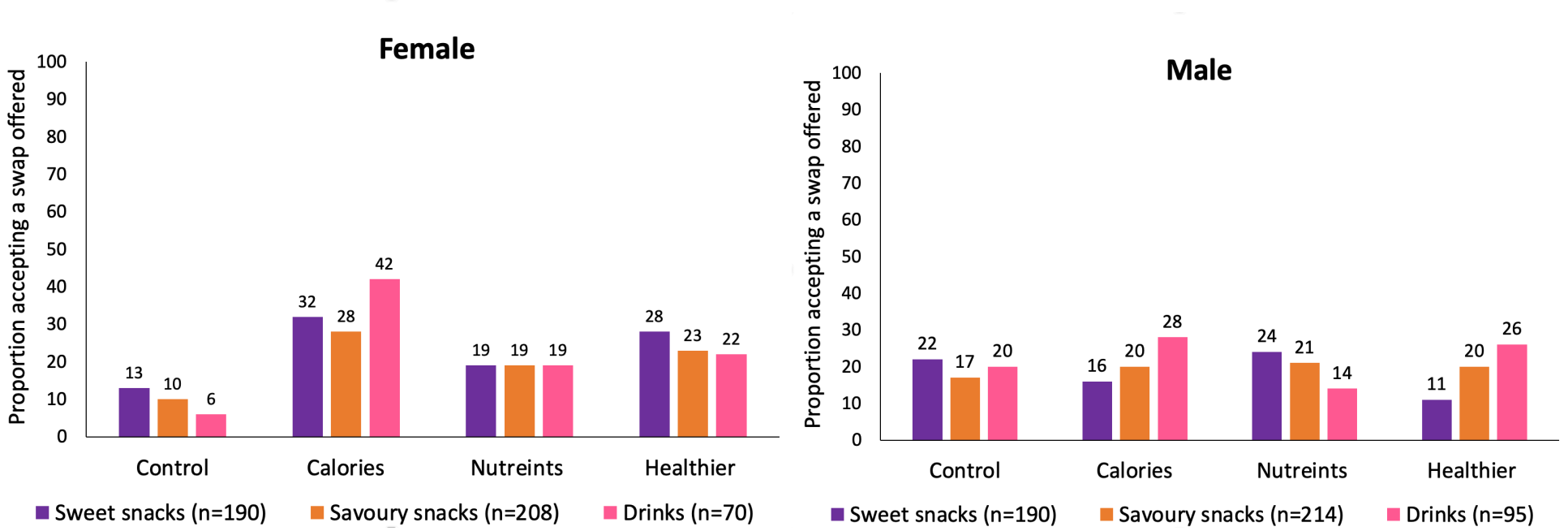


Figure 4.8: Subgroup outcome (a) gender. Among those offered swaps, the proportion of participants accepting swaps offered for snacks and drinks for females and males separately.

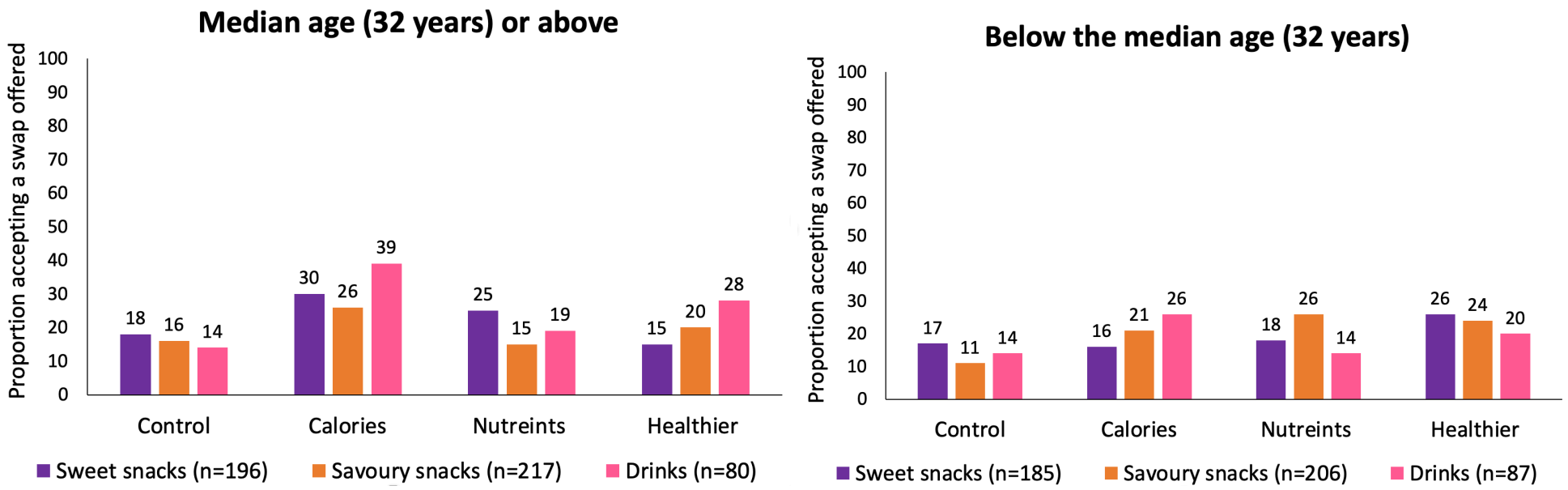


Figure 4.9: Subgroup outcome (a) age. Among those offered swaps, the proportion of participants accepting swaps offered for snacks and drinks for those who are the median age or above (32 yrs) and those who are below the median age separately.

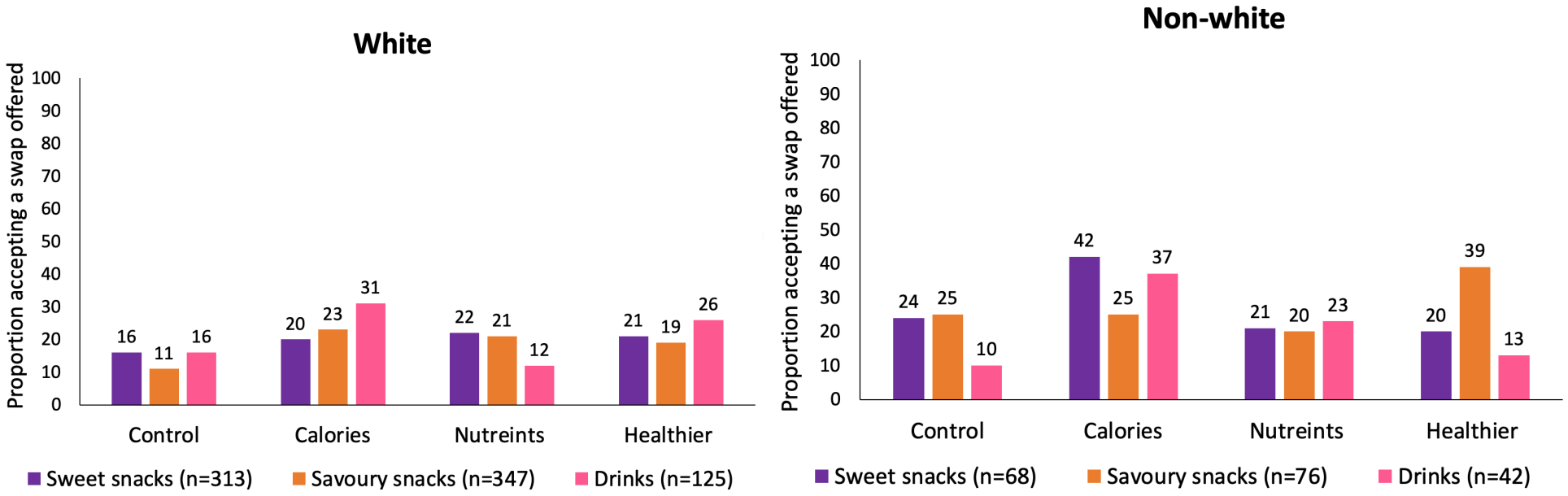


Figure 4.10: Subgroup outcome (a) ethnicity. Among those offered swaps, the proportion of participants accepting swaps offered for snacks and drinks for white and non-white participants separately.

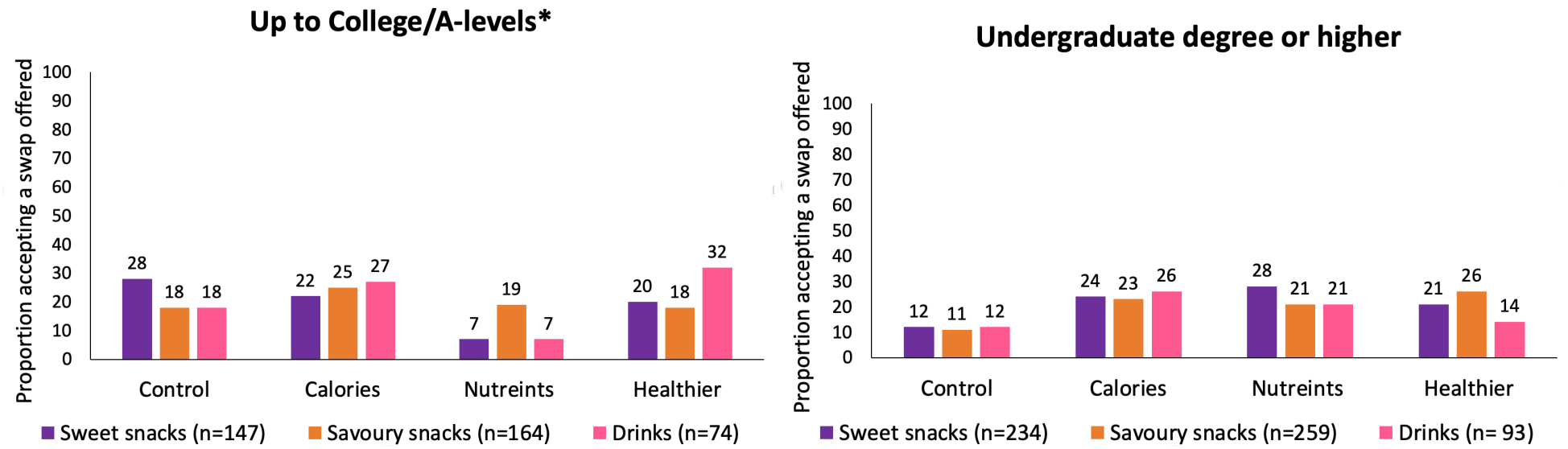


Figure 4.11: Subgroup outcome (a) education. Among those offered swaps, the proportion of participants accepting swaps offered for snacks and drinks for those who have completed College or A-levels and those with an undergraduate degree or higher separately. *Note: Up to college / A-levels includes participants who have no formal education up to those who have completed College or A-levels (i.e., secondary education).

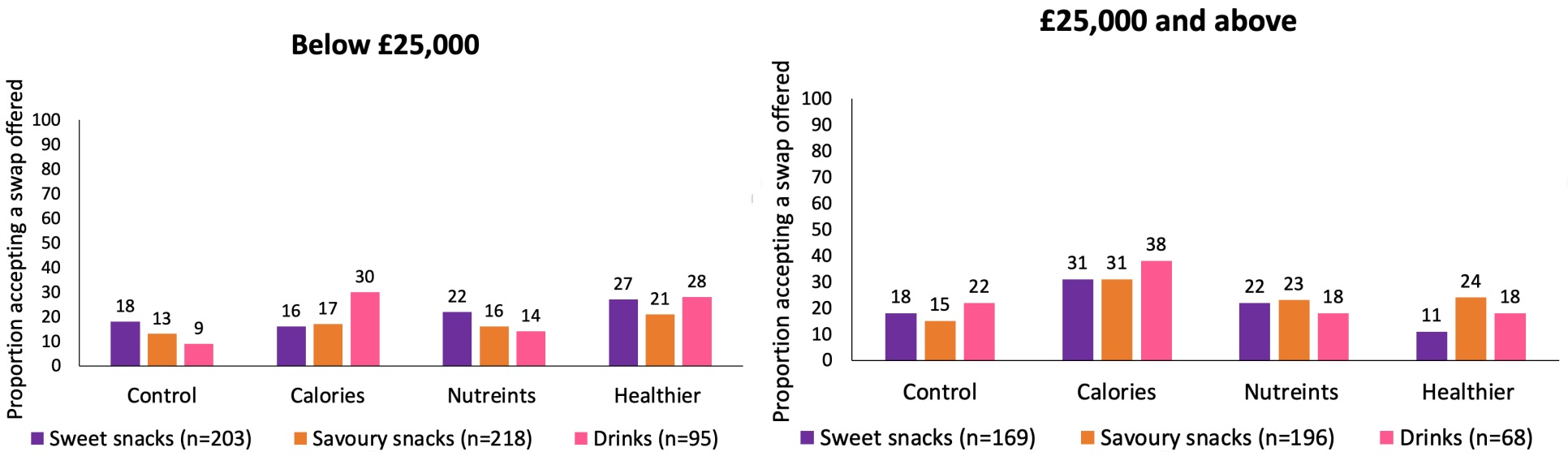


Figure 4.12: Subgroup outcome (a) income. Among those offered swaps, the proportion of participants accepting swaps offered for snacks and drinks for those earning below £25,000 and those earning £25,000 and above separately.

4.3.6 Subgroup outcome (b): Intervention acceptability and demographic variables

There was no evidence that intervention acceptability ratings differed substantially by subgroup. The pattern of results outlined in section 4.3.3 broadly remained the same when examined by sub-group (Figures 4.13 - 4.17). Across all subgroups, acceptability ratings were higher among those exposed to the calorie-focused message than those exposed to the control message. This was also largely the case for the nutrient and health-focused messages with a few exceptions. Male participants presented with the nutrient and health-focused messages rated the intervention as less acceptable (5% and 11% respectively) than males in the control group. Similarly, fewer of those below the median age in the nutrient and health-focused message groups rated the intervention as acceptable (5% and 2% respectively) compared to those below median age in the control group. The analyses also indicated that the intervention may be marginally more acceptable to women, non-white participants, those who have not attended third-level education, and those with higher income, but differences were relatively small.

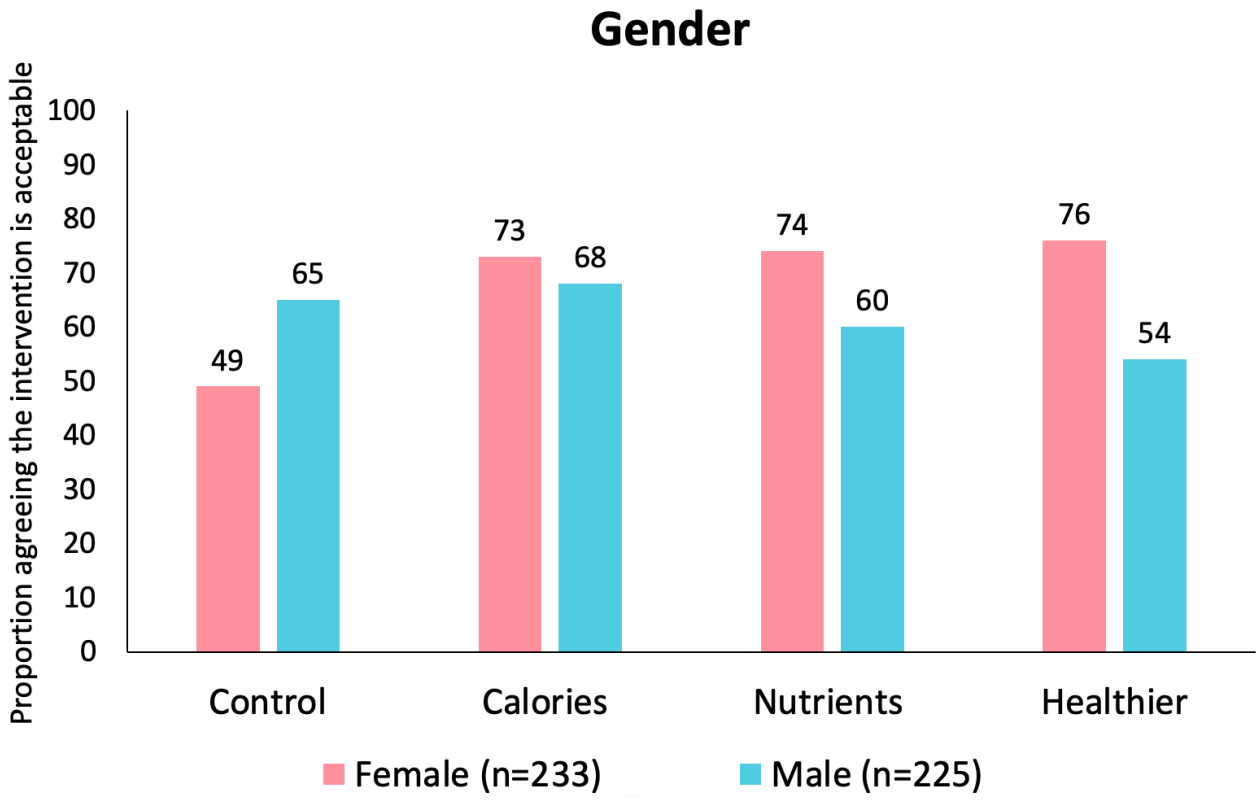


Figure 4.13: Subgroup outcome (b) intervention acceptability & gender. The proportion of participants in each group rating the intervention as acceptable (i.e., 4 or 5 on the Likert scale) for females and males separately.

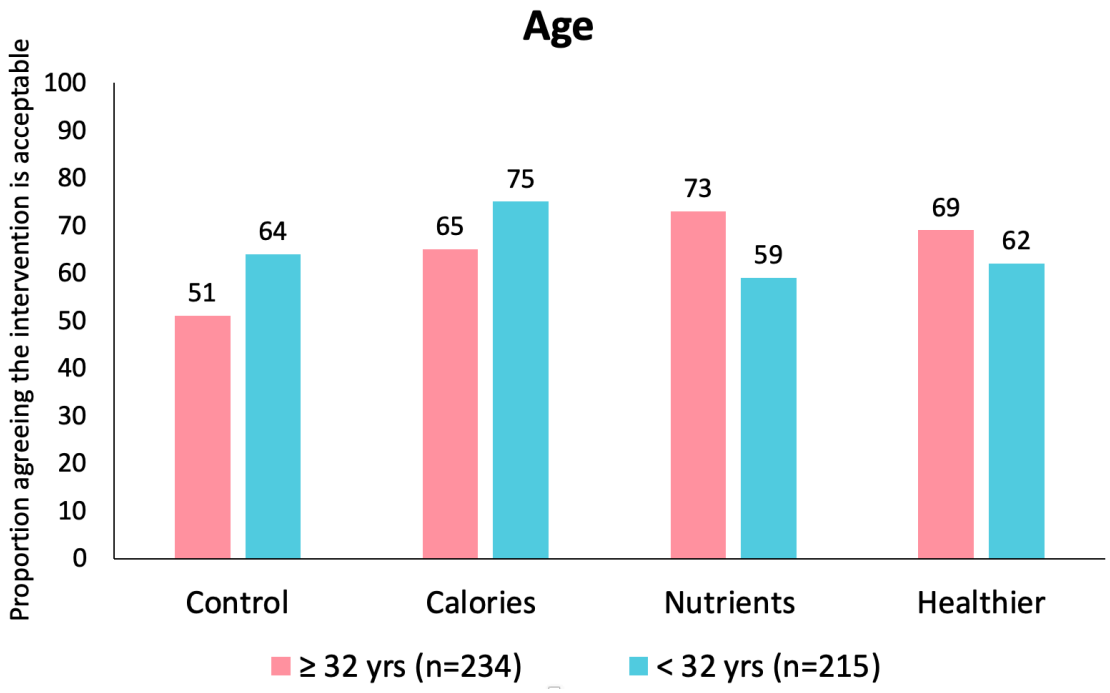


Figure 4.14: Subgroup outcome (b) intervention acceptability & age. The proportion of participants in each group rating the intervention as acceptable (i.e., 4 or 5 on the Likert scale) for those who are the median age (32 yrs) or above and those who are below the median age separately.

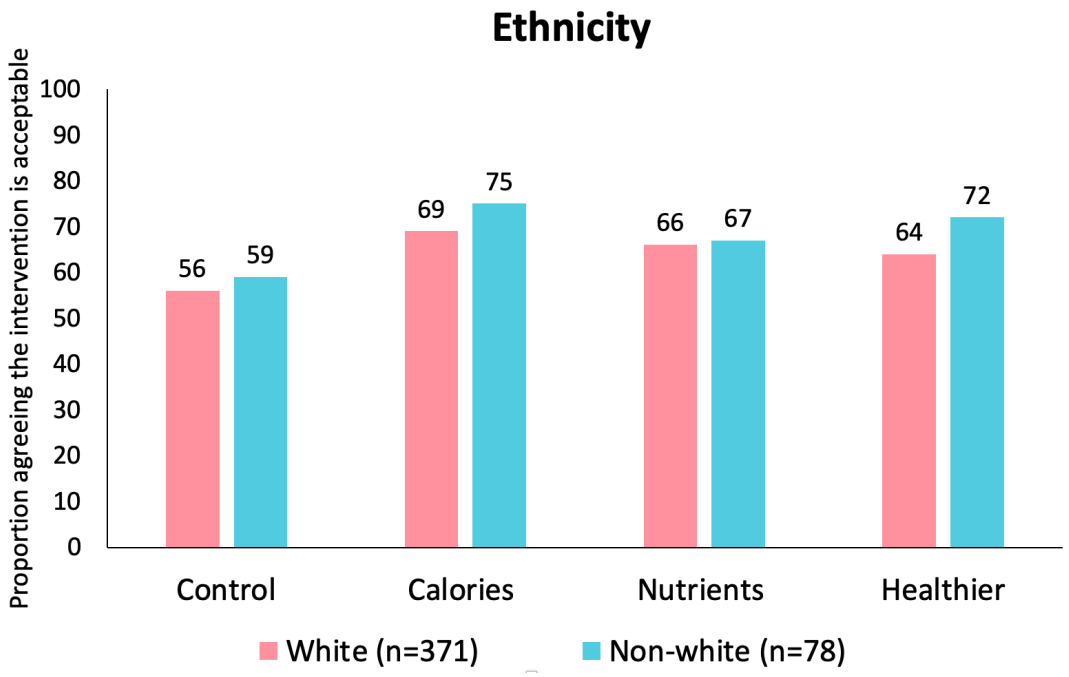


Figure 4.15: Subgroup outcome (b) intervention acceptability & ethnicity. The proportion of participants in each group rating the intervention as acceptable (i.e., 4 or 5 on the Likert scale) for white and non-white participants separately.

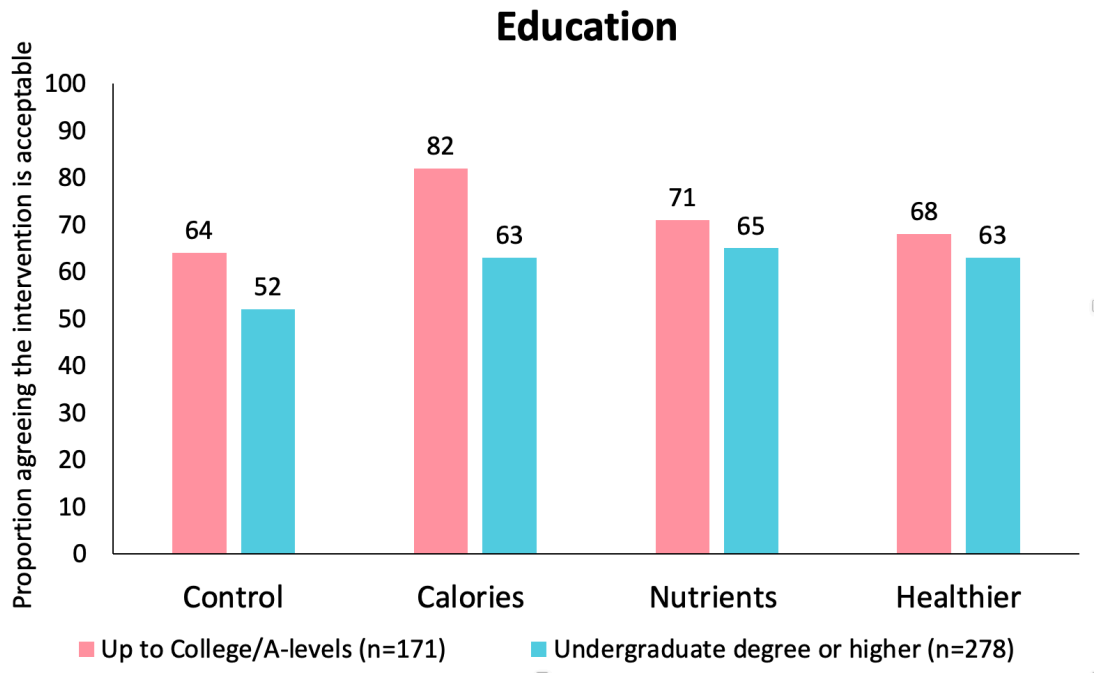


Figure 4.16: Subgroup outcome (b) intervention acceptability & education. The proportion of participants in each group rating the intervention as acceptable (i.e., 4 or 5 on the Likert scale) for those who have completed College or A-levels and those with an undergraduate degree or higher separately.

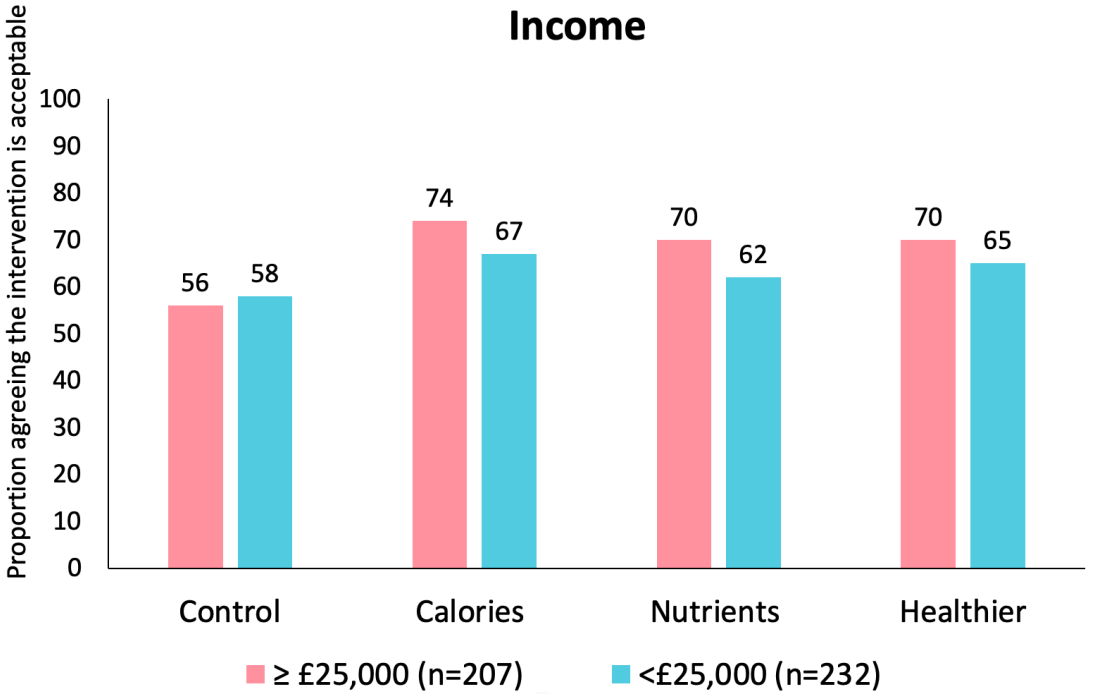


Figure 4.17: Subgroup outcome (b) intervention acceptability & income. The proportion of participants in each group rating the intervention as acceptable (i.e., 4 or 5 on the Likert scale) for those earning below £25,000 and those earning £25,000 and above separately.

4.4 Discussion

4.4.1 Summary of findings

The aims of this pilot study were to (i) generate estimates of effect sizes for the potential effect of different health-based messages on swap acceptance and energy ordered; (ii) examine the acceptability (in principle) of offering swaps accompanied by different health-based messages in the context of an online workplace canteen and; (iii) check that there is no evidence of substantial differences in intervention effects between demographic groups. The findings from this study showed the largest potential effect sizes for the calorie-focused message across both the swap acceptance and energy outcomes. Overall, a higher proportion of participants in the calorie-based message group accepted swaps offered for snacks and drinks than those in the no-message control group and the other message groups (healthier and nutrient). Similarly, larger reductions in total energy ordered were observed for the calorie-focused message group compared with control (-19 kcal, d=0.25) than the nutrients (-10 kcal, d=0.14) and the healthier (-11 kcal, d=0.16) message groups.

In terms of acceptability, the majority (65%) of participants agreed that it would be acceptable for their employer to prompt them with swaps for their lunch choices in the canteen. However, those presented with the calorie-focused message gave the highest intervention acceptability ratings. Compared with the control group (57%), 70% of those presented with the calorie-focused message agreed that offering swaps in a workplace canteen is acceptable, compared with 66% in the nutrients and healthier groups respectively.

Finally, when swap acceptance was examined by subgroups, the overall pattern of results aligned with the main analysis. However, there was some evidence of descriptive differences in the effect of the messages with regard to swap acceptance rates, and to a lesser extent intervention acceptability by subgroups. The calorie-focused message intervention may be more effective in women (women vs men swap acceptance for sweet: 32% vs 16%; savoury: 28% vs 20%; drinks: 42% vs 28% respectively), those over the median age of 32 years (median or above age vs below median age swap acceptance for sweet: 30% vs 16%; savoury: 26% vs 21%; drinks: 39% vs 26% respectively) non-white participants (non-white vs white swap acceptance for sweet: 42% vs 20%; savoury: 25% vs 23%; drinks: 37% vs 31% respectively), and those earning £25,000 and above (£25,000 and

above vs below £25,000 swap acceptance for sweet: 31% vs 16%; savoury: 31% vs 17%; drinks: 38% vs 30% respectively). However, there was little evidence of potential 'backfire' from the calorie-focused message by subgroups. Across almost all subgroups, a higher proportion of swaps were accepted by participants that were exposed to the calorie-focused message than those exposed to the control message in all product categories. There were more exceptions to this for the other message groups, which lent weight to the argument that the calorie-focused message should be brought forward to the next study.

4.4.2 Findings in context

a. Estimates of effect size

The pattern of effect sizes indicates that the calorie-focused message may have potential for increasing swap acceptance and reducing energy ordered. A recent study testing the effect of different messages on swap-acceptance in a supermarket setting reported a similar numeric mean trend in favour of a calorie-focused message, although it was underpowered to detect a significant effect (Bunten et al., 2021). Although the effect sizes observed are promising, this study tested a very basic calorie message which simply stated that the swap offered is lower-calorie. It may be that other calorie-focused messages that provide additional information would be more effective.

With respect to the smaller effect sizes observed for the nutrient and healthier messages there are a number of potential explanations. Firstly, it is possible that information on individual nutrients is less salient to consumers than calories. This may have reduced the effect of the nutrient-focused message. Secondly, as the focus was on energy reduction (i.e., swaps had to be at least 50 kcal lower in energy to be offered as a swap), some of the swaps offered were only slightly lower in sugar/saturated fat (i.e., the ≥0.5g is small) than initially selected items, if participants in the nutrient-focused message group realised this, it may have reduced their motivation to accept swaps offered.

In terms of the health-focused message, it is possible that this message was not specific enough to motivate participants to swap their original higher-energy selections for the lower-energy alternatives offered. Similar to FoPL symbolic formats, the health-focused message simply stated, "this is healthier". Research suggests that although consumers like simplified messages that highlight at a glance whether a product is "healthy", they like to know how this decision has been made (Grunert & Wills, 2007). The addition of an explanation as to

why the product was labelled as healthier may have circumvented this issue but would have detracted from the simplicity of the message.

It is also possible that the health-based message was not perceived as credible information. As the primary objective of this PhD is to examine whether swap-based interventions can reduce the energy content of food and drinks pre-ordered, products were selected to be offered as swaps based on their lower energy and to a lesser degree their saturated fat/sugar content, rather than their overall 'healthfulness' (i.e., their superior nutrient profile). It is possible that participants presented with the health-based message realised this, causing them to distrust the message and thus ignore the message. For instance, for sweet snacks the swaps offered for an Eat Natural Almond & Apricot Bar 50g was a Perkier Goji & Cranberry Quinoa Bar 35g. Although this swap had 118 kcal fewer calories, it had almost the same sugar content (i.e., only 0.8g less sugar) as the initially selected product. Qualitative research suggests that some consumers are sceptical of symbols with health claims in general, and question whether products carrying these labels are indeed more healthful or are intended to promote the interests of the food and drinks industry (Neuman et al., 2014).

It is important to note that from this analysis, we cannot be certain that the calorie message is significantly better than the other messages, but the effect sizes suggest it might be. This is discussed further in section 4.2.4.

b. Intervention acceptability

Although the majority (65%) of participants agreed that the intervention was acceptable, 25% of the control group felt that it would be unacceptable for their employer to prompt them with swaps when ordering their lunch at work. The finding that all messages increased the proportion of participants agreeing that swap-based interventions are acceptable in the workplace compared with control supports the idea that providing consumers with information as to *why* they are being offered swaps is potentially important for intervention acceptability and subsequent efficacy (Sekhon et al., 2017). The finding that the strongest potential acceptability for a swap-based intervention that accompanies swap offered with a calorie-focused message aligns with previous research suggesting that consumers would like to have access to this information when ordering from a menu (Bleich & Pollack, 2010).

Overall, the acceptability findings confirm that accompanying swaps offered with a calorie-message would potentially be acceptable.

c. Subgroup analyses

Although there was some indication that the messages may be more effective in women, those over the median age of 32 years, non-white participants and those earning £25,000 and above, there was little evidence of potential 'backfire' (i.e., those presented with the messages did *not* order more calories than the control group on average) from the calorie-focused message by subgroups. Across almost all subgroups, a higher proportion of swaps were accepted by participants that were exposed to the calorie-focused message than those exposed to the control message in all product categories. There were more exceptions to this for the other message groups, which lent weight to the argument that the calorie-focused message should be brought forward to the next study. Future studies with larger sample sizes will use interaction analyses to check for potential differential effects by demographic characteristics.

4.2.3 Strengths and limitations

This pilot study has both strengths and limitations. Certain aspects of the study have low ecological validity. As the study was a hypothetical choice experiment; participants could not taste the menu items and were not spending their own money. As such, choices may not accurately reflect real-life behaviour. However, efforts were made to ensure that the study setting reflected a real-world online canteen as closely as possible. For example, participants were explicitly asked to make choices that were in keeping with their usual drink and snack choices, and menu items were commonly consumed in the UK, meaning that although participants could not taste swaps offered they were likely to be familiar with them. In terms of the selection of swaps offered, I made the judgement as to which swaps were close in flavour and texture to the original item offered. Ideally, I would have completed some preliminary work with participants to check whether they agreed with me regarding the similarity of swaps offered, however, this additional work was not possible due to limited resources. Approximately half of the sample selected a low or zero calorie drink from the outset only half of participants were offered a swap for drinks, meaning that effect sizes for drinks are likely to be less accurate. It is possible that given the low ecological validity of this study, the findings will not accurately reflect the behaviours of Bupa staff in the field trial.

However, given the lack of research on swap-based interventions in canteen environments, there was very little available information upon which to base important design decisions such as the messages used when offering swaps which had to be made prior to the field trail. Furthermore, given budget constraints it was not possible to conduct multiple versions of the field trial. As such, a pragmatic decision was taken to use a hypothetical choice study to help inform the field study, As outlined above steps were taken to ensure that ecological validity was maximised where possible. I acknowledge that in hindsight a supporting piece of qualitative research with Bupa staff to explore the different proposed messages would have bolstered the quality of this chapter.

In general, the findings from this initial study are subject to a large degree of uncertainty because the confidence intervals around most of the estimates are wide. It is, therefore, likely that differences between proportions will be within the margin of error. This calls into question the validity of using this data to inform power calculations. In cases where there is pre-existing research on a topic, it is preferable to base power-calculations on this information as opposed to running a pilot trial which is resource intensive. However, in this case pilot data was the only data that was available to me at the time when the study was being designed as no previous research had measured differences in energy due to swap-based interventions. Under circumstance where there is little or no previous research on which to base power calculations, pilot studies are used in the literature prior to a full-scale trial to provide estimates (Sim, 2019). Although, confidence intervals were wide and estimates were within the margin of error, the full scale RCT described in the next chapter was sufficiently powered as a result of the information generated from this preliminary work. No inferential statistics were conducted for this study which means that it was not possible to tell which effects are trending towards significance. The decision to not conduct inferential statistics was, however, taken based on the CONSORT guidance on pilot trials which suggests that hypothesis testing for efficacy should not be conducted to prevent the misinterpretation of results from underpowered studies (Eldridge et al., 2016).

The strengths of this study are its randomised design and its recruitment of participants who closely match the target population (i.e., UK employed adults) for the intervention. However, neither BMI nor dietary restraint were measured, both of which might influence swap acceptance and energy ordered. This is addressed in the full-scale study reported in the next chapter.

4.2.4 Conclusion & future research

In conclusion, across all comparisons, the calorie message yielded the largest potential effect sizes. Although it is not possible to draw firm conclusions, this may be an indication that the calorie message is most likely to increase swap acceptance. However, the effect sizes were small, indicating that a large sample will be needed for the fully powered study. This pilot trial found that the calorie-focused message may hold the most promise for increasing the perceived acceptability of the intervention. This may suggest that consumers believe that calorie reduction is important and that messages focusing on calories could potentially be used in workplace canteens.

Taken together, these findings suggest that accompanying swaps offered with a calorie-focused message may be a promising approach and should be tested further. However, it also raises the question of how a calorie-focused message may be designed to enhance its potential ability to encourage consumers to swap their high-energy selections for lower-energy alternatives. This pilot tested a very simple message that did not specify any numeric information. It is possible that providing the exact number of calories saved by accepting a swap may be an effective strategy because it is specific without being overwhelmingly detailed, and it prevents consumers from having to do effortful calculations between products to assess the potential saving if a swap is accepted (Policastro et al., 2017). Some research suggests that providing interpretational aids such as physical activity calorie equivalents (PACE) may help consumers better understand energy-information (Daley et al., 2020; Grunert & Wills, 2007). PACE information which provides the number of minutes walking required to burn off the calories contained in an item may help to improve understanding by translating energy into a more tangible and familiar metric (Bleich et al, 2010; Blumenthal & Volpp, 2010; Fitch et al., 2009). The addition of specific information, such as PACE, is, therefore, another potential strategy for enhancing calorie-focused messaging. This form of information has been used by UK retailer Ocado to accompany lower-energy swaps offered but has yet to be empirically tested. These conclusions informed the development of a full-scale online RCT, as described in Chapter 5.

Chapter 5

The effect of calorie-focused messaging on the acceptance of swaps to reduce the energy content of snacks and non-alcoholic drinks ordered in an experimental online workplace canteen: A randomised controlled trial

5.1 Introduction [11]

The findings from the pilot study reported in the previous chapter suggest that accompanying swaps offered with a calorie-focused message is likely to be well received by potential intervention recipients and may be a promising approach to increasing the acceptance of lower-energy swaps offered. The calorie-focused message tested in the pilot study was very basic, simply stating that the swap offered was 'lower-calorie'. One question is whether other calorie-based messages may yield strong effects. This study will compare the effect of accompanying swaps offered with no specific information (control) to one of three different calorie-focused messages on swap acceptance and energy ordered; the vague calorie message used in the pilot study, an exact numeric-calories message typically used on menus, and an interpretational aid in the form of a physical activity calorie equivalent (PACE) message. The rationale for testing each of these calorie-focused messages is described below. As well as examining the effect of these messages on swap acceptance and energy ordered, this study will examine the acceptability of the

[11] This chapter is based on a published paper and is reproduced with permission from Breathnach et al., (2021). The authors Sarah Breathnach (SB), Dimitris A Koutoukidis (DAK), Phillippa Lally (PL), David Boniface (DB), Alex Sutherland (AS) and Clare H Llewellyn (CHL) contributions were as follows: SB, DAK, PL and CHL designed the study; SB conducted the research, the data cleaning and statistical analysis. DB provided support with the statistical analysis. SB, DAK, PL, AS, DB and CHL interpreted the data. SB drafted the manuscript and had primary responsibility for the final content. AS acquired funding to run the study. All authors read, critically revised, and approved the final manuscript.

intervention and the messages presented. The development of these research questions is discussed in detail at the end of this section.

5.1.1 Vague calorie message

Energy savings yielded from the acceptance of lower-energy swaps will range in size depending on the nature of the originally selected item and the suggested alternative. If energy savings are perceived as small, a message highlighting the exact amount of energy saved may discourage consumers from accepting the swap offered. Consumers may decide that the cost of forgoing the rewarding taste of their chosen item is not worth the small energy saving. In this case, a message simply stating that the swap contains fewer calories (i.e., the message tested in the pilot study) may be most effective. However, vague information may be less salient and, therefore, more difficult to process (Higgins, 1996; Wilson et al, 2016) than a message quantifying the exact amount of energy saved, even if small. It is, therefore, possible that the potential effect of a calorie-focused message could be enhanced by providing some additional information.

5.1.2 Numeric-calories message

Consumers are accustomed to seeing numeric calorie information on product packaging and a number of governments are in the process of introducing legislation regarding calorie-disclosures on menus (UK Government, 2021). As discussed in Chapter 1, providing consumers with information on the exact energy content of items (i.e., calorie labelling), has shown mixed efficacy. A Cochrane systematic review and meta-analysis concluded that calorie information on menus may reduce calories ordered (by 47 kcal across a full meal, 95%CI: -78 to -15) but this was based on low-quality evidence (Crockett et al., 2018). Research suggests that consumers want calorie information when eating out and believe it would influence their ordering behaviours (Bleich & Pollack, 2010; Diabetes UK, 2018; Lando & Labiner-Wolfe, 2007). However, the mixed efficacy of calorie labelling to influence consumer choice has prompted researchers to test strategies for enhancing its potential effect.

5.1.3 Physical activity calorie equivalent (PACE) message

Research has suggested that one reason for the mixed efficacy of calorie-disclosures may be that consumers have difficulty contextualising calorie information and that interpretational aids may help (Dowray et al., 2013; Grunert & Wills, 2007). A systematic review and meta-analysis found that interpretational aids for energy information presented on menus reduced energy consumption by 81 kcal compared with the 13 kcal reduction achieved by standard numeric energy labelling (Sinclair et al., 2014). As noted in Chapter 4, PACE messaging, which provides the number of minutes walking required to burn off the calories contained in an item is an example of an interpretational aid that has been used previously by a UK online supermarket Ocado when offering customers lower-energy swaps, but it has yet to be tested empirically in this context. It is thought that PACE messaging may help consumers to contextualise energy-information by translating energy into a more tangible and familiar metric (Bleich et al, 2017; Blumenthal & Volpp, 2010; Fitch et al., 2009).

A recent systematic review and meta-analysis reported that PACE labels on product packaging and menus reduced energy consumed by 80 kcal (95% CI: -189 to -30) compared with when no information was provided, but did not significantly reduce energy ordered compared with calorie-only information (-51 kcal, 95%CI -131 to 28). Providing PACE information did, however, significantly reduce the amount of food (in grams) consumed by participants compared with when nutritional labelling was presented (Daley et al., 2020). Another study found that providing participants with energy (in kcal) and PACE information significantly increased the likelihood that lower-energy snacks and drinks would be selected (OR: 2.10 95%CI: 1.01 to 4.37) compared with when no information was provided. Providing energy information alone was not found to significantly increase the likelihood that a lower-energy snack or drink would be selected (OR: 1.30, 95%CI: 0.62 to 2.69). Further exploratory analysis indicated that the PACE message significantly increased the likelihood that lower energy products would be selected compared with the providing energy information alone (OR: 1.90, 95%CI: 0.96 to 3.77) (Masic et al., 2017). Accompanying suggested swaps with PACE messaging might, therefore, enhance the overall effectiveness of a swap-based intervention. Testing the PACE message against a vague calorie message and a numeric-calorie message will also provide an insight into whether incrementally increasing the tangibility of information (i.e., the interpretability, concreteness, and meaningfulness to the public) provided increases the acceptance of swaps offered.

5.1.4 Other research questions

The study will re-examine intervention acceptability. In addition to asking participants about the extent to which they would find being offered swaps for their food choices in their workplace canteen acceptable (i.e., the acceptability measure used in Chapter 4), participants will specifically be asked about the degree to which the messages accompanying the swaps offered might encourage unhealthful behaviours such as excessive calorie-counting. Those presented with the PACE message will also be asked a series of questions about the acceptability of the PACE message and the degree to which they think it might encourage unhealthful behaviours such as excessive exercising. These questions have been included in the study in light of concerns that have been raised in the literature and media about the use of calorie information (Gonzalez-Nahm et al., 2020; McGeown, 2019) and PACE information in particular (BBC, 2019) potentially triggering unhealthful behaviours, especially in vulnerable individuals (e.g., those with a history of eating disorders).

The study will also explore the potential effect of the price of swaps offered, and self-reported dietary restraint on swap acceptance. Dietary restraint refers to the process of intentionally self-regulating one's eating behaviours with the goal of limiting energy intake or losing weight (Schaumberg & Anderson, 2016). As such, it may influence the acceptance of lower-energy swaps offered. Similarly, price has been cited in the literature as an important factor influencing dietary choices (Kottke et al., 2013; Wolfenden et al., 2015). To maximise the number of swaps that could be offered, two types of swaps were offered (similar and dissimilar swaps). These are described in detail in section 4.2.6 of Chapter 4. Similarity between originally selected items and swaps offered may influence swap acceptance (this is discussed in Chapter 2, section 2.4.1). With this in mind, the potential effect of swap-type on swap acceptance will be explored. Finally, subgroup analyses conducted in Chapter 4 will be repeated to monitor intervention effects in different demographic groups.

5.1.5 Aims

The primary aims of this study were to examine the effect of three calorie-focused messages (a vague calorie message, an exact numeric-calories message, and a PACE message) on: (i) the acceptance of lower-energy swaps offered; and (ii) energy ordered within the context of an experimental online workplace canteen.

Additional aims of this study were to (i) examine questions relating to the acceptability of the intervention and participants' beliefs about potential future behaviours associated with the use of the calorie-focused messages; (ii) explore the effect of price, dietary restraint, and swap type on swap acceptance and; (iii) check for any notable differences in intervention effects between demographic groups.

5.2 Methods

5.2.1 Design and setting

This was an ethically approved (ref no.: 12861/002) and prospectively registered (AsPredicted.org ref no.:32783, https://aspredicted.org/fp58x.pdf) 4-arm randomised controlled trial conducted using the simulated online canteen that I developed for the pilot study described in Chapter 4. The simulated online canteen allowed employees to hypothetically pre-order their sweet snacks (n= 17), savoury snacks (n= 9), and non-alcoholic drinks (n= 25) for the workday. A detailed description of the website and its development can be found in Chapter 4. The CONSORT checklist was used for reporting this study and is available in Appendix 5.1, Additional File 1.

5.2.2 Participants

Participants were recruited between December 2019 and January 2020 through Prolific Academic. Participants were pre-screened by Prolific Academic for eligibility, and invitations were sent to a random subsample of a pool of 9,356. Invitation and response rates are not recorded by the platform, therefore, this information was unavailable. This study employed the same eligibility criteria as the pilot study described in Chapter 4 (please see section 4.2.4 for details). A link to the study appeared on the Prolific Academic dashboard of eligible participants. Interested participants were directed to a survey platform via the link where they could read the information sheet and provide consent electronically by ticking a box.

5.2.3 Randomisation & blinding

Randomisation and blinding was conducted following the same procedure employed for the pilot study, please see section 4.2.3 of Chapter 4 for details.

5.2.4 Online ordering task

The online ordering task in this study was identical to the pilot study, please see section 4.2.4 of Chapter 4 for details.

5.2.5 Swaps offered

The swaps offered in this study were identical to the pilot study, please see section 4.2.6 of Chapter 4 for details. A list of all menu items and swaps offered can also be found in Appendix 4.1, Additional File 1.

5.2.6 Interventions

Participants were randomly allocated to receive one of the following messages when swaps were offered as shown in Figure 5.1:

- Control: *"How about a swap?"*
- Fewer-calories: *"How about a swap? This has fewer calories".*
- Numeric-calories: "*How about a swap? Save [x] calories"*.
- PACE: "*How about a swap? Save [x] calories = [y] min walk"*.

The price of each item was presented beneath the image of the item. In the pilot study, prices were standardised for snacks and drinks. To increase the ecological validity of this study, a database of price data was generated by searching for items on supermarket websites and recording their 2019 prices. The recommended retail price was taken for each item (special offers were disregarded), where the price differed across websites, Tesco's price was used.

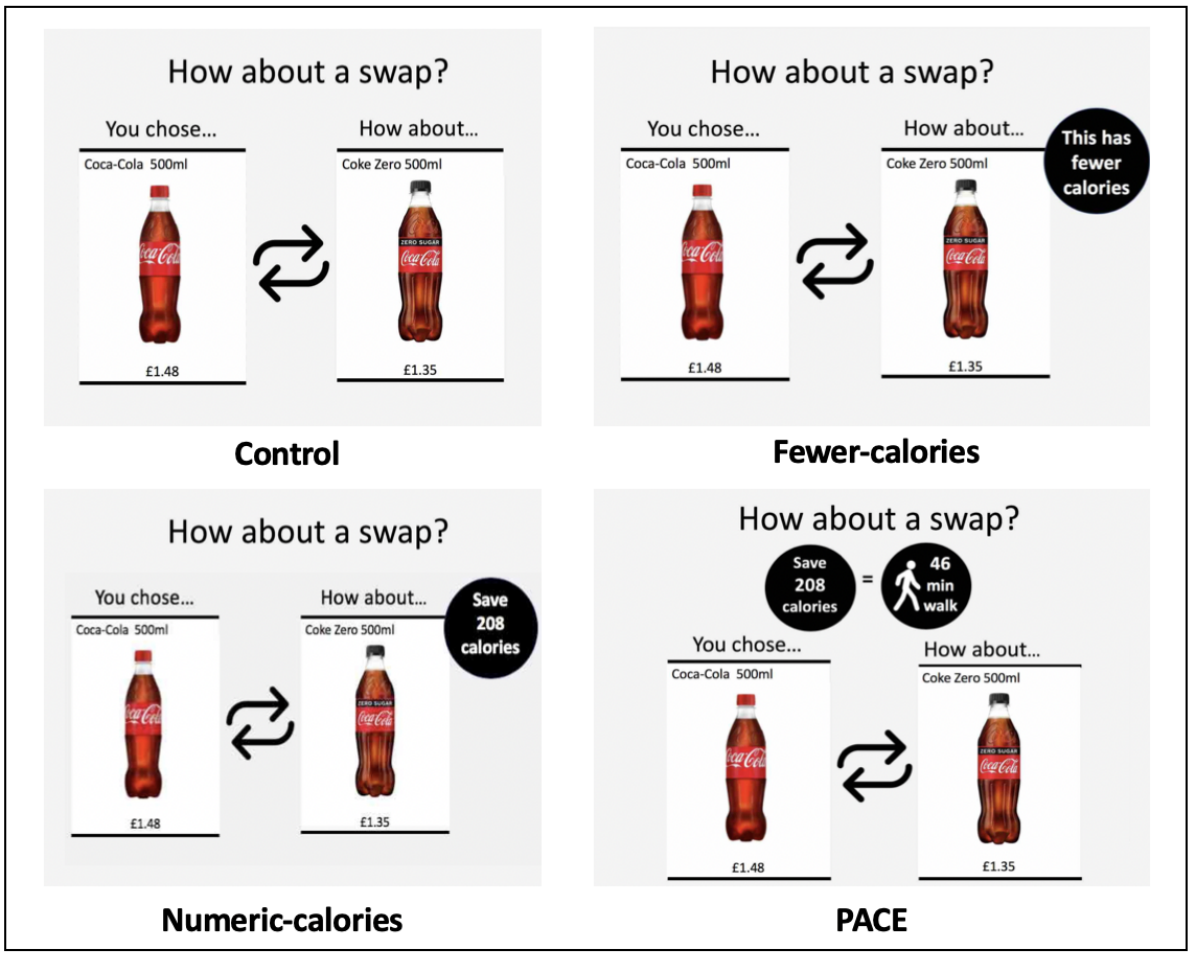


Figure 5.1: An example of the intervention when selecting a Coca-Cola. (Top left) the control condition; (top right) the fewer-calories message; (bottom left) the numeric-calories message; (bottom right) the PACE message.

Development of the PACE message

Physical activity was presented in minute format rather than distance format for the following reasons: (i) most previous studies testing PACE information have employed the time over distance format (Daley et al., 2019); (ii) research points to greater consumer support for the time format (Dowray et al., 2013) and; (iii) there is qualitative evidence that time may be a more familiar frame of reference than distance (Swartz et al., 2013).

Walking was the type of activity chosen for the following reasons: (i) most previous studies testing PACE information have opted to present walking time on the grounds that walking is the most common form of physical activity and it is therefore likely to be relatable to a large population (Masic et al., 2017); (ii) in this study, information is being provided on the potential energy-savings yielded from accepting swaps for

snacks and drinks that are at least ≥50 kcal energy lower in energy content. In cases where swaps offered are just at the ≥50 kcal energy savings threshold, a higher intensity activity (e.g., cycling) would require very short amounts (~5 minutes) of time to burn the energy and so may be less motivating.

The decision to present both the number of calories saved and the number of minutes of walking saved in the PACE condition was made based on preliminary work (a survey conducted with n=70). Social media users were asked to indicate which of the two messages depicted in Figure 5.2 they would find most motivating. Respondents overwhelmingly preferred option B in which both the number of calories saved and the PACE equivalent are shown. In addition, from a public health perspective it is unlikely that energy (kcal) information will be replaced by an alternative format in the near future. If PACE labels were to be implemented by the Government, they would most likely be introduced alongside existing energy information to help increase the tangibility of the energy information. PACE information in combination with energy information in calories (kcal) was tested as this is the format that would be most likely to be implemented. It was also the format used by supermarkets offering swaps to consumers (Ocado, 2016).

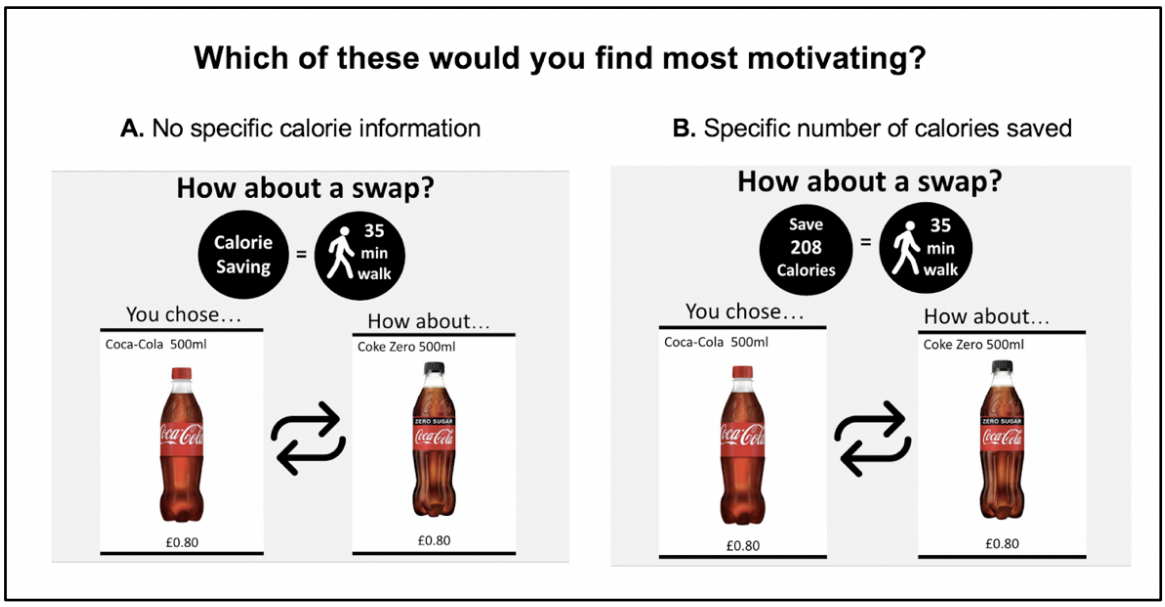


Figure 5.2: Options presented to social media users during preliminary work.

The message indicates minutes of moderate walking. The PACE information was calculated using the METs Calculator developed by the Compendium of Physical Activity (Ainsworth et al., 2011). The input for the calculator was based on the average Briton, who according to the Office for National Statistics (2010) is 39 years old and weighs 77kg. The description of the activity selected is "2.8-3.2mph moderate pace, firm surface".

5.2.7 Post-trial survey

Once participants had made their three selections and had accepted or declined any swaps offered, they completed a short survey (Appendix 5.2, Additional File 1). The first two questions on the survey were attention checks. Participants were asked to indicate whether or not they had been offered a swap. Those who confirmed that they were offered a swap were asked to indicate which type of message accompanied the swap(s) they were offered; "a calorie message (i.e., the fewer and numeric calories groups); a calorie & physical activity message (i.e., the PACE group) or; no message (i.e., the control group)".

The survey was also used to explore the acceptability of the swaps intervention and the messages accompanying the prompts to swaps. To measure intervention acceptability, participants were asked to indicate the extent to which they agreed with the following statement: "*I would find being offered swaps for my food choices in my workplace canteen acceptable*". To assess beliefs about future behavioural consequences of the messages, participants in the three intervention groups were asked to indicate the extent to which they agreed with the following statement: "*The* [name of the message presented to the participant e.g. fewer-calories, numeric-calories or PACE] *message would make me want to count calories excessively*". Participants in the PACE group were asked about the extent to which they agreed with the following statement: "*The physical activity message would make me want to exercise excessively*". In both cases, the word excessively was intended to be understood by participants as triggering them to be *more* conscious of their energy intake or exercise regime than they would *normally* be, or desire to be. Participants in the PACE group were also asked about the extent to which they agreed that the physical activity message was acceptable, helpful and appropriate. Response options were on a scale from 1 (strongly disagree) to 5 (strongly agree).

Finally, participants completed the Dietary Intent Scale (DIS), a nine-item measure of dietary restraint created by Stice et al., (1998) based on the Dutch Restrained Eating Scale (DRES; Van Strien et al, 1986). The scale is internally (a = 0.94) and temporally reliable (1-month test-retest= 0.92). Higher scores indicated more dietary restraint (score range = 9-45). Upon completion, participants were debriefed and reimbursed with £0.50 for their participation.

5.2.8 Outcome measures & statistical analysis

Table 5.1 below outlines the outcome measures and methods of statistical analysis employed. A decision was made a priori to analyse the three product categories separately because previous research has pointed to variation in average swap acceptance by the type of product (Koutoukidis et al., 2019). To be included in the study, participants had to meet the eligibility criteria and complete the ordering task (i.e., order a sweet snack, a savoury snack, and a drink). There were some missing data for the post-trial questions [i.e., exploratory outcomes (a) and (b)], because these questions were added later in the data collection process. Missing data were not imputed as the dropout rate was small (3.7%) and there was no evidence of differential attrition (Figure 5.2). Thirty-seven participants (1%) were not offered any swaps because they initially selected the lowest energy items in all three product categories. These participants were excluded from all analyses. For all outcomes, only those offered a swap were included in the analyses because the outcomes are all related to prompts to swap. As the primary analyses were conducted separately for each product category, only those offered a swap within the relevant category were included (Figure 2).

Estimates of comparative effectiveness are reported as either odds ratios or mean differences with 95% confidence intervals (CI). Standardised effect sizes reported for means are Cohen's *d*. The square root of the mean squared error was used as the estimate of the pooled standard deviation in the effect size calculations reported (Becker, p.14, 2000). Although post-hoc adjustments are not required when making pre-defined comparisons (Li et al., 2017), a conservative approach was taken. Bonferroni corrected p-value thresholds for statistical significance were applied to each model. The thresholds varied by outcome measure depending on the number of

comparisons being made (please see Table 5.1). Statistical analyses were conducted in Stata (version 16) (Stata Corp, 2019) or SPSS (version 25) (IBM Corp, 2017).

Table 5.1: Study outcome measures and methods of statistical analysis employed.

Outcome measure	**Statistical analysis**	**Bonferroni corrected p-value threshold**
Primary outcomes		
(a) Acceptance of swaps offered between groups separately for each of the three categories: (i) sweet snacks (ii) savoury snacks and; (iii) drinks.	● Three separate binary logistic regression models (i.e., one for each product category), changing the reference group to allow differences between the intervention groups to be examined as well as comparing each of these to the control. ● DVs: Model 1: Sweet swap accepted (yes/no); Model 2: Savoury swap accepted (yes/no); Model 3: Drink swap accepted (yes/no). ● IV: Intervention group (4 categories: Control, Fewer-calories, Numeric-Calories, PACE) ● The 6 comparisons in each model were: Control v Fewer-calories; Control v Numeric-calories; Control v PACE; Numeric v Fewer-calories; PACE v Numeric calories; PACE v Fewer-calories.	● $p < 0.0083$ (6 comparisons)
(b) The energy (kcal) of products ordered between groups for those offered swaps separately in each of the three categories: (i) sweet snacks (ii) savoury snacks (iii) drinks.	● Three one-way analyses of covariance (ANCOVAs) adjusting for the energy content (in kcal) of the initially selected item in each category (i.e., before a swap was offered), with Fisher's least significant difference (LSD) post-hoc tests. ● DVs: Model 1: Energy (in kcal) content of sweet snack *finally* ordered; Model 2: Energy (in kcal) content of savoury snack *finally* ordered; Model 3: Energy (in kcal) content of drink *finally* ordered. ● IV: Intervention group (4 categories: Control, Fewer-calories, Numeric-Calories, PACE)	● $p < 0.0083$ (6 comparisons)

	● Covariates: Model 1: Energy (in kcal) content of sweet snack *initially* ordered; Model 2: Energy (in kcal) content of savoury snack *initially* ordered; Model 3: Energy (in kcal) content of drink *initially* ordered. ● The 6 comparisons were: Control v Fewer-calories; Control v Numeric-calories; Control v PACE; Numeric v Fewer-calories; PACE v Numeric calories; PACE v Fewer-calories.	
Secondary outcomes		
(a) The total energy (kcal) of items ordered (i.e., combining sweet snacks, savoury snacks and drinks) between intervention groups.	● ANCOVA adjusting for the total energy initially ordered, with Fisher's least significant difference (LSD) post-hoc tests. ● DV: Total energy (in kcal) content of items (i.e., all 3 items) finally ordered ● IV: Intervention group (4 categories: Control, Fewer-calories, Numeric-Calories, PACE) ● Covariate: Total energy (kcal) content of items (i.e., all 3 items) initially ordered ● The 6 comparisons were: Control v Fewer-calories; Control v Numeric-calories; Control v PACE; Numeric v Fewer-calories; PACE v Numeric calories; PACE v Fewer-calories.	● $p < 0.0083$ (6 comparisons)
(b) Among participants offered at least one swap, acceptance of at least one swap offered between groups (all categories combined).	● Binary logistic regression with control as the reference category. ● DV: At least 1 swap accepted (yes/no) ● IV: Intervention group (4 categories: Control, Fewer-calories, Numeric-Calories, PACE) ● The 3 comparisons were: Control v Fewer-calories; Control v Numeric-calories; Control v PACE.	● $p < 0.017$ (3 comparisons)
Acceptability & inadvertent harm		
(a) Likert scale ratings of intervention acceptability	● Ordinal logistic regression.	● $p < 0.0083$ (6 comparisons)

by intervention groups.	● DV: Acceptability was modelled as an ordinal measure including Likert scale ratings of 1,2,3,4,5 as separate groups. ● IV: Intervention group (4 categories: Control, Fewer-calories, Numeric-Calories, PACE) ● The 6 comparisons were: Control v Fewer-calories; Control v Numeric-calories; Control v PACE; Numeric v Fewer-calories; PACE v Numeric calories; PACE v Fewer-calories. ● When reporting proportions descriptively (e.g. Figure 5.6), Likert scale ratings of 4 or 5 were considered in agreement with the statement and ratings of 1 and 2 were considered disagreement.	
(b) Likert scale ratings for questions about future excessive calorie counting between intervention groups.	● Ordinal logistic regression. ● DV: Agreement that the message received would encourage excessive calorie counting was modelled as an ordinal measure including Likert scale ratings of 1,2,3,4,5 as separate groups. ● IV: Intervention group (4 categories: Control, Fewer-calories, Numeric-Calories, PACE) ● The 3 comparisons were: Fewer-calories v Numeric-calories; Fewer-calories v PACE; Numeric-calorie v PACE. ● When reporting proportions descriptively (e.g. Figure 5.7), Likert scale ratings of 4 or 5 were considered in agreement with the statement and ratings of 1 and 2 were considered disagreement.	● $p < 0.017$ (3 comparisons)
(c) The acceptability, helpfulness and appropriateness of the PACE message in the PACE group. And (ii) beliefs about excessive physical activity.	● This was analysed descriptively. When reporting proportions, Likert scale ratings of 4 or 5 were considered in agreement with the statement and ratings of 1 and 2 were considered disagreement.	● N/A

Exploratory outcomes		
(a) Subgroup analysis of the primary outcomes (a) and (b) by gender, age, ethnicity, income, and education.	● The analysis outlined for primary outcome (a) was repeated separately for gender (male and female), age (below the median and median or above), ethnicity (white and non-white), income (below £25K and £25K and above per year) and education (up to and including college/A-levels completed and undergraduate or higher). ● The 6 comparisons were: Control v Fewer-calories; Control v Numeric-calories; Control v PACE; Numeric v Fewer-calories; PACE v Numeric calories; PACE v Fewer-calories.	● $p < 0.0083$ (6 comparisons)
	● The analysis outlined for primary outcome (b) was repeated separately for gender (male and female), age (below the median and median or above), ethnicity (white and non-white), income (below £25K vs £25K and above per year) and education (up to and including college/A-levels completed and undergraduate or higher). ● The 6 comparisons were: Control v Fewer-calories; Control v Numeric-calories; Control v PACE; Numeric v Fewer-calories; PACE v Numeric calories; PACE v Fewer-calories.	● $p < 0.0083$ (6 comparisons)
(b) Primary outcome (a) adjusted for dietary restraint or price within the three separate categories.	● Three separate binary logistic regressions, with control as the reference group. ● DVs: Model 1: Sweet swap accepted (yes/no); Model 2: Savoury swap accepted (yes/no); Model 3: Drink swap accepted (yes/no). ● IVs: Intervention group (4 categories: Control, Fewer-calories, Numeric-Calories, PACE) ● Each of these 3 models (sweet, savoury and drink swap accepted) were repeated separately with additional adjustment for either dietary restraint (a continuous score from 9-45 on the DIS) or price (a continuous number indicating the difference in price in £ between the initially selected item and the swap offered).	● $p < 0.017$ (3 comparisons)

	● A total of 6 models were conducted with the following 3 comparisons in each model: Control v Fewer-calories; Control v Numeric-calories; Control v PACE.	
(c) Primary analysis (a) repeated for swap-type.	● Four separate binary logistic regressions (two for sweet - dissimilar swaps (i.e., fruit) and similar swaps (i.e., all other items), and two for savoury - dissimilar swaps (i.e., or carrot sticks) and similar swaps (i.e., all other items). ● DVs: Model 1: Sweet swap (fruit) accepted (yes/no); Model 2: Sweet swap (all other items) accepted (yes/no); Model 3: Savoury swap (carrot sticks) accepted (yes/no); Model 4: Savoury swap (all other items) accepted (yes/no) ● IVs: Intervention group (4 categories: Control, Fewer-calories, Numeric-Calories, PACE) ● The 3 comparisons for each model were: Control v Fewer-calories; Control v Numeric-calories; Control v PACE.	● $p < 0.017$ (3 comparisons)
Primary analysis (a) was repeated including ineligible participants that completed the study, as a sensitivity analysis.		

5.2.9 Sample size

The power calculation for this study was based on the results from the pilot study reported in Chapter 4. In this study, the smallest difference between groups was observed for sweet snack swap acceptance. Adding a calorie-focused message increased the proportion of participants accepting a sweet snack swap (22.8% compared to 17.3%) by 5.5 percentage points (pp).

To estimate sample size, the minimum detectable effect size (MDES) was set at a 5.5pp change in swap acceptance, power was set to 0.8, alpha 0.05. Power was set to 80% because this is the minimum widely acceptable and widely used power cut-off in clinical trials (Cook et al., 2018). Based on this input, the required total sample size was 807 per arm. In the pilot, 15% of participants selected fruit initially meaning that they were not offered a sweet swap. To account for participants that may not be offered swaps, this number was inflated by 15% (n=121) bringing the recommended sample size to 928 per arm. A total sample size of 3,712 was required for a four-arm trial.

5.3 Results

Out of the 9,356 participants deemed eligible by Prolific Academic, 3,888 (42%) participants consented and were randomised to one of four groups. Of those, 3,481 (90%) participants were included in the analysis (Figure 5.3).

Participants were on average 35.6 (SD = 10.5) years old. Just under two-thirds (63%) of the sample was female, 91% identified as white, and 61% had completed some form of tertiary-level education. About half (51%) of the sample had an annual salary of at least £25,000 (Table 5.2). Average completion time for the study was 4 minutes 8 seconds (SD= 1m 9s) and attention checks showed sufficient engagement with the task (Appendix 5.3, Additional File 1).

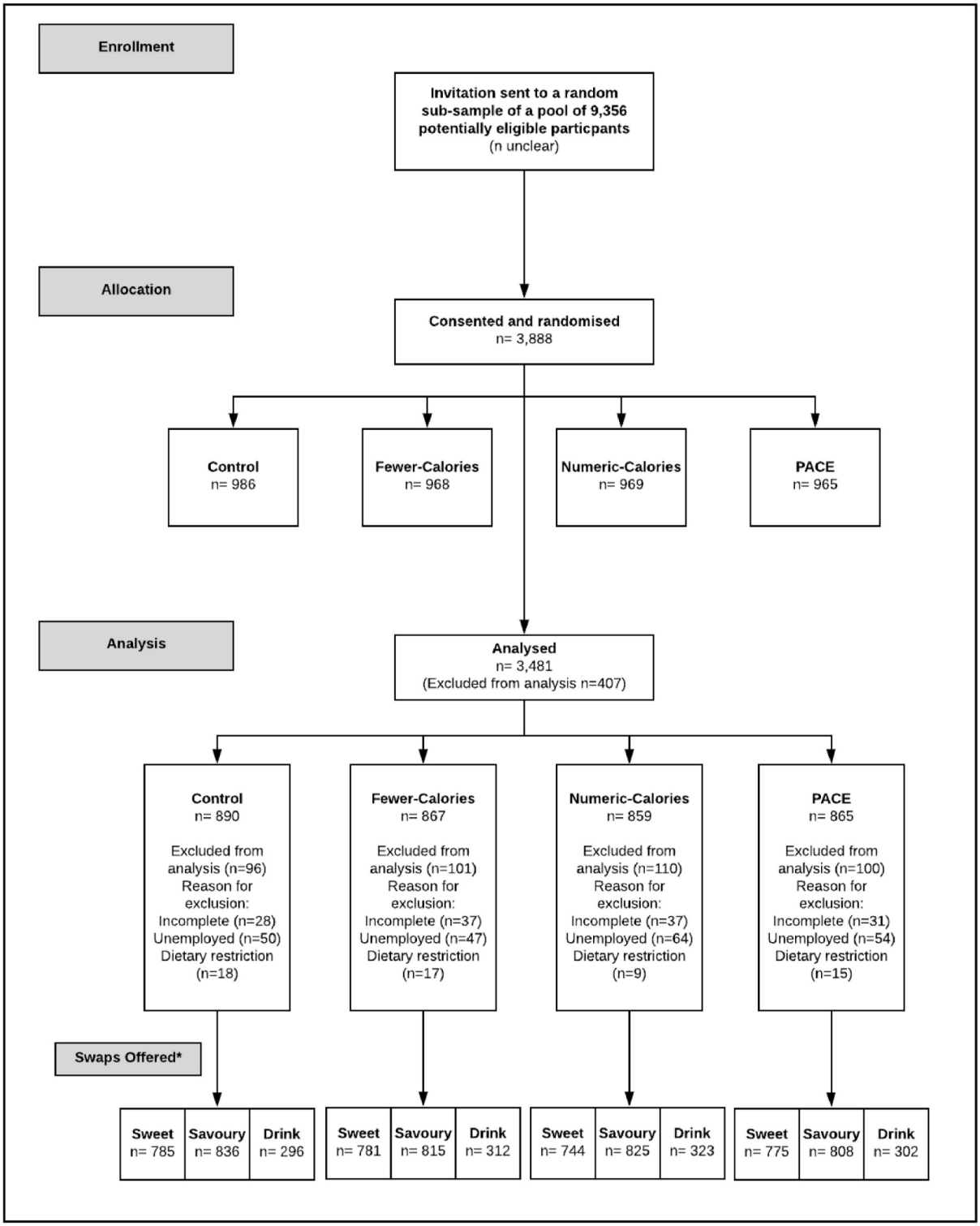


Figure 5.3: CONSORT Flow diagram

Note: The swaps offered section above provides a breakdown of the number of participants in each group that were offered swaps for their initial selections in each product.

Table 5.2: Baseline characteristics of participants, by trial arm.

	Control (n=890)	**Fewer-calories (n=867)**	**Numeric-calories (n=859)**	**PACE (n= 865)**	**Total (n=3,481)**
Age, *years*, mean ± SD	35.8 ± 10.2	35.6 ± 10.6	35.8 ± 10.7	35.3 ± 10.6	35.6 ± 10.5
Gender, *female*, n (%)	586 (65.8)	558 (64.4)	515 (60.0)	548 (63.4)	2,207 (63%)
Ethnic group, n (%)					
White	815 (91.6)	780 (90.0)	779 (90.7)	779 (90.1)	3,153 (91%)
Mixed/Other	19 (2.1)	33 (3.8)	25 (2.9)	25 (2.9)	102 (3%)
Asian/Black	56 (6.3)	54 (6.2)	55 (6.4)	61 (7.0)	226 (6%)
Education, n (%)					
None-Secondary	98 (11.0)	100 (11.5)	88 (10.2)	80 (9.3)	366 (11%)
College / A-level	211 (23.7)	258 (29.8)	267 (31.1)	239 (27.6)	975 (28%)
Undergraduate	370 (41.6)	336 (38.7)	330 (38.4)	346 (40.0)	1,382 (40%)
Graduate & higher	211 (23.7)	173 (20.0)	174 (20.3)	200 (23.1)	758 (21%)
Income, n (%)					
Below £15.5K	173 (19.4)	159 (18.3)	171 (19.9)	164 (19.0)	667 (19%)
£15.5K - £25K	256 (28.8)	274 (31.6)	249 (29.0)	262 (30.3)	1,041 (30%)
£26K - £39K	301 (33.8)	257 (29.7)	256 (29.8)	264 (30.5)	1,078 (31%)
£40K or above	140 (15.7)	152 (17.5)	152 (17.7)	149 (17.2)	593 (17%)
Prefer not to say	20 (2.3)	25 (2.9)	31 (3.6)	26 (3.0)	102 (3%)
DIS score, mean ± SD	21 ± 7	20 ± 7	21 ± 7	21 ± 7	21 ± 7

NOTE: PACE: Physical Activity Calorie Equivalent; DIS: Dietary Intent Scale

Of the three food and drink selections made by participants, almost everyone (99%) in the sample was offered at least one lower-energy swap during the study. Table 5.3 shows the percentage acceptance rate of swaps across groups. Of the 7,602 swaps offered, 1,617 (21%) were accepted overall. Table 5.3 also shows the proportion of participants in each group offered and accepting swaps for each product category.

Table 5.3: Number of participants offered and accepting swaps for each product category by group.

	Control (n=890)	**Fewer-calories (n=867)**	**Numeric-calories (n=859)**	**PACE (n=865)**	**Total (n=3,841)**
Sweet snacks					
Swaps offered n	785	781	744	775	3,085
Swaps accepted n (%)	107(14%)	144 (18%)	170 (23%)	207 (27%)	628 (20%)
Savoury snacks					
Swaps offered n	836	815	825	808	3,284
Swaps accepted n (%)	102(12%)	149 (18%)	170 (21%)	207 (26%)	628 (19%)
Drinks					
Swaps offered n	296	312	323	302	1,233
Swaps accepted n (%)	74 (25%)	80 (26%)	95 (29%)	112 (37%)	361 (29%)

NOTE: Proportions accepting swaps in parentheses. Fewer swaps were offered for drinks because a lower-energy alternative only existed for 48% of drinks on offer. The percentage of swaps accepted is based on the number of swaps offered, not the total n in each group.

5.3.1 Primary Outcome (a) Swap acceptance by product category

Compared with control, the numeric-calories and PACE messages significantly increased the odds of accepting a sweet snack swap. All interventions also significantly increased the odds of accepting savoury swaps compared with control. Only the PACE message significantly increased the odds of accepting a drink swap compared with control (Figure 5.4). The PACE group also significantly outperformed the fewer-calories group in every swap category.

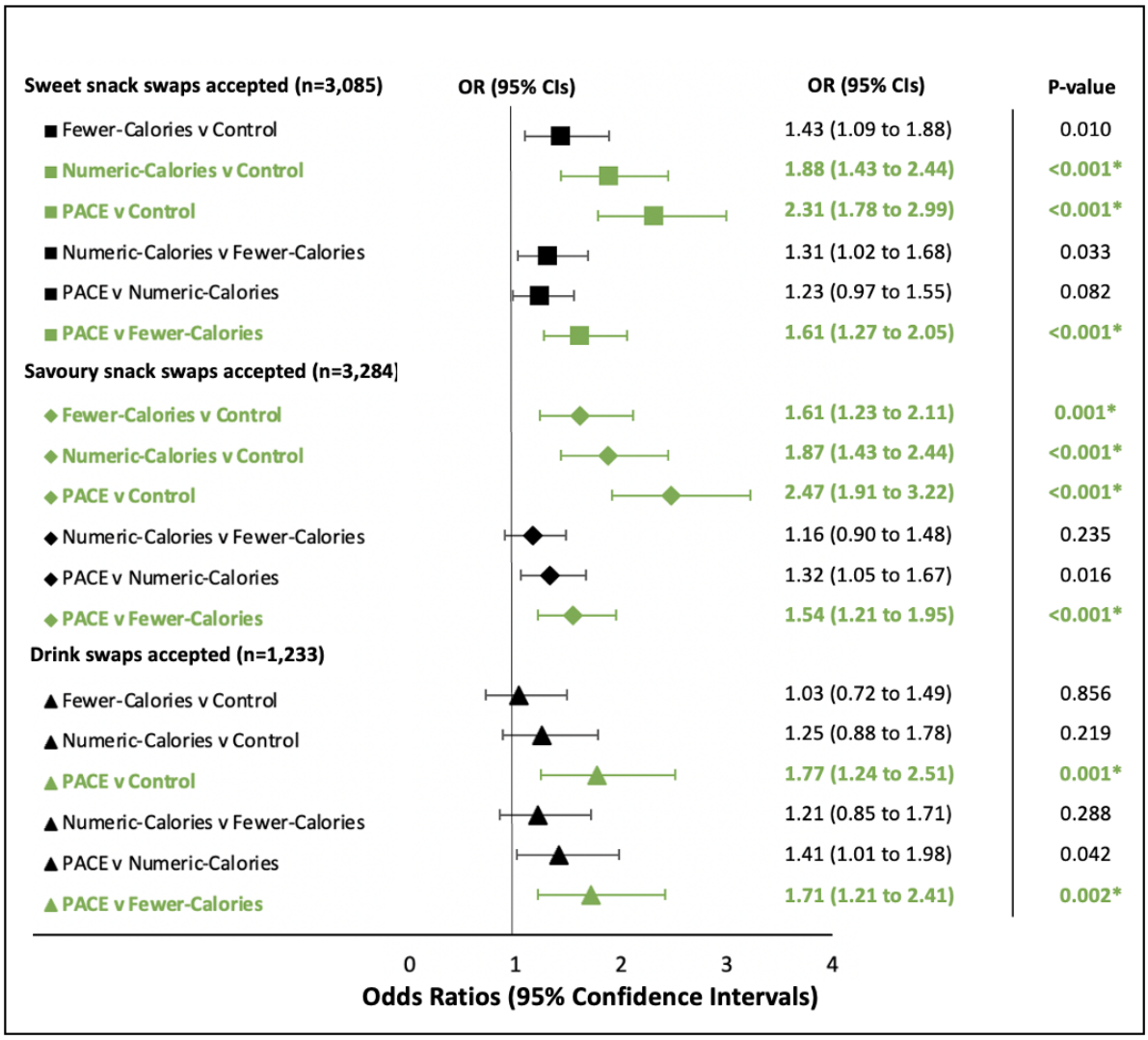


Figure 5.4: Odds of a sweet, savoury or drink swap being accepted by group.

NOTE: Odds ratios (OR), 95% Confidence Intervals and non-adjusted p-values.
* Meets Bonferroni adjusted statistical significance threshold of p<0.008.

5.3.2 Primary Outcome (b) Energy ordered by product category

Regarding the energy content of sweet snacks ordered, both the numeric-calories messaging and the PACE messaging significantly reduced the energy content of sweet snacks ordered compared with control (mean=215 kcal) by -10kcal (95% CI: -14 to -6) and by -14kcal (95% CI: -18 to -10), respectively. The fewer-calories messaging did not significantly reduce the energy content of sweet snacks compared with the control (mean difference: -5kcal, 95% CI: -9 to -0.6, p=0.02, i.e., not <0.008). When comparing between intervention groups, the only significant difference in energy ordered was observed between the PACE group and the fewer-calories message group. All three intervention messages significantly reduced the energy content of savoury snacks ordered compared with the control (mean = 177kcal); the fewer-calorie messaging by -6kcal (95% CI: -10 to -2), the numeric-calories messaging by -9kcal (95% CI: -13 to -5) and the PACE messaging by -14 kcal (95% CI: -18 to -11). The PACE messaging also significantly reduced energy when compared with both the fewer-calories (mean difference: -8kcal, 95% CI: -12 to -4) and numeric-calories message (mean difference: -5kcal, 95% CI: -9 to -1). None of the intervention messages significantly reduced the energy content of drinks ordered compared with the control (Figure 5.5 and Table 5.5).

5.3.3 Secondary Outcome (a) The total energy (kcal) ordered

Compared with control, all three messages significantly reduced total energy ordered, the PACE message by 30 kcal (95% CI: -37 to -23), the numeric-calories message by 19 kcal (95% CI: -26 to -12), and the fewer-calories message by 11 kcal (95% CI: -17 to -4). When comparing between intervention groups, the PACE group ordered significantly fewer calories overall than both the fewer-calories group (mean difference= -20kcal, 95% CI: -29 to -10) and the numeric-calories group (mean difference= -11kcal, 95% CI: -17 to -4) (Table 5.4).

Table 5.4: Means and effect sizes for total calories ordered controlling for initial calories selected (450 kcal) by intervention allocation (i.e., total calories ordered after exposure to the intervention) (n=3,444). This analysis excludes those (n=37) not offered any swaps. Non-adjusted p-values presented with an indication * of statistical significance at Bonferroni adjusted threshold of p<0.008.

Group	Mean Final kcals	Group	Mean Final kcals	Mean Difference (95% CI)	P-Value	Effect Size *(d)*
Fewer Calories	405	Control	416	-11 (-17 to -4)	0.002*	0.15
Numeric Calories	397	Control	416	-19 (-26 to -12)	<0.001*	0.26
PACE	386	Control	416	-30 (-37 to -23)	<0.001*	0.42
Numeric Calories	397	Fewer Calories	405	-8 (-15 to -1)	0.017	0.11
PACE	386	Fewer Calories	405	-20 (-26 to -13)	<0.001*	0.26
PACE	386	Numeric Calories	397	-11 (-18 to -4)	0.001*	0.15

Note: Effect Sizes reported are Cohen's *d.* For the effect size calculations, the pooled standard deviations used was $\sqrt{5206} = 72$. Sample sizes were as follows: Control n=878; Fewer Calories n=858; Numeric Calories n=852; PACE n=856.

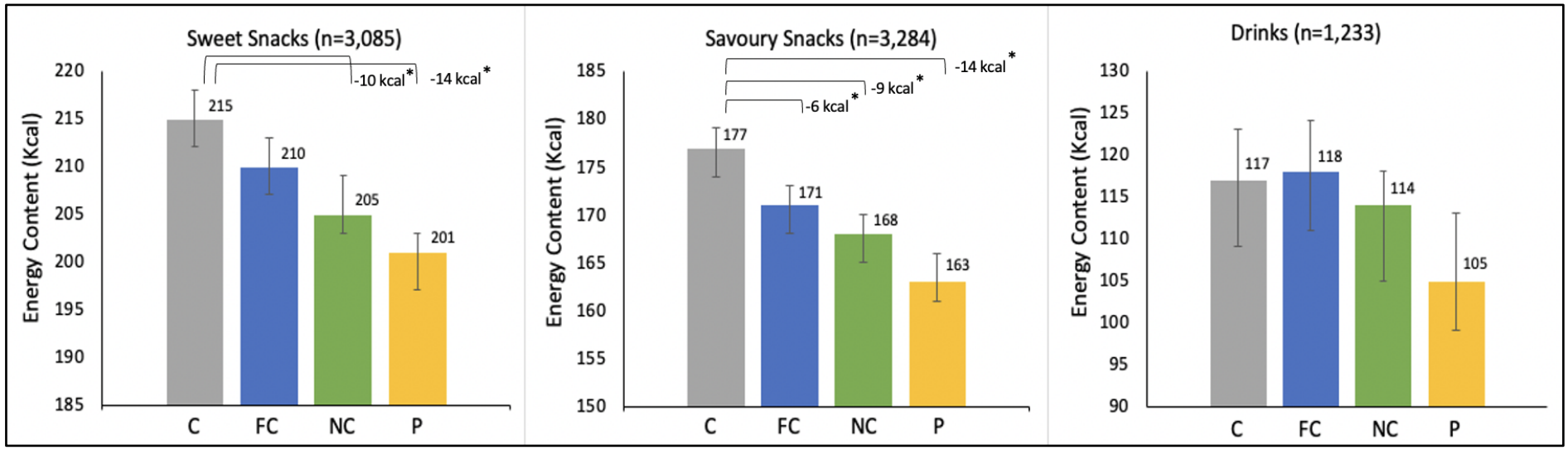


Figure 5.5: Means and 95% confidence intervals for final calories ordered adjusting for initial calories ordered (sweet snacks= 228 kcal; savoury snacks = 189 kcal; drinks = 148 kcal). C= Control; FC= Fewer-calories; NC= Numeric-calories; P=PACE. Comparisons with the control group as reference. *Meets Bonferroni adjusted statistical significance threshold of $p<0.008$.

Table 5.5: Mean differences in energy ordered between groups from sweet snacks (n=3,085), savoury snacks (3,284) and drinks (n= 1,233) controlling for initial calories selected (sweet snacks= 228 kcal; savoury snacks = 189 kcal; drinks = 148 kcal). Non-adjusted p-values presented with an indication * of statistical significance at Bonferroni adjusted threshold p<0.008. Cohen's *d* Effect sizes are also presented.

	Sweet Snacks			**Savoury Snacks**			**Drinks**		
Group Comparison	*Mean Difference (95% CI)*	*P-Value*	*Effect Size (d)*	*Mean Difference (95% CI)*	*P-Value*	*Effect Size (d)*	*Mean Difference (95% CI)*	*P-Value*	*Effect Size (d)*
Fewer-calories v Control	-5 (-9 to 0.6)	0.025	0.12	-6 (-10 to -2)	0.002*	0.15	1 (-9 to 10)	0.919	0.02
Numeric-calories v Control	-10 (-14 to -6)	<0.001*	0.23	-9 (-13 to -5)	<0.001*	0.23	-3 (-13 to 6)	0.475	0.05
PACE v Control	-14 (-18 to -10)	<0.001*	0.33	-14 (-18 to -11)	<0.001*	0.35	-12 (-22 to -3)	0.018	0.20
Numeric-calories v Fewer-calories	-5 (-9 to -0.6)	0.025	0.12	-3 (-7 to 0.8)	0.124	0.08	-4 (-13 to 6)	0.475	0.07
PACE v Fewer-calories	-9 (-13 to -5)	<0.001*	0.21	-8 (-12 to -4)	<0.001*	0.20	-12 (-22 to -3)	0.013	0.20
PACE v Numeric-calories	-4 (-8 to 0.3)	0.070	0.09	-5 (-9 to -1)	0.007*	0.13	-9 (-19 to 0.7)	0.070	0.15

Note: For the effect size calculations, the pooled standard deviations used were as follows: Sweet snacks = √1870 = 43, Savoury snacks= √1582 =40, and Drinks= √3773=61. Sample sizes were as follows: Sweet snacks: Control n=785; Fewer Calories n=781; Numeric Calories n=744; PACE n=775. Savoury snacks: Control n= 836; Fewer Calories n= 815 ; Numeric Calories n= 825; PACE n=808. Drinks: Control n= 296; Fewer Calories n=312; Numeric Calories n= 323; PACE n= 302.

5.3.4 Secondary Outcome (b) At least one swap accepted

Of those offered a swap (n=3,444), at least one swap was accepted by 29% of participants in the control group, 37% of participants in the fewer-calories group, 41% of participants in the numeric-calories group and 46% of participants in the PACE message group. Compared with control, the odds of accepting at least one swap were 1.4 (95% CI: 1.2 to 1.7, p=0.001), 1.7 (95% CI: 1.4 to 2.1, p<0.001) and 2.2 (95% CI: 1.8 to 2.7, p<0.001) times greater in the fewer-calories, numeric-calories and PACE groups respectively.

5.3.5 Acceptability & inadvertent harm: Outcome (a) Intervention acceptability

On average, 67% of participants agreed that being offered swaps for their food choices at work would be acceptable. Figure 5.6 presents the proportions of participants in each group agreeing (ratings of 4 or 5) and disagreeing (ratings of 1 or 2) with the statement: "*I would find being offered swaps for my food choices in my workplace canteen acceptable*". Table 5.6 presents the ordinal regression analysis for Likert scale ratings. Compared with the control group, those in the PACE (OR: 1.74, 95%CI: 1.46 to 2.08) and numeric-calories (OR: 1.74, 95%CI: 1.46 to 2.08) groups rated the intervention as significantly more acceptable. However, there was no significant difference between the fewer-calories group and the control group. Those in the PACE group (OR: 1.46, 95%CI: 1.23 to 1.76) also rated the intervention as significantly more acceptable than those in the fewer-calories group (Table 5.6).

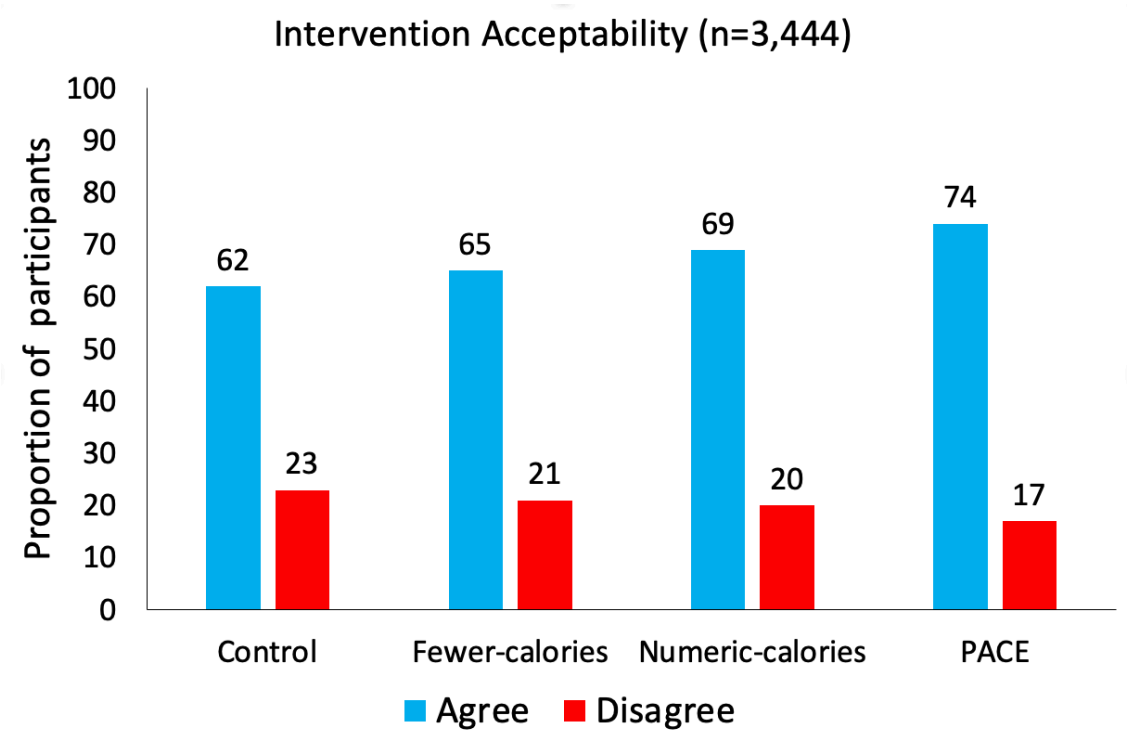


Figure 5.6: Proportion of participants in each group agreeing (ratings of 4 or 5) and disagreeing (ratings of 1 or 2) with the statement: "I would find being offered swaps for my food choices in my workplace canteen acceptable".

Table 5.6: Ordinal logistic regression for acceptability ratings of offering swaps by intervention allocation (i.e., after exposure to the intervention). This analysis excludes those (n=37) not offered any swaps. Non-adjusted p-values presented with an indication * of statistical significance at Bonferroni adjusted threshold.

		Acceptability OR (95% CI)	**P-value**
Ref. category		(n=3,455)	
Control	**Fewer-calories**	1.19 (0.99 to 1.41)	0.050
Control	**Numeric-calories**	1.39 (1.17 to 1.68)	<0.001*
Control	**PACE**	1.74 (1.46 to 2.08)	<0.001*
Fewer-calories	**Numeric-calories**	1.18 (0.99 to 1.40)	0.071
Numeric-calories	**PACE**	1.25 (1.04 to 1.49)	0.015
Fewer-calories	**PACE**	1.46 (1.23 to 1.76)	<0.001*

*Meets Bonferroni adjusted statistical significance threshold of p<0.008.

5.3.6 Acceptability & inadvertent harm: Outcome (b) Beliefs about future excessive calorie counting

In the PACE group, 25% of participants agreed that the message they saw would encourage them to count calories excessively. This was significantly higher than the 15% of participants exposed to the numeric-calories message and the 11% of participants exposed to the fewer-calories message who agreed that the message would encourage this behaviour (Figure 5.7). For the ordinal logistic regression analysis, acceptability was modelled as an ordinal measure including 1,2,3,4,5 as separate groups (Table 5.7).

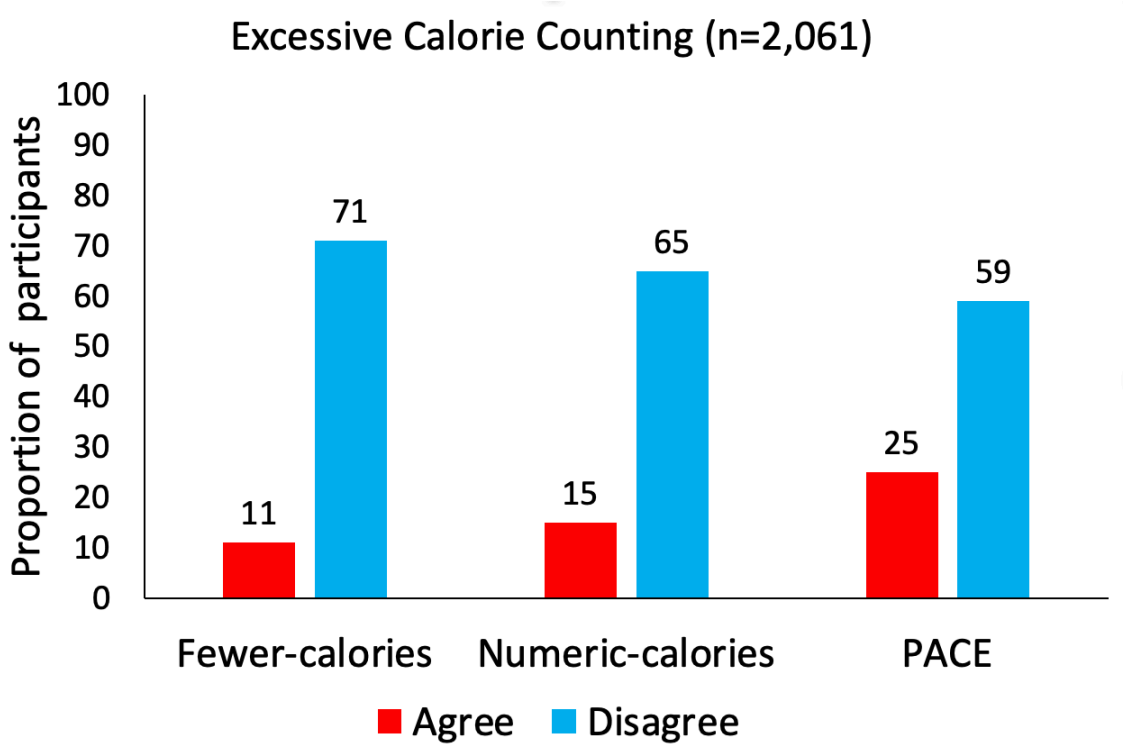


Figure 5.7: Proportion of participants agreeing (rating of 4 or 5) and disagreeing (rating of 1 or 2) with the statement "the calories message would make me want to count calories excessively" by intervention allocation. This analysis excludes the control group and those not offered any swaps (n=37) (n= 2,061).

Table 5.7: Ordinal logistic regression for Likert scale ratings of agreement with the statement "the calories message would make me want to count calories excessively" by intervention allocation (n= 2,061). This analysis excludes the control group and those not offered any swaps (n=37). Non-adjusted p-values presented with an indication * of statistical significance at Bonferroni adjusted threshold.

		Acceptability OR (95% CI)	**P-value**
Ref. category		(n=2,061)	
Fewer-calories	**Numeric- calories**	1.38 (1.13 to 1.68)	0.001*
Fewer-calories	**PACE**	1.91 (1.57 to 2.34)	<0.001*
Numeric-calories	**PACE**	1.39 (1.14 to 1.70)	0.001*

*Meets Bonferroni adjusted statistical significance threshold of p<0.017.

5.3.7 Acceptability & inadvertent harm: Outcome (c) Acceptability, helpfulness, appropriateness, and potential adverse effects of the PACE message

Of those presented with PACE information (n=860), 15% reported that it would make them want to excessively exercise. Most participants in this group, however, agreed that the PACE message was acceptable (78%), helpful (66%), and appropriate (64%) (Figure 5.8).

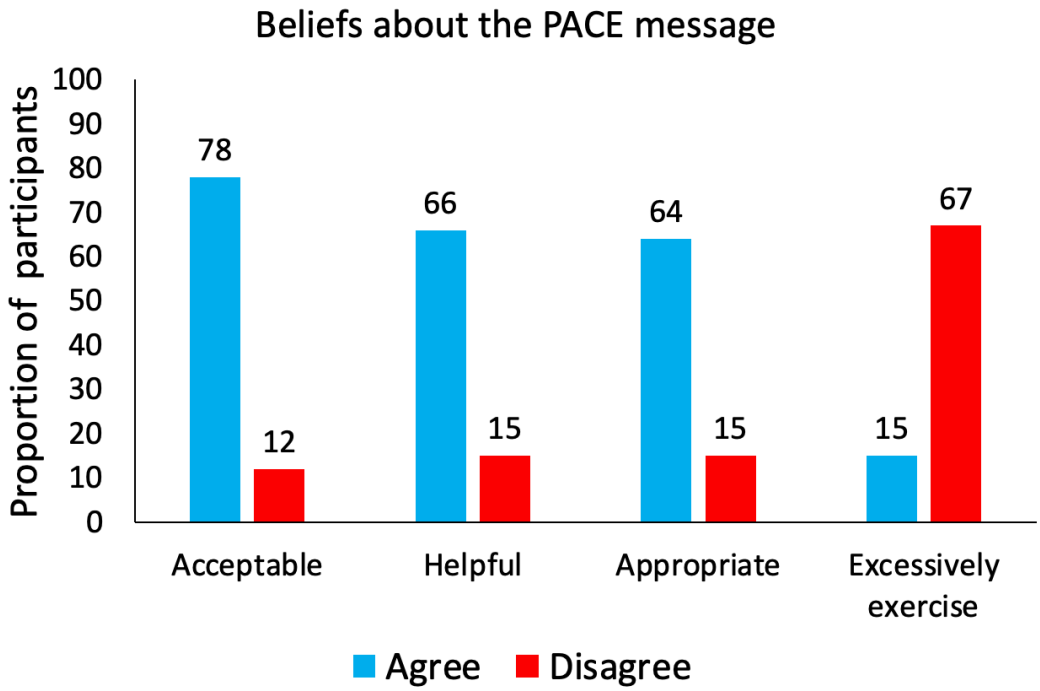


Figure 5.8: Proportion of participants in the PACE group agreeing or disagreeing that the physical activity message: (i) is acceptable (ii) is helpful (iii) is appropriate (n=851), (iv) would make them want to excessively exercise (n=654). This analysis excludes those (n=37) not offered any swaps.

5.3.8 Exploratory Outcome (a) Subgroup analysis of the primary outcomes (a) and (b) by participant characteristics

When examined by sub-group, the overall direction of effect aligned with the main analysis and there was no evidence of clear differences in swap acceptance (Tables 5.8 - 5.12) or energy ordered (Figures 5.9 to 5.13) by gender, age, ethnicity, education or income.

Table 5.8: Swap acceptance & gender. The effect of message type on the likelihood that a sweet, savoury and drink swap is accepted compared with control. Analysis for female and male participants separately. Odds ratios, 95% confidence intervals (CI), non-adjusted p-values presented with an indication * of statistical significance at Bonferroni adjusted threshold of p<0.008.

Female		**Sweet Swap Accepted OR (95% CI)**	**P-value**	**Savoury Swap Accepted OR (95% CI)**	**P-value**	**Drink Swap Accepted OR (95% CI)**	**P-value**
Ref. category		(n=1,928)		(n=2,058)		(n=700)	
Control	**Fewer-calories**	1.39 (1.01 to 1.94)	0.044	1.59 (1.13 to 2.24)	0.008	1.06 (0.67 to 1.69)	0.794
Control	**Numeric-calories**	1.92 (1.39 to 2.65)	<0.001*	1.95 (1.40 to 2.73)	<0.001*	1.17 (0.73 to 1.86)	0.511
Control	**PACE**	2.59 (1.90 to 3.52)	<0.001*	2.66 (1.92 to 3.67)	<0.001*	1.74 (1.10 to 2.76)	0.018
Fewer-calories	**Numeric-calories**	1.37 (1.01 to 1.87)	0.042	1.22 (0.89 to 1.67)	0.201	1.09 (0.69 t0 1.73)	0.689
Numeric-calories	**PACE**	1.34 (1.01 to 1.79)	0.041	1.66 (1.24 to 2.25)	0.001*	1.49 (0.95 to 2.34)	0.084
Fewer-calories	**PACE**	1.85 (1.38 to 2.47)	0.001*	1.36 (1.02 to 1.82)	0.038	1.63 (1.04 to 2.58)	0.033
Male		(n=1,156)		(n=1,225)		(n=533)	
Control	**Fewer-calories**	1.51 (0.92 to 2.50)	0.107	1.64 (1.04 to 2.59)	0.032	1.0 (0.55 to 1.81)	1.000
Control	**Numeric-calories**	1.94 (1.20 to 3.14)	0.007*	1.74 (1.12 to 2.71)	0.014	1.39 (0.79 to 2.43)	0.246
Control	**PACE**	1.87 (1.15 to 3.04)	0.012	2.19 (1.41 to 3.40)	<0.001*	1.85 (1.07 to 3.22)	0.029
Fewer-calories	**Numeric-calories**	1.28 (0.83 to 1.98)	0.264	1.06 (0.71 to 1.57)	0.771	1.39 (0.81 to 2.39)	0.232
Numeric-calories	**PACE**	0.96 (0.63 to 1.46)	0.862	1.255 (0.85 to 1.83)	0.242	1.33 (0.81 to 2.18)	0.259
Fewer-calories	**PACE**	1.23 (0.79 to 1.92)	0.350	1.33 (0.89 to 1.98)	0.155	1.85 (1.08 to 3.16)	0.24

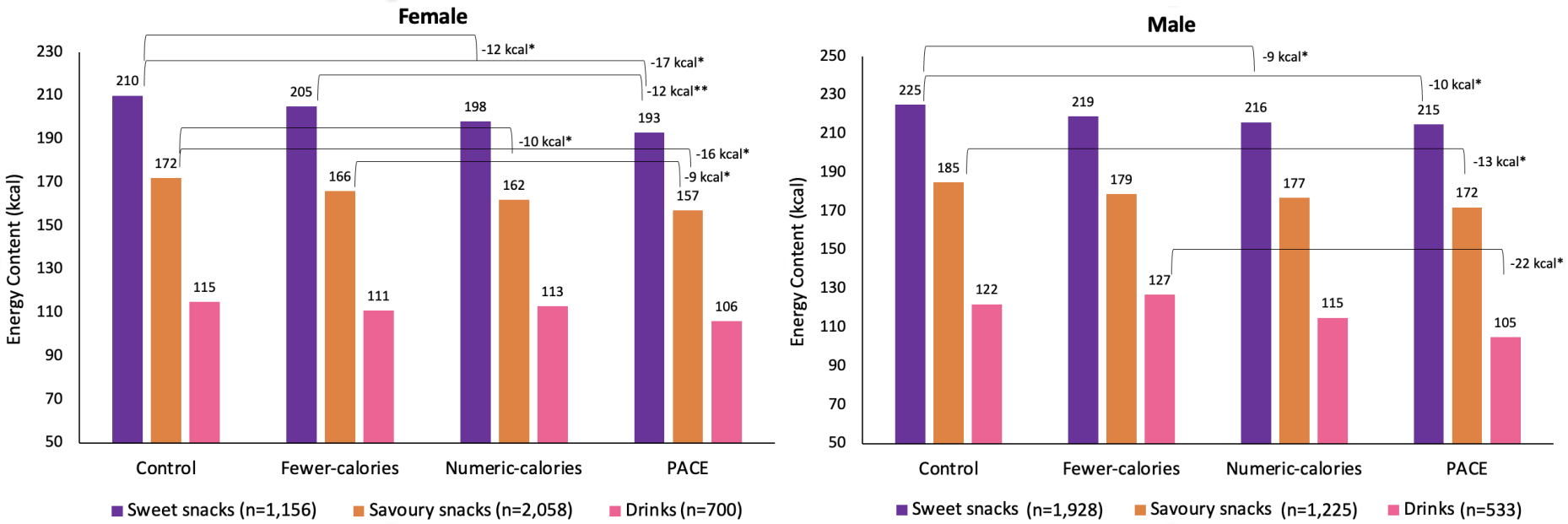


Figure 5.9: Energy ordered & gender. Means for calories ordered from snacks and drinks controlling for initial calories selected by intervention allocation (i.e., calories ordered after exposure to the intervention). *Meets Bonferroni adjusted statistical significance threshold of p<0.008.

Table 5.9: Swap acceptance & age. The effect of message type on the likelihood that a sweet, savoury and drink swap is accepted compared with control. Analysis for participants median age (33 years) and above, and below separately. Odds ratios, 95% confidence intervals (CI) and non-adjusted p-values presented with an indication * of statistical significance at Bonferroni adjusted threshold of p<0.008.

Older (median age or above)		**Sweet Swap Accepted OR (95% CI)**	**P-value**	**Savoury Swap Accepted OR (95% CI)**	**P-value**	**Drink Swap Accepted OR (95% CI)**	**P-value**
Ref. category		n= 1,620		n= 1,728		n= 614	
Control	**Fewer-calories**	1.42 (0.98 to 2.06)	0.065	1.54 (1.07 to 2.21)	0.019	1.30 (0.77 to 2.18)	0.333
Control	**Numeric-kcal**	1.88 (1.30 to 2.07)	0.001*	1.76 (1.23 to 2.52)	0.002*	1.68 (1.01 to 2.81)	0.045
Control	**PACE**	2.20 (1.54 to 3.16)	<0.001*	2.23 (1.57 to 3.17)	<0.001*	2.09 (1.25 to 3.48)	0.005*
Fewer-calories	**Numeric-calories**	1.32 (0.94 to 1.86)	0.107	1.14 (0.82 to 1.59)	0.417	1.30 (0.80 to 2.12)	0.288
Numeric-kcal	**PACE**	1.17 (0.85 to 1.63)	0.337	1.26 (0.917 to 1.74)	0.152	1.24 (0.77 to 1.99)	0.372
Fewer-calories	**PACE**	1.55 (1.11 to 2.17)	0.010	1.45 (1.05 to 2.01)	0.026	1.61 (0.99 to 2.62)	0.052
Younger (below the median age)		n= 1,465		n= 1,556		n= 619	
Control	**Fewer-calories**	1.45 (0.97 to 2.16)	0.070	1.70 (1.12 to 2.59)	0.012	0.83 (0.49 to 1.39)	0.418
Control	**Numeric-calories**	1.87 (1.27 to 2.76)	0.001*	2.01 (1.34 to 3.02)	0.001*	0.93 (0.56 to 1.53)	0.793
Control	**PACE**	2.41 (1.66 to 3.50)	<0.001*	2.82 (1.91 to 4.17)	<0.001*	1.50 (0.92 to 2.45)	0.100
Fewer-calories	**Numeric-calories**	1.29 (0.89 tov1.86)	0.165	1.18 (0.82 to 1.70)	0.371	1.13 (0.68 to 1.85)	0.643
Numeric-calories	**PACE**	1.29 (0.92 to 1.79)	0.136	1.4 (1.00 to 1.95)	0.048	1.61 (1.00 to 2.58)	0.049
Fewer-calories	**PACE**	1.67 (1.18 to 2.36)	0.004*	1.65 (1.17 to 2.34)	0.005*	1.81 (1.11 to 2.96)	0.018

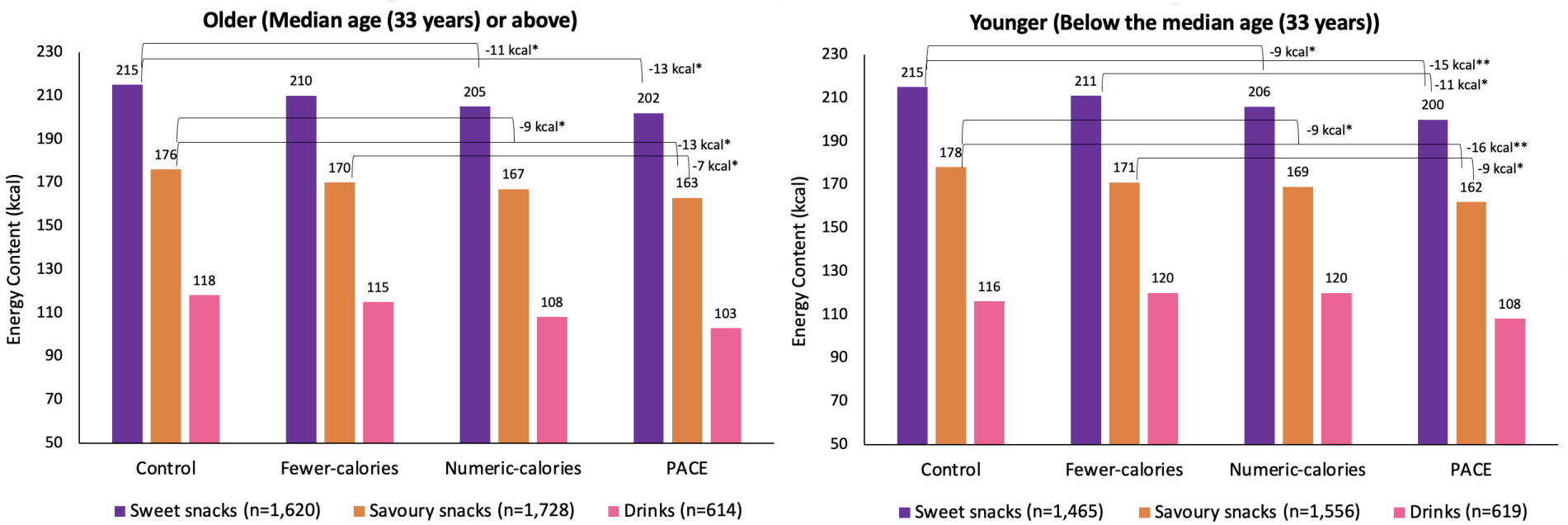


Figure 5.10: Energy ordered & age. Means for calories ordered from snacks and drinks controlling for initial calories selected by intervention allocation. (i.e., calories ordered after exposure to the intervention). *Meets Bonferroni adjusted statistical significance threshold of p<0.008.

Table 5.10: Swap acceptance & ethnicity. The effect of message type on the likelihood that a sweet, savoury and drink swap is accepted compared with control. Analysis of white and non-white participants separately. Odds ratios, 95% confidence intervals (CI) and non-adjusted p-values presented with an indication * of statistical significance at Bonferroni adjusted threshold of p<0.008.

White		**Sweet Swap Accepted OR (95% CI)**	**P-value**	**Savoury Swap Accepted OR (95% CI)**	**P-value**	**Drink Swap Accepted OR (95% CI)**	**P-value**
Ref. category		**(n=2,787)**		**(n=2,977)**		**(n=1,097)**	
Control	**Fewer-calories**	1.43 (1.07 to 1.92)	0.015	1.52 (1.14 to 2.03)	0.005*	1.16 (0.78 to 1.72)	0.462
Control	**Numeric-calories**	1.85 (1.39 to 2.46)	<0.001*	1.90 (1.44 to 2.52)	<0.001*	1.37 (0.93 to 2.02)	0.106
Control	**PACE**	2.41 (1.84 to 3.17)	<0.001*	2.52 (1.91 to 3.31)	<0.001*	1.91 (1.31 to 2.80)	0.001*
Fewer-calories	**Numeric-calories**	1.29 (0.99 to 1.68)	0.059	1.25 (0.96 to 1.62)	0.093	1.18 (0.82 to 1.71)	0.367
Numeric-calories	**PACE**	2.41 (1.84 to 3.17)	0.001*	1.32 (1.04 to 1.69)	0.024	1.39 (0.98 to 1.99)	0.068
Fewer-calories	**PACE**	1.68 (1.30 to 2.17)	0.001*	1.66 (1.28 to 2.13)	<0.001*	1.65 (1.15 to 2.37)	0.007*
Non-white		**(n=298)**		**(n=307)**		**(n=136)**	
Control	**Fewer-calories**	1.35 (0.59 to 3.06)	0.468	2.34 (1.02 to 5.34)	0.044	0.5 (0.17 to 1.48)	0.210
Control	**Numeric-calories**	2.02 (0.91 to 4.49)	0.086	1.55 (0.65 to 3.68)	0.324	0.72 (0.27 to 1.92)	0.511
Control	**PACE**	1.53 (0.68 to 3.41)	0.301	2.1 (0.91 to 4.84)	0.082	1.12 (0.44 to 2.88)	0.810
Fewer-calories	**Numeric-calories**	1.49 (0.72 to 3.08)	0.281	0.661 (0.32 to 1.38)	0.269	1.44 (0.47 to 4.37)	0.519
Numeric-calories	**PACE**	0.76 (0.37 to 1.54)	0.445	1.35 (0.65 to 2.85)	0.420	1.56 (0.59 to 4.12)	0.372
Fewer-calories	**PACE**	1.13 (0.54 to 2.34)	0.743	0.90 (0.45 to 1.80)	0.760	2.24 (0.76 to 6.59)	0.142

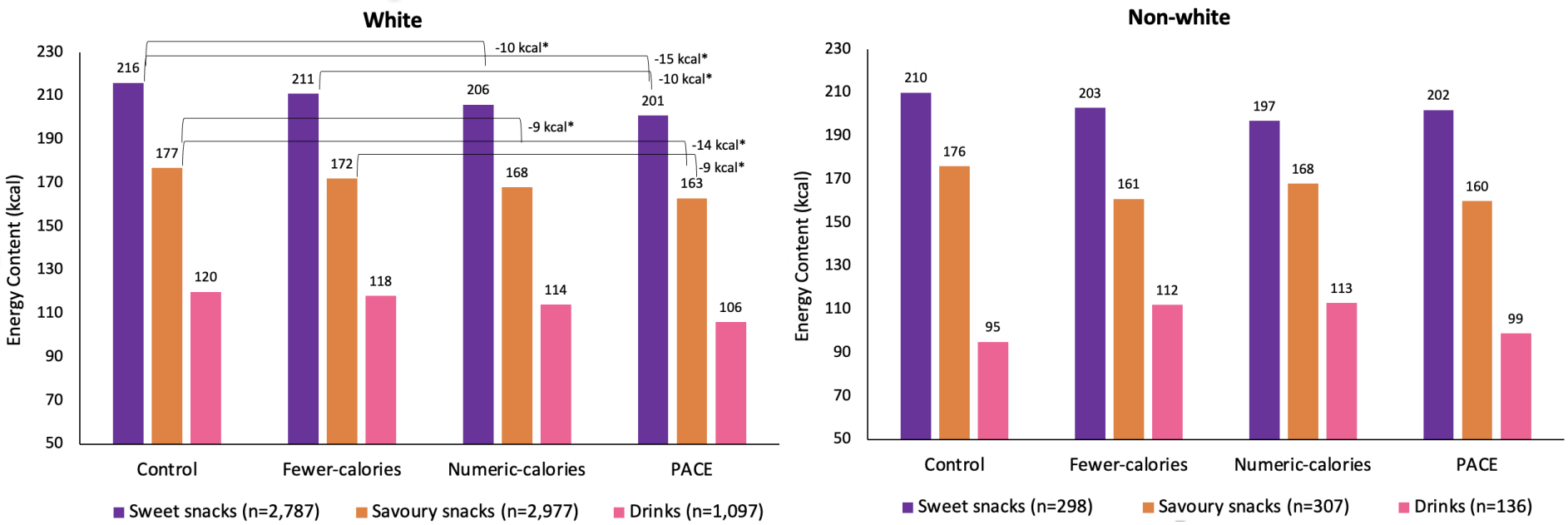


Figure 5.11: Energy ordered & ethnicity. Means for calories ordered from snacks and drinks controlling for initial calories selected (i.e., calories ordered after exposure to the intervention) by intervention allocation. *Meets Bonferroni adjusted statistical significance threshold of $p<0.008$.

Table 5.11: Swap acceptance & education: The effect of message type on the likelihood that a sweet, savoury and drink swap is accepted compared with control. Analysis for participants with lower and higher education completed separately. Odds ratios, 95% confidence intervals (CI) and non-adjusted p-values presented with an indication * of statistical significance at Bonferroni adjusted threshold of p<0.008.

Up to College/A-levels		**Sweet Swap Accepted OR (95% CI)**	**P-value**	**Savoury Swap Accepted OR (95% CI)**	**P-value**	**Drink Swap Accepted OR (95% CI)**	**P-value**
Ref. category		**(n=1,204)**		**(n=1,279)**		**(n=521)**	
Control	**Fewer-calories**	1.55 (0.98 to 2.44)	0.060	1.64 (1.04 to 2.60)	0.035	1.24 (0.67 to 2.30)	0.497
Control	**Numeric-calories**	1.91 (1.22 to 3.00)	0.005*	1.73 (1.09 to 2.74)	0.020	1.39 (0.76 to 2.57)	0.287
Control	**PACE**	2.04 (1.29 to 3.19)	0.002*	2.26 (1.43 to 3.56)	0.001*	2.00 (1.10 to 3.64)	0.023
Fewer-calories	**Numeric-calories**	1.24 (0.84 to 1.82)	0.286	1.04 (0.70 to 1.56)	0.814	1.12 (0.65 to 1.95)	0.674
Numeric-calories	**PACE**	1.06 (0.72 to 1.563)	0.754	1.30 (0.88 to 1.92)	0.184	1.44 (0.85 to 2.43)	0.177
Fewer-calories	**PACE**	1.31 (0.88 to 1.94)	0.172	1.37 (0.92 to 2.03)	0.121	1.62 (0.95 to 2.76)	0.078
Undergraduate Degree or Higher		**(n=1,881)**		**(n=2,005)**		**(n=712)**	
Control	**Fewer-calories**	1.38 (0.98 to 1.95)	0.064	1.62 (1.15 to 2.27)	0.005	0.98 (0.62 to 1.55)	0.925
Control	**Numeric-calories**	1.89 (1.35 to 2.63)	<0.001*	1.99 (1.44 to 2.78)	<0.001*	1.23 (0.79 to 1.92)	0.355
Control	**PACE**	2.49 (1.82 to 3.42)	<0.001*	2.62 (1.91 to 3.60)	<0.001*	1.75 (1.12 to 2.72)	0.013
Fewer-calories	**Numeric-calories**	1.36 (0.99 to 1.88)	0.061	1.23 (0.90 to 1.68)	0.185	1.26 (0.81 to 1.98)	0.318
Numeric-calories	**PACE**	1.32 (0.98 to 1.77)	0.065	1.31 (0.98 to 1.75)	0.064	1.42 (0.92 to 2.19)	0.115
Fewer-calories	**PACE**	1.80 (1.32 to 2.45)	<0.001*	1.62 (1.20 to 2.18)	0.002*	1.79 (1.14 to 2.81)	0.012

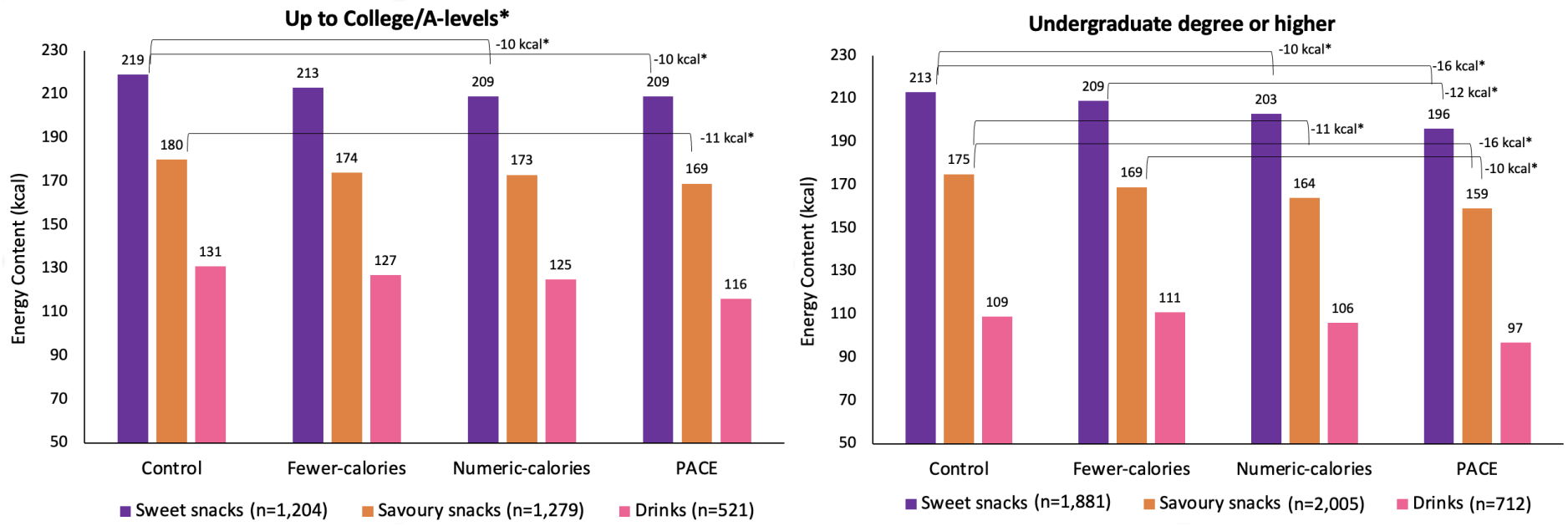


Figure 5.12: Energy ordered & education. Means for calories ordered from snacks and drinks controlling for initial calories selected by intervention allocation (i.e., calories ordered after exposure to the intervention). *Meets Bonferroni adjusted statistical significance threshold of p<0.008. NOTE: * Up to college / A-levels includes participants who have no formal education up to those who have completed College or A-levels (i.e., secondary education).

Table 5.12: Swap acceptance & income: The effect of message type on the likelihood that a sweet, savoury and drink swap is accepted compared with control. Analysis of higher and lower-earning participants separately. Odds ratios, 95% confidence intervals (CI) and non-adjusted p-values presented with an indication * of statistical significance at Bonferroni adjusted threshold of p<0.008. Those responding, "prefer not to say" (n=93) were excluded from this analysis.

£25K and above		**Sweet Swap Accepted OR (95% CI)**	**P-value**	**Savoury Swap Accepted OR (95% CI)**	**P-value**	**Drink Swap Accepted OR (95% CI)**	**P-value**
Ref. category		**(n=1,458)**		**(n=1,578)**		**(n=549)**	
Control	**Fewer-calories**	1.33 (0.89 to 1.97)	0.162	1.36 (0.93 to 1.98)	0.116	0.77 (0.45 to 1.31)	0.342
Control	**Numeric-calories**	1.97 (1.35 to 2.87)	<0.001*	1.68 (1.16 to 2.43)	0.006*	0.99 (0.61 to 1.64)	0.985
Control	**PACE**	2.27 (1.56 to 3.28)	<0.001*	2.19 (1.53 to 3.13)	<0.001*	1.42 (0.85 to 2.38)	0.183
Fewer-calories	**Numeric-calories**	1.48 (1.03 to 2.14)	0.034	1.23 (0.87 to 1.77)	0.240	1.28 (0.78 to 2.13)	0.326
Numeric-kcal	**PACE**	1.15 (0.82 to 1.61)	0.407	1.30 (0.94 to 1.81)	0.116	1.42 (0.87 to 2.33)	0.154
Fewer-calories	**PACE**	1.71 (1.20 to 2.44)	0.003*	1.61 (1.14 to 2.27)	0.007*	1.84 (1.09 to 3.11)	0.023
Below £25K		**(n=1,534)**		**(n=1,610)**		**(n=648)**	
Control	**Fewer-calories**	1.57 (1.07 to 2.31)	0.022	2.13 (1.41 to 3.20)	<0.001*	1.23 (0.73 to 2.07)	0.431
Control	**Numeric-calories**	1.71 (1.16 to 2.52)	0.007*	2.19 (1.46 to 3.31)	<0.001*	1.48 (0.88 to 2.49)	0.140
Control	**PACE**	2.41 (1.66 to 3.48)	<0.001*	2.88 (1.92 to 4.29)	<0.001*	2.14 (1.30 to 3.52)	0.003*
Fewer-calories	**Numeric-calories**	1.09 (0.76 to 1.55)	0.649	1.03 (0.73 to 1.46)	0.848	1.19 (0.73 to 1.97)	0.473
Numeric-kcal	**PACE**	1.41 (1.01 to 1.98)	0.046	1.35 (0.96 to 1.89)	0.080	1.45 (0.90 to 2.32)	0.126
Fewer-calories	**PACE**	1.53 (1.09 to 2.14)	0.013	1.35 (0.96 to 1.89)	0.080	1.73 (1.08 to 2.78)	0.022

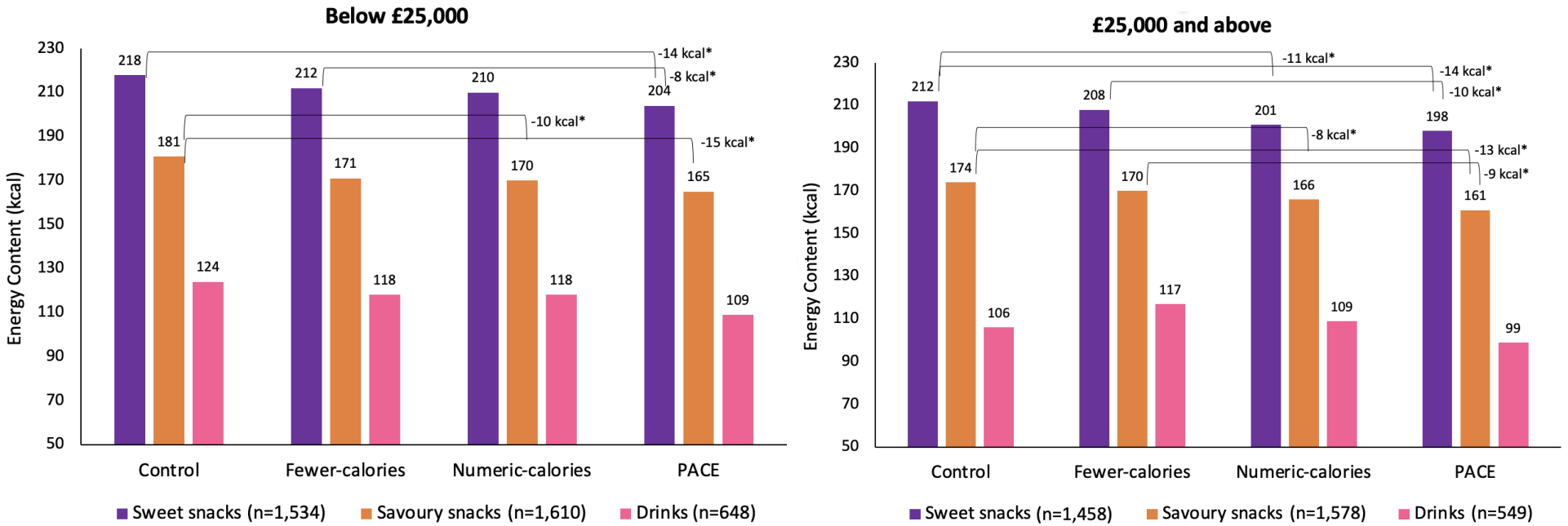


Figure 5.13: Energy ordered & income. Means for calories ordered from snacks and drinks controlling for initial calories selected by intervention allocation (i.e., calories ordered after exposure to the intervention). Those responding, "prefer not to say" (n=93) were excluded from this analysis. *Meets Bonferroni adjusted statistical significance threshold of $p<0.008$.

5.3.9 Exploratory Outcome (b): Primary outcome (a) adjusted for dietary restraint or price

Higher levels of dietary restraint (Table 5.13) and cheaper swaps offered (Table 5.15b) were both significantly positively associated with swap acceptance for most products but did not attenuate the effect of the messaging (please see Figure 5.5 for effect sizes from the unadjusted models for Primary outcome (a) swap acceptance). For every 1-unit increase on the dietary restraint score, the odds of a swap being accepted increased by 1.05 (95% CI: 1.05 to 1.07).

Table 5.13: The effect of score (out of 15) on the DIS scale (Dietary Restraint) on the likelihood that a sweet, savoury and drink swap is accepted. Odds ratios, 95% confidence intervals (CI) and non-adjusted p-values presented with an indication * of statistical significance at Bonferroni adjusted threshold of p<0.008.

	Sweet Swap Accepted OR (95% CI) n=3,055	**P-value**	**Savoury Swap Accepted OR (95% CI) n=3,253**	**P-value**	**Drink Swap Accepted OR (95% CI) n=1,223**	**P-value**
Control (reference)	-		-		-	
Fewer-calories	1.55 (1.17 to 2.05)	0.002*	1.68 (1.28 to 2.21)	<0.001*	1.08 (0.74 to 1.57)	0.683
Numeric-calories	1.95 (1.49 to 2.56)	<0.001*	1.87 (1.43 to 2.45)	<0.001*	1.28 (0.89 to 1.84)	0.176
PACE	2.42 (1.86 to 3.15)	<0.001*	2.49 (1.91 to 3.23)	<0.001*	1.83 (1.27 to 2.62)	0.001*
Dietary restraint	1.05 (1.05 to 1.07)	<0.001*	1.05 (1.03 to 1.05)	<0.001*	1.06 (1.03 to 1.07)	0.017

*ns for this outcome are lower because this was not a required question. The DIS score range was 9-45. Higher DIS scores indicate more restraint.

The average price of initially selected items and swaps offered for each menu by intervention groups is displayed in Table 5.14a. On average, swaps in each category were cheaper than the initial item selected, although there was considerable variation in price change. For sweet snacks, swaps offered were between 75p cheaper and 65p more expensive than initially selected items. For savoury snacks, swaps offered were between 65p cheaper and 15p more expensive. For drinks, swaps offered were either the same price or up to 45p cheaper as initially selected items. For every £1 decrease in swap price, the odds of a *sweet* swap being accepted increased by 1.87 [95% CI: 1.30 to 2.68, p<0.001]. For every £1 decrease in swap price, the odds of a *savoury* swap being accepted increased by 2.70 [95% CI: 1.95 to 3.75, p<0.001]. As none of the swaps offered for drinks were more expensive, price analysis was not conducted for this product category (Table 14b).

Table 5.14a: Prices of initially selected items, swaps offered and price difference for those offered swaps only.

	Initially selected £ mean ± SD	**Swaps offered £ mean ± SD**	**Price difference £ mean (95% CIs)**
Sweet snacks (n=3,085)	0.74 ± 0.17	0.68 ± 0.21	-0.06 (-0.07 to -0.05)
Savoury snacks (n=3,284)	0.87 ± 0.17	0.75 ± 0.14	-0.12 (-0.13 to -0.11)
Drinks (n=1,233)	1.42 ± 0.13	1.28 ± 0.19	-0.14 (-0.15 to -0.13)

Note: For price difference, negative values reflect a cheaper swap offered and positive values a more expensive swap offered. SD = standard deviation ; *95% CIs = 95% confidence intervals.*

Table 5.14b: The effect of price difference (i.e., cheaper swaps) on the likelihood that a sweet and savoury swap is accepted compared with control. Odds ratios, 95% confidence intervals (CI) and non-adjusted p-values presented with an indication * of statistical significance at Bonferroni adjusted threshold of p<0.017.

	Sweet Swap Accepted OR (95% CI) n=3,085	**P-value**	**Savoury Swap Accepted OR (95% CI) n=3,284**	**P-value**
Control (reference)	-		-	
Fewer-calories	1.43 (1.09 to1.89)	0.010*	1.60 (1.21 to 2.10)	0.001*
Numeric-calories	1.87 (1.42 to 2.45)	<0.001*	1.86 (1.42 to 2.44)	<0.001*
PACE	2.32 (1.79 to 3.01)	<0.001*	2.53 (1.94 to 3.29)	<0.001*
Swap cheaper	1.87 (1.30 to 2.68)	0.001*	2.70 (1.95 to 3.75)	<0.001*

Note: The price difference variable is calculated by subtracting the price of the swap offered from the initially selected item.

5.3.10 Exploratory Outcome (c): Primary analysis (a) repeated for swap-type

Participants were more likely to accept similar than dissimilar swaps. However, the PACE message significantly increased the odds of accepting fruit as a swap for sweet snacks (OR 2.07, 95% CI 1.35 to 3.17) and carrot sticks as a swap for savoury snacks (OR 2.55, 95% CI 1.44 to 4.51) compared with control (Table 5.15). This analysis was not conducted for drinks as all swaps offered were considered to be similar.

Table 5.15: The effect of swap-similarity on the likelihood that a sweet and savoury snack swap offered is accepted compared with control. Analysis for similar and dissimilar swaps separately. Odds ratios, 95% confidence intervals (CI) and non-adjusted p-values presented with an indication * of statistical significance at Bonferroni adjusted threshold of p<0.017.

	Sweet Swap Accepted OR (95% CI) n=2,040	**P-value**	**Savoury Swap Accepted OR (95% CI) n=2,134**	**P-value**	**Sweet Swap Accepted OR (95% CI) n=1,045**	**P-value**	**Savoury Swap Accepted OR (95% CI) n=1,150**	**P-value**
	Similar swap				**Dissimilar swap**			
Control (reference)	-		-		-		-	
Fewer-calories	1.67 (1.18 to 2.35)	0.004*	1.67 (1.23 to 2.27)	0.001*	1.10 (0.70 to 1.72)	0.663	1.33 (0.69 to 2.54)	0.388
Numeric-calories	2.31 (1.65 to 3.23)	<0.001*	1.96 (1.44 to 2.65)	<0.001*	1.25 (0.79 to 1.97)	0.330	1.89 (1.04 to 3.42)	0.035
PACE	2.49 (1.79 to 3.45)	<0.001*	2.69 (1.99 to 3.63)	<0.001*	2.07 (1.35 to 3.17)	0.001*	2.55 (1.44 to 4.51)	0.001*

Note: Dissimilar swaps = Fruit for sweet snacks and carrot sticks for savoury snacks. Similar swap = all other items on each of the sweet and savoury menus.

5.3.11 Sensitivity analysis: Primary analysis (a) repeated including ineligible participants

Sensitivity analyses of primary outcome (a) including the 274 ineligible participants did not alter estimates reported for the sample that excluded them (Table 5.16).

Table 5.16: Sensitivity analysis: The effect of message-type on the likelihood that a sweet, savoury and drink swap is accepted compared with control when the 274 ineligible participants are included in the model. Odds ratios, 95% confidence intervals (CI) and non-adjusted p-values presented with an indication * of statistical significance at Bonferroni adjusted threshold of p<0.017.

	Sweet Swap Accepted OR (95% CI) (n=3,315)	**P-value**	**Savoury Swap Accepted OR (95% CI) (n=3,537)**	**P-value**	**Drink Swap Accepted OR (95% CI) (n=1,337)**	**P-value**
Control (reference)	-		-		-	
Fewer-calories	1.36 (1.05 to 1.76)	0.020	1.56 (1.20 to 2.02)	0.001*	0.96 (0.68 to 1.37)	0.853
Numeric-calories	1.73 (1.34 to 2.23)	<0.001*	1.83 (1.41 to 2.36)	<0.001*	1.23 (0.88 to 1.73)	0.220
PACE	2.24 (1.75 to 2.87)	<0.001*	2.31 (1.80 to 2.96)	<0.001*	1.63 (1.16 to 2.28)	0.004*

5.4 Discussion

5.4.1 Summary of findings

Almost all of the messages significantly increased the likelihood that a sweet or savoury snack swap would be accepted compared with the control where a swap was offered with no specific message (Figure 5.4). There was evidence that the likelihood of acceptance increased in line with the addition of more tangible information. The word 'tangible' is used here to refer to information that is easily interpretable, concrete, and meaningful to the public. The most tangible PACE message significantly outperformed the control and fewer-calories message in every swap category, and for most subgroup of participants. The PACE message was also the only message to increase the likelihood of a drink swap being accepted. Almost all of the messages significantly reduced the energy content of sweet and savoury snacks, but none of the interventions led to significant energy reductions in drinks (Figure 5.5). The intervention was viewed as acceptable by the majority of participants (Figure 5.6) with ratings being similar to those reported in the pilot study described in Chapter 4. However, there was some indication of inadvertent harm around excessive calorie counting, especially for the PACE group (Figure 5.7), and excessive exercising for the PACE group (section 5.3.7).

5.4.2 Findings in context: Swap-acceptance

Although the evidence for the efficacy of nutrition labelling in reducing calorie consumption is mixed (Crockett et al., 2018), this study found that compared with offering a swap with no specific information, calorie-focused messages significantly increased the acceptance of lower-energy snack swaps. The findings were slightly different for drinks. The results suggested that on the whole, participants were more willing to accept swaps for drinks - even in the control condition where no specific information was presented. For example, in the control condition, 25% of participants accepted a drink swap, but only 14% accepted a sweet snack and only 12% accepted a savoury snack; this pattern of findings was observed across the other three experimental conditions as well (Table 5.3). This high baseline acceptance rate of

drink swaps creates a potential ceiling effect. It is possible that a higher number of drink swaps were accepted in the control condition because the low-energy drinks were often like-for-like (e.g., Coke Zero for classic Coca-Cola) and therefore much closer to the original choice. This was not always the case for snacks. Although I attempted to match snacks as closely as possible, like-for-like swaps were not always possible. The addition of PACE information did, however, increase swap acceptance presumably by making the energy information provided more tangible. On the other hand, for the two snacks, swap acceptance followed a more gradual increase as the messaging made the benefits of swapping more tangible across the groups.

While the differences in effect size between messages, particularly between numeric-calories and PACE were not always statistically significant, the direction of effect sizes indicates an incrementally stronger effect of messages that provide more tangible information (Figure 5.4). This is in line with previous research which finds consumer nutrition knowledge to be moderate or low and recommends the addition of interpretational aids to enhance understanding (Blumenthal & Volpp, 2010; Cadario & Chandon, 2020). Providing such aids to consumers at the point of choice simplifies cross-product comparisons for consumers and reduces energy-purchased (Allan & Powell, 2020). The PACE message typically performed the best overall, followed by the numeric-calories message and then the fewer-calories message. The consistently larger effect of the PACE messaging was in line with evidence pointing to the increased efficacy of PACE messaging over other types of labelling (Daley et al., 2020). Providing information about the amount of physical activity that would be required to expend the energy contained in a given food or drink may aid consumer understanding of calorie information by translating it into a more tangible and familiar metric (Bleich & Pollack, 2010; Blumenthal, 2010; Fitch et al., 2009). Indeed, almost half of those participants presented with the PACE messages accepted at least one swap. This is similar to the figures reported in previous supermarket-based studies (Koutoukidis et al., 2019) despite participants in the current study being offered fewer swaps on average from the outset. With respect to the magnitude of the effect, the PACE message used in the current study doubled the odds of at least 1 swap being accepted (section 5.3.4). A previous online trial testing the effect of messaging on the selection of lower-energy items over higher-energy alternatives reported an almost

identical effect size for a PACE label compared with a no label control (Masic et al., 2017).

The 21% overall acceptance rate (i.e., across the 3 product categories) recorded in the current study was higher than the 13% acceptance rate reported in a previous study testing lower-energy swaps offered for groceries (Bunten et al. 2021). It may be the case that people are more likely to accept lower-energy swaps for discretionary treat items than grocery items. It is important to note that ecological validity in both studies (the current study and Bunten et al., 2021) is low given that participants did not have to spend their own money nor did they have to eat the swaps offered. It is possible that swaps acceptance in real world studies may be lower than the rates reported here. The finding that swap acceptance rates for sweet snacks were among the highest of the grocery product categories (Koutoukidis et al., 2019) may provide some support for this idea. The swap acceptance rates for sweet (20%) and savoury (19%) snacks across all groups broadly align with the swap acceptance rates for the Chocolate & Sweets category (25%) of grocery items reported by Koutoukidis et al., (2019) and the Crisps Snacks & Nuts category (19%) reported by Forwood et al (2015). This is the first study (to my knowledge) to report on swap acceptance rates for drinks (Table 5.3). The overall swap acceptance rate for drinks in the current study (29%) was slightly higher than the rate reported in Chapter 4 (22%). However, the swap acceptance rate for the fewer-calories message in Chapter 4 was higher than the current study (32% versus 26%). Also of note is the considerably higher acceptance rate for drinks among those in the control condition in the current study (24%) compared with the pilot study (14%). The lower acceptance rate identified in Chapter 4 may be due to chance. The pilot study was considerably smaller (n= 42 in the control group for drinks versus n=296 in the current study) and, therefore, less reliable.

5.4.3 Findings in context: Energy ordered

The messages led to significant reductions in energy ordered (Figure 5.5) which were small (6 kcal - 14kcal per product on average), as expected, given the small difference in calories between initially selected and offered products and an average acceptance rate of 21%. Previous studies comparing the effect of PACE information compared

with no information have reported larger reductions in energy (Daley et al., 2020) but this is likely to be because these are based on the energy across entire meals as opposed to individual items like snacks and drinks for which energy content is likely to be lower from the outset.

There is a lack of interventions that can effectively reduce energy intake in the workplace (Lassen et al., 2018). Given the growth of online grocery shopping (Munson et al., 2017) and the introduction of pre-ordering within schools (Delaney et al., 2017), it is reasonable to expect that many workplace canteens may implement such systems soon. Across the groups, only 37 (1%) participants initially selected the lowest energy choices in all 3 categories of products (e.g. fruit, carrot sticks and water) indicating that snack and drink choices are a good target for intervention. More widely, such labelling has the potential to incentivise the food industry to reformulate foods and drinks or reduce their size so that they contain less energy. However, this needs to be balanced against any potential harm from PACE labelling which is discussed in the next section. This will enable public health agencies to make informed decisions regarding implementation.

5.4.4 Findings in context: Intervention acceptability & beliefs about future behaviours

Offering tailored swaps was widely acceptable across all groups (67% agreeing it is acceptable in the workplace) and in line with results from the pilot (65% agreeing it is acceptable in the workplace). The trend in the data suggested that the more effective the intervention, the more acceptable it was deemed to be by participants. The highest acceptability ratings were observed among participants presented with the PACE message (74% agreement) (Figure 5.6, Table 5.6). This messaging brought the acceptance rate in line with previous studies offering swaps in supermarket settings (76% agreement) (Koutoukidis et al., 2019). However, some researchers have argued that calorie labelling may cause inadvertent harm, especially to those who are susceptible to or who have an eating disorder (McGeown, 2019). Responses to the post-trial questions provided some support for the argument that PACE messaging may be more likely to ‘trigger’ excessive calorie counting than a calories-only message (Figure 5.7) and among those presented with the PACE message, 15% reported that it would make them want to excessively exercise (section 5.3.7). However, these

findings are only a reflection of participants' perceptions of their potential future behaviours. In the context of a workplace intervention, the pre-ordering system could be designed, so that staff could opt-in or out of receiving certain messages protecting vulnerable individuals from being triggered. To my knowledge, this is the first study that has examined the evidence of potential harm from PACE labelling. Future research should also aim to test these messages and the swap-based intervention using real online canteens systems over extended periods of time to explore the effect of repeated exposure on disordered eating cognitions and behaviours (i.e., one of the aims of the pilot field trial reported in protocol described in the next chapter).

5.4.5 Findings in context: Subgroup analyses

Exploratory analysis by socioeconomic status and demographic characteristics did not show clear differences in intervention effects among subgroups (Tables 5.8 - 5.12; Figures 5.9 - 5.13). Although it remains unclear if the tested interventions would increase inequity if implemented widely, recent research testing the effect of labelling on energy ordered, also found no evidence that the effectiveness of a similar swap-based intervention differed for people of low or high socio-economic status (Marty et al., 2020). This is examined further in Chapter 8 through the use of interaction analyses.

5.4.6 Findings in context: The potential influence of swap-type, dietary restraint and price

In the current study, the odds of a participant accepting a swap were higher for similar swaps than for dissimilar swaps (i.e., fruit or carrot sticks) offered (Table 5.15). This finding aligns with Payne-Riches et al (2019)'s study which reported that although 30% of accepted swaps were out-of-category items (relatively dissimilar), the majority of swaps accepted were from the same sub-category (i.e., very similar) as the originally selected item. The finding that the PACE message significantly increased the odds that fruit or carrot sticks would be accepted as a swap indicates that the message may be enough to motivate swap acceptance even when the swap offered is different to the initially selected item.

With respect to dietary restraint (Table 5.13), the finding that higher levels of dietary restraint is significantly positively associated with swap acceptance aligns with previous research which found that self-reported dietary restraint was associated with increased choice of lower-energy products (Masic et al., 2017). The finding that dietary restraint did not appear to weaken the effect of the messages suggests that they may be effective in increasing swap acceptance regardless of this participant characteristic. In the final study reported in Chapter 8, the interaction between dietary restraint and the swaps with PACE messaging intervention is examined.

The finding that cheaper swaps are more likely to be accepted (Table 14b) aligns with research from other studies conducted in workplace canteens which have reported price reductions on more healthful foods and drinks being associated with increased purchasing of these products (Kottke et al., 2013; Wolfenden et al., 2015). More importantly, the finding that the price difference between the initially selected item and the swap offered does not seem to attenuate the effect of the messages is reassuring given that in a real-world canteen environment it is likely that some swaps offered will be cheaper and others more expensive. However, as this was a hypothetical choice experiment and participants were not spending their own money it is not possible to say with certainty that this effect will be observed in a real-world setting.

5.4.7 Strengths and limitations

Strengths of the study include the randomised design and the large sample of working adults. The demographic distribution of the sample was similar to the general population of England and Wales with respect to ethnicity and income. According to figures from the Office for National Statistics (ONS), the population of England and Wales was 86% white. It was 91% white in the current study (ONS, 2011). Average earnings in 2017 were £25,308 for women and £31,103 for men (ONS, 2017). In the current study, 51% of the sample had an annual salary in excess of £25,000. In contrast with some previous research, where participants selected between pre-determined pairs of high and low energy foods (Masic et al., 2017), participants in the current study were presented with a wide range of popular snacks and drinks from which they made their selections. This design more closely mirrors the way in which choices would be made when using a real online canteen, increasing the ecological

validity of the findings. Furthermore, prior to making their first selection (or prior to being offered a swap), participants in this study were unaware that they would be offered lower-energy swaps, which reduced demand characteristics (i.e., participants selecting lower-energy items because they knew the study aimed to reduce energy ordered or selecting high energy items to be offered a swap).

This study has some limitations. It's primary limitation is its hypothetical nature, both in terms of food choices and acceptability ratings. This limitation is discussed in detail in the general discussion presented in Chapter 9, section 9.3. However, this study aimed to mitigate the concern regarding food choices by asking participants to only select what they would normally buy and by only using very common food and drinks that would be familiar to most people. Secondly, the sample was highly educated, with 61% having completed some form of tertiary-level education compared with 44% of the general UK population (OECD, 2016). This might limit the generalisability of the results. Although it remains unclear if the tested interventions would increase inequity if implemented widely, exploratory analysis by socioeconomic status and demographic characteristics did not show clear differences. Potential for self-report bias for measures such as BMI are discussed in Chapter 9. Finally, it is important to note the limitations of the items used to measure potential harm of the interventions. The question examining the potential harms of the messages asked participants whether they felt that the interventions may cause them to *excessively* count calories and/or exercise. In both cases, the word 'excessively' was intended to be understood by participants as triggering them to be *more* conscious of their energy intake or exercise regime than they would *normally* be, or desire to be. As there are no existing scales or validated measures that were applicable, this question wording (i.e., the use of the word excessively) was taken from descriptions of disordered eating used in the literature. However, this question was open to interpretation by participants and may not have been accurately measuring what was intended. The addition of a definition of what was specifically meant by this may have helped to ensure that participant interpretation matched the question's intended objective.

5.4.8 Implications for future research

The findings from the pilot study reported in Chapter 4 indicated that a calorie-focused message may be acceptable to potential recipients and may help to increase the acceptance of lower-energy swaps offered for snacks and drinks compared to when no message is provided. The objective of the current study was to examine the effect of offering swaps on energy ordered and to test a series of calorie-focused messages that ranged in terms of tangibility (i.e., a vague calorie message, an exact numeric-calories message, and a PACE message) to examine their effect on the acceptance of lower-energy swaps offered for snacks and drinks. Following this, the intention was to conduct a pilot feasibility trial testing a swap and pre-ordering based intervention in a real-world canteen and use the message that yielded the highest swap-acceptance rates and intervention acceptability ratings to accompany the prompts to swap.

The findings from this study point to the particular promise of adding a PACE message when delivering prompts to swap as a means of increasing swap acceptance and intervention acceptability. The next step will, therefore, be to examine the feasibility of running an RCT testing the effect of pre-ordering and swaps accompanied by PACE information on energy purchased in a workplace setting. The aim of the feasibility study is to provide important information on recruitment, adherence and retention to assess whether a full-scale trial would be feasible, and to provide estimates of the potential effect of an intervention combining pre-ordering with prompts to swap accompanied by PACE information on energy (kcal) purchased across an entire lunch menu in a real-world canteen. In addition the pilot trial will allow for an examination of the potential effect of the interventions over time which was not captured in the current study.

Although intervention (pre-ordering and prompts to swap) acceptability ratings were high overall, the findings from the current study raised some concerns about potential adverse consequences of the PACE message. These findings are, however, based on simple Likert scale ratings. A qualitative component will be included in the pilot trial which will allow for a deeper investigation of the acceptability of pre-ordering, prompts to swap and PACE messaging.

5.4.9 Conclusion

Offering lower-energy swaps for drinks and snacks may be a potentially effective strategy for reducing energy ordered in an online canteen setting. Increasing the tangibility of information provided when offering swaps increased swap acceptance, with the PACE messaging being the most effective. PACE messaging may, thus, be the most promising way to increase the acceptance of offered swaps for snack foods and drinks. However, it is not yet known what effect offering swaps for items across an entire lunch menu might have on energy ordered in a real-world canteen. An initial quantitative examination suggests high intervention acceptability overall but there was some evidence that the PACE message may have potential adverse effects. A pilot feasibility study will be conducted to address remaining questions relating to; (i) whether it is possible to run an RCT testing pre-ordering and a swap based intervention in a real-world canteen; (ii) the potential effect of pre-ordering and offering swaps with PACE information for items across an entire lunch menu in a real-world setting and; (iii) the acceptability of pre-ordering, prompts to swap and PACE messaging among potential recipients. The next chapter describes the protocol for this pilot feasibility trial.

Chapter 6

Reducing the energy content of food and drinks purchased in a workplace canteen through pre-ordering and substitution suggestions: A trial protocol for the Bupa Eats pilot feasibility study

6.1 Background

The studies outlined in Chapters 4 and 5 used an experimental online canteen to test the potential effect of offering swaps with and without messages on energy pre-ordered by working adults. The study in Chapter 5 found that accompanying swaps offered with PACE information is an effective way to boost swap acceptance and intervention acceptability within the context of an experimental online canteen. The intended next step was to conduct a pilot feasibility study to examine whether it is possible to run a randomised controlled trial (RCT) testing the effect of pre-ordering and swaps on energy purchased in a real-world workplace canteen. In October 2018, I partnered with Bupa, with the intention of conducting this pilot trial which Bupa staff named "Bupa Eats". We worked together for 18 months to design the Bupa Eats pilot. However, due to Covid-19 the pilot had to be stopped before randomisation could take place. Only information on the recruitment rate was obtained and this is presented at the end of the chapter. This chapter presents the trial protocol for this work. The protocol was finalised in February 2020, and is presented in the future tense as if it was going to be conducted. The study was pre-registered (AsPredicted ref no.: 36598).

6.2 Introduction

Meal pre-ordering has been viewed as a potentially cost-effective strategy for improving the healthfulness of dietary choices, reducing food waste and improving canteen operations

(Migliavada et al., 2021). The studies reviewed in Chapter 3 pointed to the potential of pre-ordering to improve the dietary choices of adults. Alongside this, a pre-ordering website is a potentially ideal environment in which to test the added value of an additional behavioural intervention, such as a lower-energy swap offered alongside PACE information. Miller at al. (2016) found that adding a nudge that provides nutritional recommendations at the time of pre-ordering significantly increased selection of fruits, vegetables, and low-fat milk by 8%, 15% and 13%, respectively, compared with pre-ordering alone in a sample of children aged 9-12 years. In another study, existing pre-ordering systems in 10 primary school canteens were enhanced with behaviourally informed strategies such as menu labelling, healthy food availability, placement, and prompting. This enhanced version of the system was found to significantly reduce the average energy (difference: -136 kcal, 95% CI: -167 to -104), saturated fat (difference: -2.37g, 95% CI: -3.08 to -1.67), and salt (difference: -0.23, 95% CI: -0.33 to -0.12) contents of lunches per student compared with pre-ordering alone (Delaney et al., 2017). Chapter 4 pointed to the promise of offering swaps as a strategy to improve the healthfulness of dietary choices made by adults. This raises the question of whether combining pre-ordering with a swap-based intervention would reduce energy ordered in a real-world canteen.

Early phase feasibility studies are an essential step to ensure successful implementation of large-scale trials (Van Teijlingen & Hundley, 2001). This study explores the feasibility of running an RCT testing the effect of pre-ordering and prompts to swap in a workplace canteen setting. In accordance with CONSORT guidance, this trial will test whether the components of the study can all work together (Eldridge et al., 2016). A mixed methods design will be employed. As qualitative and quantitative methods possess different epistemological properties, it is hoped that these methods will help to illuminate different aspects of the intervention (Abildgaard et al., 2016). The quantitative component will provide estimates of important parameters that are needed to design a full trial (Arain et al., 2010) while the qualitative component will provide an in-depth and detailed understanding of the intervention and the pilot findings from the perspective of both study participants and staff involved in its delivery (Tashakkori & Teddlie, 2003).

6.3 Study aims

The aim of this pilot study is to assess the feasibility of the overall trial procedures to answer the question: *Is it possible to run an RCT testing the effect of pre-ordering and swaps on*

energy purchased in a workplace setting? The pilot will focus on the processes of the study to ensure recruitment, randomisation, intervention delivery, and data collection all run smoothly. Focus groups will be used alongside the RCT to explore in-depth the processes involved in delivering the intervention and how participants and canteen staff experience the intervention. This study will provide estimates of important parameters (e.g., recruitment rates, adherence rates, potential intervention effect sizes) that are needed to design a full trial (Eldridge et al., 2016) and will provide information on the intervention's evidence of potential efficacy (i.e., does it appear that the intervention could reduce energy ordered by staff at work?). This study could contribute to public health, if it leads to the refinement of an intervention which can be delivered within the workplace at scale.

The primary objectives are:

1. To assess the feasibility of recruitment to provide evidence that when recruitment is scaled-up, a multi-centre trial would be feasible.
2. To assess adherence to the study procedures and interventions (e.g., use of the pre-ordering system).
3. To assess retention rates.

The secondary objectives are:

4. To map the process of delivering the interventions in practice.
5. To assess the acceptability of the interventions & potential inadvertent harms (i.e., changes in dietary restraint).
6. To obtain variance estimates for calories ordered within the canteen to inform the measurement of the primary outcome for a larger trial and, subsequently, the sample size calculation.
7. To estimate the effect of pre-ordering and pre-ordering with swaps offered on energy (kcal) purchased in the canteen (i.e., exploratory analysis examining evidence of potential efficacy).

6.4 Study design

This study will employ a mixed-methods design (Tashakkori & Creswell, 2007). In phase 1, quantitative data will be collected and in phase 2, qualitative data will be collected.

RCT

The pilot will be run as a three-arm, individually randomised, parallel, controlled trial. Participants will be randomly allocated to one of three groups:

1. **Pre-ordering:** Employees will pre-order their lunches online (i.e., they will order their lunch in the morning online rather than at lunchtime in the canteen).
2. **Pre-ordering + Swaps & PACE:** Employees will pre-order and will be prompted with lower-energy swaps accompanied by PACE information on potential energy saved while pre-ordering.
3. **Control:** No intervention received. Participants order from the canteen as usual.

The study will run for a total of 4 weeks. During week 1, baseline data will be collected. Baseline data collection will also allow participants time to get used to using their study clubcards (which will be used to enable tracking of participants' purchases), and the dedicated till. During weeks 2, 3 and 4, participants randomised to the intervention groups will use the pre-ordering system when they wish to purchase lunch from the canteen. A weekly reminder will also be sent to participants by email asking them to log whether they used the canteen each day during the study. This information will be compared against till data, so that adherence and retention can be measured. This is described in detail in sections 6.8 and 6.9.

Qualitative component

Participant and staff focus groups will be conducted. Thematic analysis will be used to analyse the data (please see sections 6.8 and 6.9).

6.5 Participant identification & recruitment

6.5.1 Study partner

In October 2018, Bupa Healthcare UK responded to an advertisement posted on the website of the organisation (The Behavioural Insights Team[12]) that sponsors my PhD. This advertisement said that we were seeking a partner organisation for a healthy eating project (Appendix 6.1, Additional File 1). To be eligible, the organisation needed to have at least 500 employees, an onsite canteen and be able to track canteen purchases. Twenty-four

[12] The Behavioural Insights Team is a social purpose research company. They are my employer and the sponsor of this PhD research. More information on the organisation can be found at www.bi.team.

expressions of interest were received. After follow-up discussions, Bupa Healthcare UK agreed to participate. Bupa's Behavioural Science Team is leading the work internally.

6.5.2 Study setting

The pilot will be conducted at Bupa's office in Salford Quays, Manchester. Approximately 1,800 employees are based in the Salford office. There are 15 departments spread across 5 floors, the largest of these departments being a customer service call centre (288 staff members). This site was selected as it is the largest office with an onsite canteen. Bupa's canteen ('The Hive') is managed by Gather & Gather, an external provider. The Hive offers 9 menus outlined in Table 6.1.

Table 6.1: Bupa menu descriptions and regularity with which menu options change.

Menu	Description of the menu	Options change
1. Hot dishes	3 options that change on a daily basis, one fish (£4.50), one meat (£4.50), and one vegetarian (£3.95). Two sides are included in the price of a main. If only one side is selected, 50p is deducted from the price of the meal. If no sides are selected £1.00 is deducted.	Daily
2. Sides	6-8 options that change on a daily basis. Side dishes (e.g. white rice, bread roll) can be purchased without a main and are 55p each.	Daily
3. Panini & deli sandwiches	6 options that change on a daily basis and are handmade by the deli staff. Options range in price from £2.75 for a vegetarian panini to £3.20 for a meat filled baguette.	Daily
4. Salad bar	2 size options available - a small 50cl (£1.17) or a large 75cl (£1.65) salad and a choice of 6-9 components available that change on a daily basis. The salad bar is self-service. Employees can select their container and can fill it with as many different salads as they wish. The price is fixed regardless of content or weight	Daily
5. Soup & packaged sandwiches	20 options available, 17 sandwiches and 1 soup of the day (with bread; with bread and butter; alone).	Monthly*
6. Jacket potatoes	10 options with various fillings such as beans, cheese, and tuna. Jackets range in price from 88p for a plain potato to £2.68 for tuna and cheese.	Never**
7. Sweet snacks	15 options available. A mixture of fresh fruit, yoghurt and chocolate that ranged in price from £0.60p to £1.20. Two	Never

	of the options were fresh fruits that are made available to staff free of charge.	
8. Savoury snacks	21 options available. A mixture of crisps and popcorn that ranged in price from £0.50p to £1.10.	Never
9. Drinks	18 options available. 9 diet/no-sugar drinks (including bottled water) and 9 full-sugar/fat drinks that ranged in price from £0.65p to £1.80. Tap water is available in the office free of charge.	Never

*Soup changes every few days.; **The jacket potato 'of the day' changes daily. Never means no change during the trial period.

Bupa's catering company Gather & Gather has provided the hot dish menu options that will be available on each day of the 4-week trial. The canteen manager will inform UCL of the sides and salad-bar menu options the evening before service, so that they can be uploaded to the pre-ordering system and swaps can be selected and programmed. The panini & deli sandwiches menu is decided on the day of service by the canteen and so no swaps will be offered for these items. Within each of the menus which change regularly, not all options will change on a daily basis. Appendix 6.2, Additional File 1 provides examples of options available for each menu.

Canteen use varies from day to day. Currently, approximately 80-100 hot dishes, 100 soups, 80 salad boxes and 40 jacket potatoes are served per day. Staff pay for their lunch with cash or bank card at the till point. Fruit and salad bar items are cheaper than if bought off-site as they are subsidised by Bupa.

6.5.3 Study participants

Eligible participants will be employees of Bupa, Salford, who self-identify as regular (i.e. twice per week) users of the canteen. This figure was based on combined data from the UK and USA that found on average staff visit their canteen 2.4 times per week (Omnico, 2019) and on the fact that participants should be allowed multiple opportunities to use the pre-ordering system. Participants must be intending to be in the office (i.e., have no annual leave planned) for the duration of the 4 week trial. This is to ensure that retention rates can be accurately assessed. Participants must also have access to a computer and the Internet, and must be willing and able to provide informed consent. Employees will not be eligible if they are following any restricted diet such as a vegetarian, vegan, dairy-free, sugar-free, or gluten-free diet. These criteria are in place to accommodate the limited range of swaps that

can be offered due to the foods available in the canteen. During the consent process, screening questions will be presented to participants.

6.6 Intervention

This study will use a simulated online canteen ordering platform developed using REDCap, (Research Electronic Data Capture) similar to that used in Chapters 4 and 5 (Harris et al., 2009), but adapted to present the full canteen menu. All nine menus will be available; (1) hot dishes, (2) sides, (3) panini & deli sandwiches, (4) salad bar (5) soup & packaged sandwiches, (6) jacket potatoes, (7) sweet snacks, (8) savoury snacks, and (9) drinks. An image of the printed menu for hot dishes that is usually displayed in the physical canteen will be published on the website each day. A written description will be provided for the sides, panini & deli sandwiches, and the salad bar menu options each day. Images of each menu item for all other menus (i.e., those that will not change during the trial) will be displayed on the website. The website will have a page for participants to select a time slot for collection. Available time slots will be in 30-minute increments. The first available collection time will be at 11.30am and the last will be at 2.30pm.

During the trial, participants in the intervention groups will be sent an email each morning at 7.00am reminding them to order their lunch through the system. This email will contain a link to the pre-ordering website and instructions for ordering (Figure 6.1). Participants will not have to buy lunch in the canteen every day but will be asked to use the system when they do intend to buy from the canteen during the trial. Using their study clubcard number, participants will log in to the website and will make their selections. Participants allocated to the pre-ordering + swaps intervention will be prompted with swaps for eligible items. When swap items are offered, they will be accompanied by the following message: "*Would you consider swapping to [name of swap] (price)? This swap would save you [x] calories* which is equivalent to approximately *[y] minutes walking".* This text will be accompanied by an image that makes salient the number of calories and minutes walking potentially saved (Figure 6.7). In the case of the salad-bar menu, where salads are self-assembled and so precise calorie information is unavailable, the following calorie-only message will be presented: *"How about a swap? This has fewer calories"*. Participants in this group will be prompted with swaps at the point of selection rather than at the checkout. Participants can accept the new item by clicking "*No, I will stick with my choice*" or "*Yes, I would like to swap*". Once participants have made their final selection, they will be asked to select a collection

time slot. Participants can also leave a note for the canteen to ask for changes to the order (e.g., no gravy on the chicken). This has been added to mirror orders placed directly from the canteen. The aesthetic of the website was adapted from earlier studies outlined in Chapters 4 and 5 to incorporate Bupa's branding and the website was renamed Bupa Eats. Figures 6.4-6.10 depict the user's experience of the website when ordering a main hot meal and a drink in the pre-ordering + swaps condition.

Participants will be able to place orders from 7.00am until 10.30am. At 10.40am each day, I will download the orders and send them to the canteen for preparation. I will also email the participants a copy of their order. This timeframe has been agreed with the canteen manager to ensure that (i) staff had sufficient time (~45 mins) to contact users about their order (if necessary) prior to service which begins at 11.30am and, (ii) there would be a minimum 1-hour period between ordering and collection. Canteen staff will prepare orders for collection at the participant's selected timeslot. Hot dishes & jacket potatoes will be served on plates and will be labelled with the participant's study ID. Plates will be kept warm under hot lamps while awaiting collection. Sandwiches, snacks and drinks orders will be labelled and will be kept on a table behind the hot-food collection point. A member of the canteen staff will check order numbers and distribute orders accordingly. The cashier will take payment at the designated Bupa Eats till (Figure 6.2) and a researcher will write the participant's clubcard ID on the receipt so that the transaction can be linked to the participant. Till receipts do not contain detailed information for salad bar items, sides or deli sandwiches/paninis. If a participant orders any of these items, the researcher will complete a checklist indicating what has been ordered so that energy estimates can be calculated (see Appendix 6.3, Additional File 1). This checklist will be stapled to the participants' receipt and the information will be manually entered into an excel spreadsheet at the end of the day.

Gather & Gather has provided recipes for each hot dish. Recipes contain the ingredient name, quantity in grams (or millilitres), and the number of portions the recipe provides. A registered dietitian analysed the nutritional content of each item using the nutrient analysis software Myfood24 (Measure Your Food On One Day 24-h recall) (Carter et al., 2015). Based on this input the software produces the energy in kilocalories per portion.

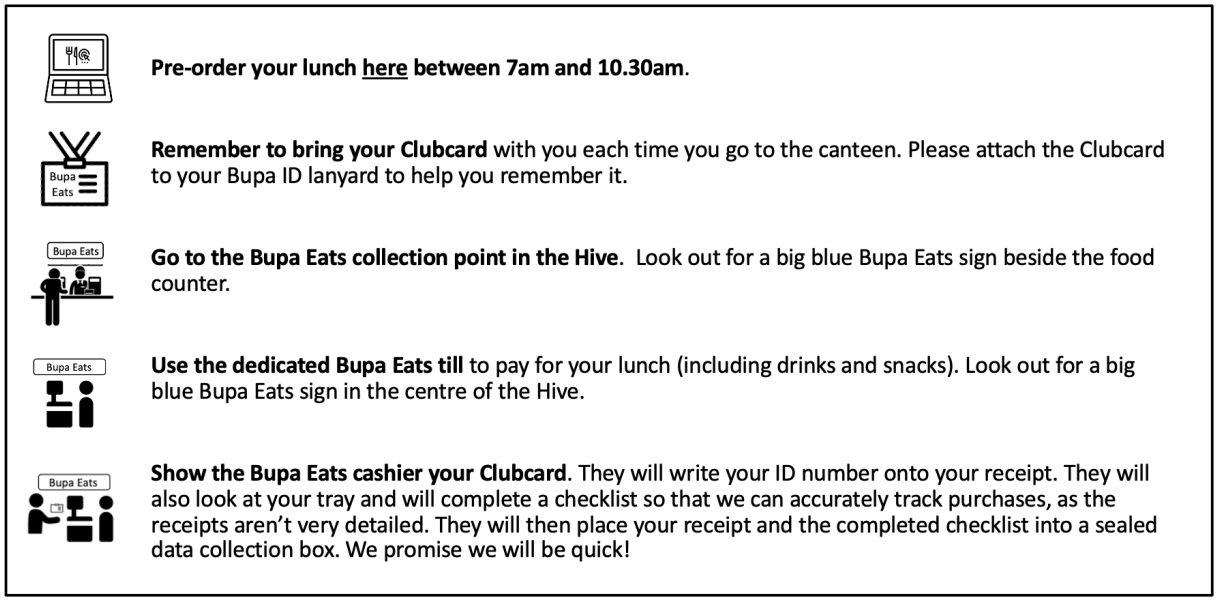


Figure 6.1: Daily reminder email with instructions for pre-ordering participants.

Figure 6.2: Designated study till point in Bupa Salford Quays

6.6.1 Procedure for control participants

During the trial, participants in the control group will be sent an email each morning at 7.00am reminding them to order their lunch from the canteen and to use the designated Bupa Eats till, so that their purchases can be tracked (Figure 6.3). This is intended to remind participants of the instructions and to ensure that both the control and treatment groups receive the same amount of communication during the trial period. Control participants will order from the canteen as usual (i.e., between the hours of 11.30am and 2.30pm), but will be asked to pay at the designated Bupa Eats till. The cashier will take payment at the designated Bupa Eats till (Figure 6.3) and a researcher will write the participant's clubcard ID on the receipt so that the transaction can be linked to the participant. If necessary, the previously described checklist will be completed. Information from receipts and checklists will be compiled and manually entered into an excel spreadsheet. Energy information for each item purchased will be added to the spreadsheet.

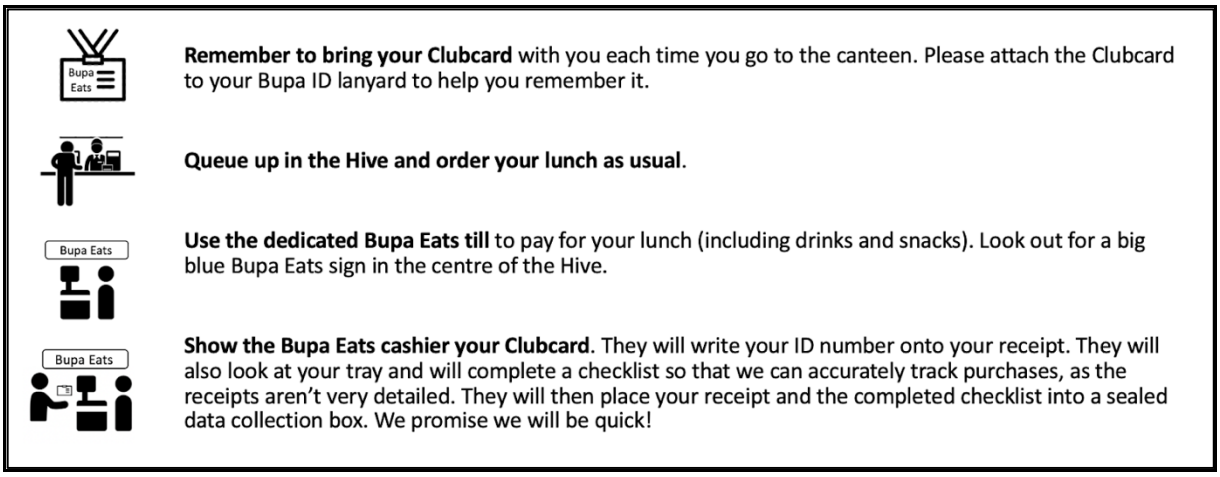


Figure 6.3: Daily reminder email with instructions for control participants.

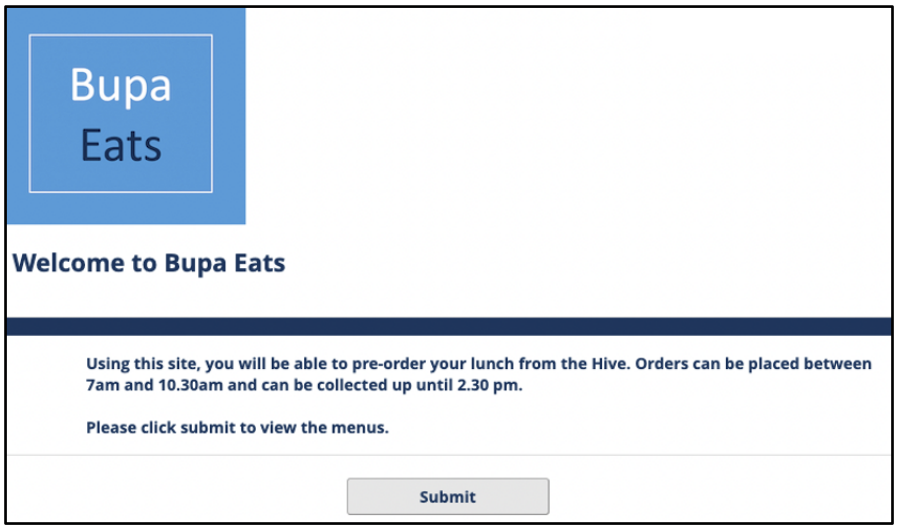


Figure 6.4: Bupa Eats landing page

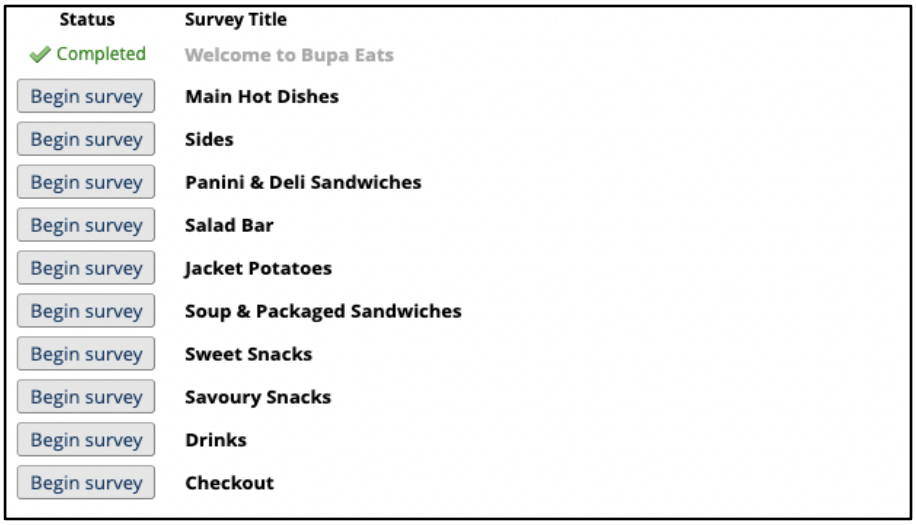


Figure 6.5: Menu overview

Figure 6.6: Main hot dishes menu

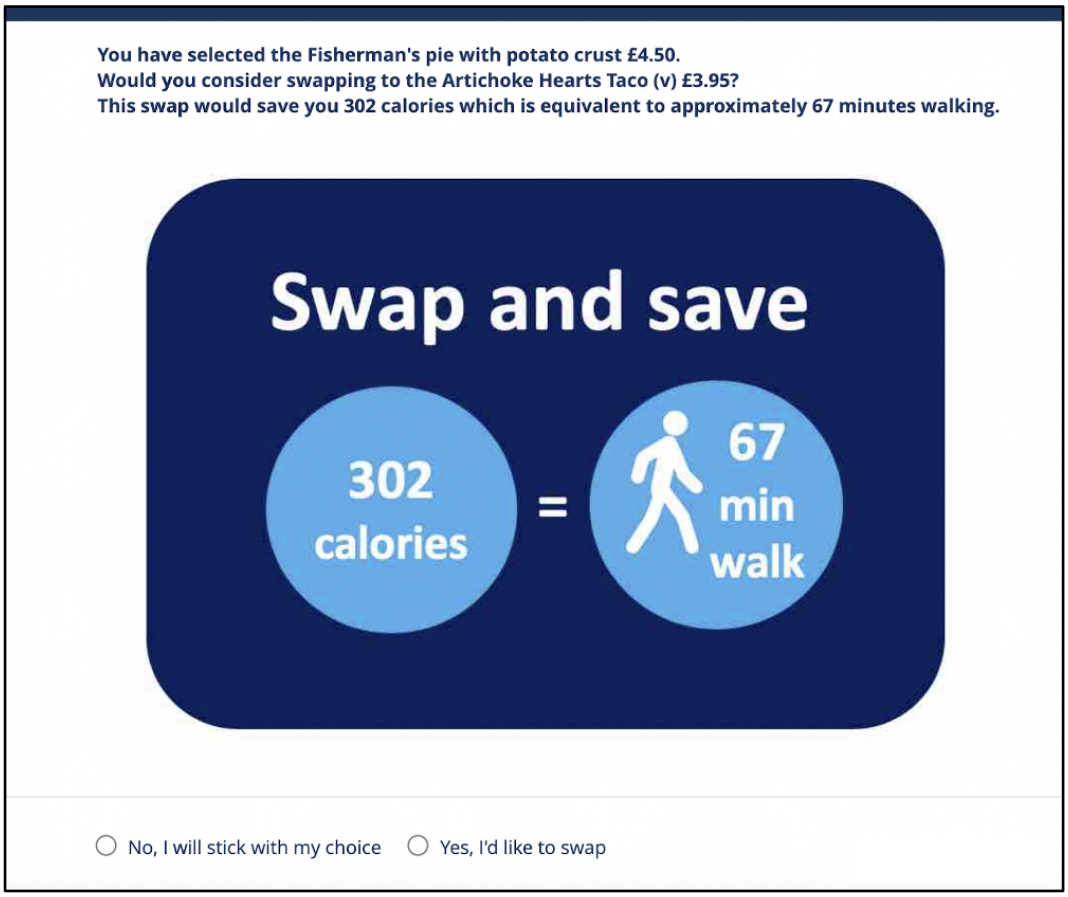


Figure 6.7: Swap offered for the Fisherman's pie

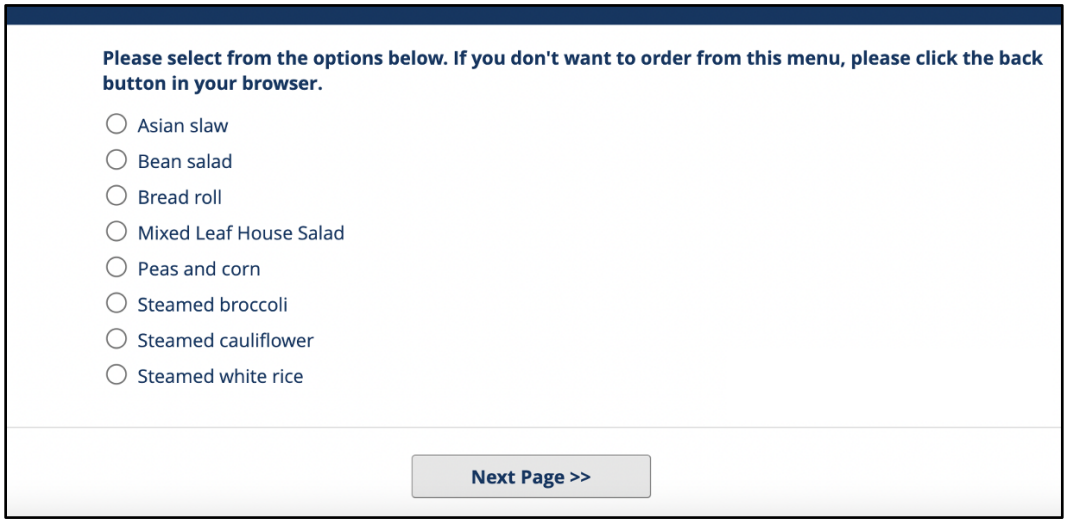


Figure 6.8: Selection of side dishes to accompany main meals

Figure 6.9: Drinks menu

Figure 6.10: Checkout with order time slot selection, order summary and notes for the kitchen

6.6.2 Swap Criteria

Participants in the pre-ordering + swaps condition will be offered one swap per initial item selected provided that a suitable swap is available. Each swap offered must be at least 50 kcal less than the originally selected item. This calorie threshold is based on evidence from modelling studies indicating that a reduction as small as 50 kcal per person per day would be sufficient to offset weight gain at the population level (Hill et al., 2003). If no item fits this criteria no swap will be offered. Additional criteria for each specific menu is outlined in Table 6.2. The procedure for offering swaps within each menu is also described below.

Table 6.2: Criteria for swaps offered by menu

Menu	Criteria	Example of Swap Offered
Main meals and sides	- Swap offered is the dish that is the next lowest in terms of energy content. - Swaps offered are at least 50 kcal less than the originally selected item.	- Artichoke Hearts Taco (339 kcal) for Fisherman's pie with a potato crust (641 kcal) - House mixed leaf (13 kcal) for Asian slaw (90 kcal).
Jacket Potatoes	- Swaps offered are as close in nature to the originally selected item as possible. - For jacket potatoes, swaps offered usually involve the removal of one of the high energy toppings. - For sandwiches, the swap offered is the sandwich that is the next lowest in terms of calories. - Swaps offered are at least 50 kcal less than the originally selected item.	- A jacket potato with baked beans (384 kcal) for a jacket potato with baked beans and cheese (633 kcal).
Pre-packaged sandwiches		- A chicken and stuffing sandwich (355 kcal) for a chicken bacon and stuffing sandwich (422 kcal).
Sandwiches & Paninis	No swaps offered	
Salad bar	- Swap offered is the dish that is the next lowest in terms of energy content. - Swaps offered are at least 50 kcal less than the originally selected item.	- A broccoli, almond & fresh chilli salad 60g (61 kcal) for the Caesar pasta salad 60g (135 kcal)
Sweet Snacks	- Swaps offered are as close in nature to the originally selected item as possible. - Swaps offered are at least 50 kcal less than the originally selected item.	- A strawberry yoghurt (141 kcal) for a granola and yoghurt pot (241 kcal).
Savoury Snacks		- A packet of Propercorn Sea Salted (87 kcal) for a packet of Walkers Ready Salted (171 kcal)
Drinks	- Swaps offered for drinks will almost always be the lower-energy version of the originally selected drink. - Where diet equivalents are unavailable or do not meet the criteria, swaps judged to be relatively close in flavour to the original item will be offered. - Swaps offered are at least 50 kcal less than the originally selected item.	- Coke Zero (<1 kcal) for Classic Coca-Cola (210 kcal). - Fanta Zero (<1 kcal) for San Pellegrino orange flavour (129 kcal).

6.6.3 Process for offering swaps by menu

Main hot dishes & sides: As described in section 6.2.5, a main hot dish comprises a main component such as a piece of meat or fish or a vegetarian alternative. Included in the price are two side dishes which can be selected from a choice of 6-8. The style of service within the canteen is such that there are no fixed accompaniments to the main components and customers can select any 2 of the 6-8 sides available. To mirror the physical canteen as closely as possible, participants will be invited to first select one of the three main components. After making this selection, participants were offered a swap if an alternative is available. After selecting a main component, participants will be able to select their side dishes (or they can opt to have one side or no sides). Participants will select sides one at a time and will be offered swaps for each side individually if a suitable alternative is available.

Salad Bar: As menu options are only decided the evening before service, I will aim to approximate the energy content of each salad based on recipes provided by the head chef. Portion size estimates will be generated by observing salad-bar average servings purchased by participants during baseline data collection for the RCT. As these estimates will be rough approximations, no specific energy or PACE information will accompany swaps offered, instead swaps will be presented with a message that reads: *"How about a swap? This has fewer calories"*.

Panini & deli sandwiches: Panini & deli sandwiches are made each morning by the canteen staff using ingredients that are left-over from service the previous day. If a pre-ordering system was to be implemented, the short turnaround between planning and service would make nutritional analysis infeasible. Consequently, no swaps will be offered for panini and deli sandwiches.

Jacket potatoes: In the physical canteen, customers are invited to build their own jacket potato from a selection of individual components including baked beans, cheese, tuna-mayo, plain tuna, and the filling of the day. To mirror the canteen set-up as closely as

possible while working within the confines of the website's functionality, participants will be presented with a list of the 10 most common combinations established through consultation with the canteen manager. This means that lower-energy swaps offered for jacket potatoes will typically be the originally selected item, less one component. For example, a participant selecting a jacket potato with baked beans and cheese would simply be offered a jacket potato with baked beans. Energy savings will, therefore, usually be achieved through the removal of a component. This approach will be taken to maintain similarity between swaps offered and originally selected items. Furthermore, this will allow for exploration of participant views on swaps offered which reflected a removal of one component of the meal. A lower-energy swap will be offered for 6 out of the 10 jacket potatoes available.

Soups and pre-packaged sandwiches: Six of the 17 pre-packaged sandwiches have been identified as lower-energy (i.e., at least 50kcal less than the majority of sandwiches) and will be offered as swaps for the remaining sandwiches on the menu. Where possible, swaps offered will be matched to the originally selected item based on its filling. The soup of the day (with and without bread) will be offered as the swap for the lower-energy sandwiches. A lower-energy swap will be available for 17 out of the 20 options on this menu. No swap will be offered for the soup of the day.

Sweet & savoury snacks and drinks: Swaps that I judge to be relatively close in flavour and texture to the originally selected item will be offered (e.g., strawberry yoghurt pot for a granola and yoghurt pot). In some cases, the swap offered will still be a chocolate treat but a different product smaller in size (e.g., Mamma Loretti's chocolate rolls 15g for Broderick's Road Rocking Choc Block 50g). In cases where a similar lower-energy alternative is unavailable, fruit will be offered as the swap. A similar process will be used to match high-energy savoury snacks to lower-energy alternatives. A lower-energy swap will be available for 14 out of the 21 savoury snacks and 7 out of the 15 sweet snacks. A lower-energy swap will be available for 9 out of the 18 drinks.

6.7 Study procedures

6.7.1 Recruitment

Potential participants will be approached via email and in person.

- Bupa's internal communications teams will send an invitation email to all staff in the Salford office. This email will contain a link to an online information sheet, consent form and short demographic survey.
- Information about the research will be displayed on screens around the Salford office.
- Team managers will be approached in person/via email by Bupa's Behavioural Science Team who will explain the research and will ask team leaders to champion the research and to promote participation within their teams. While championing the study, team leaders will also make clear that participation is completely voluntary and will not make anyone feel pressured into taking part.
- Team managers will remind their team about the trial during the team meetings.
- A promotional stand will be set-up in Bupa's Salford office for one week prior to the trial's launch where participants can learn about the study, register for the study and collect their study clubcards.
- Purposive sampling will be used to recruit participants and staff for focus groups. Unlike sampling for a quantitative survey, purposive sampling does not aim to generate a statistically representative sample. Instead, participants are selected with the aim of capturing the range and diversity of views and experiences across the whole population (Palinkas et al., 2015). For participant focus groups, I will aim to sample respondents that reflect high, medium and low engagement with the intervention. For the staff focus group, I will aim to sample respondents working in different roles within the canteen.
- Recruitment for the participant focus groups will take place in person when participants return their study cards at the end of the 4 weeks.
- Trial participants will be offered entry into a prize draw to win 1 of 3 £100 One for All vouchers. Winning participants will be sent their voucher by email.

6.7.2 Informed consent

After answering the screening questions to confirm they meet the inclusion/exclusion criteria, participants can read the information sheet. If they are happy to proceed, they will be asked to give consent electronically to take part in the study. During the consent process participants will be informed that the study will examine the influence of pre-ordering on purchasing behaviours. The exact outcome measures are not disclosed nor is the fact that the intervention is examining energy ordered. Informing participants that the system is designed to encourage lower-energy choices may change participant behaviour thereby compromising the integrity of the research (demand characteristics). Upon completion of the study participants will be fully debriefed.

Participants will be advised that they *may or may not* be offered use of the pre-ordering service during the 4 week trial period and this will be decided on an entirely random basis. Participants will be given 1 week to respond to the invitation. During this time they will have the opportunity to question me (via email or in person at the recruitment stand), or to discuss with others before deciding whether they wish to participate in the study. The consent form can be completed online either via a link in the recruitment email or using a tablet at the onsite recruitment stand.

6.7.3 Assignment of intervention

Once a participant has provided consent they will be individually randomised with a 1:1:1 allocation to one of the following groups; intervention 1 (pre-ordering), intervention 2 (pre-ordering + swaps & PACE) or control through minimisation (Altman & Bland, 2005). The sample will be stratified by gender because this is likely to influence the primary outcome measure (energy ordered). Research points to gender differences in food choices and dietary intake (Arganini et al., 2012).

MinimPY software will determine treatment allocation. To ensure unbiased treatment allocation, my supervisor Dr Pippa Lally will run the software. The process works by randomly allocating the first participant to a condition and allocating the rest of participants

based on the imbalance scores, calculated as a function of current allocations after a hypothetical allocation of the new participant in each study arm. Each new participant is allocated to the arm with the lowest imbalance score (Saghaei & Saghaei, 2011). A 20 % random element will be included in the algorithm (Altman & Bland, 2005). Dr Lally will return the list of participants to me with their treatment allocation. Due to the nature of the intervention, it is not possible for me to be blind to treatment allocation.

6.8 Data collection & management

When providing consent, participants will be asked to complete an online demographic questionnaire hosted by REDCap. This will collect information on gender, age, ethnicity, height, weight (for BMI), education and dietary restraint. Participants will also provide their Bupa email address through which they will be contacted during the study. To collect data on participant purchasing behaviour, unique ID numbers will be printed on credit card sized cards and distributed to participating staff. Participants will be given their 'study clubcards' the week before baseline data collection takes place. This will act as a participant's unique ID number for the duration of the trial. Every time participants use the canteen during the 4-week study they will need to show their card to the cashier/researcher. The cashier/researcher will write the ID number on the receipt and store it in a secure box. The checklist described in section 6.6 will be completed if necessary and attached to the relevant receipt. Receipts with participant IDs will be kept in a locked box beside the till and purchases will be manually entered into an excel spreadsheet at the end of each week. This process will allow for all participants' canteen purchases to be tracked and energy ordered to be calculated during the baseline week of the study (i.e., week 1). This process will continue to be used to track purchases made by control participants during weeks 2-4 of the study. Intervention group purchases during weeks 2-4 will be automatically tracked via the pre-ordering website. This information will be automatically recorded in a spreadsheet by REDCap and saved in Data Safe Haven (UCL's technical solution for storing, handling, and analysing identifiable data). DSH uses a walled garden approach whereby data can be collected, stored, and managed within a secure system without the need for encryption. DSH meets university and legal requirements for legal data protection. Pre-ordering participants will be asked by the

cashier if they have added anything to their pre-order. Additional purchases made by pre-ordering groups while in the canteen will be noted on the receipt by the researcher and will be manually added to the excel spreadsheet.

All participants will be asked to complete a weekly online survey indicating for each day whether they bought their lunch from the canteen. Participants will be sent reminder emails to complete the weekly survey. The days during which participants bought their lunch from the canteen will be categorised as 'adherence occasions' and will be used to estimate adherence and retention rates (please see section 6.9.1 for details).

I will conduct 4 participant focus groups (2 per intervention group) with 4-6 participants in each. Further interviews will be conducted if needed until data saturation is reached. These discussions will be semi-structured in nature and will focus on participants' experience of being involved in the trial, receiving the intervention and their views around its acceptability. All focus groups will be recorded with Dictaphones and will be transcribed for ease of coding during the analysis phase. Focus groups will last approximately 30 minutes. One staff focus group will be conducted with the kitchen manager, a kitchen staff member, and a cashier. This focus group will explore trial processes, i.e., how the kitchen staff found receiving and preparing orders; how cashiers found the clubcard tracking process and how managers found data sharing.

6.9 Outcome measures and analysis

6.9.1. RCT

A traffic light criteria will be used to assess the primary outcomes outlined below.

- Green: Criteria met – progress to full trial as is.
- Amber: Criteria partially met / slightly off the predetermined cut-offs – progress to full trial with amendments / close monitoring.
- Red: Criteria not met – full trial not feasible.

Given that pilot studies typically have smaller sample sizes than full trials, I will use 95% confidence intervals to determine which traffic light category an outcome falls into. For all outcomes, the lower limit of the 95% confidence interval must meet the designated threshold. For example, if the minimum adherence rate is set to 60%, the lower limit of the 95% confidence interval must be 60%. This stricter criteria is used to improve the accuracy of the estimates.[13]

The primary outcome measures for this pilot are as follows:

1. Recruitment/sample size

The number of participants recruited to participate in the trial. Recruitment will be measured through an online registration form. The scoping reviews pointed to a small to medium effect size generated from pre-ordering and swap-based interventions when tested separately. Whitehead et al. (2016) recommends a sample size of 25 per group for a pilot trial in which the expected standard effect sizes are small (0.2) and 15 per group for a pilot trial in which the expected standard effect sizes are medium (0.5). This would mean setting the sample size target between 45 (i.e., 15 x 3 groups) and 75 (25 x 3 groups). Low recruitment rates are common in lifestyle trials e.g. 10% (Public Health England, 2021). Based on the approximate current number of regular canteen users of the study site (n=500), a 15% rate of screen failures for not meeting the eligibility criteria on dietary requirements, and a minimum 10% recruitment rate, a minimum of 42 participants would need to be recruited. Based on this information and Whitehead et al. (2016)'s recommendations, I decided to set the minimum recruitment target at 45. There is no upper limit, as I would like to gauge the interest of potential participants in taking part in the study and a larger sample will allow for more precise estimates of feasibility. The traffic light thresholds for recruitment are:

- Green: At least 45 participants are recruited (i.e., assuming to be equivalent to at least 10%)

[13] Dean AG, Sullivan KM, Soe MM. OpenEpi: Open Source Epidemiologic Statistics for Public Health, Version. www.OpenEpi.com, updated 2013/04/06, accessed 2020/03/02.

- Amber: 25-44 participants are recruited (i.e., assuming to be equivalent to a recruitment rate of 5-9%)
- Red: Less than 25 participants are recruited (i.e., assuming to be equivalent to a recruitment rate below 5%)

2. Data Capture

The number of participants that provide baseline and intervention period data (i.e., clubcard data from the canteen). Given that this outcome is unique to this study, there was little guidance in the literature for acceptable cut-offs. As the sample size cut-offs above relate to the number of participants providing usable data, high data capture cut-offs were set.

- Green: the lower limit of the 95% confidence interval of the retention rate is ≥80%
- Amber: the lower limit of the 95% confidence interval is between 60-79%
- Red: the lower limit of the 95% confidence interval is below 60%

3. Adherence rates

Two types of adherence will be measured. The first type of adherence is defined as (i) use of the study clubcard (i.e. adherence to study procedures). The second type of adherence is defined as use of the pre-ordering system (i.e. adherence to the intervention). In order to measure adherence rates, participants will be asked to complete a short online form each week. The form will ask participants to confirm for each weekday, whether or not they purchased lunch from the canteen. Days on which participants confirm that they purchased lunch from the canteen will be considered “adherence occasions” i.e., days on which adherence can be measured. Participants in the control group will only be measured on their adherence to study procedures (use of their clubcard to purchase lunch). Participants in the intervention groups will be measured on their adherence to both study procedures and to the intervention using the methods outlined below.

(i) Adherence to study procedures will be calculated as the proportion of occasions on which a participant uses their clubcard at the designated Bupa Eats till out of the occasions they use the canteen during the intervention period.

(ii) Adherence to the intervention will be calculated as the proportion of occasions on which a participant (in the intervention group) pre-orders their lunch and collects it from the designated counter (both actions are required for this to be counted as adherence) out of the occasions they use the canteen during the intervention period.

Bupa has communicated that they would consider a minimum adherence rate of 60% (for both measures) to be necessary for the intervention to be tested at a larger scale (for wider roll-out in their offices). This is in line with guidance for minimum adherence rates for commissioned lifestyle interventions (Department of Health, 2013) .

- Green: the lower limit of the 95% confidence interval ≥60% for each adherence measure
- Amber: the lower limit of the 95% confidence interval is between 40-59%
- Red: the lower limit of the 95% confidence interval <40%

3. The retention rate

Participants for whom there is no clubcard data or weekly survey data during the final week of the study (and have not notified me that they are out of office) will be regarded as having ‘dropped out’. Based on previous feasibility studies testing health behaviour change interventions an overall retention rate ≥ 70% will be considered necessary to indicate the feasibility of a full scale RCT (Anderson et al., 2018). The exit survey will be used to verify that the absence of data is due to withdrawal/lack of interest.

- Green: the lower limit of the 95% confidence interval ≥ 70%
- Amber: the lower limit of the 95% confidence interval is between 50-69%
- Red: the lower limit of the 95% confidence interval <50%

The secondary outcomes measures for this pilot are as follows:

4. Variance estimates for energy (kcal) ordered

The standard deviation for energy ordered will be measured during the baseline week to inform sample size calculations for a full-scale trial. The minimum detectable effect size will be set to a 50 kcal reduction (Hill, 2003).

5. Difference in energy ordered between groups

Mean differences in energy (kcal) ordered between groups will be estimated to provide an indication of the success of the intervention and the effect size. In line with CONSORT guidelines, no hypothesis testing will be conducted (Eldridge et al., 2016).

6. Map the process of delivering the interventions in practice

This will be qualitatively explored through focus groups with canteen staff delivering the intervention (i.e., preparing the orders). A detailed visual model will be produced describing the process from start to finish and key barriers and facilitators will be included in order to generate a model of 'what works' from a procedural perspective for future trials.

7. Acceptability

Focus groups will be conducted with participants in each arm[14] in order to assess their experience of participating in the trial, the acceptability of the interventions (the pre-ordering system and the acceptability of swaps offered with PACE information), and their overall experience of participating in the study, including potential facilitators or barriers to adherence. For those in the pre-ordering with swaps+PACE group, a particular focus will be placed on the swaps offered and their acceptance. Any participants who dropout (either formally by contacting me or by not providing data) will also be approached and

[14] This will include the control group who will be asked about the study procedures only.

asked to participate in a focus group. These data will help with the refinement of the intervention and trial procedures if needed.

Qualitative outcomes 6 & 7 will be analysed using Thematic Analysis (Braun and Clarke, 2006). This will involve the following steps:

1. Familiarisation: I will first familiarise myself with the data by carefully reading the transcripts.
2. Code generation: I will then begin to generate initial codes by systematically coding relevant and interesting pieces of data.
3. Theme searching: Similar responses will then be grouped together to develop potential themes. All data relevant to these potential themes will be gathered.
4. Thematic review: Transcripts will be read several times and thematic labels will be revised. I will check that coded extracts fit under the theme they have been allocated to and whether they fit with the entire data set (e.g., are they substantially different from one another). I will then group them into major and minor themes to develop a coding tree.
5. Naming & defining themes: The themes will be named and defined. The data will be reviewed by a second coder and an interrater reliability score will be calculated to ensure consistency. Any discrepancies will be resolved through discussion.
6. Reporting: I will present key themes, selecting vivid examples of data to contextualise the findings and relating back to the research questions and previous literature.

Analytical outputs will include rich descriptions of experiences and attitudes and explanatory accounts that set out the full range of barriers and facilitators and how they interact with the context. Verbatim interview quotations will be provided in research outputs to highlight themes and findings where appropriate. NVivo qualitative data software program version 10 (QSR International, 2020) will be used to help manage and analyse the data.

Given the findings from Chapter 5 that 25% of those presented with the PACE message believed that the message would encourage excessive calorie counting, participants will

be asked to complete the Dietary Intent Scale (Stice, 1998) before and after the trial in order to examine the effect of repeated exposure to the intervention on disordered eating cognitions (i.e., changes in dietary restraint).

6.10 Ethical approval

The study protocol and documents have been reviewed and approved by UCL REC (Reference: 12861/004) and Bupa's Information Governance Board. It has also been registered with UCL's data protection department.

6.11 Conclusion

The study had to be stopped after the 2-week recruitment period due to Covid-19. A total of 70 employees enrolled in the trial during the recruitment period. This figure exceeded the target of 45 set out in the traffic light criteria. Chapter 7 details the first of two studies that were conducted in lieu of this pilot field trial. These studies are intended to answer some of the questions that this pilot aimed to address related in particular to: (i) the acceptability of the intervention among potential recipients (Chapter 7) and; (ii) the potential effect of a swap-based intervention on energy ordered across an entire canteen menu (Chapter 8).

Chapter 7

Experience of using an online pre-ordering system for a workplace canteen that offers lower-energy swaps: A think-aloud study

7.1 Introduction [15]

Chapter 6 detailed the preparatory work that was completed for the intended Bupa Eats pilot trial. As the Covid-19 pandemic made it impossible for the pilot trial to be conducted within the timeframe of this PhD, a new research strategy was implemented. The study described in this chapter forms one half of this new research strategy. In this study, Bupa staff were invited to hypothetically test the pre-ordering system and give their feedback on the website via a video-conference call. One of the aims of the study was to gather data on the pilot trial research question relating to the acceptability of a pre-ordering system that offers swaps with PACE information to employees. Although intervention acceptability was assessed in the studies described in Chapters 4 and 5, assessments used on both occasions were brief quantitative measures intended to gather initial feedback from participants on the acceptability of these interventions. Findings from both studies pointed to high overall acceptability ratings for pre-ordering and prompts to swap, and suggested that the messaging around the prompt to swap may positively influence

[15] This published paper is reproduced with permission from Breathnach et al. (2020). The authors Sarah Breathnach (SB), Dimitris A Koutoukidis (DAK), Phillippa Lally (PL), Christopher R van Rugge (CRvR), Alex Sutherland (AS) and Clare H Llewellyn (CHL) contributions were as follows: Conceptualization, SB PL, CHL and DAK; methodology, SB PL, CHL and DAK.; data curation, SB; formal analysis, SB PL and DAK; validation CRVR and SB; resources, PL and AS; writing—original draft preparation, SB; writing—review and editing, SB PL, CHL AS and CRVR.; visualization SB; supervision PL, CHL DAK and AS; project administration, SB. All authors have read and agreed to the published version of the manuscript.

intervention acceptability. However, although findings reported in Chapter 5 showed that the majority of participants exposed to the PACE message found it acceptable (78%), helpful (66%), and appropriate (64%), they also pointed to some potential adverse consequences of accompanying swaps offered with PACE messages, with a quarter of participants agreeing that the message they saw would encourage them to count calories excessively. One of the aims of the pilot field trial was to explore the effect of repeated exposure to the interventions on disordered eating cognitions and behaviours. Due to the tight timeline for conducting the current study, it was not possible to obtain the ethical approval required to qualitatively explore this sensitive topic with participants. Although it was not possible to directly explore potential harms of the messages with participants (e.g., whether the messages might trigger disordered eating behaviours), the current study provides an opportunity for the findings from Chapter 5 to be explored in greater depth, to help build a better picture of how different aspects of the intervention are perceived by potential recipients.

Research suggests that intervention acceptability is an important prerequisite for successful implementation (Diepeveen, 2013; Hilbert, 2007; Stok, 2015). Evidence from studies testing behavioural interventions indicates that intervention adherence and efficacy may be moderated by perceived acceptability (Larsen et al., 2020; Stok et al., 2015). Indeed, one study reported that acceptability ratings for the intervention were significantly correlated with the number of swaps accepted (Forwood et al., 2015). Despite the recognition that acceptability is an important outcome when evaluating interventions, systematic theories that define and guide the assessment of intervention acceptability have only recently begun to emerge. In the digital sphere, the Technology Acceptance Model (TAM, Davis, 1985) and the Unified Theory of Acceptance and Use of Technology (UTAUT, Venkatesh et al., 2003) have, however, been widely used to predict the potential acceptance or rejection of a technology. The TAM model examines factors relating to ease of use, perceived usefulness and attitudes towards using the system which are believed to predict actual system use. While the UTAUT takes a broader approach factoring in social influence, facilitating conditions, expected effort and personal characteristics of the user such as age and gender.

With respect to intervention acceptability specifically, the Theoretical Framework of Acceptability (TFA) conceptualises intervention acceptability as a multifaceted construct reflecting the degree to which those receiving the intervention consider it to be appropriate based on anticipated or experiential cognitive and emotional responses to the intervention (Sekhon et al., 2017). The TFA comprises seven constructs: (i) affective attitude which is how an individual feels about the intervention overall; (ii) burden which is the amount of effort participants perceive to be required to engage with the intervention; (iii) Ethicality which is the degree to which the intervention fits with an individual's value system; (iv) perceived effectiveness which is the extent to which the intervention is perceived to be likely to achieve its purpose; (v) intervention coherence which is the extent to which the participant understands the intervention and how it works; (vi) opportunity costs which is the extent to which benefits, profits, or values must be given up to engage in the intervention and; (vii) self-efficacy which is the participant's confidence that they can perform the behaviour(s) required to participate in the intervention. Aspects of this model such as the affective attitude, perceived usefulness and burden domains overlap nicely with the aforementioned TAM and UTAUT models. In line with previous research examining the acceptability of health-based interventions (Chakrapani et al., 2020; Palsola et al., 2020), the current study draws on the TFA framework to guide the examination of intervention acceptability.

An additional focus of the study was to explore the factors influencing swap acceptance. The studies reviewed in Chapters 2 and 3 highlighted a range of acceptance rates (13-34%) for swaps offered for grocery products across studies. Findings reported from the study in Chapter 5 showed comparatively high swap acceptance rates (~21%) and pointed to the potential efficacy of a PACE message in increasing the acceptance of swaps offered for snacks and drinks hypothetically pre-ordered. Alongside the framing of swaps offered, the scoping review suggested that aspects relating to the nature of swaps offered (such as similarity, price, and energy saved) may influence the acceptance of swaps offered for grocery products. However, little is known about the factors potentially influencing the acceptance of swaps offered for full lunch orders. Gathering information

on the facilitators and barriers to swap acceptance will be important to inform: (i) the design of the swaps intervention tested in the second half of the new research strategy outlined in Chapter 8, and; (ii) future studies testing swap-based interventions in canteen settings.

7.1.1 Aims

This study aimed to explore (a) the acceptability of a workplace canteen intervention combining pre-ordering and prompts with PACE messaging to swap to lower-energy alternatives and (b) the factors influencing the acceptance of lower-energy swaps offered.

7.2 Methods

7.2.1 Design

This qualitative study was ethically approved by University College London's Behavioural Science and Health Departmental Research Ethics Committee (ref: 12861/004). The Consolidated Criteria for Reporting Qualitative Research (COREQ) checklist was used for reporting this study (Appendix 7.1, Additional File 1). A 'think-aloud' methodology (Ericsson & Simon, 1993; Nielsen et al., 2002) was employed, which involved participants narrating to me their thoughts and decisions, as they navigated the pre-ordering website that was intended for use in the Bupa Eats pilot trial. Think-aloud approaches have been widely used in the study of consumer decision making and in human-computer user-experience (Bettman & Park, 1980; Perski et al., 2017; Stefano et al., 2010). A concurrent think-aloud approach was selected over a retrospective approach to capture stream-of-consciousness decision making as opposed to post-hoc rationalisations. Data generated in-the-moment are also regarded as more reliable than data generated from memory (Perski et al., 2017) and verbalisation without stimuli (i.e., without being able to see the pre-ordering website) may result in less exhaustive comments (Guan et al., 2006). Semi-structured open-ended interview questions based on a flexible topic guide (Appendix 7.2) supplemented the think-aloud procedure to capture views that were unlikely to be spontaneously verbalised. For example, opinions regarding the acceptability of the intervention as a whole.

7.2.2 Participants

An initial recruitment target of 30 participants was set based on similar previous research (Simons, et al., 2018). Participants were Bupa employees. Participants were eligible for the study if they were full- or part-time employees, self-identified as regular (i.e., twice per week) canteen customers, and had internet access. Employees were excluded if they were following a restricted diet such as vegan, dairy-free, sugar-free, or gluten-free, as this would influence the appropriateness of the swaps offered. Employees (*n*=70) who had enrolled in the Bupa Eats pilot trial were invited via email in March 2020 to participate in this qualitative study. Of those enrolled in the pilot trial, 20 (29%) consented to participate. Ten non-trial participants (i.e., employees of Bupa who had not consented to the trial) were also simultaneously recruited to diversify the sample to include employees that may be less interested in using the pre-ordering system. An advertisement was posted on the company's internal communication channel to recruit these participants. This advertisement was theoretically visible to a pool of 1,800 employees. Upon meeting the initial recruitment target and completing data analysis, a data saturation assessment was conducted (Table 7.1). Data saturation refers to the point at which no new themes are identified from the data (Braun & Clarke, 2019). This check was conducted once the 30 interviews has been conducted and the data analysis had been completed (please see section 7.2.8 for an explanation of this process). To conduct a data saturation assessment, a matrix of the interview data was created, with rows representing each theme and columns for each participant interview. Once a theme was identified in a participant's transcript, the box corresponding to that theme was marked with a tick in the matrix. Table 7.1 summarises all the themes that were identified through the think-aloud interviews, all of which had been identified by participant number 6. As can be seen from the table, theme 4 (T4) 'organisational ethos' is the final theme to be identified and first appears with participant number 6. No new themes were identified in the subsequent transcripts. The table demonstrates this for participants 7-10. Had data saturation not been reached, a further round of data collection would have been completed. The assessment, however, indicated that data saturation had been achieved (Table 7.1).

Although no new themes were identified after the 6th transcript was coded; the remaining transcripts were important in contributing to the richness and depth of the findings and so were retained. This is in line with other conceptualisations of data saturation such as conceptual depth discussed in the literature (Nelson, 2017). Participants of the Bupa Eats pilot completed a screening questionnaire during the initial consent process to indicate eligibility. Non-pilot participants were verbally asked to confirm that they met the eligibility criteria prior to completing the interview.

Table 7.1. *Summary of data saturation check. Rows represent participant interviews. Columns represent themes identified.* The table shows that no new themes were identified after coding the 6th transcript.

ID	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
1	✓		✓		✓	✓	✓	✓						✓
2	✓				✓	✓	✓		✓	✓	✓			✓
3	✓		✓		✓		✓	✓	✓			✓		✓
4	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
5	✓		✓			✓	✓		✓	✓			✓	✓
6	✓		✓	✓									✓	✓
7	✓	✓	✓			✓		✓		✓				✓
8	✓		✓		✓	✓	✓						✓	✓
9		✓	✓	✓		✓	✓	✓	✓			✓		✓
10			✓	✓		✓	✓					✓		✓

T1: Ordering timeframe; T2: Visual decision making for pre-ordering; T3: Desired service logistics; T4: Organisational ethos; T5: Temptation; T6: Information provision; T7: Perceived meaningfulness of energy savings; T8: Preference for similarity; T9: User-friendly process; T10: Tangibility of information provided; T11: Price; T12: Visual decision making for swaps; T13: Expected satiety; T14: Personal autonomy. NB: themes in the table reflect the 5 minor themes highlighted in Figure 7.2 and the 9 sub-themes in Figure 7.3 shown later in this chapter.

7.2.3 Pre-ordering website

The pre-ordering system used in this study was the website that was intended to be used in the Bupa Eats pilot trial described in the previous chapter. Details of the website are provided below, but further information can be found in section 6.6. of Chapter 6. The website was designed to emulate an online pre-ordering version of Bupa's physical canteen. For the pilot trial, orders would have been placed through the website between 7.00am and 10.30am and participants in the current study were also told that this is how the system would work. Participants could select from nine menus: (1) main hot dishes, (2) sides, (3) panini and deli sandwiches, (4) salad-bar, (5) jacket potatoes, (6) soups and pre-packaged sandwiches, (7) savoury snacks, (8) sweet snacks, and (9) drinks. Further details of these menus can be found in Table 6.1, section 6.5.2 of Chapter 6. Some of the menus change on a daily basis but for the purposes of this study, the menu reflected a single day. The "menu of the day" for the study was chosen at random from the three-week rotation. Appendix 6.2 outlines of all menu items available and swaps offered in each of the 9 menu categories. Within each menu, items were displayed in alphabetical order. An image of the printed menu for hot dishes that is usually displayed in the physical canteen was displayed on the website. A written description was provided for the sides, panini & deli sandwiches, and the salad bar menu options. Images of each menu item for all other menus (i.e., those that would not have changed during the trial) were displayed on the website.

Participants were offered lower-energy swaps at the point of choice of their initial selection if a suitable swap was available (Figure 7.1). Swaps offered were accompanied by either a PACE message which read "How about a swap? Save [x] calories = [y] min walk" or in the case of the salad-bar menu, where salads are self-assembled and so precise calorie information was unavailable, a calorie-only message which read "How about a swap? This has fewer calories." Swaps could be declined or accepted by clicking either "No, I will stick with my choice" or "Yes, I would like to swap". Once selections have been made, participants could navigate to the checkout section of the website. In the checkout section, an estimated collection time could be selected. Timeslots ran in 30-minute increments from 11.30am to 2.30pm when service in the canteen ends. The checkout section also provided a summary of the final order and a textbox for adding notes for the kitchen.

7.2.4 Swaps offered

For all items, participants were offered one suggested swap immediately after making each selection if a suitable alternative was available. Swaps offered were simply lower-energy items on the same menu as the original selection to ensure the highest possible similarity. The exception to this was the main hot dishes. Swaps for main hot dishes were dissimilar to the initially selected item given that only a small number of mains are on offer each day and are deliberately different to provide variety. The swap offered for main meals was the dish that was the next lowest in terms of energy content. To qualify as a swap, the alternative had to contain at least 50 kcal less than the originally selected item. If no item fitted this energy-saving criterion, no swap was offered. In order to maximise the number of swaps that could be offered, swapping criteria (described below) was tailored to each menu. Table 6.2 in Chapter 6 outlines in detail the criteria for swaps offered by menu. A registered dietitian analysed the nutritional content of menu items using recipes provided by the canteen's catering company and the nutrient analysis software Myfood24 (Measure Your Food on One Day 24-h recall) (Carter et al., 2015)

Figure 7.1: An example user journey of a participant ordering from the Jacket Potato menu. (**1**) Welcome page; (**2**) main menu; (**3**) jacket potato menu; (**4**) prompt to swap the jacket potato with baked-beans and cheese to a jacket potato with baked-beans; (**5**) estimated collection time selection page; and (**6**) order summary with a text box for notes for the kitchen. Adapted and reproduced with permission from Breathnach et al., (2020).

7.2.5 Think-aloud script

A script was developed to help guide participants through the pre-ordering website. Within the script was a flexible topic guide. The topic guide was split into four sections and was

structured to follow the flow of the user experience (i.e., questions were asked in the order in which stimuli was presented to the participant) but was flexible to allow for follow-up questions and prompts. The first section explored initial views of the logistics of using the pre-ordering website (e.g., feedback on the time-frame within which orders could be placed). Section 2 examined participant feedback on the swaps offered and the messaging accompanying swaps offered. Section 3 explored participants' reflections on the pre-ordering system after having placed their hypothetical order. At the end of the session participants were invited to provide general comments and ask questions. The script was piloted with two staff members from Bupa to ensure comprehension and that the questions flowed logically. Their data were not included in the analysis. The script can be found in Appendix 7.2, Additional File 1.

7.2.6 Data collection

Consenting participants (n=30) took part in an interactive semi-structured interview via *Google Meet* video-conference platform. This took place over a three-week period between the 23rd of March and the 8th of April 2020. I conducted all 30 sessions. Prior to these sessions, interested employees were sent an email containing a PDF version of the information sheet and consent form along with a request for their availability. Participants were then sent a calendar invite for the video-conference call. At the beginning of the call, I provided participants with a link to an online version of the information sheet, and participants were asked to confirm their consent by completing the online form. Following this, participants were redirected to the pre-ordering website. They were asked to use the screen-sharing functionality to enable me to visually follow their navigation. Participants were invited to place a hypothetical lunch order by navigating the menu(s) from which they would usually order in the canteen. Participants not offered swaps for their initial choices were asked to imagine it was a new day and to place a new order either from the same menu or another menu that they would usually order from (for example, if they initially selected a sandwich and were not offered a swap, they were asked to choose a different sandwich that they would like to eat or to make a selection

from another menu such as the mains). This strategy enabled me to elicit feedback from all participants on swaps offered.

Sessions were audio recorded and lasted a median of 18.5 min (range 12–32 min). No notes were taken during the sessions. Way With Words transcription service was used. Audio recordings were deleted once they had been transcribed and checked for accuracy. Transcripts were not returned to participants for comment. After the call, participants completed a short demographic questionnaire about their gender, age, ethnicity, education-level, height and weight (so that BMI could be calculated). Participants received a £10 gift voucher for taking part.

7.2.7 Reflexivity [16]

Prior to the think-aloud sessions, trial participants had met me in Bupa's canteen during the in-person recruitment for the Bupa Eats pilot study whereas non-trial participants had not met me in-person. Participants were informed that this was an academic research project. Trial participants were told that the aim of the Bupa Eats pilot was to explore the influence of a new online ordering system on purchasing behaviours in the canteen. All participants were told that the aim of the think-aloud session was to gather feedback on the pre-ordering website. Trial participants were aware that I was responsible for conducting the Bupa Eats pilot trial, but participants (pilot/non-pilot) did not know that this project formed part of my PhD research. It is, nevertheless, possible that the familiarity between me and trial participants might have inhibited frank conversation. While I endeavoured to remain objective when developing the topic guide and collecting feedback about the intervention, it is possible that my personal connection to the intervention may have resulted in me having supportive predispositions towards the website which may have influenced my interviewing and interpretation of the results. However, inter-rater reliability was high, indicating a low likelihood of bias. The second data coder was a male PhD student with a background in environmental psychology.

[16] Reflexivity typically involves reflecting on one's own judgments, practices, and belief systems during the data collection process and is a requirement of the COREQ checklist.

7.2.8 Data analysis

Data were analysed in NVivo 12 (QSR International, 2020) using a combination of deductive and inductive thematic analysis (Braun & Clarke, 2006). A deductive approach refers to analysis that is guided by a predetermined theoretical framework while an inductive analysis is driven by the data gathered (Braun & Clarke, 2006). A deductive approach was used to address the research question relating to intervention acceptability. The intention was to use the TFA (Sekhon et al., 2017) to guide this analysis and this approach worked well, helping to structure the narrative and describe the themes. In contrast to intervention acceptability, there was no clear theoretical framework that should be used when examining the factors influencing swap acceptance (i.e., research question 1). One potential framework is the 'capacity, opportunity, motivation, behaviour' (COM-B) model, which forms part of the Behaviour Change Wheel Framework. The COM-B model posits that enactment of a given behaviour depends on an individual's ability to perform the behaviour, their opportunity to participate in the behaviour, and their motivation to engage with the behaviour. For behaviour change to occur, a change in at least one of the three domains (capability, opportunity and motivation) must take place (Michie et al., 2011). It is routinely used by researchers when evaluating behavioural interventions including those examining dietary behaviours. The COM-B model was initially tested with the data, but it did not help to explain the findings beyond that which could be explained by the data itself. Instead, applying an inductive approach allowed for the data to dictate the structure of the analysis and prevented the data from being forced into predefined categories unnecessarily.

A broadly critical realist framework approach was applied during data analysis. The critical realist approach to qualitative research focuses on understanding rather than describing phenomena and takes a flexible approach to analysis using different designs and methods depending on the research question (Vincent & Mahoney, 2018). As the aim of the current study was to make sense of participants' views relating to (i) factors influencing swap acceptance and (ii) intervention acceptability, data were analysed using a thematic approach.

Analysis followed the Braun and Clarke process (2006), beginning with familiarisation of the data through careful reading of the transcripts, and subsequent generation of initial codes and the search for themes. Themes were generated by grouping similar responses together. These groups were reviewed and given thematic labels and definitions to reflect their shared underlying meaning. These groups were subject to constant review and discussion with the other authors to ensure that the thematic labels accurately reflected the coded extracts. I conducted an initial phase of coding and an agreed set of codes were generated through subsequent discussion with the other authors. To ensure internal homogeneity and external heterogeneity,[17] I examined all extracts that had been collated under each theme. This resulted in some thematic refinement with some themes being collapsed into others. The coding tree for the factors influencing swap acceptance can be found in Figure 7.2. Finally, themes relating specifically to the acceptability of the intervention were coded deductively into the relevant TFA domains. In a number of cases the data could be mapped to more than one TFA domain. Due to this overlap, the TFA domains of "burden" and "opportunity cost" were combined to form one dimension, as were the domains of "intervention coherence" and "perceived effectiveness". The coding tree for the factors influencing intervention acceptability can be found in Figure 7.3. Once all authors were satisfied with the refinement process, I re-coded all transcripts using the refined coding frame. Using this coding frame, 4 of the 30 transcripts were coded by a second researcher (CRVR). The inter-rater reliability was high (k = 0.88) and any differences were resolved through discussion. Participants did not provide feedback on the findings.

[17] Internal homogeneity means that "data within themes should cohere together meaningfully" and external heterogeneity means that "there should be clear and identifiable distinctions between themes" (Braun & Clark 2006, p.20).

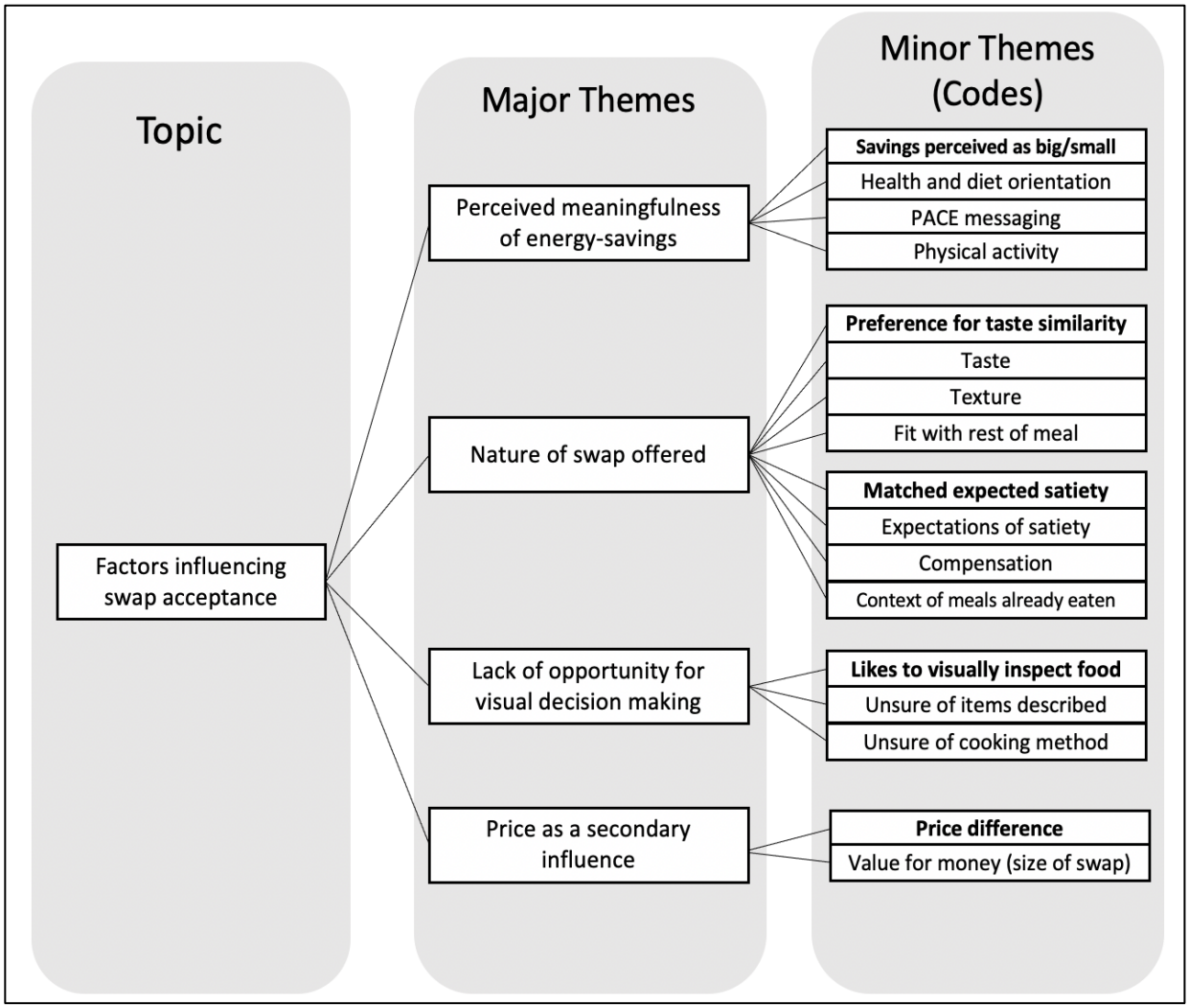


Figure 7.2: Coding tree for factors influencing swap acceptance. Minor themes are highlighted in bold and codes contributing to these themes are displayed beneath. Reproduced with permission from Breathnach et al., (2020).

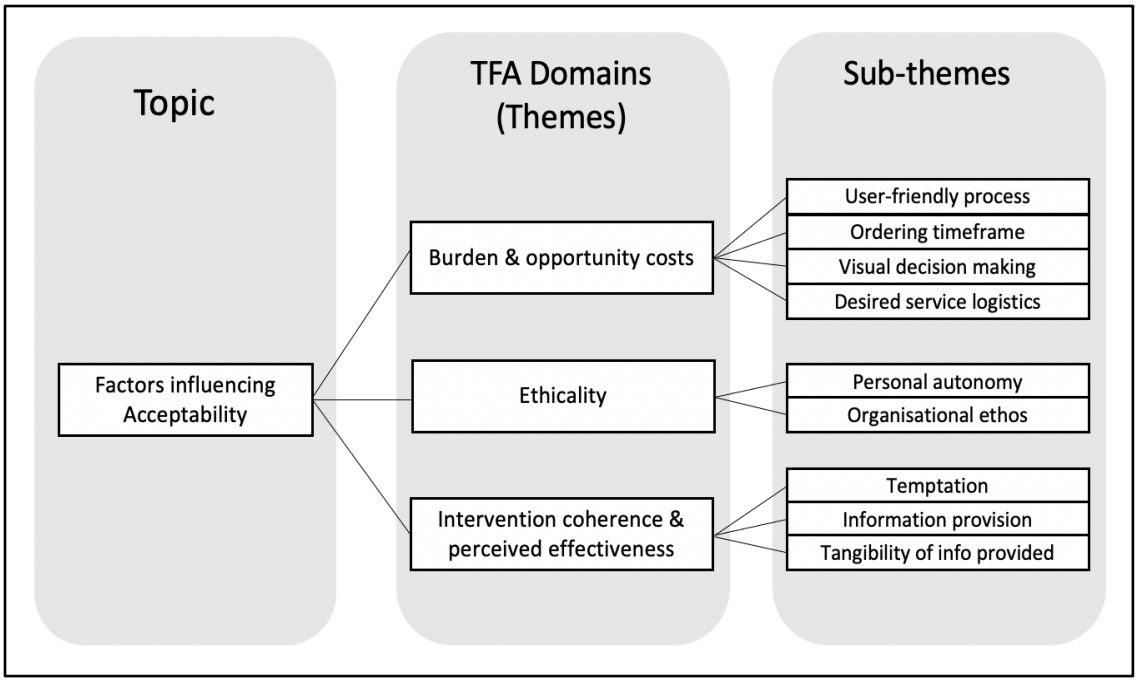


Figure 7.3: Coding tree for factors influencing intervention acceptability guided by the Theoretical Framework of Acceptability (Sekhon et al., 2017). Reproduced with permission from Breathnach et al., (2020).

7.3 Results

Participants (*n* = 30) ranged in age from 24 to 58 (median: 37 years) and were 53% female (please see Table 7.2 for demographic characteristics). Most participants (21/30) ordered from more than one menu. Participants were offered swaps in 59% of choices made. All participants were offered at least 1 swap. Table 7.3 summarises each of the relevant TFA themes and the sub-themes categorised as facilitators and barriers to the acceptability of the pre-ordering website.

Table 7.2: Summary table of participant characteristics.

Characteristic	**Total *n* = 30**
Age, years, mean ± SD	39 ± 9.1
Sex, female, *n* (%)	16 (53)
Ethnic group, *n* (%)	
White	26 (86)
Asian/Black	2(7)
Prefer not to say	2(7)
Education, *n* (%)	
None-Secondary	6 (20)
Vocational/Professional qualification	6 (20)
Undergraduate degree	14 (46)
Postgraduate	2 (7)
Prefer not to say	2 (7)
BMI (kg/m^2), *n* (%)	
Underweight (< 18.5)	0 (0)
Healthy weight (18.5–24.9)	15 (50)
Overweight (25–29.9)	7 (20)
Obesity ($\geq$30)	6 (23)
Prefer not to say	2 (7)

Reproduced with permission from Breathnach et al., (2020).

Table 7.3: Summary table of TFA themes with definitions and the sub-themes as facilitators and barriers to the acceptability of the pre-ordering+swaps website.

Themes Guided by TFA	Sub-Theme	Facilitator	Barrier	Mixed
Burden and opportunity costs: Perceived required effort to engage with the intervention and the extent to which benefits or values must be given up to do so.	User-friendly process	X		
	Concerns about the ordering timeframe		X	
	Preference for visual decision making		X	
	Desired service logistics			X
Ethicality: How the intervention fits with an individual's value system.	Concerns about imposing on personal autonomy			X
	Alignment with organisational ethos			X
Intervention coherence and perceived effectiveness: The extent to which the participant understands the purpose of the intervention, how it works, and perceives it to be likely to achieve its purpose.	Pre-ordering reducing temptation	X		
	Appreciation for information provision	X		
	Tangibility of information provided	X		

NOTE: TFA Domains not listed are those under which no themes emerged. Reproduced with permission from Breathnach et al., (2020).

7.3.1 Intervention acceptability

TFA Domains: Burden and Opportunity Cost

Sub-theme: User-friendly process

Almost all participants felt that ordering their lunch through the website each morning would require minimal effort. Participants regarded the website as easy to use, noting that its intuitive layout and the clear instruction provided would likely make pre-ordering a quick process.

> *"It was very easy to use, straightforward, step-by-step process. You could easily work your way through it."*—Participant 15, female. [18]

Sub-theme: Concerns about the ordering timeframe

Despite participants confirming that placing orders between 7.00am and 10.30am each morning would fit with the work schedule of most in the organisation, the restrictive timeframe within which pre-orders could be placed presented as a potential barrier to its use and in turn its acceptability. Some worried that the ordering timeframe may not fit with the work pattern of their particular team.

> *"I suppose in terms of the service that we offer, we all work different shifts. So, I don't know whether it would be something that you would have to be in the office to be able to access that platform, or whether it's something you can maybe even go on your phone or something in the morning?"*—Participant 21, female.

Participants didn't always feel confident that they would remember to place their order in time and some worried that work commitments may cause them to miss the window.

> *"I probably would [use it]. I think there needs to be some kind of prompt. I think quite a lot of people, if you go into work and you've got a meeting straightaway,*

[18] All quotes presented in this chapter are reproduced with permission from Breathnach et al., (2020)

you might need to, as I say, get a prompt. You might forget to order."—Participant 26, male.

Others remarked that they might not be able to forecast in the morning what they would like to eat for lunch.

"I would want to order a little bit closer to lunchtime for that, just to know what I feel like."—Participant 4, female.

While the restricted ordering timeframe was regarded as initially off-putting, some participants discussed the idea of viewing pre-ordering as another work-related task and incorporating it into their morning routine as a way to help to bridge this barrier.

"On a Monday, I come in, book my desks for three weeks in advance. So, on Monday you'd make it as part of that. But even then, on Thursday and Friday, you make it as part of your morning routine."—Participant 28, male.

Sub-theme: Preference for visual decision making

Participants reflected that they valued looking at the foods before making selections. They explained that it was not always possible to gauge from the menu exactly what each dish would contain and how it would be prepared. Some participants felt that not being able to physically see the dishes on offer before committing to them was a drawback of pre-ordering. The addition of images or a more detailed description of menu items to the website were cited as potential ways to overcome this challenge.

"I don't think I'd like that [pre-ordering], especially with our canteen. I think I'd like to see the dish or at least have a photo or something, or a good description of it."—Participant 19, male.

Sub-theme: Desired service logistics

Participants highlighted the logistical benefits that pre-ordering affords users. While participants spoke about features of the service that were specific to the set-up of their company's canteen, certain features were viewed as generally desirable to participants and could, therefore, be applied in other settings. For instance, participants liked having

to specify an estimated collection time-slot and felt that this may facilitate the scheduling of breaks during their working day.

> *"I think if I was made to pick a timeslot to go and get my lunch, it would force me to take my lunch at that time. So that's good, in that sense."*—Participant 29, female.

While participants generally found it easy to select a collection time-slot and liked the structure it provided, they appreciated the fact that they would not be bound to it given that food would be plated on their arrival at the canteen. Some participants felt that food being plated on arrival was preferable as it would reduce the risk of compromised food quality.

> *"I would rather it be made ready for collection when you get there, because you don't just want it on a plate sat in some warmer somewhere."*—Participant 23, female.

Others expressed concerns about having to wait for their food to be plated, describing this as potentially defeating the perceived purpose of pre-ordering as a time-saving tool.

> *"I'm just wondering, what have I actually gained here? I'm presumably going to still be in the same queue as people who haven't pre-ordered…If more than half the population of [the company] start pre-ordering, then I could be in a longer queue to pick up pre-ordered meals than I would be for not pre-ordering."*—Participant 25, male.

Time-saving was described as a key factor encouraging staff to use the pre-ordering website. The implementation of a separate "express" queue for the collection of pre-orders was highlighted as important in ensuring time-savings.

> *"As long as you don't have to join the normal queue where they've not pre-ordered, because obviously then it defeats the purpose. If you get seen straight away, then I think that's absolutely fine."*—Participant 26, male.

Finally, participants spoke about pre-ordering enabling them to guarantee they get the lunch they want. A canteen's ability to reserve food for those who pre-order would facilitate use of the website.

> *"The benefit of it for me is that nothing would ever run out, I assume, if I ordered it. They've guaranteed it."*—Participant 12, male.

TFA Domain: Ethicality

Sub-theme: Concerns about imposing on personal autonomy

Divergent opinions emerged among participants regarding the prompts to swaps. Among those that perceived prompts to swap as a gentle nudge that could be ignored, intervention acceptability was high.

> *"I think, like I say, it's just to get you thinking about things. I don't think it's too personal or anything like that. Yes, I think it's good."*—Participant 10.

Participants worried that while they personally regarded the prompts to swap as acceptable, the prompts could elicit negative reactions from colleagues if viewed as too prescriptive.

> *"There's a lot of people that I work with who are really set in their ways and would feel like they were being told what to do. And I could definitely imagine complaints about it."*—Participant 1, female.

In other cases, prompts to swap were perceived as an infringement of personal autonomy.

> *"It's acceptable, but I'm not sure the response will be very good…It's kind of Big Brother. It's someone that you've never met, will never meet is pushing you down or prompting you down an avenue. I'd be more likely to say no."*—Participant 19, male.

Among those who perceived the prompts to swap as prescriptive, a preference for PACE and nutritional information to be provided upfront when viewing each menu was expressed.

> *"What to me would be more useful is to tell you the calories and how long it would take to burn off each of these [menu items individually]."*—Participant 5.

There was also some indication that participants may grow tired of being prompted to swap over time.

> *"It might get a bit tedious sometimes, if you're ordering this on a daily basis, and you're going through swaps daily, and you're saying no to it."*—Participant 8, male.

Sub-theme: Alignment with organisational ethos

Participants acknowledged that encouraging healthier choices among employees of a health insurance company was acceptable, believing that the organisation had a duty to engage in health promotion activities of this nature.

> *"Definitely yes [it's acceptable], considering the nature of the company [healthcare]. I think it should be almost part of their responsibility to the employee to promote good health and wellbeing."*—Participant 9, female.

Participants felt that it was important for employers to give their staff access to health-promoting tools like a pre-ordering system.

> *"I think it's something that should be advocated in the workplace because for me if you're encouraging your employees to be healthy then give them the tools to do that job. As an employer, you can be part of that process.*"—Participant 18, female.

Participants expressed uncertainty regarding whether it would be acceptable for employers within other industries to prompt staff in this way. Participants felt that this would depend on company culture and individual preferences.

> *"It's difficult to answer [whether this would be acceptable in other companies], it depends on the culture. But, yes, I think it is. I think it's becoming more and more acceptable."*—Participant 7, male.

TFA Domains: Intervention Coherence and Perceived Effectiveness

Sub-theme: Pre-ordering reducing temptation

Participants indicated that they perceived the intervention to be coherent by discussing the rationale behind pre-ordering. Participants acknowledged that the sight and smell of tempting foods in the canteen often derailed their intentions to eat healthfully and caused them to impulse-buy high-energy foods.

> *"This would make me be a little bit more organised to get exactly what I want, rather than when you go down and you see certain things probably a little bit more unhealthy, you're swayed by the smells and the visuals of it."*—Participant 3, male.

Participants also discussed the website as a welcome planning tool or a "commitment device" to help them stay on track.

> "*For me, it's committed me to have what I'm supposed to."*—Participant 16, female.

Sub-theme: Appreciation for information provision

Participants discussed the lack of availability of nutritional information within the physical canteen as a factor making healthier choices a challenge. Providing energy and physical activity information with prompts to swap was viewed as a website feature that would not only encourage participants to use it but would also help them to make more informed decisions.

> *"Eating in the canteen is really hard, because you don't know what the calories are with different options. That information isn't available. So, certainly for me, it's there now…. I can imagine, if we've got more information on the calories, I'd be making a more informed choice."*—Participant 14, female.

Participants indicated perceived effectiveness as they described the information as prompting them to make more conscious choices and acknowledged that this may, in turn, result in healthier choices in real life.

> *"If you just choose your food off-site, you don't tend to stop and think, do you? Whereas, with it there on the screen, each time it comes up with lots of minutes of walking, you'd probably choose at some point to swap one of them."*—Participant 2, female.

Sub-theme: Tangibility of information provided

Alongside the general provision of information, participants expressed an awareness of the purpose of presenting PACE information when offering swaps. Participants spoke about the PACE message aiding their understanding of potential energy-savings by translating the information into a tangible metric and this was perceived as a factor facilitating the acceptability and potentially the use of the website.

> *"It's quite good because it puts into perspective the calories that you'd save and the fact that it's like 67 minutes walking, it makes you think about what you're ordering and I guess how much maybe exercise and things like that… It puts it in layman's terms that most people can relate to."*—Participant 13, female.

7.3.2 Factors influencing swap acceptance

Perceived meaningfulness of energy-savings

When deciding whether to accept or reject swaps offered, participants commented on the calorie and PACE information accompanying the prompts to swap. Participants described the PACE information as motivating swap acceptance when it was perceived as substantial enough to be a worthwhile trade-off.

> *"You think, do I need to have this at all? Saving 77 calories is actually, in the day, when you're on 1300 [calories], quite a bit for something that's just a side as well."*—Participant 16, female.

Health consciousness and inclination towards calorie counting or dieting emerged as factors potentially influencing the degree to which energy-savings influenced swap acceptance. Those with little interest cited this as a reason for rejecting swaps offered.

> *"I'm not really bothered about calories. I'd rather have the food. I'm not particularly calorie counting. It's a nice thing to consider if you are calorie counting, but personally I'm not."*—Participant 8, male.

Equally, those who self-identified as dieting or calorie conscious cited this as a reason for accepting swaps offered.

> *"I'm personally trying to lose a bit of weight, so having to do a 34-min walk, makes you think, well if I'm going to the gym later, that means I don't have to do as much."*—Participant 10, female.

However, when the energy-savings were perceived to be small, the provision of PACE information emerged as a potential barrier to swap acceptance. Interestingly, judgements about the value of the energy-savings differed across participants. There was some evidence that decision making may be moderated by individual activity levels.

> *"There needs to be a bit more of a gap…It's just 77 calories, it's nothing…If you were saving 150 calories. Then you go, actually, yes and then you say, it's 35 minutes' walk then you say God damn that's a lot."*—Participant 20, male.

> *"I just would ignore it [20 minutes of walking saved by swapping] because I know I exercise a lot anyway. Do you know what I mean? It doesn't impact me really."*—Participant 4, female.

Nature of swaps offered

The nature of the swap offered was a recurring motif that mainly centred around two sub-themes which reflected "a preference for similarity" and "a preference for matched expected satiety".

Sub-theme: Preference for taste similarity

In instances where the swap was viewed as an equivalent alternative to the initially selected item, participants reported feeling inclined to swap.

> *"Yes, I think that's quite a decent swap because they're still like a crispy snack, aren't they? So, as long as it's a fairly like-for-like then that's quite a good option."*—Participant 17, female.

Equally, swaps that were different in nature to the initially selected dish discouraged participants from swapping. This was particularly true for main hot meals for which the swaps offered were entirely different meals.

> [swap offered was artichoke heart tacos for fish pie] *"I think it's good to have the option. I think, maybe if the swaps were a bit more similar. Say if it was another fish dish, it might be a bit more persuasive then, rather than it being a completely different type of meal."*—Participant 29, female.

Others explained that when they make their selections, particularly from the salad bar, each component would provide different flavour or textural quality. Swaps offered that were not expected to complement the other aspects of the dish were perceived as less acceptable.

> "I wouldn't swap [coleslaw for broccoli] because I would want something with a bit of sauce on it to go with the rice and broccoli which are dry."—Participant 2, female.

Alongside this, swaps offered that were perceived as failing to be an appropriate accompaniment to the rest of the meal discouraged participants from accepting the swaps offered.

> *"Now, I probably, just because of what it is [mixed salad], wouldn't think that would go with as well as the Asian slaw so I wouldn't [swap]."*—Participant 4.

Sub-theme: Preference for matched expected satiety

Participants expressed a reluctance to swap when they considered the alternative to be less substantial or satisfying than their initial selection. While participants tended to reject swaps offered that they did not like, sometimes participants were more willing to give up the "tasty" component of the meal than they were to sacrifice the component they expected to be filling. For example, participants offered a swap which was the same meal but without cheese seemed more willing to accept this than participants who were asked if they wanted to swap the starchy component of their salad for a vegetable.

> *"It's just not as satisfying for me to swap out potatoes for broccoli."*—Participant 22, female.

> [Swap offered was jacket potato with baked beans for a jacket potato with baked beans and cheese]. *"Yes, I feel like it makes sense, and I would much rather give up the cheese than take an extra hour's walk."*—Participant 15, female.

However, some expressed a concern that accepting the swaps offered may result in compensatory behaviours.

> [Swap offered was bean salad for white rice]. *"Because I generally try not to snack in the afternoon. So, I want a more filling lunch. Or, like, if I have salad, right, if salad is the main component of my lunch, I'll get hungry quicker. And then, I'll look to possibly in the afternoon have something like a chocolate or a coke or something."*—Participant 28, male.

Participants indicated that the acceptance or rejection of swaps may be based on the broader context of what they had already eaten that day or what they were planning to eat that day. Participants were less likely to swap if this was their main meal of the day.

> *"I'll stick with the original selection, because on that particular day I would probably have a jacket potato with cheese and beans, it's probably a day where I'm not going to have a hot meal at home later."*—Participant 23, female.

Lack of opportunity for visual decision making

In line with the factors influencing the acceptability of pre-ordering, not having an opportunity to see swaps offered emerged as a barrier to the acceptance of swaps. This was particularly problematic when participants were unsure of the exact nature of the swap offered.

> [Swap offered was Japanese shichimi togarashi chicken for artichoke heart tacos]. *"One of the reasons I picked artichoke hearts taco is I actually understood what it meant. And then saying can I go for a what, a Japanese what? So now you're offering me something where, yes, I'd want to actually see it before I went for that."*—Participant 25, male.

Price as a secondary influence

Participants largely did not discuss the price of swaps offered, indicating that this was not a primary concern. When price was mentioned it was usually done so in the context of other factors such as taste or similarity, implying that the cost of the swap was not a major factor for deciding whether to accept a swap offered.

> *"So, I've gone for the Oasis Summer Fruits. And it's: would you consider going to the Fruits Zero, which is the same price, same flavour, sugar free? I probably would [swap]."*—Participant 30, male.

7.4 Discussion

7.4.1 Summary

Overall, implementing a pre-ordering system for a workplace canteen was largely regarded as acceptable and many participants viewed it as a useful tool to help them to choose lower-energy lunches at work. Participants were, however, unsure as to whether the intervention would be acceptable in non-health related organisations. Aspects of the intervention that facilitated perceived acceptability included its user-friendly process, certain aspects of the service logistics such as being able to reserve desired meals and use an express queue, the availability of energy information through the website, participants' belief that the intervention was informative rather than prescriptive and that pre-ordering may help to reduce temptation. Aspects of the intervention that presented as potential threats to acceptability were concerns about the ordering timeframe, preferences for visuals when ordering, concerns that prompts to swap were threatened personal autonomy and certain aspects of the service logistics such as collection delays. Factors such as perceived similarities of the swap offered in taste, texture and expected satiety to the originally selected item facilitated swap acceptance.

7.4.2 Intervention acceptability

Burden & opportunity costs

Practical considerations such as having a user-friendly process for pre-ordering, an ability to reserve pre-ordered meals and a swift collection service emerged as key facilitators of acceptability within this domain. These findings have implications for the development and refinement of pre-ordering systems. Although canteen pre-ordering systems as mobile apps already exist, it would be reasonable to speculate that their use may increase rapidly with the return to workplaces and social distancing measures following the Covid-19 pandemic. The current findings suggest that for employees to use a pre-ordering system it needs to be perceived as conferring a tangible benefit such as saving them time or guaranteeing that their desired meal is reserved. While participants expressed a preference for food to be plated on their arrival at the counter rather than ahead of time, this is likely to become unacceptable if it significantly slows down the process of collecting lunch from the canteen. Widespread uptake of pre-ordering may also increase queuing time in the canteen, which could reduce the effectiveness of the intervention. The implementation of an express queue for pre-ordering customers and a system for reserving their orders may increase the likelihood that staff will use the system.

Pre-ordering was also viewed as potentially providing ancillary benefits, with participants commenting that having to select an estimated collection time slot may facilitate the scheduling of breaks during their working day. Survey data of workers from across Europe highlight the important role that lunch-breaks play in boosting wellbeing at work (Corvo et al., 2020). However, the findings on the potential burden of the ordering timeframe echoed previous research conducted in a hospital canteen setting, which reported that difficulty remembering to pre-order was a key barrier to pre-ordering (Stites et al., 2015). Practical additions, like providing users with reminders to pre-order may help reduce concerns around the restricted ordering timeframe. Aesthetic and functional features of the system are also likely to influence acceptability. Existing pre-ordering mobile apps on the market typically do not present foods with pictures. The current findings suggest that the inclusion

of images and detailed descriptions of menu items may facilitate acceptability and, in turn, the use of such systems.

Ethicality

As employees of a healthcare company, participants felt that the intervention aligned well with the ethos of their organisation. However, there was some indication that acceptability may be context-dependent and that the intervention may be less acceptable to employees within other industries. Intervention acceptability ratings reported in Chapter 5 were collected from employed adults across the UK and were high, suggesting that the intervention is likely to be well received across sectors. Before implementing an intervention of this nature in non-health related settings, an assessment of acceptability should nevertheless be conducted with employees. Participants largely perceived the intervention as preserving their freedom of choice, viewing it as an informative addition to the online canteen. This finding fits with previous research which shows greater public support for interventions that are viewed as guiding rather than restricting choices (Diepeveen et al., 2013). It also fits with the findings from studies examining the acceptability of offering swaps for grocery items in which 70–76% of participants agreed that they would like to see swaps as a feature when shopping online (Koutoukidis et al., 2019; Payne Riches, et al., 2019). However, some participants felt that the swap aspect of the intervention was too prescriptive. Previous research has indicated that choice-architecture interventions are more likely to be opposed by recipients when they are perceived as autonomy-threatening, but that this may be influenced by individual personality traits. The authors reported that more reactant individuals are prone to oppose nudges because they are perceived as autonomy-threatening while more empathic people are likely to support such interventions (Jung & Mellers, 2016). Offering the personalisation of system features may encourage greater numbers of staff to pre-order. For instance, enabling users to opt-out of the swap feature in the current intervention may circumvent the issue of swaps offered being perceived by some as threatening their autonomy. Indeed, the swaps intervention was viewed as more acceptable among participants in Forwood et al's (2015) study when it was framed as something participants

had consented to. There was also some indication that prompts to swap may become tedious over time, especially if users are being offered (and rejecting) the same alternatives. Acceptability is likely to be enhanced by varying the types of swap offered and limiting the frequency with which users are prompted.

Intervention coherence & perceived effectiveness

Participants demonstrated a solid understanding of the key mechanisms through which the intervention works, and this was associated with intervention acceptability and an intention to pre-order. Comments made pointed to an appreciation that proximity to palatable food can cue craving and indicated an awareness that temptation can increase the selection of higher-energy food and drinks (Duckworth et al., 2016; Hofmann et al., 2009). Participants acknowledged that pre-ordering would afford them both the opportunity to make decisions in the absence of tempting cues, and also to act as a commitment device binding them to these decisions, which may reduce the intention-behaviour gap. This is in contrast to previous research in which German employees were opposed to ordering their lunch in the previous week and most did not want to pre-order on the day (by 9.00am). Respondents in this study reported a willingness to pay 2 to 3 euros more for meals that could be selected spontaneously (Ohlhausen & Langen, 2019).

Participants expressed an appreciation for the novel information displayed on the website, and comments seemed to support the hypothesis discussed in Chapter 5 that PACE information prompts people towards menu items with less energy by making energy information more tangible (Daley et al., 2020). In terms of delivery, participants expressed a desire for energy information to be presented at the point of choice rather than exclusively when swaps are offered.

7.4.3. Factors potentially influencing swap acceptance

While prompting healthier alternatives has been regarded as a promising intervention (Hartmann-Boyce et al., 2018), little is known about the factors that influence swap acceptance. The findings from the current study indicate that similar swaps are likely to

be more acceptable to consumers. This may be because (i) they are less likely to significantly reduce the expected enjoyment of one's meal; and (ii) deciding whether to accept a dissimilar swap may require more demanding "system 2" decision making (Kahneman (2011, p13) describes this as a *"slower, more deliberate and effortful form of thinking"*)**,** which could cause users to become disengaged, thereby reducing the likelihood that a swap is accepted (Payne-Riches et al., 2019). Although research conducted by Payne-Riches et al., (2019) in a supermarket setting reported that offering "out-of-category" lower-salt swaps (i.e., items from a different shelf location in a supermarket to the initially selected item), did not decrease swap acceptance, out-of-category swaps offered in supermarkets may be more similar to initially selected items (e.g., pita bread for a bagel) than swaps offered in canteen contexts as the range of alternative products available in supermarkets is far greater. In the current study, participants were often less willing to sacrifice the element of the meal that they perceived to be most filling (e.g., to swap starchy foods for vegetables), than they were to give up the tasty topping part of the meal (e.g., the cheese on top of a baked potato). Offering swaps that remove the higher-energy components of the meal, for example, offering a jacket potato with tuna as a swap for a jacket potato with tuna and cheese, may help to increase swap acceptance while maintaining similarity.

While participants expressed a need for similarity, in terms of an item's perceived ability to satisfy hunger, this must be balanced against the need for swaps offered to be perceived as yielding meaningful energy-savings. Judgements regarding the magnitude of energy-savings varied by individual, meaning that no universal threshold for what constitutes a worthwhile energy-saving was identified. Nevertheless, given that participants tended to dislike being prompted with swaps multiple times during a single session, offering swaps that generate small energy savings should perhaps be avoided. This finding links with the results from Payne-Riches et al., (2019) study which found that participants were more likely to select swaps offered that yielded larger salt savings, even if they were in some cases out-of-category alternatives.

Finally, price did not emerge as a key factor influencing swap acceptance in the current study, despite being reported as among the most important influences on dietary choice (Waterlander et al., 2019). This aligns with findings from another study testing a swap-based intervention which found that although price was rated as one of the most important factors influencing food-choice, no significant association between the importance attached to price and any of the outcomes such as swap acceptance was observed (Payne-Riches et al., 2019). The weaker than expected influence of price observed in the current study may be explained by the small difference in price between initial selections and swaps offered. The study reported in Chapter 8 provides some quantitative exploratory analysis examining the differential effect of the intervention by price difference between initial selected items and swaps offered.

7.4.4 Strengths and limitations

The study has both strengths and limitations. It is the first to elicit experiences of a website design based on participants' real canteen menu and so, while orders placed were hypothetical, they are likely to have reflected participants' real choices. Furthermore, the display of menus and the ordering process reflected how pre-ordering would work if implemented in the real world. Although participants made no reference to the PACE message potentially triggering unhealthy future behaviours such as excessive calorie counting, this was not explicitly investigated for ethical reasons. Participants were recruited from one company only, limiting the generalisability of the findings. This is discussed further in Chapter 9 (section 9.3).

It is also likely that recruitment involved a form of self-selection as the majority of participants were those who had registered to participate in the Bupa Eats pilot trial. Therefore, individuals who agreed to participate may have already been positively inclined towards the intervention. I tempered this with recruitment of non-pilot participants and major differences in attitudes between pilot participants and non-pilot participants were not observed. Due to time constraints, I was not able to verify the accuracy of the analyses with participants. While I endeavoured to remain objective, it is possible that my personal connection to the intervention may have resulted in me having supportive

predispositions towards the website which may have influenced the conduct of the study. However, the 'think-aloud' methodology may reduce the likelihood that responses are influenced by the interviewer compared with solely interview-based studies. Additionally, the iterative refinement of the themes with those who are authors on the published version of this study and the high inter-rater reliability with an independent coder indicate that the themes are robust. This study is also the first to provide an insight into the factors potentially influencing swap acceptance. It is important to note that participants were commenting on the acceptability of swaps without having eaten the swaps offered. As such, these findings should be viewed as exploratory only.

7.4.5 Implications for future implementation of the intervention

The findings from this study have important implications for the second half of the new research strategy which is intended to address the pilot trial question regarding the potential effect of a swap-based intervention for a canteen pre-ordering system. Feedback from participants highlighted several modifications that could be made to the intervention to make it more acceptable to participants and to potentially increase swap acceptance. Table 7.4 outlines modifications which will be made to the intervention ahead of the online RCT described in Chapter 8.

The findings from the online study reported in Chapter 5 indicated that accompanying swaps offered with a PACE message may be the most promising approach to increasing the acceptance of lower-energy swaps offered for snacks and drinks. As it was not feasible to test more than two intervention conditions in the pilot trial, the pre-Covid-19 plan was to carry forward the PACE message to the pilot trial meaning that pre-ordering would be tested against a pre-ordering with swaps+PACE intervention. The online nature of the RCT that was planned in lieu of the pilot trial meant that although it was not possible to test pre-ordering, it would now be possible to test two versions of the swap-based intervention (with and without PACE information) across a full canteen menu. This would allow me to check that the findings reported in Chapter 5 apply when a full meal is ordered. With this in mind, a decision was made to test two versions of the swap-based

intervention (with and without PACE information) across a full canteen menu in Chapter 8.

Table 7.4: Potential modifications to the intervention that could be made ahead of the online RCT testing potential effect of the swap-based intervention on energy ordered.

Theme	Modification
Intervention acceptability	
Preference for visual decision making	- Add images and more detailed description of menu items to the website. For main hot meals, replace the image of the menu with images of the meals and provide detailed descriptions to circumvent the issue of customers being confused about the nature of the swap offered.
Concerns about imposing on personal autonomy	- Among those who perceived the prompts to swap as prescriptive, a preference for nutritional information to be provided upfront when viewing each menu was expressed. Add energy information to all menus, so that before swaps are offered participants can tell which menu items are lower-energy.
Factors influencing swap acceptance	
Perceived meaningfulness of energy-savings	- For main hot dishes and sandwiches, instead of the swap offered being the menu item that is the next lowest in terms of energy content, offer the menu item that yields the largest potential energy saving as the swap. By offering a main-meal as a swap for a main meal (even if it was the lowest energy of the 3 options), I also hoped to address the preference for matched satiety.
	- Participants tended to dislike being prompted with swaps multiple times during a single session. This was especially true for the salad bar. At the salad-bar employees can fill a box with a mixture of different components. Given the nature of the salad bar, the same swap was being offered multiple times which participants found annoying. The swaps offered were

	also at the lower-end of the energy savings scale. Consider not offering swaps for the salad bar, focus on offering swaps with energy savings at the higher end of the energy savings range.
Preference for taste similarity (This was particularly the case for main hot meals for which the swaps offered were entirely different meals).	- For main hot dishes, instead of offering one swap, offer two swaps. The first swap offered is the main hot dish that offers the largest potential energy saving (this addresses the issue of perceived meaningfulness of energy-savings, as the swap offered is still a main hot dish (all of which were of a similar size in the canteen), it should also address (to some extent) participants desire for matched expected satiety. The second swap offered can be an item from another menu that matches the initial selection in terms of its main protein (e.g. offer a chicken tikka sandwich for a chicken curry). This may help to address the preference for taste similarity.

7.4.6 Future research

With respect to wider future research, studies could examine intervention acceptability with employees from other industries and among vulnerable populations (e.g., those with a history of eating disorders). It will also be important for future studies to qualitatively explore the factors influencing swap acceptance in real-world settings, where participants have experienced the intervention over a sustained period of time.

7.4.7 Conclusion

When implementing a pre-ordering system for a workplace canteen, practical considerations such as having a user-friendly process for pre-ordering that provides energy information at relevant timepoints, an ability to reserve pre-ordered meals and an efficient collection service are likely to facilitate acceptability. Personalisation of website features may help to protect individual autonomy and thus enhance acceptability. Swaps

offered should be as similar as possible in terms of taste, texture and expected satiety to the originally selected item while also yielding meaningful energy-savings. The next chapter details the final study of this PhD thesis. Drawing on all the findings described thus far, the study attempts to address the pilot trial research question regarding the potential effect of a swap-based intervention on energy ordered across a full canteen menu.

Chapter 8

The effect of offering swaps with and without a physical activity calorie equivalent (PACE) message on the energy content of lunches pre-ordered in an experimental online canteen: A randomised controlled trial

8.1 Introduction [19]

This chapter details the second half of the research that was conducted in lieu of the planned pilot trial with Bupa. As outlined in Chapter 6, the intention was to pilot the interventions; pre-ordering with swaps+PACE information vs pre-ordering alone vs control (no pre-ordering or swaps) in a real-world canteen environment with a full canteen menu in order to explore whether running a full RCT would be feasible, and to explore the potential effect of the intervention on energy ordered in the canteen. Instead, the pre-ordering website that was developed for the field trial was first tested in a 'think-aloud' study (Chapter 7) with Bupa employees to address the field trial objectives relating to intervention acceptability. The study also allowed for the qualitative examination of other important research questions relating to participants' user experience and the factors influencing swap acceptance which informed the current study. However, field trial

[19] The paper is under review for publication and is reproduced with permission from the authors: Sarah Breathnach (SB), Dimitris A Koutoukidis (DAK), Phillippa Lally (PL), Alex Sutherland (AS) and Clare H Llewellyn (CHL) contributions were as follows: SB, DAK, PL and CHL designed the study; SB conducted the research, the data cleaning and statistical analysis. SB, DAK, PL, AS and CHL interpreted the data. SB drafted the manuscript and had primary responsibility for the final content. Alex Sutherland acquired funding to run the study. All authors read, critically revised, and approved the final manuscript. All analyses were devised in consultation with the departmental statistician.

objectives regarding the potential efficacy of the interventions remain unanswered. Some of these questions are addressed in the current hypothetical choice experiment. Although, due to the nature of pre-ordering (i.e., it requires a real canteen setting), it was not possible to test this aspect of the intervention, the current study was able to provide effect size estimates for the potential effect of offering swaps on total energy across lunches ordered. Furthermore, it was able to provide information on whether PACE information enhances intervention efficacy relative to offering swaps alone. Finally, this study provided an opportunity to explore whether a swap-based intervention could potentially bring energy ordered in the workplace for lunch into line with public health recommendations. Current guidance from Public Health England (2018c) encourages adults to consume no more than 600 calories (kcal) at lunch.

The current study used a large online sample of UK working adults to test the potential effect that offering swaps and pre-ordering might have on the energy ordered in a workplace canteen. The study explored whether lower-energy swaps offered across a full canteen menu including items such as hot meals or sandwiches would be accepted. And whether there was an added benefit of providing a tangible message with the prompt to swap by comparing the energy ordered by those offered swaps with no information and those offered swaps with PACE information.

8.1.1 Aims

The aim of this study was to test the effect of (i) offering lower-energy swaps, and (ii) offering lower-energy swaps with a PACE message, versus pre-ordering alone, on the total energy of items pre-ordered for lunch within the context of an experimental online workplace canteen.

8.2 Methods

8.2.1 Design and setting

This was a three-arm randomised controlled trial that was pre-registered with AsPredicted.org (ref: 56358 https://aspredicted.org/pw2qr.pdf) and was ethically approved by UCL's Research Ethics Committee (ref: 12861/005). The CONSORT checklist was used for reporting this study and is available in Appendix 8.1, Additional File 1. An adapted version of the online experimental canteen previously described in Chapter 7 was used for the current study. In the current study, participants could order from 6 instead of 9 menus which were: (1) main hot dishes (n=3); (2) jacket potatoes (n=10) (3) soup & sandwiches (n=15); (4) sweet snacks (n=18); (5) savoury snacks (n=20) and; (6) non-alcoholic drinks (n=18). Again, menu options were based on those from Bupa's canteen. Three menu categories (sides; panini & deli sandwiches and; salad-bar) were removed for the following reasons: (i) sides were included in the main meal options for ease of ordering; (ii) no swaps could be offered for panini & deli sandwiches in the real-world canteen due to practical reasons so this was omitted; and (iii) following advice from participants in the qualitative study (Chapter 8) swaps would not be offered for salad bar items going forward and so this menu was also omitted from the current study. In Bupa's canteen, main hot meal options change on a daily basis. To reflect this, the website was programmed with 5 days of hot dish options (i.e., 15 different hot dishes, 3 options per day for 5 days) and participants were randomly assigned to view and choose from the main hot meals (n=3) for 1 of 5 different days. Full menus can be found in Appendix 8.2, Additional File 1. An image of each menu item was published on the website and images of main hot meals were accompanied with a written description, in line with participant feedback provided in Chapter 7.

8.2.2 Participants

Participants were recruited through Prolific Academic in February 2021. To be eligible for the study, participants had to be ≥18 years, a UK resident, speak English fluently, and be in full or part-time employment. Those following restricted diets, e.g., vegetarian or dairy-

free, were ineligible, as this would affect the acceptability of swaps offered. Prolific Academic pre-screened participants on these criteria and sent invitations to eligible panel members. Potential participants could also access the study via a link published on the Prolific Academic dashboards of all eligible panel members. Participants could follow this link where they were able to confirm their eligibility, read the information sheet, and provide consent.

8.2.3 Randomisation & blinding

Simple randomisation was performed using Predictiv. Predictiv is a platform for running randomised controlled trials that was developed by the organisation sponsoring this PhD, The Behavioural Insights Team (Behavioural Insights Team LTD, 2021). The platform's randomisation functionality was used to assign participants evenly to 1 of 15 groups (i.e., 1 of 3 trial arms and 1 of 5 menus). The platform does this by assigning a random integer between 1 and 15 representing the 15 conditions. The platform ensures balance by ranking the conditions (1-15) by the number of participants who have already been allocated to each and assigning the next participant to one of the 7 conditions with the fewest participants.

Although I was not blind to intervention allocation, as all study procedures were automated I was not able to alter any aspects of the study following its launch. Due to the nature of the intervention, it was not possible to blind participants to the intervention. However, participants were only aware of the trial arm that they were exposed to and were unaware of the other trial arms and the primary aim of the trial until they were debriefed at the end of the study.

8.2.4 Online ordering task

Once participants had been randomised, they were directed to REDCap where they completed a question regarding their current subjective feeling of hunger. Given that (i) hunger and energy ordered are likely to be correlated and; (ii) participants could place their orders at any time of the day (e.g., after lunch), subjective feeling of hunger was

measured so that it could be adjusted for in an exploratory model testing the effect of the intervention on energy ordered. The measure was a single item taken from a longer scale used in previous research (Stubbs et al., 2000). The item asked “how hungry do you feel” and participants could respond using a visual analogue scale (VAS), which is a graphic slider scale anchored with the extremes of “not at all” (0) on the far left, and “extremely” (100) on the far right. Higher scores indicate higher-levels of hunger. The VAS is the recommended method of eliciting self-report data on subjective feelings (e.g., hunger, pain.) and has been used in previous studies to assess in-the-moment appetite (Purcell et al., 2014). Participants were then asked to imagine they worked for a company that had a pre-ordering website for their canteen and to order their lunch for the day using the website. They were told to make choices that were in keeping with what they would typically have for lunch during their working day (full task instructions can be found in Appendix 8.3, Additional File 1). All orders were hypothetical and so participants did not have to pay for their lunch. Lower-energy swaps were offered for menu items initially selected, if a suitable alternative was available.

8.2.5 Swaps offered

Swaps offered were determined using the criteria outlined in this section. To qualify as a swap, alternatives had to contain at least 50 kcal less than the originally selected item. This threshold was set because a minimum of 50kcal reduction per-person per-day has been identified as being clinically relevant (Hill et al., 2003). This minimum reduction of 50 kcal applied to all menus. The remaining criteria for swaps offered differed slightly for main hot dishes and the other menus. These criteria are described separately below.

a. Swap criteria for main hot dishes

To provide variety, main hot dishes served in Bupa’s canteen are dissimilar to each other. This meant that, although offering ‘within menu’ swaps ensures participants are offered a hot dish for a hot dish, swaps offered for these meals are completely different to the originally selected meal which may reduce swap acceptance. To maximise the potential acceptance of swaps offered, 2 swaps were offered for each main dish. The first swap

offered in the majority of cases was the hot dish with the lowest energy content on the menu (this was to address the wish for meaningful energy savings).[20] The second swap offered was either a jacket potato or an item from the soup and sandwich menu that was deemed to be similar to the originally selected item. Judgements regarding similarity were based on the main protein source in the dish. Where possible, the main protein source was matched. For example, a tuna sandwich was offered for haddock with crushed potatoes. Figure 8.1 outlines the decision process for offering swaps for main dishes. The decision to offer two swaps, one of which was the menu item yielding the largest potential energy savings was based on feedback from Bupa staff described at the end of Chapter 7.

b. Swap criteria for all other menus

For all items, except the main dishes, participants were offered 1 suggested swap immediately after making each selection. To ensure that swaps offered were as similar to the original selection as possible, swaps offered were from the same menu as the original selection. Again, similarity was usually based on matching the protein source. However, there were exceptions to this rule. These are detailed in Table 8.1 below in which the swap criteria for each menu category are outlined.

[20] A preference for matched perceived satiety was highlighted as potentially influencing swap acceptance in Chapter 8. Accounting for this in the current study was a challenge. It was hoped that by offering a main hot dish as a swap for a main hot dish (even if it was the lowest-energy option on the menu) might somewhat address this given that main hot meals in the canteen were similar portion sizes.

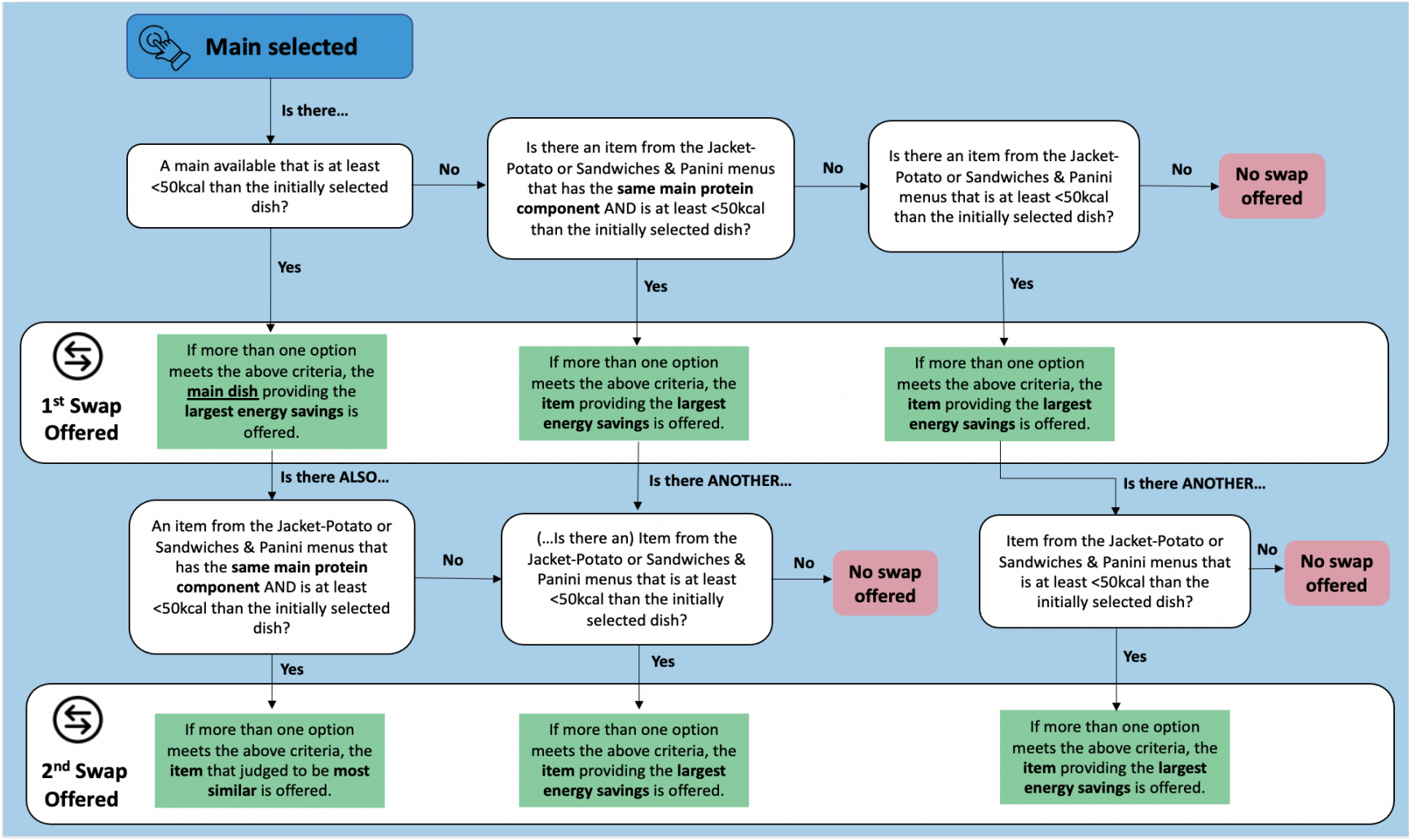


Figure 8.1: Flow diagram outlining the criteria for swaps offered for main dishes.

Table 8.1: Criteria for swaps offered by menu category

Menu	Criteria	Example of Swap Offered
Main meals (n=3)	See Figure 8.1	
Jacket Potatoes (n=10)	- Swaps offered are as close in nature to the originally selected item as possible. - Swaps offered are at least 50kcal less than the originally selected item. - For jacket potatoes, swaps offered usually involve the removal of one of the high energy toppings. - For sandwiches, the swap offered is the sandwich that has the same protein and is at least 50kcal lower. If not possible, the swap offered is the sandwich lowest in terms of calories. If not possible, soup is offered.	- A jacket potato with baked beans (384 kcal) for a jacket potato with baked beans and cheese (633 kcal).
Soup & Sandwiches (n=15)		- A smoked ham & mustard sandwich (262 Kcal) for a BLT (355 kcal).
Sweet snacks (n=18)	- Swaps offered are as close in nature to the originally selected item as possible. - Swaps offered are at least 50kcal less than the originally selected item.	- A strawberry yoghurt (141 kcal) for a granola and yoghurt pot (241 kcal).
Savoury snacks (n=20)		- A packet of Propercorn Sea Salted (87 kcal) for a packet of Walkers Ready Salted crisps (171 kcal)
Drinks (n=18)	- Swaps offered for drinks will almost always be the lower-energy version of the originally selected drink. - Where diet equivalents are unavailable or do not meet the criteria, swaps judged to be relatively close in flavour to the original item will be offered. - Swaps offered are at least 50kcal less than the originally selected item.	- Coke Zero (<1 kcal) for Classic Coca-Cola (210 kcal). - Fanta Zero (<1 kcal) for San Pellegrino orange flavour (129 kcal).

A lower-energy swap was available for 71% of options (Table 8.2). The energy contents of menu items were analysed by a registered dietitian using recipes provided by Bupa's catering company and energy information published on the supplier's website. Swaps were offered immediately after selection. Participants could decline or accept the swap for all menus except the main hot menu by clicking either "*No, I will stick with my choice*" or "*Yes, I would like to swap*". For the main hot menu (where 2 swaps were offered), participants could decline or accept the swaps offered by clicking: "*No, I will stick with my choice*", "*Yes, I would like to swap to [name of swap 1]" or* "*Yes, I would like to swap to [name of swap 2]".*

Table 8.2: Menu categories with examples of swaps offered, % swaps available, means (range) of energy content for all items offered in each category.

Menu	Examples of items offered	Initially selected item	Swap(s) offered	% Swaps available	Mean (range) energy of menu items
Main hot meal (n=3)	1. Beef lasagne (680 kcal) 2. Haddock with crushed potatoes, peas and broccoli (415 kcal) 3. Moroccan style tomato & chickpea pie, mixed leaf salad (591 kcal)	1. Beef lasagne, mixed leaf salad (680 kcal)	1. Haddock with crushed potatoes, peas and broccoli (415 kcal) 2. Beef, Horseradish & rocket sandwich (336 kcal)	100% (3/3)	595 kcal (415-831 Kcal)
Jacket potatoes (n=10)	1. Jacket potato with baked beans & cheese (633 kcal) 2. Jacket potato with tuna mayo (497 kcal)	1. Jacket potato with baked beans & cheese (633 kcal)	1. Jacket potato with baked beans (384 kcal)	80% (8/10)	478 kcal (275-728 kcal)
Soup & sandwich (n= 15)	1. Bacon Lettuce Tomato sandwich (355 kcal) 2. Chicken & stuffing sandwich (335 kcal) 2.Tomato and basil soup (235 kcal)	1. Bacon Lettuce Tomato sandwich (355 kcal)	1. Smoked ham & mustard sandwich (262 kcal)	80% (12/15)	350 kcal (235-449 kcal)
Sweet snacks (n=18)	1. Chocolate brownie (283 kcal) 2. Yoghurt (141 kcal) 3. Fruit salad (74 kcal)	1. Chocolate brownie (283 kcal)	1. Broderick's Chocolatey Solid Brick (217 kcal)	72% (13/18)	215 kcal (74-471 kcal)
Savoury snacks (n=20)	1. McCoys crisps (252 kcal) 2. Eat real chips (213 kcal) 3. Propercorn Popcorn (87 kcal)	1. McCoys Flame Grilled Steak (252 kcal)	1. Popchips BBQ (97 kcal)	75% (15/20)	173 kcal (87-261 kcal)
Drinks (n=18)	1. Oasis Summer Fruits (86 kcal) 2. Coca-cola (210 kcal) 3. Water (0 kcal)	1. Oasis Summer Fruits (86 kcal)	1. Oasis Summer Fruits Zero (17 kcal)	50% (9/18)	56 kcal (0-210 kcal)

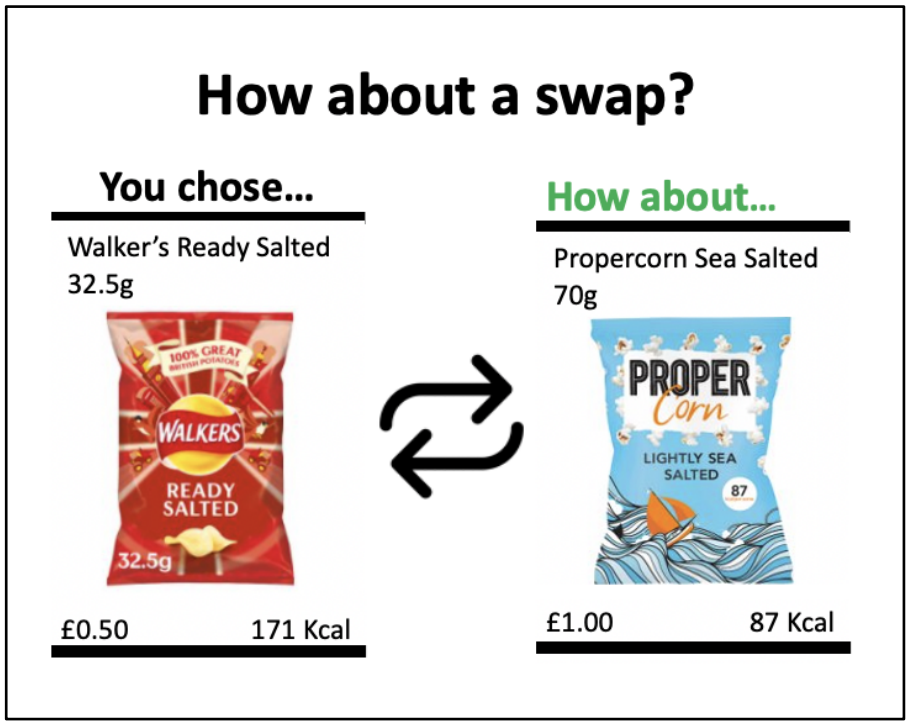
8.2.6 Interventions

Participants were randomly assigned to one of three conditions:

- Control: No swaps offered.
- Swaps: Swaps offered are accompanied by the message : “How about a swap?”
- Swaps+PACE: Swaps offered are accompanied by the message: “*How about a swap? Save [x] calories = [y] min walk”*.

In all conditions, both the price and energy content (in kcal) was displayed on the website beside each menu item. The addition of calorie-disclosures in all conditions was based on the feedback from participants described in Chapter 7. This meant that all participants, including the control group, had access to information on the calorie content of their choices and could calculate the energy difference between menu items if they so wished. In the conditions where swaps were offered, both the price and energy content of swaps offered were displayed. Figures 8.2 and 8.3 provide examples of how the energy content and the price of the swap item was presented in each condition. Prices were based on a price list for menu items that was provided to me by Bupa’s canteen manager. The PACE information was calculated using the method described in section 5.2.6 of Chapter 5.

(a)



(b)

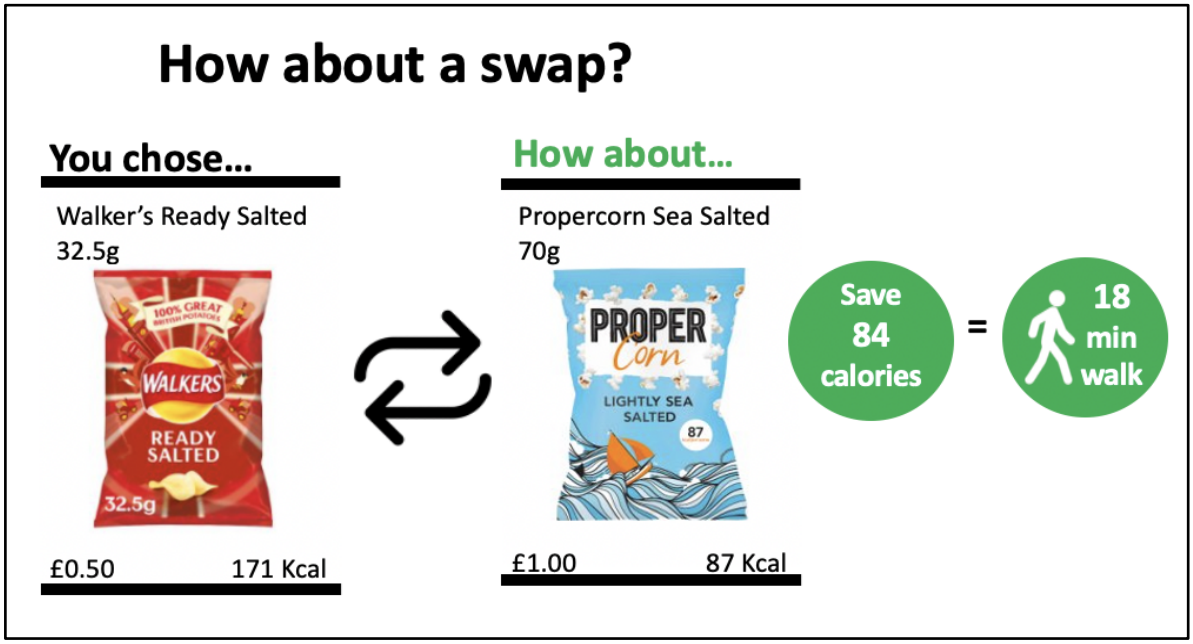


Figure 8.2: An example of the intervention when selecting a savoury snack in which 1 swap is offered, by condition. (a) the swaps condition; (b) the swaps+PACE condition.

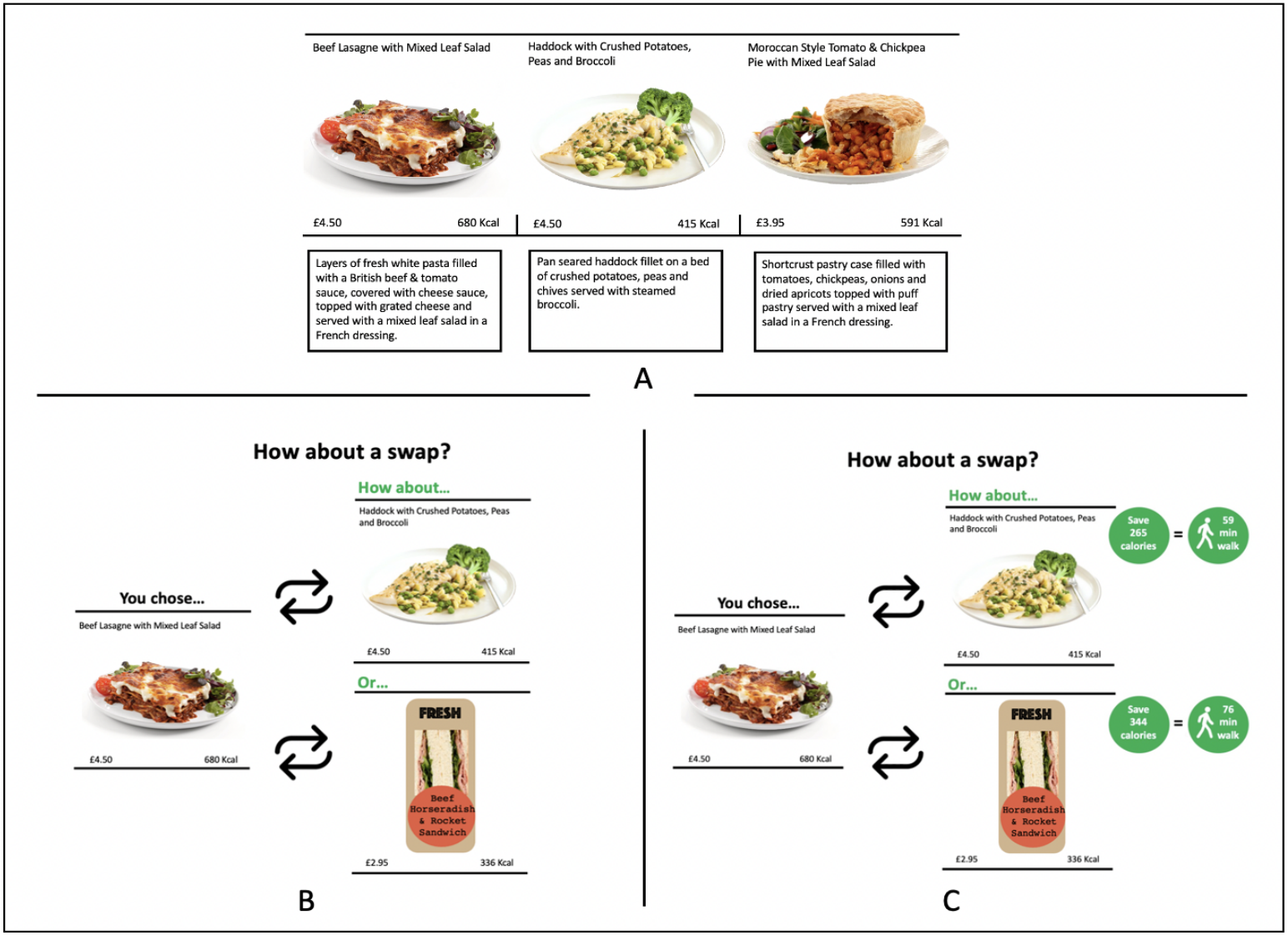


Figure 8.3: Intervention example: (A) Main meal menu day 1; (B) swaps condition; (C) swaps+PACE condition.

8.2.7 Post-trial survey

The post-trial survey (available in Appendix 8.4, Additional File 1) was used to assess the following:

a. Attention to task

The first question on the post-trial survey was an attention check. Participants in the two intervention groups were asked to indicate whether or not they had been offered a swap.

b. Acceptability

Acceptability was assessed by asking participants the extent to which they felt it would be acceptable for their employer to: (a) implement a pre-ordering system for their workplace canteen and; (b) offer them swaps for their food choices. Only those in the intervention groups were asked question (b). Response options were as follows: 1= completely unacceptable, 2= unacceptable, 3= neither acceptable nor unacceptable, 4= acceptable, 5= completely acceptable. No questions about excessive calorie counting or excessive exercise were asked due to time constraints.

c. Demographic characteristics

Participants then answered questions relating to their characteristics on the following measures: (i) dietary restraint, (ii) physical activity and; (iii) Body Mass Index (BMI).

(i) A shortened version of The Dietary Intent Scale (DIS) was used to assess dietary restraint. The DIS is a nine-item measure created by Stice et al., (1998) based on the Dutch Restrained Eating Scale (DRES; Van Strien et al., 1986). The scale is internally ($\alpha = 0.94$) and temporally reliable (1-month test-retest = 0.92). Due to time constraints, the scale was reduced to 3 items. The scale was shortened by assessing the correlation between items (using the data from Chapter 5 in which participants completed the full scale), removing highly correlated items and then checking Cronbach's alpha. The Cronbach's alpha remained high after retaining 3 key items (highlighted below) at $\alpha = 0.81$. Response options were: 1= Never, 2= Seldom, 3= Sometimes, 4= Often, 5= Always. Higher scores indicated more dietary restraint (score range = 3-15).

The Dietary Intent Scale

Please choose the response that best describes your eating behaviour in the past 6 months:

1. I take small helpings in an effort to control my weight
2. I hold back at meals in an attempt to prevent weight gain
3. **I limit the amount of food I eat in an effort to control my weight (retained)**
4. I sometimes avoid eating in an attempt to control my weight
5. I skip meals in an effort to control my weight
6. I sometimes eat only one or two meals a day to try to limit my weight
7. I eat diet foods in an effort to control my weight
8. **I count calories to try to prevent weight gain (retained)**
9. **I eat low-calorie foods in an effort to avoid weight gain (retained)**

(ii) Physical activity was assessed using the Scottish Physical Activity Screening Questionnaire (Scot-PASQ) (Physical Activity Health Alliance, 2013). The tool was developed and validated by National Health Service Scotland in partnership with The University of Edinburgh. The tool has up to 2 questions depending on answers provided. The first question asks: “How many days in the past week have you been physically active for a total of 30 minutes or more?”. Participants responding four days or less are asked the following second question: “Have you been physically active for at least two and a half hours (150 minutes) over the course of the past week?” Yes/No. Those answering 5, 6 or 7 days to question 1 or those answering, ‘yes’ to question 2 were categorised as “meeting guidelines”.

(iii) BMI: Participants were asked to indicate their height (in centimetres or feet and inches) and their weight (in kilograms or stones and pounds). BMI was calculated by dividing the weight in kg by height in meters squared.

Finally, participants provided demographic information including: age, gender, ethnicity, and highest level of education completed. Upon completion, participants were debriefed and reimbursed with £0.50.

8.2.8 Outcome measures & statistical analysis

To be included in the analysis, participants had to order at least one food item, not order from all 6 menu categories (i.e., mains, sandwiches, jackets, sweet, savoury, drinks) because this was deemed to be an unrealistic amount of food for lunch), and complete the checkout. An intention-to-treat approach was taken whereby the 19 participants (1%) across the treatment groups who were offered no swaps (because they selected the lowest-energy items on all the menu categories from which they ordered) were included in the analysis. Table 8.4 presents the study outcomes and corresponding methods of statistical analyses employed. The analysis of secondary outcome (a) (swap acceptance) was pre-registered as swap acceptance on a scale from 0-6, however, as those ordering from all 6 menus (i.e., all categories within 1 daily menu) were excluded as improbable values, the scale ranged from 0-5 swaps accepted.

A Benjamini-Hochberg (BH) correction (Benjamini & Hochberg, 1995) was used to adjust the $p<0.05$ significant level for multiple comparisons in the ANCOVA and regression models. The BH procedure has been shown to adequately control the alpha level when making multiple comparisons for tests with positively correlated dependent variables (Center for Biologics Evaluation and Research, 2017). A worked example is provided below.

Example: in the current 3-arm RCT (1 control group, 2 treatment groups) with 1 primary outcome 3 statistical tests will be conducted, as we compare each of the 2 treatment coefficients against the control coefficient and against one another. Suppose the 3 statistical tests produce *p*-values of: **H1: 0.06; H2: 0.015; H3: 0.005.** These values are ranked in increasing order, and compared. Table 8.3 below describes this process

Table 8.3: Benjamini-Hochberg p-value threshold procedure

#	p-value	Original significance threshold	New significance threshold	p-value < new significance threshold?
1	0.005	0.05	0.05*(1/3) = 0.017	Yes
2	0.015	0.05	0.05*(2/3) = 0.033	Yes
3	0.06	0.05	0.05*(3/3) = 0.05	No

The lowest p-value (0.005) must be < 0.017 to be accepted (which it **is**)
The 2nd lowest must be < 0.033 to be accepted (which it **is**)
The 3rd lowest must be < 0.05 to be accepted (which it **isn't**) – everything thereafter would also be rejected.

The BH correction was employed instead of the previously used Bonferroni correction for pragmatic reasons. Bonferroni is the most conservative approach and requires a larger sample size to be recruited than the BH method (please see section 8.2.9). Mean differences or odds ratios (OR) with 95% confidence intervals (CI) were used to report estimates of comparative effectiveness. Standardised effect sizes reported for means are Cohen's *d*. The square root of the mean squared error was used as the estimate of the pooled standard deviation in the effect size calculations reported (Becker, p.14, 2000). Statistical analyses were conducted in Stata (version 16) (Stata Corp, 2019) or SPSS (version 25) (IBM Corp, 2017).

Table 8.4: Study outcome measures and methods of statistical analysis employed.

Outcome measure	**Statistical analysis**	**Benjamini-Hochberg corrected p-value threshold**
Primary outcome		
(a) The total energy (kcal) of items ordered.	● One ANCOVA with post-hoc tests controlling for the energy content of the initial item ordered, with Fisher's least significant difference (LSD) post-hoc tests. ● DV: Total energy (in kcal) content of items finally ordered ● IV: Intervention group (3 categories: Control, Swaps, Swaps+PACE) ● Covariate: Energy (in kcal) content of the first item ordered. ● The 3 comparisons were: Control v Swaps; Control v Swaps+PACE; Swaps v Swaps+PACE. ● The above analysis was also conducted for each of the 6 menu categories separately, controlling for the energy content of the initially ordered item on each menu.	● 3 comparisons - First p-value must be <0.017 - Second p-value must be <0.033 - Third p-value must be <0.05
Secondary outcome		
(a) The number of swaps accepted (restricted to the groups being offered swaps) controlling for the number of	● One ordinal logistic regression controlling for the number of swaps offered. ● DV: Number of swaps accepted (0,1,2,3,4,5)	● 1 comparison ($p<0.05$)

swaps offered.	● IV: Intervention group (2 categories: Swaps, Swaps+PACE) ● Covariate: Number of swaps offered (0,1,2,3,4,5) ● The 1 comparison was: Swaps v Swaps+PACE.	
(b) The proportions of participants ordering a lunch that meets the Public Health England (PHE, 2018c) guideline of containing 600 kcal or less.	● One binary logistic regression ● DV: Order contains ≤600 kcal (yes/no) ● IV: Intervention group (3 categories: Control, Swaps, Swaps+PACE) ● The 3 comparisons were: Control v Swaps; Control v Swaps+PACE; Swaps v Swaps+PACE.	● 3 comparisons - First p-value must be <0.017 - Second p-value must be <0.033 - Third p-value must be <0.05
(c) Likert scale ratings of intervention acceptability for: (i) pre-ordering (all groups) and; (ii) the swaps feature (intervention groups only).	● (i) This was analysed descriptively only. The proportion of participants in each group rating pre-ordering as acceptable (rating of 4 or 5) and unacceptable (1 or 2) was reported. ● (ii) Ordinal logistic regression ● DV: Acceptability of the swaps feature was modelled as an ordinal measure including Likert scale ratings of 1,2,3,4,5 as separate groups. ● IV: Intervention group (2 categories: Swaps, Swaps+PACE) ● The 1 comparison was: Swaps v Swaps+PACE.	● 1 comparison (p<0.05)
Exploratory outcome		

(a) Interaction analyses examining differences in intervention effects (for the primary outcome - total energy content of items ordered) by each of the following variables: gender, age, ethnicity, education, BMI, physical activity level, dietary restraint, and hunger.	• Two-way ANCOVA with post-hoc test, interaction terms between interventions (swaps and swaps+PACE) and the following variables: gender (male vs female), age (median age or above vs below median age), ethnicity (white vs non-white), education (Up to College/A-levels vs undergraduate or higher), BMI (≥30kg/m^2 vs <30), physical activity level (meeting guidelines vs not meeting guidelines), dietary restraint (median score or above vs below the median), and hunger (median score or above vs below the median). A separate model was conducted for each interaction term. Control was the reference category in all models and Fisher's least significant difference (LSD) post-hoc tests were used. • DV: Total energy (in kcal) content of items finally ordered • IV: Intervention group (3 categories: Control, Swaps, Swaps+PACE) • Covariate: Energy (in kcal) content of the first item ordered. • The 2 comparisons were: Control v Swaps; Control v Swaps+PACE	• 2 comparisons - First p-value must be <0.025 - Second p-value must be <0.05
(b) The effect of price difference between the initially selected item and the swap offered on swap acceptance by intervention groups (restricted only	• Multilevel logistic regression with an interaction term for intervention and price difference. Analysis was conducted at the 'swap-level' and clustering was used to indicate that observations may be correlated within	• 1 comparison (p<0.05)

to groups being offered swaps).	each participant but would be independent between participants. Robust standard errors were used to account for potential heterogeneous effects. For main hot meals where two swaps were offered, price difference was calculated using the price of the swap that was accepted. Where no swap was accepted, the average price difference for the two different swaps offered was used. ● DV: Swap accepted (yes/no) ● IV: Intervention group (2 categories: Swaps, Swaps+PACE) ● The 1 comparison was: Swaps v Swaps+PACE.	
(c) The acceptance of swaps offered (restricted to the groups being offered swaps), separately for each of the 6 categories: (i) main meals; (ii) jacket potatoes; (iii) soup & sandwiches; (iv) sweet snacks; (v) savoury snacks and; (vi) drinks.	● Binary logistic regression ● DV: Swap accepted (yes/no) ● IV: Intervention group (2 categories: Swaps, Swaps+PACE) ● The 1 comparison was: Swaps v Swaps+PACE.	● 1 comparison ($p<0.05$)

Note: IV = Independent Variable and DV= Dependent Variable.

8.2.9 Sample size

A power calculation was conducted for the primary outcome; the difference in energy (kcal) ordered between each of the trial arms (Table 8.5). The power calculations account for the BH correction. As it is not possible to apply the Benjamini-Hochberg (BH) correction before having the actual data, the following steps were taken. First, an uncorrected ($p<0.05$) calculation was conducted, which provided an upper bound on power. Then, a calculation using the Bonferroni correction ($p<0.017$), which provides a lower bound. Power using the BH correction will lie somewhere between these two bounds. In this study, the maximum number of comparisons made will be 3.

The minimum detectable effect size (MDES) was initially set at a 35-40kcal reduction. While a 50kcal reduction would be a clinically relevant calorie reduction for adults (Hill et al., 2003), the MDES was reduced to 35-40kcal because the relative effect between the experimental arms was expected to be smaller than the effect between the experimental arms and control. Reducing the MDES to 35-40kcal will allow for the detection of this reduction if present. Baseline (mean 423kcal & SD; 236kcal) energy estimates were taken from a Pilot RCT conducted in 6 workplace canteens across the UK (Vasiljevic et al., 2018).

Based on the input outlined above, the required total sample size was 2,214 to detect a ~35 kcal change in energy ordered at an alpha level of 0.05 (an uncorrected analysis) or a 40kcal difference at an alpha level of 0.017 (Bonferroni). A final sample of n= 2,453 was recruited to account for 10% attrition (2,214 + 221). Sample size calculations were completed using Stata version 16 (Stata Corp, 2019).

Table 8.5: Sample size estimates for the primary outcome (energy ordered) based on a range of energy-reductions with upper, middle, and lower bounds for required n. NB: The "in budget" colour coding excludes the budget that was available to account for 10% attrition.

Av Energy Reduction	N per arm	Total n	In Budget	N per arm	Total n	In Budget	N per arm	Total n	In Budget
	Upper Bound (P<0.05)			Middle (P<0.033)			Lower Bound (P<0.017)		
30kcal	973	**2919**	No	1,096	**3,288**	No	1505	**4515**	No
31kcal	911	**2733**	No	1,027	**3,081**	No	1227	**3681**	No
32kcal	855	**2565**	No	964	**2,892**	No	1151	**3453**	No
33kcal	804	**2412**	No	906	**2,718**	No	1083	**3294**	No
34kcal	758	**2274**	No	854	**2,562**	No	1020	**3060**	No
35kcal	715	**2145**	Yes	806	**2,418**	No	963	**2889**	No
36kcal	676	**2028**	Yes	762	**2,286**	No	910	**2730**	No
37kcal	640	**1920**	Yes	721	**2,163**	Yes	862	**2586**	No
38kcal	607	**1821**	Yes	684	**2,052**	Yes	817	**2451**	No
39kcal	576	**1728**	Yes	649	**1,947**	Yes	776	**2328**	No
40kcal	548	**1644**	Yes	617	**1,851**	Yes	738	**2214**	Yes

8.3 Results

A subsample of a pool of 17,773 eligible panel members received invitations to participate. Of those invited, 2,477 panel members consented and were equally randomly assigned to 1 of 3 conditions. Of these participants, 87% followed the instructions and completed the study; these 2,150 participants were included in the analysis (Figure 8.4).

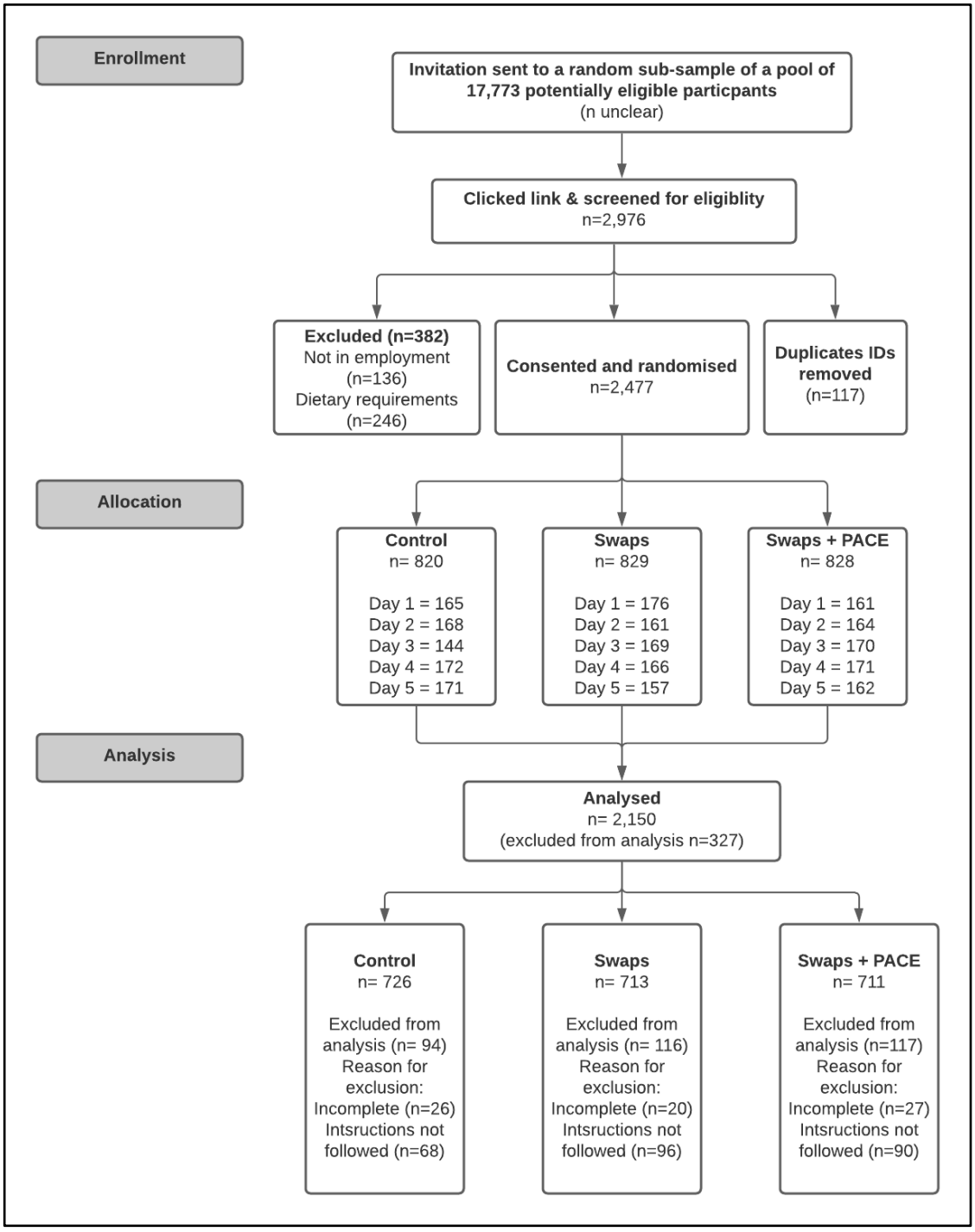


Figure 8.4: CONSORT flow diagram.

Table 8.6 displays the baseline characteristics of participants. Just over half of the sample was female (54.2%). Participants were on average 36.8 years of age (SD = 11.6). The majority (80%) of the sample identified as white and half (51%) had completed tertiary-level education. The study took 8.2 (SD= 3.18) minutes to complete on average, and attention checks indicated high levels of task engagement (Appendix 8.5, Additional File 1).

Table 8.6: Baseline characteristics of participants

	Control (n= 726)	**Swaps (n= 713)**	**Swaps+PACE (n= 711)**	**Total (n= 2,150)**
Age, *years*,	36.5 ± 11.5	36.8 ± 11.9	37.2 ± 11.5	36.8 ± 11.6
Gender, *female*	380 (52.3)	387 (54.3)	397 (55.8)	1,164 (54.2)
Ethnic group				
White	576 (79.3)	587 (82.3)	560 (78.8)	1,723 (80.1)
Mixed/Other	57 (7.9)	43 (6.0)	47 (6.6)	147 (6.8)
Asian/Black	88 (12.1)	79 (11.1)	102 (14.3)	269 (12.5)
Prefer not to say	5 (0.7)	4 (0.6)	2 (0.3)	11 (0.5)
Education				
None to Secondary	352 (48.5)	357 (50.1)	337 (47.4)	1046 (48.7)
Undergraduate degree	238 (32.8)	237 (33.2)	235 (33.1)	710 (33.0)
Graduate & higher	136 (18.7)	115 (16.1)	135 (18.9)	386 (17.9)
Prefer not to say	0	4 (0.6)	4 (0.6)	8 (0.4)
Anthropometry				
Weight, kg	77.4 ± 19.0	77.1 ± 18.0	76.9 ± 18.5	77.1 ± 18.5
BMI, kg/m2	26.2 ± 5.6	26.3 ± 5.5	26.3 ± 5.6	26.3 ± 5.6
BMI <30	577 (79.5)	558 (78.3)	553 (77.8)	1,688 (78.6)
BMI ≥30	148 (20.4)	147 (20.6)	153 (21.5)	447 (20.8)
Prefer not to say	1 (0.1)	8 (1.1)	5 (0.7)	14 (0.7)
Physical activity				
Meeting guidelines	454 (62.5)	433 (60.7)	443 (62.3)	1,330 (61.9)
Not meeting guidelines	272 (37.5)	279 (39.3)	268 (37.7)	819 (38.1)
Prefer not to say	0	1 (0.1)	0	1 (0.1)
Hunger score (range: 1-100)	53.8 ± 24.7	52.0 ± 24.3	53.1 ± 24.0	52.9 ± 24.3
Dietary restraint (range: 0-15)	7.5 ± 2.8	7.9 ± 2.8	7.6 ± 2.7	7.7 ± 2.8
Average energy (kcal) content of first item ordered	474 ± 184	459 ± 175	458 ± 172	464 ±177

NOTE: PACE: Physical Activity Calorie Equivalent; BMI; Body Mass Index. Physical activity: meeting guidelines = 150 minutes per week of exercise based on the SCOTPAQ screening questionnaire. Higher scores in hunger and dietary restraint indicate higher hunger and restraint, respectively. The average energy (kcal) content of the first item ordered reported is the covariate that is used in the ANCOVA for the primary analysis. Average energy (kcal) content of first item ordered refers to item select before swaps were offered.

8.3.1 Primary outcome: Total energy ordered

Participants ordered from 3 (SD=0.91) categories within each daily menu on average. The energy content of lunch orders ranged from 226 kcal to 2,336 kcal and the average energy content was 781 kcal (SD= 315 kcal). Those in both intervention groups ordered significantly less energy than the control group [control mean = 819 kcal], the swaps group by -47 kcal [95%CI: -75 to -19, p=0.001], and the swaps+PACE group by -66 kcal [95%CI: -94 to -38, p<0.001] (Figure 8.5, standardised effect sizes can be found in Table 8.7). The difference in the average energy content of final lunches ordered between intervention groups was not statistically significant [-19 kcal, 95%CI: -47 to 10, p=0.197]. Pairwise comparisons for mean energy ordered (and 95% confidence intervals) from each menu by condition are displayed in Figure 8.6 (standardised effect sizes can be found in Table 8.8).

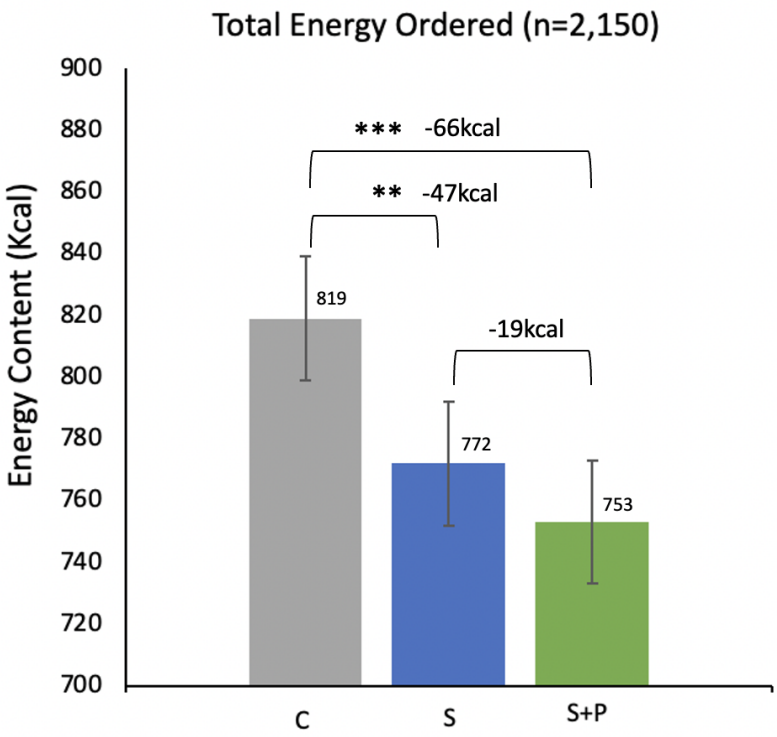


Figure 8.5: Means and 95% confidence intervals for total energy ordered (adjusted for energy content of first item ordered) with BH-adjusted p-values: Meets BH threshold*, p<0.01**, p<0.001***. C=Control; S=Swaps; S+P=Swaps+PACE.

Table 8.7: Standardised effect sizes (Cohen's d) for differences in total energy ordered controlling for energy content of first item ordered (464 kcal) by intervention allocation (n=2,150). Non-adjusted p-values presented with an indication * of statistical significance at BH adjusted threshold.

Group Comparison	***Mean Difference (95% CI)***	***Pooled SD***	***P-Value***	***Effect Size (d)***
Swaps (n=713) v Control (n=726)	- 47 (-75 to -19)	271	0.001*	0.19
Swaps+PACE (n =711) v Control (n=726)	-66 (-94 to -38)	271	<0.001*	0.26
Swaps+PACE (n=711) v Swaps (n=713)	-19 (-47 to 10)	271	0.197	0.07

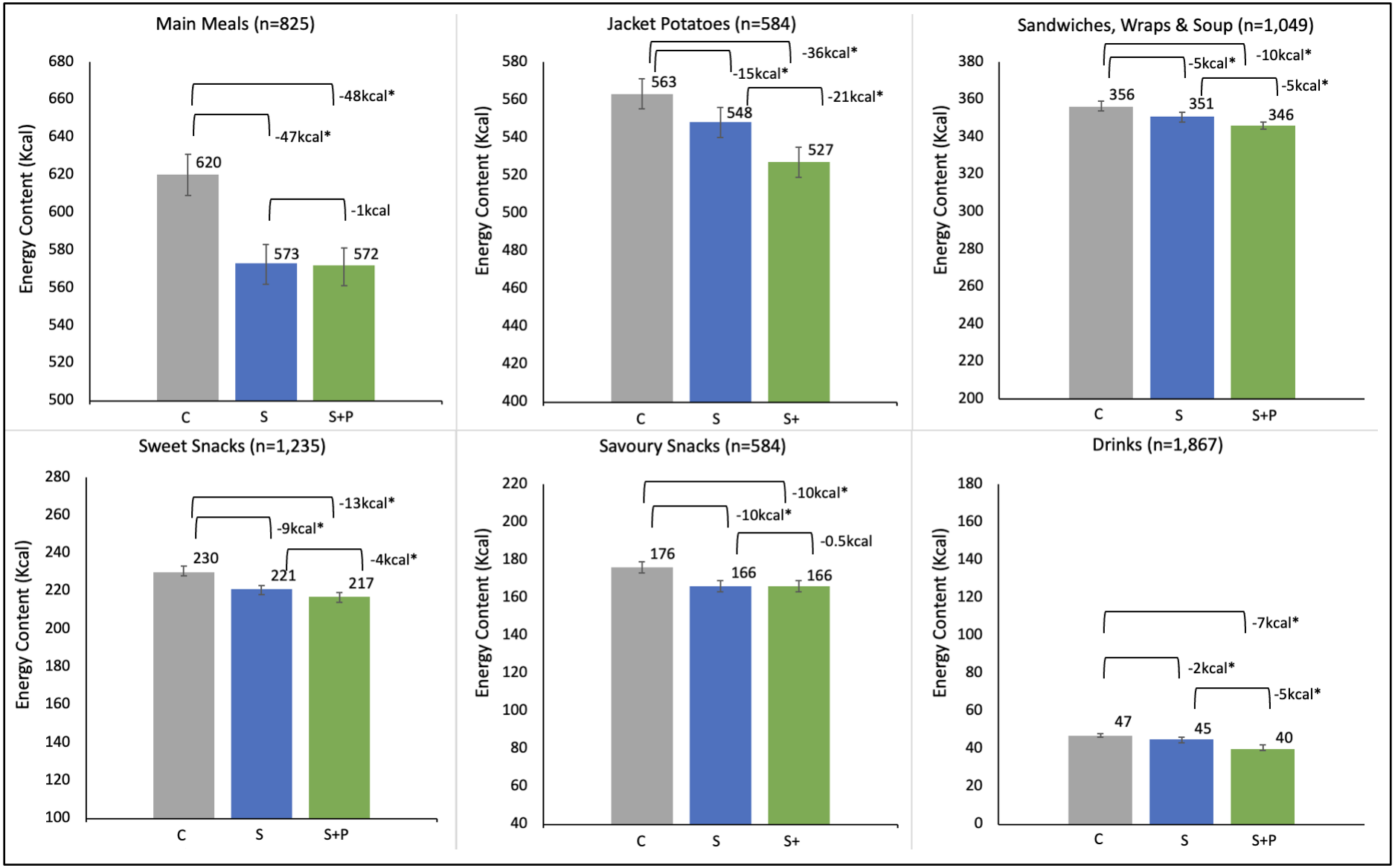


Figure 8.6: Means and 95% confidence intervals for energy ordered (adjusted for energy of the initially selected item in each category) with BH-adjusted p-values: *Meets BH threshold. C= control; S= swaps; S+P= swaps+PACE. n = the total number of items ordered from that category across all 3 arms.

Table 8.8: Standardised effect sizes for mean differences in energy ordered between groups for each menu controlling for energy content of the initial item ordered in each menu category. Non-adjusted p-values presented with an indication * of statistical significance at BH adjusted thresholds. Cohen's *d* Effect sizes are also presented.

	Main Meals				***Jacket Potatoes***				***Sandwiches, Wraps & Soup***			
Group Comparison	*Mean Difference (95% CI)*	*Pooled SD*	*P-Value*	*Effect Size (d)*	*Mean Difference (95% CI)*	*Pooled SD*	*P-Value*	*Effect Size (d)*	*Mean Difference (95% CI)*	*Pooled SD*	*P-Value*	*Effect Size (d)*
Swaps v Control	-47 (-63 to -33)	89	<0.001	0.53	-15 (-26 to -4)	56	0.010	0.27	-5 (-8 to -2)	22	0.004	0.23
Swaps+PACE v Control	-48 (-63 to -33)	89	<0.001	0.54	-36 (-47 to -25)	56	<0.001	0.64	-10 (-13 to -6)	22	<0.001	0.45
Swaps+PACE v Swaps	-1 (-15 to 14)	89	0.938	0.01	-21 (-33 to -10)	56	<0.001	0.38	-5 (-8 to -1)	22	0.005	0.23
	Sweet Snacks				***Savoury Snacks***				***Drinks***			
Group Comparison	*Mean Difference (95% CI)*	*Pooled SD*	*P-Value*	*Effect Size (d)*	*Mean Difference (95% CI)*	*Pooled SD*	*P-Value*	*Effect Size (d)*	*Mean Difference (95% CI)*	*Pooled SD*	*P-Value*	*Effect Size (d)*
Swaps v Control	-9 (-13 to -6)	25	<0.001	0.36	-10 (-14 to -5)	25	<0.001	0.40	-2 (-4 to -0.7)	17	0.008	0.12
Swaps+PACE v Control	-13 (-17 to -10)	25	<0.001	0.52	-10 (-14 to -5)	25	<0.001	0.40	-7 (-9 to -5)	17	<0.001	0.41
Swaps+PACE v Swaps	-4 (-7 to -0.6)	25	0.021	0.16	-0.5 (-5 to 4)	25	0.798	0.02	-5 (-6 to -2)	17	<0.001	0.29

Note: Sample sizes were as follows: Main Meals: Control (n=253); Swaps (n=277); Swaps+PACE (n=295). Jacket Potatoes: Control (n=195); Swaps (n=192); Swaps+PACE (n=197). Sandwiches: Control (n=381); Swaps (n=345); Swaps+PACE (n=323). Sweet Snacks: Control (n=435); Swaps (n=403); Swaps+PACE (n=397). Savoury Snacks: Control (n=319); Swaps (n=282); Swaps+PACE (n=291). Drinks: Control (n=629); Swaps (n=611); Swaps+PACE (n=627). Control values for initial content energy were as follows: Main Meals: 290 kcal; Jacket Potatoes: 562 kcal; Sandwiches: 356 kcal; Sweet Snacks: 230 kcal; Savoury Snacks: 176 kcal; Drinks 47 kcal.

8.3.2 Secondary outcomes

a. Swap acceptance

At least one lower energy swap was offered to almost all (99%) intervention participants while placing their lunch order. Of the 2,936[21] swaps offered, 413 (14%) were accepted overall. The swaps acceptance rate for swaps offered within each menu by intervention group is shown in Table 8.9. The swaps+PACE intervention significantly increased the odds of a swap being accepted, when controlling for the total number of swaps offered, compared to the swaps only intervention [OR: 1.63, 95%CI: 1.27 to 2.09, p<0.001].

Table 8.9: Number (%) of participants offered and accepting swaps within each menu by intervention group (n=1,424).

	Mains	Jackets	Sandwiches	Sweet	Savoury	Drinks
Swaps (n=713)						
Swaps offered n (%)	277 (39%)	184 (26%)	290 (41%)	276 (39%)	221 (31%)	234 (33%)
Swaps accepted n (%)	52 (23%)	13 (7%)	17 (6%)	42 (15%)	26 (12%)	16 (7%)
Swaps+PACE (n=711)						
Swaps offered n (%)	295 (41%)	184 (26%)	273 (38%)	261 (37%)	213 (30%)	228 (32%)
Swaps accepted n (%)	54 (18%)	32 (17%)	32 (12%)	60 (23%)	26 (12%)	43 (19%)
Total offered	572*	368	563	537	434	462
Total accepted	106 (20%)	45 (12%)	49 (9%)	102 (19%)	52 (12%)	59 (13%)

Note: Swaps offered is the number (%) of participants in each intervention group that were offered a swap on a given menu. Swaps accepted is the number (%) of participants that accept a swap out of those offered a swap on a given menu. *People were offered 2 swaps for main meals (total swaps offered = 572 x 2).

[21] Although 2 swap options were offered for main meals, this figure counts these options as 1 swap offered given that only 1 swap could be accepted.

b. Meeting public health recommendations

The proportion of participants who ordered a lunch meeting Public Health England's (2018c) energy intake recommendation was 26% in the control condition, 31% in the swaps condition and 36% in the swaps+PACE condition. Both the swaps [OR 1.28, 95%CI 1.02 to 1.61, p=0.0326] and the swaps+PACE [OR: 1.57, 95%CI: 1.25 to 1.96, p<0.001] groups were significantly more likely to order lunches meeting these energy guidelines. Those in the swaps+PACE group were not significantly more likely to meet guidelines than those in the swaps group [OR: 1.22, 95%CI: 0.98 to 1.52, p=0.076].

c. Intervention acceptability

Intervention acceptability was high with 92% of participants agreeing that it would be acceptable for their employer to implement a pre-ordering system for their workplace canteen. Among those in the intervention groups, 65% agreed that being offered swaps for their food choices while pre-ordering would be acceptable (Figure 8.7).[22] Those in the swaps+PACE condition were significantly more likely to perceive the intervention as acceptable (OR: 1.32, 95%CI: 1.09 to 1.60, p<0.004) than those in the swaps only condition.

8.3.3 Exploratory outcomes

(a) Moderation analysis

There was some evidence of main effects of demographic characteristics, with those who identify as white (-60 kcal, *d*=0.22), those above the median age (-104, *d*=0.39), those who score higher on dietary restraint (-71 kcal, *d*=0.24) and lower on momentary hunger (-37 kcal, *d*=0.14) ordering less energy on average. However, there was no evidence that the intervention effect differed by gender, age, ethnicity, education, BMI, physical activity level, dietary restraint, or hunger (all $p_{interaction}$>0.05, Figure 8.8).

[22] The acceptability of prompts to swap was not investigated among control group participants.

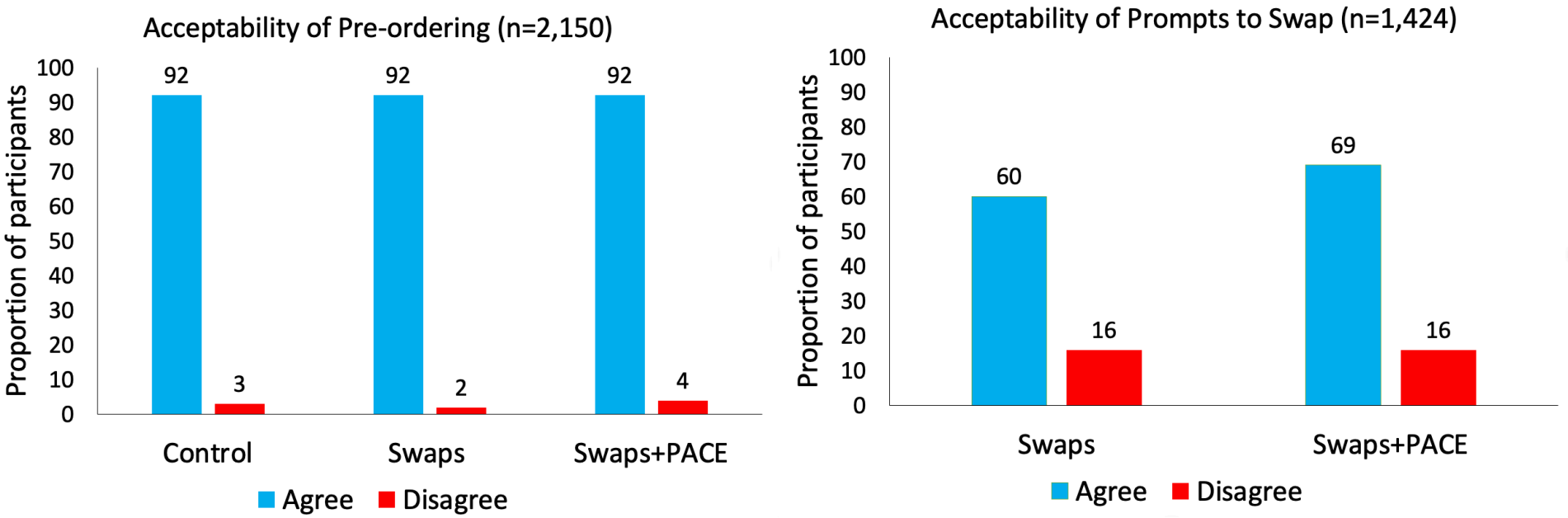
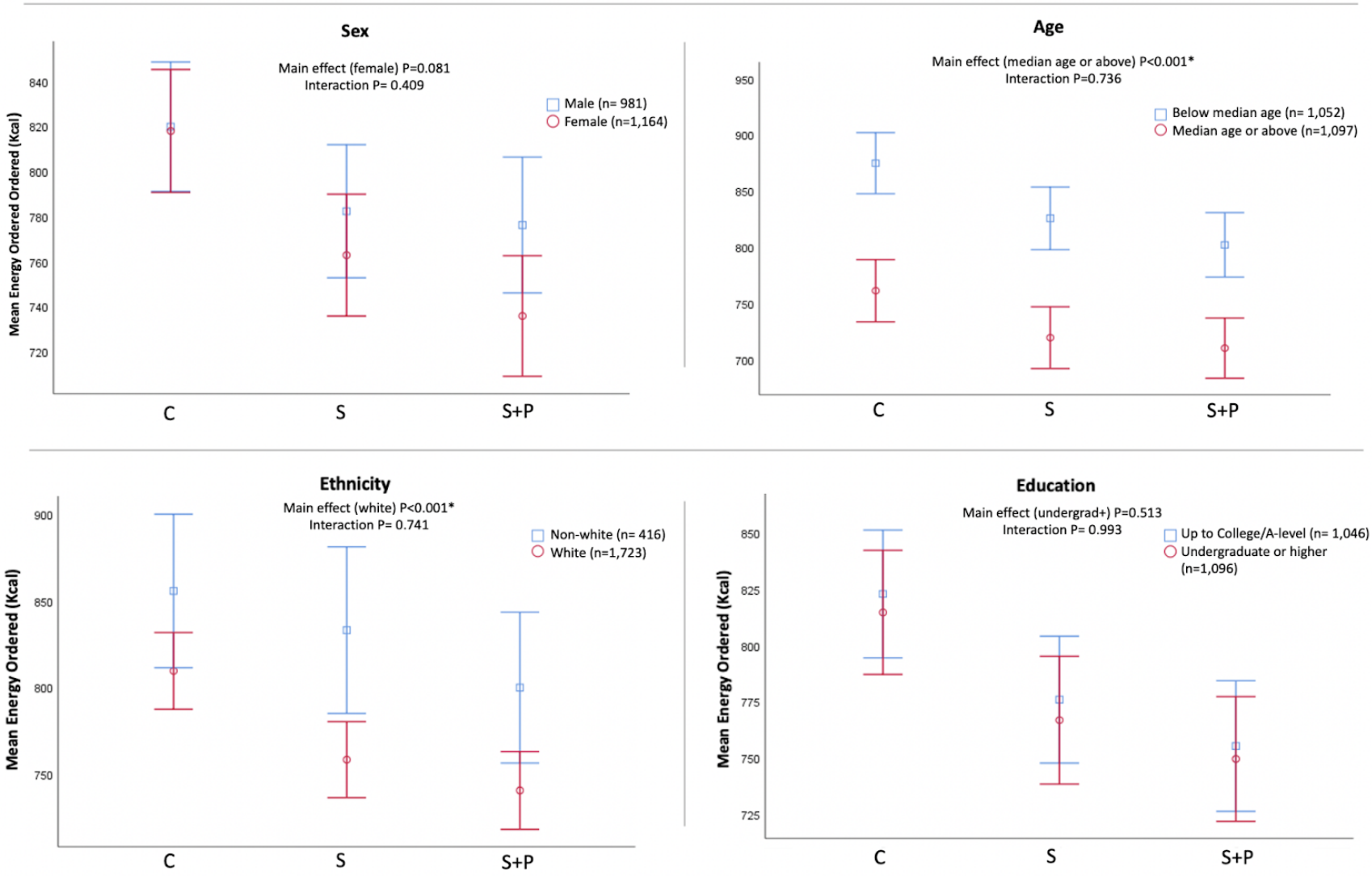


Figure 8.7: Proportion of participants in each group responding 'acceptable' (ratings of 4 or 5) and 'unacceptable' (ratings of 1 or 2) to the statements (1) "How acceptable do you think it would it be for your employer to implement a pre-ordering system for your workplace canteen like the one you have just used? And; (2) "How acceptable do you think it would be for your employer to offer you swaps for your food choices in your workplace canteen?"


Sex
Main effect (female) P=0.081
Interaction P= 0.409
Male (n= 981)
Female (n=1,164)
Mean Energy Ordered Ordered (Kcal)
840
820
800
780
760
740
720
C
S
S+P
Age
Main effect (median age or above) P<0.001*
Interaction P=0.736
Below median age (n= 1,052)
Median age or above (n=1,097)
950
900
850
800
750
700
C
S
S+P
Ethnicity
Main effect (white) P<0.001*
Interaction P= 0.741
Non-white (n= 416)
White (n=1,723)
Mean Energy Ordered (Kcal)
900
850
800
750
C
S
S+P
Education
Main effect (undergrad+) P=0.513
Interaction P= 0.993
Up to College/A-level (n= 1,046)
Undergraduate or higher (n=1,096)
Mean Energy Ordered (Kcal)
850
825
800
775
750
725
C
S
S+P

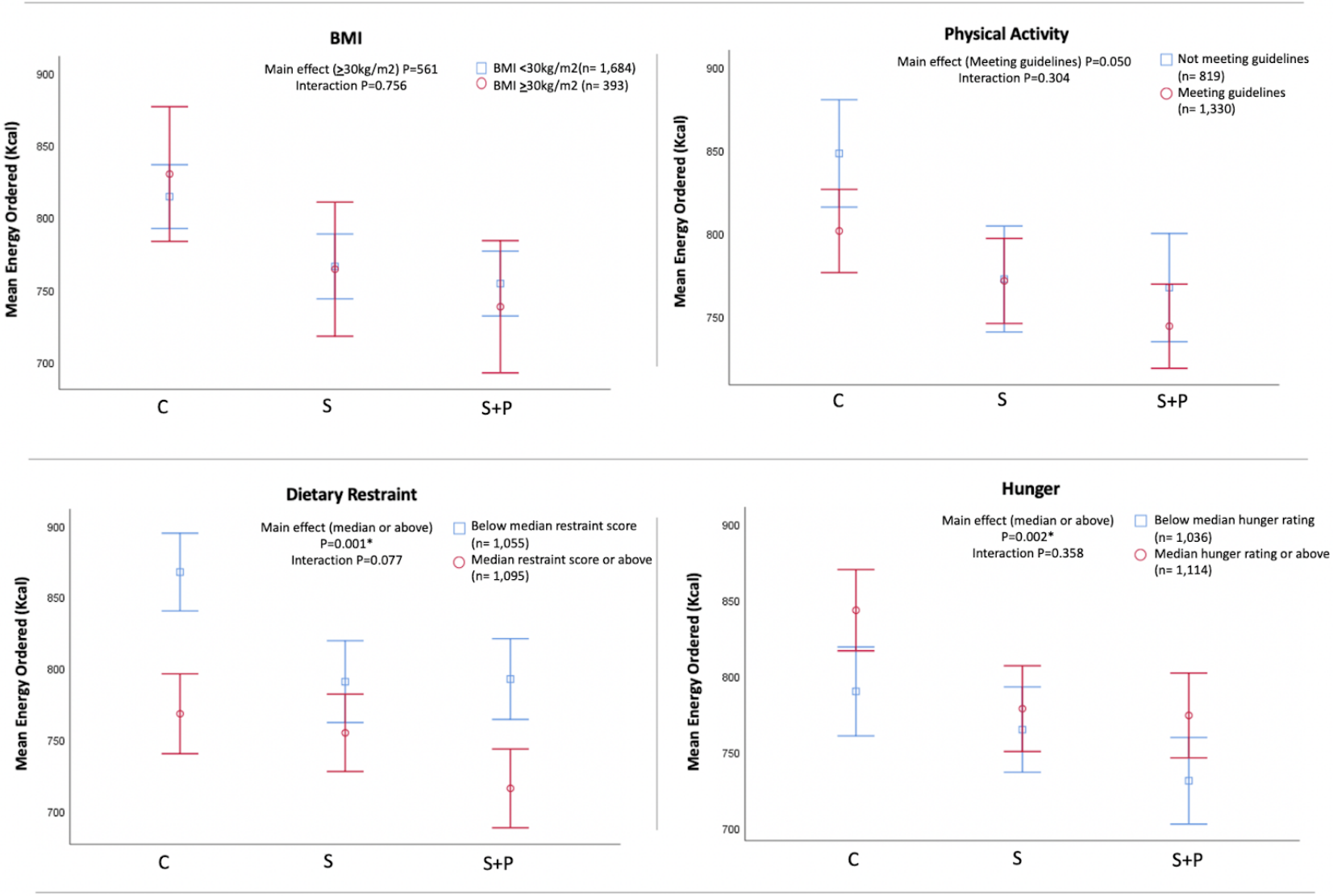


Figure 8.8: Interaction effect by gender, age, ethnicity, education, BMI, physical activity level, dietary restraint and hunger. Estimated marginal means for final energy ordered controlling for the energy content of the first item ordered with 95% confidence intervals (CIs). C= control; S= swaps; S+P= swaps+PACE. *Benjamini-Hochberg-adjusted significance level threshold.

(a) Swap acceptance and swap price

The average price of lunch orders was £5.51 (SD=£1.84), £5.29 (SD=£1.82) and £5.31 (SD=£1.86) in the control, swaps, and swaps+PACE groups, respectively. The average price of initially selected items and swaps offered for each menu by intervention groups is displayed in Table 8.10. For half of the menus (jacket potatoes, sandwiches and drinks), all swaps offered were either cheaper or the same price as initially selected items. For the other half of the menus, hot meals, sweet snacks and savoury snacks, swaps offered were up to £0.55 more expensive than initially selected items, but swaps offered were cheaper on average for all menus except for savoury snacks .

Table 8.10: Prices of initially selected items, swaps offered and price difference for those offered swaps only.

	Initially selected £ mean ± SD	**Swaps offered £ mean ± SD**	**Price difference £ mean (95% CIs)**
Mains (n=572)	4.38 ± 0.22	3.03 ± 0.82	-1.36 (-1.43 to -1.29)
Jacket potatoes (n=368)	2.06 ± 0.39	1.45 ± 0.27	-0.61 (-0.65 to -0.58)
Sandwiches (n=563)	2.86 ± 0.26	2.32 ± 0.47	-0.54 (-0.57 to -0.51)
Sweet snacks (n=537)	1.45 ± 0.41	1.23 ± 0.33	-0.22 (-0.25 to -0.19)
Savoury snacks (n=434)	0.74 ± 0.23	1.02 ± 0.19	0.28 (0.25 to 0.31)
Drinks (n=462)	1.35 ± 0.14	0.91 ± 0.21	-0.44 (-0.46 to -0.42)

Note: For price difference, negative values reflect a cheaper swap offered and positive values a more expensive swap offered. SD = standard deviation ; 95% CIs = 95% confidence intervals

A main effect of swap price was observed. For every £1 decrease in swap price, the odds of a swap being accepted increased by 1.85 [95% CI: 1.46 to 2.36, p<0.001]. The interaction analysis demonstrated a greater effect of price difference (between initially selected items and swaps offered) on swap acceptance for those in the swaps groups than the swaps+PACE group [$p_{interaction}$ <0.002] (Figure 8.9, Table 8.11).

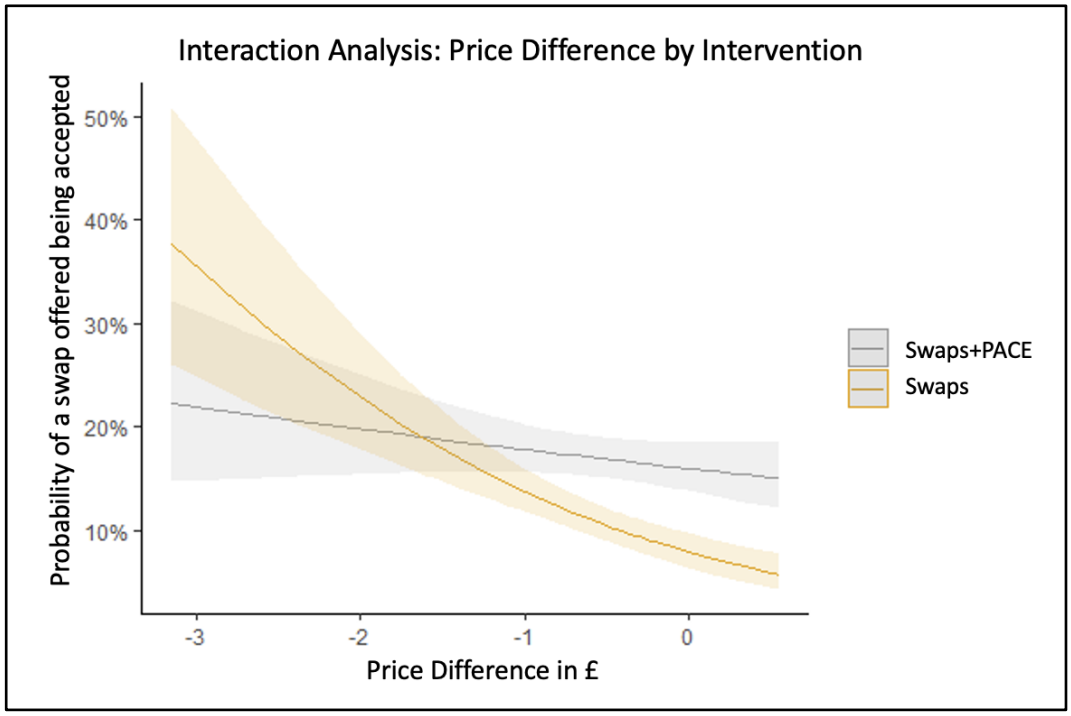


Figure 8.9: Interaction analysis for the effect of price difference on the likelihood of accepting a swap offered, by intervention group (swap alone versus swap+PACE). Predicted probabilities and 95% CIs. Clustering at the participant level (observations= 2,936).

(b) Swap acceptance by menu

There was some evidence of differences in swap acceptance by menu (Table 8.9). Compared with those in the swaps only group, participants in the swaps+PACE group were significantly more likely to accept swaps offered for jacket potatoes, sandwiches, and drinks (Table 8.11).

Table 8.11: Exploratory outcome (c). Swap acceptance by condition for each menu, with the Swaps only intervention as the reference category.

	Odds Ratio	95% Confidence Interval	P-value
		Main hot menu (n=572)	
Condition (Swap+PACE)	0.97	0.64 to 1.48	0.886
Constant	0.23	0.17 to 0.31	<0.001
		Jacket potato menu (n=368)	
Condition (Swap+PACE))	2.77	1.40 to 5.47	0.003*
Constant	0.08	0.04 to 0.13	<0.001
		Sandwiches menu (n=563)	
Condition (Swap+PACE)	2.13	1.15 to 3.94	0.016*
Constant	0.06	0.04 to 0.10	<0.001
		Savoury snack menu (n=434)	
Condition (Swap+PACE)	1.04	0.58 to 1.86	0.887
Constant	0.13	0.09 to 0.20	<0.001
		Sweet snack menu (n=537)	
Condition (Swap+PACE)	1.66	1.07 to 2.58	0.023
Constant	0.18	0.13 to 0.25	<0.001
		Drinks menu (n=462)	
Condition (Swap+PACE)	3.17	1.73 to 5.81	>0.001*
Constant	0.07	0.04 to 0.12	<0.001

8.4 Discussion

8.4.1 Summary of findings

The aim of this study was to address the objectives of the intended pilot field trial relating to the potential efficacy of a swap-based intervention for an online workplace canteen. Offering lower-energy swaps was found to significantly reduce the energy content of lunches pre-ordered compared with not offering swaps. Accompanying swaps offered with PACE messaging did not significantly reduce energy pre-ordered compared with offering swaps alone. However, the addition of a PACE message significantly increased swap acceptance relative to when this information was not provided. Both interventions resulted in significantly more participants ordering lunches that met public health recommendations of containing ≤ 600 kcal, compared with the control group. Intervention acceptability was high overall, but significantly higher among those presented with PACE information when swaps were offered than those who were not shown this message.

8.4.2 Findings in context: Energy ordered & swap acceptance

Only 14% of lower-energy swaps were accepted overall. When compared with supermarket studies, this mirrors the acceptance rate for swaps lower in saturated fat (Koutoukidis et al., 2019) and energy (Bunten et al., 2021), but is smaller than the 34% acceptance rate for swaps lower in salt (Payne-Riches et al., 2019). Offering swaps for lunch choices, nevertheless, significantly reduced energy ordered by between 47 kcal and 66 kcal on average. When considering the pre-post figures reported by Bunten et al. (2021), effect sizes observed in the current study appear to be slightly smaller (30 kcal, *d*=0.35 vs 66 kcal, *d*=0.26 in the current study). However, it is difficult to draw comparisons given the very different intervention settings. How the energy reductions reported in the current study compare with reductions achieved by other interventions of a similar nature is addressed in the general discussion in the next chapter.

When comparing the effect of adding a PACE message to prompts to swaps on energy ordered by product category, the energy reductions observed in the current study were smaller than those reported in Chapter 5 for sweet snacks (-14 kcal, d=0.33 vs -4kcal,

d=0.16), savoury snacks (-14 kcal, 0.35 vs = -0.5 kcal, d=0.02) and drinks (= -12kcal, d=0.2 vs = -5 kcal, d=0.29). For snacks, this may be explained by the higher swap acceptance rates observed in Chapter 5. In Chapter 5, offering swaps with PACE information increased swap acceptance for sweet and savoury snacks by 13 and 12 percentage points respectively compared with offering swaps alone. In contrast, in Chapter 8 offering swaps with PACE information increased swap acceptance for sweet and savoury snacks by 8 and 0 percentage points respectively compared with offering swaps alone. The differences in swap acceptance rates and energy ordered may be explained by the differences in products offered between the studies. In Chapter 5, the lowest energy swaps offered for sweet (fruit = 45kcal) and savoury snacks (carrot sticks = 17kcal) were lower in energy than the swaps offered in these categories in the current study (fruit = 74kcal for sweet snacks and popcorn = 87kcal for savoury snacks). In both studies, adding a PACE message increased drink swap acceptance by 12 percentage points. The slightly higher energy savings reported in Chapter 5 are likely due to the slightly larger range in energy content of products available (mean= 76 kcal, range= 0-237 kcal) than in the current study (mean=56 kcal, range= 0-210 kcal).

8.4.3 Finding in context: Intervention acceptability

The high acceptability ratings (92%) for pre-ordering fit with the overall positive views on pre-ordering expressed by participants interviewed in the previous chapter. Two-thirds (65%) of those offered swaps regarded prompts to swap as an acceptable feature of a workplace pre-ordering system which is similar to the 67% reported in Chapter 5. The finding that fewer regarded prompts to swap as an acceptable feature of a workplace pre-ordering website than pre-ordering alone fits with the qualitative findings from Chapter 7 that some people have reservations about the swaps feature of the pre-ordering website. The acceptability ratings for the swaps feature are nevertheless in line with ratings reported in other previous studies (Koutoukidis, 2019), and echo recent research which finds that canteen customers generally expect a trend towards the increased availability and promotion of healthy menu options (Czarniecka-Skubina, 2020). The current findings indicate that providing PACE information when offering lower-energy swaps significantly increases intervention acceptability (Swaps =60% v swaps+PACE=69%). The results of the current study align with those reported

in Chapter 5 and indicate that offering swaps with calorie-focused information, particularly PACE significantly increases swap acceptance. Potential reasons for this are explored in the next chapter.

8.4.4 Findings in context: Moderation analysis

The exploratory findings showed some evidence of main effects of demographic characteristics, with those who identify as white, those above the median age, those who score higher on dietary restraint and lower on momentary hunger ordering less energy on average. In the case of age, the effect size (d=0.39) was larger than the effect size obtained from the swaps+PACE intervention (*d*=0.26). Previous research has reported similar findings. Bunten et al., (2021) reported a significant main effect of age on the acceptance of lower-energy swaps offered. Other studies have also pointed to larger reductions in saturated fat observed among older participants but these studies did not report interaction effects (Huang, 2006; Koutoukidis et al., 2019). Although main effects were observed, the exploratory findings revealed no evidence that the interventions have differential effects by demographic characteristics. This is a reassuring finding considering that one of the main criticisms levelled against interventions that rely on individual decision making and agency is that they potentially increase health inequalities (Coggon & Adams, 2021). A potential exception to this is the finding that unrestrained eaters seemed to tend towards being more influenced by the intervention than restrained eaters. This trend might mean that offering swaps would potentially be most effective for those most in need of intervention (i.e., consumers with lower dietary restraint). However, this finding was non-significant and as the exploratory analyses were underpowered, no firm conclusions can be drawn.

8.4.5 Findings in context: Price & swap acceptance

Most swaps offered in this study were cheaper than their high-energy counterparts, because they were either vegetarian or had fewer extras (e.g., swaps for a jacket potatoes with beans and cheese was a jacket potatoes with beans only). The analysis indicates that offering cheaper swaps significantly increases the likelihood that a swap will be accepted. Recent research supports the idea that even small price reductions (£0.20), can influence food purchasing behaviours in the canteen environment

(Garnett et al., 2017). It seems that when the price difference between initially selected items and swaps offered is small or the swap offered is more expensive, PACE messaging increases swap acceptance, but as the swap becomes cheaper the effect of the price difference becomes more impactful for the swaps only group. Although price was not directly manipulated in this study (i.e., participants were not randomised to receive cheaper or more expensive swaps), the interaction analysis indicates that Swap+PACE and Swap accompanied by a price reduction could possibly be equally effective in terms of swap acceptance for a reasonably implemented price reduction of approximately £1-1.5. Swap acceptance is lowest when swaps alone are offered, however, adding either price reduction or PACE increases the probability of swap acceptance. To maximise efficacy, organisations should aim to offer cheaper lower-energy alternatives. Where this is not possible, the addition of PACE information might aid swap acceptance. Further research is required to examine, in detail, the relative effect of price difference on swap acceptance.

8.4.6 Strengths and limitations

Among the strengths of this study was its randomised design and its large sample of employed adults that approximately matched the distribution of the UK population in terms of gender, ethnicity and education. Partnering with Bupa and simulating a pre-ordering website using their canteen menus meant that the effect of offering lower-energy swaps for lunch time meals could be tested in a way that closely resembles how choices would be made when using an online canteen in real life. Furthermore, swaps offered and intervention delivery was informed by the qualitative research undertaken with Bupa employees outlined in Chapter 7.

The hypothetical nature of this study is its primary limitation both in terms of lunch choices made and acceptability ratings. Measures were taken to minimize this issue. For instance, real-world canteen menus were presented and participants were explicitly asked to make selections that were in line with their usual lunch choices. This limitation along with potential self-report bias (for BMI etc.) are discussed in detail in the general discussion presented in Chapter 9, section 9.3. Although the measure of dietary restraint was based on a validated scale, due to time constraints, a shortened unvalidated version was used, which still maintained a high Cronbach's alpha (α =

0.81). It is also possible that total energy intake at baseline may have been an effect modifier, but it was not measured due to well-known limitations of existing methods. However, no evidence that the effect depended upon hunger, dietary restraint, physical activity level, or BMI (a reasonable proxy for energy intake and expenditure) was observed, so such effect modification of total energy intake, if it exists, is likely to not be clinically meaningful. The exploratory subgroup analyses were not sufficiently powered. Fully powered analysis would have required approximately double the sample size for which I did not have sufficient budget. Finally, although this study was informed by a piece of qualitative research conducted with Bupa staff (i.e., the intervention's target group), this study was a relatively limited in scope and was completed later in the programme of research (i.e., after the messaging and types of swaps offered has been selected). It is likely that the design of the intervention would have benefitted from more extensive qualitative research earlier in the research process. For example, to examine perceived acceptability of different types of messages or indeed the barriers and facilitators to swap acceptance with a more extensive menu. No usability research was conducted prior to this study. Usability research is important for ensuring that the design of the platform would not present any barriers to its use. Although participants in the qualitative study reported finding the website generally easy to use, these participants were accompanied by me when navigating the site and could ask me questions while placing their hypothetical order. It would be important to perform some more detailed (perhaps unmoderated) usability testing to check the clarity of instructions, ease of navigation and whether the layout is intuitive/easy to learn prior to trialling the pre-ordering platform in a real-world context.

8.4.7 Conclusion

The findings indicate that offering lower-energy swaps do have the potential to reduce the energy of lunches ordered through online canteens. Accompanying swaps offered with PACE information did not change the energy of lunches ordered compared to offering swaps alone, but it did increase the swap acceptance rate and intervention acceptability. One of the key questions from the pilot field trial that remains unanswered relates to the repeated effect of the intervention over time. Future work should do as the pilot field trial intended and test the effect of a pre-ordering website

that prompts users with swaps on energy ordered over extended periods of time to observe sustainability of any intervention effects. In the final chapter, I discuss how the findings of the current work compare with other interventions of a similar nature and the potential implications of these findings for researchers and organisations.

Chapter 9

General Discussion

9.1 Introduction

Excess weight increases morbidity and mortality (The GBD 2015 Obesity Collaborators, 2017). Biological, behavioural, societal, and environmental factors interact leading to positive energy balance and excess weight. Strategies to reduce population energy intake may substantially contribute to halting the rise in obesity (Butland et al., 2007; Public Health England, 2018a). Modelling studies support a small-changes approach to energy reduction, indicating that weight gain could be prevented at the population level by reducing energy intake by just 50 kcal/day (Hill et al., 2003). Prompting consumers to swap their initial food and drink selections for lower-energy alternatives while shopping may help bring energy intake into line with public health recommendations. Swap-based interventions have been tested in online supermarket settings and the results show reductions in the saturated fat (Huang et al., 2006; Koutoukidis et al., 2019), salt (Payne-Riches et al., 2019) and energy content (Bunten et al., 2021) of grocery baskets. Like online supermarkets, pre-ordering websites for workplace canteens provide a platform for the delivery of health promotion interventions. However, swap-based interventions have not yet been tested in this context. After the home, the workplace is the most common environment where food is consumed (Liu et al., 2015) and UK workers consume about one-third of their daily energy at work (Vasiljevic et al., 2018). Effective and acceptable strategies to reduce energy consumed in the workplace are needed as part of the wider strategy to reduce population energy intake.

Using a range of methodologies, this thesis aimed to test a swap-based intervention to reduce energy ordered in an online pre-ordering system for a workplace canteen.

Studies 1 and 2 were systematic scoping reviews of the literature which aimed to determine what experimental evidence was available on the efficacy and acceptability of (i) swap-based interventions (Study 1) and; (ii) pre-ordering interventions (Study 2) to improve the healthfulness of dietary choices made by adults. Study 3 was an exploratory online RCT in which three health-based messages were pilot tested (i.e.: "How about a swap?…" Followed by one of the following: "This has fewer calories"; "This has less saturated fat/sugar"; "This is healthier"). The aims were to generate effect sizes for the potential effect of these messages on swap acceptance, and examine the acceptability in principle of these messages to inform the design of Study 4. Study 4 was an online RCT in which the calorie-focused message tested in Study 3 was carried forward and tested alongside two other calorie-focused messages (i.e., "How about a swap? Save [x] calories" and; "How about a swap? Save [x] calories = [y] min walk") to examine the effect of these messages (containing varying degrees of information) on swap acceptance. The next study was intended to be a pilot trial examining the feasibility of running an RCT testing pre-ordering and pre-ordering with swaps in a real-world canteen with Bupa UK. Due to Covid-19, this trial was replaced by two alternative pieces of research which aimed to address the pilot research questions related to: (i) intervention acceptability and; (ii) potential effect sizes for reductions in energy ordered. Using qualitative 'think-aloud' methodology, Study 5 explored the acceptability of the interventions with the Bupa UK staff who had consented to participate in the feasibility trial, and the factors potentially influencing swap acceptance. The experimental pre-ordering website and swap-based interventions were modified based on the feedback gathered from Bupa employees, and in the final study (6), two versions of the swap-based intervention were tested using an online RCT with a large sample of employed UK adults to examine the potential effect that these interventions may have on energy ordered in a workplace canteen setting. This chapter provides an overview of the findings from each of these studies and their contribution to the literature along with their limitations and future directions for research and practice.

9.2 Summary of findings and contribution to the literature

Study 1 is, to my knowledge, the first systematic literature review of any kind to examine swap-based interventions. The review pointed to the potential for swap-

based interventions to improve the healthfulness of dietary choices made by adults, but highlighted a limited evidence base for interventions offering lower-energy swaps. It also showed that swap acceptance rates varied across studies and that little research had examined how the messaging accompanying swaps-offered may influence swap acceptance. Study 2 is also, to my knowledge, the first systematic literature review to examine pre-ordering interventions. Two of the three studies indicated that pre-ordering is a potentially effective strategy for reducing the energy content of meals ordered, indicating that this may be a promising intervention to combine with prompts to swap. Study 3 suggested that when pre-ordering snacks and drinks, accompanying lower-energy swaps offered with a calorie-focused message is likely to be acceptable to intervention recipients. It also provided indicative evidence that this message may help to increase swap acceptance compared with when no specific message is presented (i.e., “How about a swap?”), making the case for calorie-focused messages to be tested in a full-scale online RCT. Study 4 is the first study to demonstrate a beneficial effect of providing messages alongside prompts to swap in terms of swap-acceptance and energy ordered, but also the first study to investigate and highlight the potential unhealthful behaviours that a PACE message may induce. Study 5 provided qualitative evidence confirming that pre-ordering, prompts to swaps, and pre-ordering with prompts to swap accompanied by PACE messages are all potentially acceptable workplace canteen interventions. It also provided important information about how these interventions could be modified to become more acceptable and potentially more efficacious in future research in real-world canteens. Finally, study 6 is the first to provide experimental evidence that offering lower-energy swaps for lunchtime meals selected through an online canteen may effectively reduce energy ordered across the total meal. This thesis makes a contribution to the academic literature, by improving our understanding of how and when offering lower-energy swaps is effective, and to public health by refining an intervention which could be delivered in workplace canteens. The following sections provide an overview of each study followed by their limitations and future implications.

9.2.1 What experimental evidence is available on the effect and acceptability of swap-based interventions to improve the healthfulness of dietary choices made by adults?

The systematic literature review examined the experimental evidence for swap-based interventions to improve dietary choices. The review identified 8 studies testing the effect of offering swaps, and pointed to the potential for these interventions to reduce the salt, saturated fat, and energy content of grocery baskets in real and hypothetical online supermarket settings. The direction of evidence was most clear for offering lower-salt swaps and lower-saturated fat swaps, with all studies reporting significant reductions in the target nutrient. Standardised effect sizes in studies offering lower-salt swaps were small *d*=0.28 (Eyles et al., 2017), *d*=0.29 (Payne Riches et al., 2019) and, *d*=0.34 (Dorsch et al., 2020). Effect sizes for offering lower saturated fat swaps were also small *d*=0.12 (Koutoukidis et al., 2019) and *d*=0.32 (Huang et al., 2006). The direction of evidence was less clear for energy reduction, due to mixed findings. One study reported a small effect size *d*=0.35 and another study reported a very small effect size *d*=0.06 which equated to a non-significant energy reduction, thus highlighting the need for research testing the effect of offering lower-energy swaps. There was some evidence that swap-based interventions are viewed as acceptable by recipients, however, no studies had examined this in depth. Among the 4 studies that examined swap acceptance, rates ranged between studies (13% to 34%) and there was little information on the factors influencing swap acceptance. There was some indication that the nature of swaps offered may increase swap acceptance - for instance, offering swaps with large reductions in a target nutrient (salt). Only one study examined the effect of framing and found no effect of a cost-based or social norm-based message compared with a calorie-based message on swap acceptance. A numeric trend (i.e., higher swap acceptance rate) in favour of the calorie-based message was observed. The findings suggested that swap-based interventions are a potentially effective strategy for improving the healthfulness of dietary choices made by adults and highlighted the potential for it to be applied in settings other than supermarkets.

9.2.2 What experimental evidence is available on the acceptability and effect of pre-ordering interventions to improve the healthfulness of dietary choices made by adults?

Study 2 was a systematic literature review examining the experimental evidence for the second intervention component - pre-ordering, and its ability to improve dietary choices among adults. Although only three studies experimentally testing pre-ordering

with adults were identified, all studies focused on energy reduction and two of the three pointed to pre-ordering as a potentially effective strategy for reducing the energy content of lunches pre-ordered. Standardised effect sizes observed were small *d*=0.21 (VanEpps et al., 2016a) to medium *d*=0.54 (Stites et al., 2016). This finding lent support to the idea that pre-ordering should be tested in the current body of work, but highlighted gaps in the literature. Previous research with children has shown that adding information nudges (e.g., highlighting which food groups are missing from one's plate) when pre-ordering may enhance intervention effects (Miller et al., 2016; Delaney et al., 2017). However, none of the studies with adults identified in the review delivered other interventions through the pre-ordering platforms. The studies presented in this thesis sought to address this. The review also highlighted the lack of research on the acceptability of pre-ordering as a strategy for improving the healthfulness of dietary choices. One study briefly examined acceptability, and ratings indicated that future uptake of pre-ordering services may be high. This study also examined some of the potential barriers to future uptake but did so very briefly (Stites et al., 2015). Given that intervention acceptability is an important prerequisite for successful implementation (Diepeveen et al., 2013; Hilbert et al., 2007; Stok et al., 2015), this review identified a need for further research.

9.2.3 How acceptable and potentially effective are health-based messages in increasing the acceptance of swaps offered for lower-energy sweet snacks, savoury snacks, and drinks?

The exploratory Study 3 was an online pilot RCT conducted with 449 working adults living in the UK who were recruited via Prolific Academic. At the time this study was being developed, there was no research testing the effect of accompanying swaps offered with messages on swap acceptance. As such, one of the aims of this pilot was to generate potential effect sizes for the effect of accompanying swaps offered with health-based messages on swap acceptance to inform the power calculations for Study 4. The findings from this study showed the largest potential effect sizes for the calorie-focused message across both the swap acceptance and energy outcomes. For sweet snacks, the calories group had a 5.5 percentage point higher acceptance rate than control while the nutrients and healthier groups had a 4.4 and 3.6 percentage points respectively higher acceptance rate than control. For savoury snacks, the calories group had a 9.9 percentage points higher acceptance rate than control while

the nutrients and healthier groups had a 6.5 and 8.4 percentage points respectively higher acceptance rate than control. Finally for drinks, the calories group had a 18.1 percentage point higher acceptance rate than control while the nutrients and healthier groups had a 1.5 and 9.7 percentage points respectively higher acceptance rate than control. Similarly, a larger effect size was observed for the calorie-focused message (*d*=0.25) for total energy reduction compared with control than the nutrients (*d*=0.14) and the healthier (*d*=0.16) messages.

The pilot was also designed to examine the acceptability of the calorie, nutrient and health-focused messages that were being tested. The findings suggested that the most straightforward message emphasizing that the lower-energy swap offered had "fewer calories" was likely to be well received. The study also found no evidence of major descriptive differences in the effect of the messages with regard to swap acceptance rates or intervention acceptability by subgroups (i.e., gender, age, ethnicity, education or income), meaning that no modifications to the design of a full-scale study needed to be made at this stage.

The pattern of effect sizes indicated that the calorie-focused message was acceptable and may have potential for increasing swap acceptance and reducing energy ordered. However, the calorie-focused message was tested in its simplest form (i.e., it did not include numeric energy information). While this had the benefit of not overwhelming customers with information, calorie-labels tested in previous research almost always provide numeric information. Providing this information has been shown to significantly reduce the energy content of food and drinks ordered from menus (Crockett et al., 2018). This raised the question of whether providing specific numeric information might encourage consumers even more to swap their high-energy selections for lower-energy alternatives. Alongside numeric-calorie information, UK online supermarket Ocado had accompanied lower-energy swaps offered with PACE information. Although this strategy had not yet been empirically tested in the context of swaps, research had shown that providing interpretational aids, such as PACE information, may help consumers to better understand energy information (Grunert & Wills, 2007), with some suggesting that this was because PACE translated energy into a more tangible and familiar metric (Bleich et al, 2017; Blumenthal & Volpp, 2010; Daley et al., 2020; Fitch et al., 2009). Based on this, the simple calorie-focused message was

carried forward and was tested alongside a numeric-calorie message and a PACE message in a full-scale RCT.

9.2.4 What is the effect of accompanying lower-energy swaps offered for snacks and drinks with calorie-focused messages (a vague calorie message, a numeric-calorie message and a PACE message) on swap acceptance among working adults in an experimental online canteen?

Study 4 was an online RCT conducted with 3,481 working adults living in the UK who were recruited via Prolific Academic. The aim of this study was to test the effect of calorie-focused messages on the acceptance of lower-energy swaps for snacks and drinks. The study showed that accompanying lower-energy swaps offered for snacks with calorie-focused messages significantly increases swap acceptance in an experimental online canteen. The most tangible PACE message significantly outperformed the control and fewer-calories (i.e., the pilot message) message in terms of swap acceptance in every product category. While the differences in swap acceptance between messages, particularly between numeric-calories and PACE were not always statistically significant, the direction of effect sizes indicated an incrementally stronger effect of messages that provide more tangible information. This is in line with previous research which finds consumer nutrition knowledge to be moderate or low and recommends the addition of interpretational aids to enhance understanding (Blumenthal, 2010; Cadario & Chandon, 2020). Providing such aids to consumers at the point of choice simplifies cross-product comparisons for consumers and reduces energy-purchased (Allan & Powell, 2020).

None of the intervention messages significantly reduced the energy content of drinks compared with control, however, the messages led to significant reductions in energy ordered for snacks which were small (6kcal, d=0.15 to 14kcal, d=0.35 per product on average compared with control), as expected, given the small difference in calories between initially selected and swaps offered. Previous studies comparing the effect of PACE information compared with no information have reported larger reductions (80 kcal in energy (Daley et al., 2020) but this is likely to be because these are based on the energy across entire meals as opposed to snacks and drinks.

This study also confirmed the pilot finding that calorie-focused messages are

acceptable to the majority of people (Control: 62%; Fewer-calories: 65%; Numeric-calories: 69%; PACE: 74%) and found that accompanying swaps offered with PACE information brought intervention acceptability ratings into line with previous research in supermarket settings (76% agreed that a swaps feature would be acceptable when shopping online for groceries) (Koutoukidis et al., 2019). However similar to Study 4, about one-fifth of participants felt that offering swaps was unacceptable (Control: 23%; Fewer-calories: 21%; Numeric-calories: 20%; PACE: 17%).

Although those in the PACE group were more likely to view prompts to swap as acceptable, there was some evidence that the PACE messaging may be more likely to trigger unhealthy behaviours such as excessive calorie counting than a calorie-only message. A quarter of participants in the PACE group agreed that the message they saw would encourage them to count calories excessively compared with 15% in the numeric-calories message group and 11% in the fewer-calories group. The PACE group were also asked whether they felt the message would encourage them to exercise excessively and 15% agreed that it would. These findings are, however, only a reflection of participants' perceptions of their potential future behaviours and 78% of the PACE group viewed the PACE message as acceptable. Taken together, the findings suggested that: (i) of the messages tested, adding PACE messaging may be the most promising way to increase the acceptance of swaps offered for snack foods and drinks and, therefore, should be the message used when examining the effect of offering swaps for items across an entire lunch on energy ordered and; (ii) a more in-depth examination of the factors influencing intervention acceptability with intervention recipients may help to maximise intervention efficacy.

9.2.5 What are the factors influencing: (i) the acceptability of a workplace canteen intervention combining pre-ordering and prompts to swap to lower-energy alternatives with PACE messaging, and; (ii) the acceptance of lower-energy swaps offered?

Using the pre-ordering website that I had developed for the Bupa Eats pilot feasibility trial, Study 5 qualitatively explored the acceptability of pre-ordering and pre-ordering with prompts to swap accompanied by PACE information with employees of Bupa UK. This study also explored the factors potentially influencing swap acceptance. The study provided further evidence that (i) pre-ordering; (ii) pre-ordering with prompts to

swap and; (ii) prompts to swap accompanied by PACE information are acceptable workplace canteen interventions. It also highlighted aspects of the interventions that facilitated perceived acceptability. For instance, participants appreciated the availability of energy information for each item of the menu on the website. This echoed previous research which has suggested that consumers would like access to energy information when ordering meals (Bleich & Pollack, 2010; Diabetes UK, 2018). Furthermore, comments made by participants about the PACE message seemed to support the hypothesis discussed in Study 4 that PACE information prompts people towards menu items with less energy by making energy information more tangible (Daley et al., 2020). In contrast, some aspects of the intervention were identified as potential barriers to acceptability. For example, there were some concerns that prompts to swap might be viewed as threatening personal autonomy. This finding mirrored previous research which has found that intervention acceptability is reduced when interventions are perceived as intrusive (Diepeveen et al., 2013). The facilitators and barriers identified have important implications for practice which are discussed in section 9.4 below.

The study also highlighted factors that may influence swap acceptance. Feedback from participants suggested that swaps offered should be as similar as possible in terms of taste, texture and expected satiety to the originally selected item while also yielding meaningful energy-savings. Having images and a detailed description of all menu items was viewed as important to both the acceptability of the intervention and swap acceptance. These novel insights were used to inform the design of the pre-ordering website and the swap interventions that were tested in the final study described in the next section.

9.2.6 What is the effect of offering lower-energy swaps with and without PACE messages on the energy of hypothetical lunches pre-ordered with working adults in an experimental online canteen?

Study 6 was an online RCT conducted with 2,150 working adults living in the UK who were recruited via Prolific Academic. This study built on the findings from Study 5 by using Bupa's real-world canteen menus and testing the effect of offering lower-energy swaps on total energy ordered across a whole meal. The study described the successful application of a swap-based intervention to an experimental online canteen

setting, showing for the first time that offering lower-energy swaps for lunchtime meals selected through online canteens may effectively reduce energy of foods ordered. Offering swaps for lunch choices, significantly reduced energy ordered by between 47kcal (*d*=0.19) and 66kcal (*d*=0.26) on average. This equates to a 5.7% and 8.1% reduction in energy ordered respectively relative to the average total energy ordered by the control group (mean 819 kcal). This is a slightly larger effect size than the 4.8% reduction in energy ordered relative to baseline in a recent study examining the effect of altering the availability of less healthful foods in a real-world-canteen, but smaller than the 11.5% reduction achieved when portion size reductions were combined with the availability intervention (Reynolds et al., 2021). The effect sizes reported in this study also align with findings of a meta-analysis of healthy eating nudges which reported average effect sizes for these interventions to range between *d*=0.12 and *d*=0.39 (Cadario & Chandon, 2017). As all participants, including the control group, were provided with energy information for menu items (based on feedback from the think-aloud study), it was possible to isolate the effect of offering swaps and offering swaps with PACE information in this study. Previous research testing the effect of placing PACE labels on products sold in real-world worksite canteens (where energy information is not widely available) reported an average energy reduction of 40 kcal when these labels were present compared to when they were absent (Viera, 2019), but found no significant difference between providing PACE information and calorie-only information. In Study 6, energy information was displayed in the control condition, and compared with the control condition, offering swaps alone significantly reduced energy ordered by 47kcal on average. A Cochrane review on energy labelling suggests that calorie-information on menus also reduces energy purchased by 47 kcal on average compared to when no labelling is provided (Crockett, 2018). It is, therefore, possible that offering swaps would yield a larger energy reduction than the 47kcal reported here, when compared with orders placed directly from the canteen where energy information is largely unavailable.

Previously, studies have focused on demonstrating the ability of swap-based interventions to improve the healthfulness of items purchased when shopping online for groceries (Bunten et al., 2021; Koutoukidis et al., 2019; Payne-Riches et al., 2019). One reason for this is that similarity between swaps offered and original selections is thought to increase the likelihood of swap acceptance, and grocery shopping usually

entails the purchasing of many discrete products for which very similar, more healthful alternatives are typically readily available. By contrast, choices made in canteen environments are typically between a smaller range of prepared meals for which close alternatives are usually unavailable. Although only 14% of lower-energy swaps were accepted overall, when compared with supermarket studies, this mirrors the acceptance rate for swaps lower in saturated fat (Koutoukidis et al., 2019) and energy (Bunten et al., 2021) but is smaller than the 34% acceptance rate for swaps lower in salt (Payne-Riches et al., 2019).

Finally, this study measured for the first time the acceptability of pre-ordering which received a very high rating (92% average) across all groups. Acceptability ratings for the swaps-feature were in line with my previous findings, with ratings being high overall, but significantly higher among those presented with PACE information when swaps were offered (69% agreeing that prompts to swap are acceptable in the workplace) than those who were not shown this message (60%). As this was a common thread across studies, potential reasons for this are discussed in detail in section 9.4 below. In both intervention groups, 16% of participants rated the swaps-feature as unacceptable. Given that this (and the ~20% of participants in Study 4) is not an insignificant proportion of people, organisations that are considering implementing a pre-ordering system may want to consider making the swaps feature optional.

9.3 Limitations

This section discusses the limitations that are applicable to most of the studies conducted, and how these limitations impact the interpretation of the results. Limitations that are specific to each study have been detailed in the relevant chapters.

9.3.1 Hypothetical choice & self-report data

This thesis employed ‘field-lab hybrid’ studies to address most of its research questions. Field-lab hybrid studies are hypothetical choice experiments usually delivered via online platforms that mimic real-world plausible scenarios. As such, the primary limitation of this research is its hypothetical nature. Real-world purchasing

decisions are often driven by taste preferences and financial considerations (Chen & Antonelli, 2020). In the studies presented, participants did not have the opportunity to try the swaps that were being offered nor did they spend their own money. Measures were taken to minimize this issue and these are detailed in each chapter. Given the hypothetical nature of these studies, it was also only possible to examine intervention acceptability *in principle* (i.e., without participants having tasted the swaps they accepted). It is possible that if participants did not enjoy their swaps, acceptability ratings would be lower.

While field-lab hybrid studies are not as tightly controlled as traditional lab experiments, nor do they test 'real' choices like field trials, they permit the testing of variables that would be difficult to examine in a field trial due to the pragmatic constraints that real-world settings inevitably impose. Field-lab hybrid studies allow for data to be easily collected from large numbers of participants, not only on the target behaviour but on key demographics. These studies provide estimates of potential intervention efficacy while also enabling researchers to ensure that proposed interventions do not enhance health inequalities or drive unexpected behaviours, evidence which is essential in helping to recruit field trial sites. Field-lab hybrid studies can provide evidence of intervention acceptability in principle, potential impact on profit margins, and potential changes to purchasing behaviours which can have significant long-term health implications. Such evidence is necessary to reassure potential sites that are interested in implementing such interventions of the viability of the intervention. They also offer tighter control over the experimental conditions than field trials (even if not as tight as lab-based experimental studies). As such, field-lab hybrid studies represent an important new middle ground of study that offer something that neither lab nor field studies can provide - reasonable ecological validity and experimental control.

Measures of height, weight (to calculate BMI) and physical activity levels were self-reported. As a consequence, they may be subject to measurement error due to social desirability bias and/or misestimation by participants (Ferrari, et al., 2007; Lassale, et al., 2013). However, errors are typically small and self-report is reasonably accurate

for height and weight meaning this is unlikely to affect interpretation of this data (Hodge et al., 2020).

9.3.2 Generalisability of findings

a. Sample

Participants in the online RCTs (i.e., studies 3, 4, and 6) were recruited via Prolific Academic, a participant sourcing platform. This means that a proportion of participants in these samples are likely to have been professional survey takers. It is, therefore, possible that the results of these studies may not entirely reflect the behaviours of the general population. Research has, however, shown that compared with other participant sourcing platforms such as Amazon Mechanical Turk (Mturk) and Crowdflower, data produced by Prolific Academic participants is of higher quality, and Prolific Academic's panel has been shown to be more diverse than Mturk (Peer et al., 2017). To help ensure that participants recruited matched the target recipients of the intervention, a recruitment criteria was applied (i.e., participants had to be employed adults living in the UK with no dietary requirements). While the demographic characteristics of panel members sampled broadly matched those of the general UK population in terms of sex, ethnicity income, and education (although participants in the current work had higher levels of education), due to data processing restrictions, it was not possible to collect postcode to measure another aspect of SES. It is, therefore, not possible to draw conclusions about the effect of the intervention according to measures of SES other than education level. However, there was no evidence of inequity according to education (based on the interaction analyses in Study 6) or income (based on subgroup analyses in Study 4), which are other measures of SES. Nevertheless, this was based on exploratory analyses, and as such cannot be considered conclusive. In addition, little is known about the generalisability of study findings outside of the UK.

Participants in the qualitative study were recruited from a single company (Bupa). It is possible that participants from other organisations within different industries (i.e., non-health related) have different attitudes. Indeed, one of the findings from this study was that participants were unsure as to whether the interventions would be acceptable to employees working outside of a healthcare organisation. However, the quantitative

acceptability findings from studies 3, 4, and 6 provide some reassurance that these interventions are acceptable (in principle) to the majority of participants who are likely to work across a range of industries. Before implementing an intervention of this nature in non-health related settings, conducting an assessment of acceptability with employees would be recommended.

b. Swaps offered

In studies 3 and 4, popular snacks and drinks were selected to ensure familiarity for a broad UK audience. In study 6, the menus were based on Bupa's real-world canteen, and participants were randomly assigned to view and choose from the main hot meals (n=3) for 1 of 5 different days. This menu variety helps to increase the generalisability of the findings. However, the minimum energy reduction for swaps offered was set at 50 kcal. Although this was based on evidence which suggests that this would be a clinically relevant reduction (Hill et al., 2003), it meant that only a limited choice of swaps were available for each item. The appeal of these swap items would affect the real-world effectiveness of the intervention. Furthermore, setting minimum energy reduction for swaps offered at 50kcal may not be feasible in a canteen context where the range of menu options is very restricted. Energy savings may need to be reduced to work within the constraints of real-world environments and, as such, may mean that effect sizes will be smaller than those observed in the present research.

In studies 3 and 4, the order in which participants selected snacks and drinks was fixed such that sweet snacks were selected first, then savoury snacks and finally, drinks. Ideally, the order in which products were presented would have been randomised. Unfortunately, this required complex programming in REDcap which I did not have the resources for at the time the studies were conducted. Given that swaps were offered immediately after selections were made, failure to counterbalance the order in which participants made selections may have influenced swap acceptance rates. Offering swaps for sweet snacks may have had a knock-on effect for the acceptance of swaps offered for savoury snacks and drinks. For instance, participants may be less likely to accept a swap for a drink if they have already accepted a swap for a sweet or savoury snack. Alternatively, if a swap is offered for a sweet snack, a participant may choose a lower-energy savoury snack to avoid being prompted again,

or a higher-energy snack if they think that they might be hungry after having previously accepted a swap. The descriptive statistics for studies 3 and 4 did not show evidence of this, with the proportions of swaps offered and accepted being similar for sweet and savoury snacks and slightly higher for drinks. This limitation was addressed in study 6 where participants could make their selections in any order.

9.3.3 Sample size and power

Although the two main randomised trials (studies 4 and 6) were sufficiently powered to detect effects for the primary analyses, these studies were not powered to examine subgroup differences. The rule of thumb for sample size requirements for interactions is that studies should be powered to detect an effect size that is at least half the size of the main effect. As the relationship between power and sample size is exponential, this would require four times the sample size required for the main effect (Baranger, 2019). Unfortunately, I did not have a sufficient budget for this. While there was no clear trend of differential effects of the intervention by subgroups, and recent (fully-powered) research testing the effect of labelling on energy ordered, found no evidence that intervention effectiveness differed for people of low or high socio-economic status (Marty et al., 2020), future research should continue to monitor this, ideally with fully powered analyses.

9.3.4 The role of theory

An a-priori theory-based logic map of how each intervention component would exert their effect and how individual characteristics may modify this effect was not created for this body of work because, in contrast to many behaviour change interventions which focus on trying to change individual behaviour from a motivation perspective, the current intervention focuses on trying to change the environment in which choices are made. As such, the current intervention does not map well onto widely-used behaviour change frameworks and theories, such as COM-B (Michie et al., 2011), the Theoretical Domains Framework (Atkins et al., 2017) or the Theory of Planned Behaviour (Ajzen, 2011). Instead, choice architecture (or Nudge Theory) (Thaler & Sunstein, 2008) was used as the overarching theory guiding this research, and choices made for intervention components were both data-driven and focused on

reducing effort (for the intervention recipient). The roles of each are discussed in turn below.

With respect to the role of Nudge Theory, this research developed an intervention that aligns with the idea of 'Nudge Plus' which describes interventions that build thinking components into nudges, while at the same time acknowledge our limited capacity for reflection, and the time constraints individuals face when making choices (John & Stoker, 2017). When considering each of the components of the current intervention (Pre-ordering + Swaps + PACE information), the pre-ordering aspect could be viewed as the traditional nudge, which aligns with Thaler & Sunstein's (2008) original conceptualization of choice architecture as being an intervention that changes behaviours in predictable ways without restricting choice, and usually targets our automatic unconscious system rather than relying on conscious cognitive processing. Indeed, pre-ordering has been hypothesised to be effective, because it does not restrict choice but rather changes the environment in which choices are made (online versus in the physical canteen), removing potentially tempting sensory cues and eliciting food choices at a time when an individual is more likely to make healthful choices (e.g., when they are potentially less hungry). Pre-ordering is thought to largely work on these subconscious mechanisms (e.g., hunger levels, absence of sensory cues, reduced present-bias) rather than trying to alter conscious behaviour. When considering the swaps component of the intervention, this aspect can be viewed as a 'Nudge-Plus'. Although it is a more actionable form of feedback than simple information provision, it encourages people to think (about whether they would like to swap), while preventing them from thinking 'too much' (about which options might be more healthful) which may result in disengagement. Similar to the prompts to swap, which aim to make information actionable, the PACE information component of this intervention aims to make energy information more tangible to the individual, so that decisions can be made more easily. Finally, by combining prompts to swap and PACE information with pre-ordering, the intervention can be delivered at a decisive moment (i.e., the point of choice) which theory suggests makes information provision more likely to be effective (Hysong et al., 2006; Tang et al., 2014).

When considering how the current intervention might align with new frameworks of behaviour change interventions, the intervention fits with the TIPPME framework for

changing environments to change behaviour outlined in Chapter 1 (Hollands et al., 2017). According to TIPPME, the current intervention would be classed as a 'properties' intervention, as it involves changing the properties of stimuli in physical micro-environments. Within this, the intervention draws on three types of properties: 'functionality', by changing how people physically interact with the menu items, 'presentation', because pre-ordering changes the sensory properties of the products by moving the choice environment online, and 'information', by providing calorie and PACE messages. Finally, the intervention focus is the product, as the intervention aims to influence behaviour by changing the product that is selected.

While there has been some discussion in the literature on the theory-based processes that might underlie pre-ordering (please see Chapter 3), very little work has been undertaken to try and map swaps onto theory. The choices made for aspects of the swap intervention, such as the type of swaps offered and messages used, were based on either previous research (e.g., in supermarket studies, swaps offered tend to be relatively similar to the initially selected item) or on the findings from data I collected. For example, many of the design decisions made for the final canteen study (Study 6) were based on the qualitative data collected from the think-aloud study with Bupa staff (Study 5). Many of the other design decisions were based on Nudge Theory's "make it easy" principle (Thaler & Sunstein, 2008). For example, in studies 4 and 6, the energy (kcal) and minutes walking *saved* by accepting the swap offered was presented rather than presenting them the energy (kcal) and minutes walking of each individual item (i.e., original and swap), because the latter would require the participant to calculate the difference. Finally, it is important to acknowledge that responses to an environmental change (pre-ordering, swaps, PACE messages) could depend on various individual characteristics such as levels of hunger and dietary restraint, or demographic characteristics. This was investigated in the current research and there was no evidence that the intervention effect differed by individual characteristics (although this analysis was not fully powered and so caution should be exercised when drawing conclusions based on this).

In summary, although an a-priori theory-based logic map of the intervention components was not created, choices for intervention components made were guided by Nudge Theory, were data-driven and focused on reducing effort. It is possible that

other design choices may have yielded stronger intervention effects but there is currently no theory to guide what these choices should be. Nevertheless, the results of this body of work show that the intervention works experimentally.

9.4 Implications for research and practice

Obesity is a complex public health issue that requires a multifaceted approach to intervention. While many of the factors that influence obesity risk such as genetic predisposition, SES, ethnicity and one's living environment, are beyond the individual's control, individual choice is a contributing factor that can potentially be positively influenced by choice architecture. Interventions targeting population energy reduction are just one of a range of interventions needed, but may, nevertheless, substantially contribute to obesity prevention (Hill et al., 2003; Public Health England, 2018a). Finding effective and acceptable ways to reduce energy consumed in the workplace may help to bring energy intake into line with public health recommendations.

The scoping reviews in chapters 2 and 3 highlighted a lack of studies testing swap-based interventions outside of supermarket settings and the lack of experimental research on pre-ordering. Pre-ordering systems have gradually been introduced in schools and workplaces but it is possible that pre-ordering might become increasingly popular in the context of a post-Covid-19 era, where companies may consider implementing pre-ordering systems to reduce the physical contact associated with long lunch queues at peak hours. The findings from this research indicate that integrating prompts to swap accompanied by PACE information into pre-ordering websites may be an effective strategy to reduce energy ordered from workplace canteens. Indeed, the results from the final study found that both offering swaps alone and with PACE information resulted in significantly more participants ordering lunches that met public health recommendations of containing ≤600 kcal, compared with when no swaps were offered.

Although the findings from this thesis point to the promise of applying swap-based interventions in experimental canteen settings, there remains a number of important questions to be answered. Some of these questions were intended to be addressed by the pilot feasibility trial and this was then not possible to examine in the new Covid-

19 era. The first of these questions is whether it is possible to run an RCT testing the effect of pre-ordering and swaps on energy purchased in a workplace setting. Although 70 participants were recruited during the 2 week recruitment period which exceeded the target of 42 set out in the traffic light criteria in the trial protocol, research questions relating to adherence and retention could not be answered. Furthermore, it was not possible to check whether study procedures, such as the intervention delivery and data collection, run smoothly, all of which is important information that should be gathered prior to launching a full-scale study to ensure its successful implementation (Van Teijlingen & Hundley, 2001). Although effect size estimates (for prompts to swap) and information regarding intervention acceptability was gathered as part of the new research strategy via an online RCT and a think-aloud study, studies to generate real-world effect size estimates and to collect qualitative data on acceptability after participants have experienced the intervention are required, especially as it was not possible to test the effect of pre-ordering in the current work. When workplace canteens reopen fully and it is safe to do so, an important next step would be to conduct a pilot trial similar to that described in Chapter 6.

Prior to conducting this pilot feasibility study, it will be important to conduct usability testing on the pre-ordering website with participants to ensure that aspects of the interface do not act as barriers to its use. This could be assessed using the think aloud method, but this time focusing on the functionality of the website (e.g., examining ease of task (ordering) completion, aspects of the display and layout, whether the intended user journey is intuitive). Alternatively, a survey tool such as the Systems Usability Scale (SUS) could be used (Brooke, 1996). The SUS is a 10-item self-report measure that assesses three components of usability: (i) effectiveness which refers to users' ability to complete the task using the system; (ii) efficiency which relates to the amount of effort required to perform the task and; (iii) satisfaction which aims to capture the users' subjective experience of using the system. Conducting prior usability testing will help ensure that any potential findings from the feasibility pilot study related to engagement issues (for example) will likely be attributable to features of the *intervention* rather than poor user experience (UX) design.

The findings from the studies conducted as part of the revised post-Covid-19 research strategy, pointed to some modifications that could be made to the intervention before

a pilot trial is conducted. For instance, when designing the original pilot trial there was uncertainty around whether it would be better to offer a dissimilar main meal as the swap option (because this is a hot meal) or an item from another menu that was more similar in terms of protein source such as a sandwich. The qualitative research highlighted that similarity was perceived as important to participants and so a second swap option for main meals was introduced in Study 6 (this was the item from another menu that matched the initially selected item in terms of protein source (e.g., a chicken sandwich as a swap for a chicken curry)). Exploratory descriptive analysis of the acceptance of swaps for main meals indicated that a higher proportion of people opted for this second option. In situations where swaps offered from the same menu would be an entirely different meal, offering two potential swaps (one dissimilar hot dish and another menu item that is similar in terms of the protein source) may help to maximise swap acceptance. Similarly, based on the qualitative findings, the provision of images, written descriptions and energy information for all menu items on the pre-ordering website should be considered. One aspect of swaps offered that was not directly explored in the current research is the option of offering swaps that are a smaller portion size. In the present studies, the focus was on offering swaps that were the best available match among the other products on the menu. In some cases these different (but very similar) products were smaller in size but testing the effect of offering smaller portion sizes was not the focus of this research for pragmatic reasons as detailed in Chapter 3. There is, however, some research which suggests that offering smaller portion sizes to consumers may reduce the energy content of lunches ordered (Schwartz et al., 2012). There is also some evidence that offering non-food incentives (e.g., a lottery ticket) alongside smaller portions may help to reduce the energy content of lunches (Reimann et al., 2015). Future research could examine the feasibility and effectiveness of offering these alternative types of swaps.

If a pilot feasibility trial confirms that an RCT would be possible, it would be important for future work to test the effect of the intervention in real-world canteens over extended periods of time to observe sustainability of any intervention effects. Little is known about how people would respond to swaps offered over time. One criticism of the research on choice architecture is that the sustained effect of nudges has not received much attention, despite this being important for behaviours like dietary choices, where sustained behavioural change across time and contexts is usually

necessary to achieve a meaningful impact on health (Van Rookhuijzen et al., 2021). Only one study provided evidence that pre-ordering may have a sustained effect, with Stites and colleagues (2015) reporting that significant reductions in the energy content of lunch orders were observed across the 8-week duration of the study. Similarly, one study examined the potential sustained effect of offering swaps in a supermarket setting. The analysis was exploratory and was based on 115 participants who had completed six shopping episodes during the study. The results indicated that larger reductions in the saturated fat content of baskets were observed for earlier than for later periods, but that the effect of the intervention was sustained over the consecutive shopping episodes. The authors noted that the intervention group appeared to have changed their behaviours in response to the intervention, opting for lower-saturated fat items from the outset (i.e., before swaps were offered) in later shopping episodes (Huang et al., 2006). Longitudinal studies are needed to assess the long-term impact of pre-ordering with prompts to swap on the energy ordered. As well as targeting energy consumption, the promotion of broader healthy dietary patterns (e.g., reducing the consumption of ultra-processed food) is important and should also be a consideration for future studies in this space.

The high ratings (92%) for the acceptability of pre-ordering indicate that interested organisations could trial this without concerns that their employees would be dissatisfied with this change. Employee surveys have pointed to a link between workplace catering services and employee wellbeing (Corvo et al., 2020) and suggest that canteen pre-ordering services may be both acceptable and welcomed by staff provided that they are implemented effectively (Migliavada et al., 2021). Workplaces can also play an integral role in helping people to live healthier lives and reduce energy intake to meet public health guidelines. The findings from the qualitative research with Bupa employees suggested that employees would welcome tools to help them to eat more healthfully and some believed that employers had a responsibility to facilitate this. Although quantitative acceptability ratings were generally high for the swaps feature (60-74%), a sizable proportion of participants (between 16% and 23%) viewed being offered swaps for their lunch choice when pre-ordering at work as unacceptable. It will be important to continue to examine acceptability of this aspect of the intervention and the factors that may facilitate this. The findings from this thesis have implications for the development and refinement of pre-ordering systems that could be

implemented in workplaces. Practical facilitators of acceptability included the website having a user-friendly process, certain aspects of the service logistics such as being able to reserve desired meals and use an express queue. Furthermore, personalisation of website features (i.e., prompts to swap, PACE messages) may help to protect individual autonomy and thus enhance acceptability. This information could be used by organisations to increase the likelihood of successful implementation of these systems. A pilot study will further help intervention refinement and inform the future implementation of the intervention. It is important to note that the current work was conducted in collaboration with a healthcare company. It is possible that given the nature of the organisation, the intervention had a higher likelihood of being perceived as acceptable. Indeed, an uncertainty as to whether the intervention would be well received in other contexts was a view expressed by Bupa staff in the qualitative study reported in chapter 7. Future studies should be conducted in non-health-related organisations in order to ensure that the intervention is acceptable and effective to employees working in other industries.

Findings from the think-aloud study (5), also provide important practical information for how swaps could be offered in real-world canteen settings, while minimizing effort required. For example, a substantial proportion of physical canteens employ a similar set-up to the canteen in Study 6 whereby many menu options change each day, and these changes are not planned well in advance. In this scenario, energy and PACE information would need to be calculated for these ever-changing menu options. It would be difficult to automate the swaps and the generation of PACE information in a context like this and it may therefore require dedicated resources. While the analysis was not powered to detect differences in swap acceptance between individual menus, there was some evidence that offering swaps may be more effective for certain menus, such as main meals, jacket potatoes, and sweet snacks. If this finding is replicated in future research, canteens could implement automated swaps and swaps+PACE interventions with minimal effort for specific menus that do not change regularly (e.g., drinks, jacket potatoes, snacks, and sandwiches).

The findings indicate that as well as providing PACE information offering cheaper swaps may help to maximise swap acceptance. Further research is required to examine, in detail, the relative effect of price difference on swap acceptance, ideally

in a setting where participants are making actual purchases with their own money. However, it is important to note that as well as being offered swaps (some of which were cheaper), all participants were provided with energy information. In particular, the findings from Study 6 support the view that multiple strategies (swaps, price incentives, calorie disclosures) are simultaneously needed to change dietary behaviour. Recently, researchers have begun to develop and test interventions that combine several evidence-based strategies into a single intervention. For instance, a study testing a pre-ordering intervention across schools in Australia recently reported that an "enhanced pre-ordering system" which employed a range of nudges, such as pre-ordering products and adjusting product availability in favour of more healthful options, providing traffic light labels and positively reinforcing healthful choices significantly reduced the energy, saturated fat, and salt content of lunches ordered compared with pre-ordering alone (Delaney et al., 2017). Future research should work towards developing and testing combined interventions.

The higher acceptability ratings among those receiving PACE information may be somewhat explained by Sekhon et al.'s (2017) Theoretical Framework of Acceptability which hypotheses that the extent to which participants understand the intervention importantly influences perceptions of acceptability. In contrast to the swaps only condition in Study 6, in which the reason why swaps were being offered may not have been immediately apparent to participants, the swaps+PACE condition presented a message accompanying swaps offered that highlighted to participants that swaps were being offered *because* they were lower in energy. This information may have aided intervention understanding among the swaps+PACE group, thereby increasing intervention acceptability. However, some researchers have argued that calorie labelling may cause harm especially to those with eating disorders (McGeown, 2019). Responses to the post-trial questions in Study 4 provided some support for the argument that PACE messaging may be more likely to trigger excessive calorie counting than a calories-only message. While this is only a reflection of participants' perceptions of their potential future behaviours, future studies should examine potential harm from PACE labelling and its long-term outcomes.

9.5 Concluding remarks

High energy intake significantly contributes to obesity. The workplace is a setting where a substantial amount of energy is consumed on a regular basis. Interventions that aim to reduce energy intake in the workplace may have large-scale impact. An intervention combining pre-ordering with prompts to swap to lower-energy alternatives is a potentially effective and acceptable strategy to reduce energy ordered in workplace canteens, and adding tangible PACE information may help to boost swap effect sizes. If replicated in a real-world setting, this intervention could be delivered as part of a suite of interventions, supported by policy action, to help bring energy intake into line with public health recommendations.

References

Abdelaal, M., le Roux, C. W., & Docherty, N. G. (2017). Morbidity and mortality associated with obesity. *Ann Transl Med, 5*(7), 161. doi:10.21037/atm.2017.03.107

Abildgaard, J. S., Saksvik, P. Ø., & Nielsen, K. (2016). How to measure the intervention process? An assessment of qualitative and quantitative approaches to data collection in the process evaluation of organizational interventions. *Frontiers in Psychology, 7*, 1380.

Action on Sugar (2020). New Calorie Reduction Targets Announced. Retrieved from: http://www.actiononsugar.org/news-centre/sugar-in-the-news/2020/2020-stories/new-calorie-reduction-targets-announced.html

Adams, J., Mytton, O., White, M., & Monsivais, P. (2016). Why are some population interventions for diet and obesity more equitable and effective than others? The role of individual agency. *PLoS medicine, 13*(4), e1001990.

Afshin, A., Peñalvo, J. L., Del Gobbo, L., Silva, J., Michaelson, M., O'Flaherty, M., . . . Mozaffarian, D. (2017). The prospective impact of food pricing on improving dietary consumption: A systematic review and meta-analysis. *PLoS One, 12*(3), e0172277. doi:10.1371/journal.pone.0172277

Ainslie, G. (1975). Specious reward: A behavioral theory of impulsiveness and impulse control. *Psychological Bulletin, 82*(4), 463-496. doi:10.1037/h0076860

Ainsworth, B., Haskell, W., Herrmann, S., Meckes, N., Bassett, D., Tudor-Locke, C., . . . Leon, A. (2011). Compendium of Physical Activities 2011: a second update of codes and MET values. *Medicine and science in sports and exercise, 43 8*, 1575-1581.

Ajzen, I. (2011). The theory of planned behaviour: Reactions and reflections. *Psychology & Health, 26*(9), 1113-1127. doi:10.1080/08870446.2011.613995

Allan, J. L., & Powell, D. J. (2020). Prompting consumers to make healthier food choices in hospitals: a cluster randomised controlled trial. *International Journal of Behavioral Nutrition and Physical Activity, 17*(1), 1-10.

Anderson, A. S., Dunlop, J., Gallant, S., Macleod, M., Miedzybrodzka, Z., Mutrie, N., . . . Taylor, R. S. (2018). Feasibility study to assess the impact of a lifestyle intervention ('LivingWELL') in people having an assessment of their family history of colorectal or breast cancer. *BMJ Open, 8*(2), e019410.

Arain, M., Campbell, M. J., Cooper, C. L., & Lancaster, G. A. (2010). What is a pilot or feasibility study? A review of current practice and editorial policy. *BMC medical research methodology, 10*(1), 1-7.

Arganini, C., Saba, A., Comitato, R., Virgili, F., & Turrini, A. (2012). Gender differences in food choice and dietary intake in modern western societies. *Public health-social and behavioral health, 4*, 83-102.

Arno, A., & Thomas, S. (2016). The efficacy of nudge theory strategies in influencing adult dietary behaviour: a systematic review and meta-analysis. *BMC public health, 16*(1), 676. doi:10.1186/s12889-016-3272-x

Atkins, L., Francis, J., Islam, R., O'Connor, D., Patey, A., Ivers, N., . . . Grimshaw, J. M. (2017). A guide to using the Theoretical Domains Framework of behaviour change to investigate implementation problems. *Implementation Science, 12*(1), 1-18.

Ball, K., Jeffery, R. W., Abbott, G., McNaughton, S. A., & Crawford, D. (2010). Is healthy behavior contagious: associations of social norms with physical activity and healthy eating. *International Journal of Behavioral Nutrition and Physical Activity, 7*(1), 86. doi:10.1186/1479-5868-7-86

Baranger, D. (2019). Interaction analyses – How large a sample do I need? Retrieved from https://davidbaranger.com/2019/08/06/interaction-analyses-how-large-a-sample-do-i-need-part-3/#

Bauer, J. M., & Reisch, L. A. (2019). Behavioural insights and (un) healthy dietary choices: A review of current evidence. *Journal of Consumer Policy, 42*(1), 3-45.

BBC. (2019). Exercise targets would trigger my eating disorder. *BBC*. Retrieved from https://www.bbc.com/news/uk-50743683

Becker, L. A. (2000). *Effect Size (ES).* Retrieved from www.uv.es: https://www.uv.es/~friasnav/EffectSizeBecker.pdf

Behavioural Insights Team LTD (2021). Predictiv. Retrieved from https://www.bi.team/bi-ventures/predictiv/

Benjamini, Y., & Hochberg, Y. (1995). Controlling the False Discovery Rate: A Practical and Powerful Approach to Multiple Testing. *Journal of the Royal Statistical Society: Series B (Methodological), 57*(1), 289-300. doi:https://doi.org/10.1111/j.2517-6161.1995.tb02031.x

Benson, C. (2009). Increasing portion size in Britain. *Society, biology and human affairs., 74*(2), 4-20.

Berners-Lee, M., Kennelly, C., Watson, R., & Hewitt, C. N. (2018). Current global food production is sufficient to meet human nutritional needs in 2050 provided there is radical societal adaptation. *Elementa: Science of the Anthropocene, 6*. doi:10.1525/elementa.310

Bettman, J. R., & Park, C. W. (1980). Effects of prior knowledge and experience and phase of the choice process on consumer decision processes: A protocol analysis. *Journal of consumer research, 7*(3), 234-248.

Bleich, S. N., Economos, C. D., Spiker, M. L., Vercammen, K. A., VanEpps, E. M., Block, J. P., . . . Roberto, C. A. (2017). A systematic review of calorie labeling and modified calorie labeling interventions: impact on consumer and restaurant behavior. *Obesity, 25*(12), 2018-2044.

Bleich, S. N., & Pollack, K. M. (2010). The publics' understanding of daily caloric recommendations and their perceptions of calorie posting in chain restaurants. *BMC public health, 10*(1), 1-10.

Blumenthal, K., & Volpp, K. G. (2010). Enhancing the effectiveness of food labeling in restaurants. *JAMA, 303*(6), 553-554.

Bodirsky, B. L., Dietrich, J. P., Martinelli, E., Stenstad, A., Pradhan, P., Gabrysch, S., . . . Popp, A. (2020). The ongoing nutrition transition thwarts long-term targets for food security, public health and environmental protection. *Scientific Reports, 10*(1), 19778. doi:10.1038/s41598-020-75213-3

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology, 3*(2), 77-101.

Breathnach, S., Koutoukidis, D. A., Lally, P., Boniface, D., Sutherland, A., & Llewellyn, C. H. (2021). The effect of messaging on the acceptance of swaps to reduce the energy content of snacks and non-alcoholic drinks ordered in an experimental online workplace canteen: A randomised controlled trial. *Appetite, 162*, 105171. doi:10.1016/j.appet.2021.105171

Breathnach, S., Llewellyn, C. H., Koutoukidis, D. A., van Rugge, C. R., Sutherland, A., & Lally, P. (2020). Experience of Using an Online Pre-Ordering System for A Workplace Canteen That Offers Lower-Energy Swaps: A Think-Aloud Study. *Nutrients, 12*(12), 3878. Retrieved from https://www.mdpi.com/2072-6643/12/12/3878

Brewer, N. T., Hall, M. G., Noar, S. M., Parada, H., Stein-Seroussi, A., Bach, L. E., . . . Ribisl, K. M. (2016). Effect of pictorial cigarette pack warnings on changes in smoking behavior: a randomized clinical trial. *JAMA internal medicine, 176*(7), 905-912.

British Soft Drinks Association (2019). *British Soft Drinks Association Annual Report 2019*. Retrieved from: https://www.britishsoftdrinks.com/write/MediaUploads/BSDA_Annual_Report_2019.pdf

Brooke, J. (1996). Sus: a “quick and dirty’usability. *Usability evaluation in industry*, *189*(3).

Bunten, A., Porter, L., Sanders, J. G., Sallis, A., Payne Riches, S., Van Schaik, P., . . . Forwood, S. (2021). A randomised experiment of health, cost and social norm message frames to encourage acceptance of swaps in a simulation online supermarket. *PLoS One, 16*(2), e0246455. doi:10.1371/journal.pone.0246455

Butland, B., Jebb, S., Kopelman, P., McPherson, K., Thomas, S., Mardell, J., & Parry, V. (2007). *Tackling obesities: future choices-project report* (Vol. 10): Citeseer.

Cadario, R., & Chandon, P. (2020). Which Healthy Eating Nudges Work Best? A Meta-Analysis of Field Experiments. *Marketing Science, 39*(3), 465-486. doi:10.1287/mksc.2018.1128

Cameron, J. D., Goldfield, G. S., Finlayson, G., Blundell, J. E., & Doucet, É. (2014). Fasting for 24 hours heightens reward from food and food-related cues. *PLoS One, 9*(1), e85970.

Cantrell, J., Vallone, D. M., Thrasher, J. F., Nagler, R. H., Feirman, S. P., Muenz, L. R., . . . Viswanath, K. (2013). Impact of tobacco-related health warning labels across socioeconomic, race and ethnic groups: results from a randomized web-based experiment. *PLoS One, 8*(1), e52206.

Carter, M. C., Albar, S. A., Morris, M. A., Mulla, U. Z., Hancock, N., Evans, C. E., . . . Frost, G. S. (2015). Development of a UK online 24-h dietary assessment tool: myfood24. *Nutrients, 7*(6), 4016-4032.

Center for Biologics Evaluation and Research (CBER). (2017). *Draft Guidance: Multiple endpoints in clinical trials guidance for industry*. Retrieved from fda.org: https://www.fda.gov/files/drugs/published/Multiple-Endpoints-in-Clinical-Trials-Guidance-for-Industry.pdf

Chakrapani, V., Shunmugam, M., Rawat, S., Baruah, D., Nelson, R., & Newman, P. A. (2020). Acceptability of HIV pre-exposure prophylaxis among transgender women in India: a qualitative investigation. *AIDS patient care and STDs, 34*(2), 92-98.

Chen, P.-J., & Antonelli, M. (2020). Conceptual Models of Food Choice: Influential Factors Related to Foods, Individual Differences, and Society. *Foods, 9*(12), 1898.

Cialdini, R. B. (2007). Descriptive Social Norms as Underappreciated Sources of Social Control. *Psychometrika, 72*(2), 263. doi:10.1007/s11336-006-1560-6

Clarke, N., Pechey, E., Kosīte, D., König, L. M., Mantzari, E., Blackwell, A. K. M., . . . Hollands, G. J. (2020). Impact of health warning labels on selection and consumption of food and alcohol products: systematic review with meta-analysis. *Health Psychology Review*, 1-24. doi:10.1080/17437199.2020.1780147

Coggon, J., & Adams, J. (2021). 'Let them choose not to eat cake...': Public health ethics, effectiveness and equity in government obesity strategy. *Future healthcare journal, 8*(1), 49-52. doi:10.7861/fhj.2020-0246

Cook, J. A., Julious, S. A., Sones, W., Hampson, L. V., Hewitt, C., Berlin, J. A., . . . Walters, S. J. (2018). DELTA2 guidance on choosing the target difference and undertaking and reporting the sample size calculation for a randomised controlled trial. *BMJ, 363*.

Cornelsen, L., & Carreido, A. (2015). Health related taxes on foods and beverages. *Food Research Collaboration Policy Brief*, 1–15.

Cornelsen, L., Quaife, M., Lagarde, M., & Smith, R. D. (2020). Framing and signalling effects of taxes on sugary drinks: A discrete choice experiment among households in Great Britain. *Health Economics, 29*(10), 1132-1147. doi:https://doi.org/10.1002/hec.4123

Correa, T., Fierro, C., Reyes, M., Dillman Carpentier, F. R., Taillie, L. S., & Corvalan, C. (2019). “Responses to the Chilean law of food labeling and advertising: exploring knowledge, perceptions and behaviors of mothers of young children”. *International Journal of Behavioral Nutrition and Physical Activity, 16*(1), 21. doi:10.1186/s12966-019-0781-x

Corvo, P., Fontefrancesco, M. F., & Matacena, R. (2020). Eating at Work: The Role of the Lunch-Break and Canteens for Wellbeing at Work in Europe. *Social Indicators Research, 150*(3), 1043-1076.

Crockett, R. A., King, S. E., Marteau, T. M., Prevost, A. T., Bignardi, G., Roberts, N. W., . . . Jebb, S. A. (2018). Nutritional labelling for healthier food or non-alcoholic drink purchasing and consumption. *Cochrane Database of Systematic Reviews*(2). doi:10.1002/14651858.CD009315.pub2

Czarniecka-Skubina, E., Górska-Warsewicz, H., & Trafiałek, J. (2020). Attitudes and Consumer Behavior toward Foods Offered in Staff Canteens. *International journal of environmental research and public health, 17*(17), 6239.

Daley, A. J., McGee, E., Bayliss, S., Coombe, A., & Parretti, H. M. (2020). Effects of physical activity calorie equivalent food labelling to reduce food selection and consumption: systematic review and meta-analysis of randomised controlled studies. *J Epidemiol Community Health, 74*(3), 269-275.

Davis, F. D. (1985). *A technology acceptance model for empirically testing new end-user information systems: Theory and results* (Doctoral dissertation, Massachusetts Institute of Technology).

de Vries, R., Morquecho-Campos, P., de Vet, E., de Rijk, M., Postma, E., de Graaf, K., . . . Boesveldt, S. (2020). Human spatial memory implicitly prioritizes high-calorie foods. *Scientific Reports, 10*(1), 15174. doi:10.1038/s41598-020-72570-x

Deery, C. B., Hales, D., Viera, L., Lin, F.-C., Liu, Z., Olsson, E., . . . Ammerman, A. S. (2019). Physical activity calorie expenditure (PACE) labels in worksite cafeterias: effects on physical activity. *BMC public health, 19*(1), 1-10.

Delaney, T., Wyse, R., Yoong, S. L., Sutherland, R., Wiggers, J., Ball, K., . . . Wolfenden, L. (2017). Cluster randomized controlled trial of a consumer behavior intervention to improve healthy food purchases from online canteens. *Am J Clin Nutr, 106*(5), 1311-1320. doi:10.3945/ajcn.117.158329

Department of Health. (2013). *Developing a specification for lifestyle weight management services*. Retrieved from London: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/142723/Weight_Management_Service_Spec_FINAL_with_IRB.pdf

Devaux, M., & Sassi, F. (2013). Social inequalities in obesity and overweight in 11 OECD countries. *Eur J Public Health, 23*(3), 464-469. doi:10.1093/eurpub/ckr058

Devaux, M., Sassi, F., Church, J., Cecchini, M., & Borgonovi, F. (2011). Exploring the Relationship Between Education and Obesity. doi:doi:https://doi.org/10.1787/eco_studies-2011-5kg5825v1k23

Diabetes UK (2018). *Public views on food labelling survey. ComRes interviewed 2,121 UK adults online, aged 18+ between 12-14th Jan 2018.* Retrieved from https://www.diabetes.org.uk/about_us/news/poll-food-labels-influence-spending

Di Angelantonio, E., Bhupathiraju, S. N., Wormser, D., Gao, P., Kaptoge, S., de Gonzalez, A. B., . . . Hu, F. B. (2016). Body-mass index and all-cause mortality: individual-participant-data meta-analysis of 239 prospective studies in four continents. *The Lancet, 388*(10046), 776-786. doi:10.1016/S0140-6736(16)30175-1

Diepeveen, S., Ling, T., Suhrcke, M., Roland, M., & Marteau, T. M. (2013). Public acceptability of government intervention to change health-related behaviours: a systematic review and narrative synthesis. *BMC public health, 13*(1), 1-11.

Dorling, J. L., van Vliet, S., Huffman, K. M., Kraus, W. E., Bhapkar, M., Pieper, C. F., . . . Group, t. C. S. (2020). Effects of caloric restriction on human physiological, psychological, and behavioral outcomes: highlights from CALERIE phase 2. *Nutrition Reviews, 79*(1), 98-113. doi:10.1093/nutrit/nuaa085

Dorsch, M. P., Cornellier, M. L., Poggi, A. D., Bilgen, F., Chen, P., Wu, C., . . . Hummel, S. L. (2020). Effects of a novel contextual just-in-time mobile app intervention (LowSalt4Life)

on sodium intake in adults with hypertension: pilot randomized controlled trial. *JMIR mHealth and uHealth, 8*(8), e16696.

Dowray, S., Swartz, J. J., Braxton, D., & Viera, A. J. (2013). Corrigendum to "Potential effect of physical activity based menu labels on the calorie content of selected fast food meals"[Appetite 62 (2013) 173–181]. *Appetite*(66), 89.

Drewnowski, A. (2009). Obesity, diets, and social inequalities. *Nutr Rev, 67 Suppl 1*, S36-39. doi:10.1111/j.1753-4887.2009.00157.x

Duckworth, A. L., Gendler, T. S., & Gross, J. J. (2016). Situational Strategies for Self-Control. *Perspectives on Psychological Science, 11*(1), 35-55. doi:10.1177/1745691615623247

Ducrot, P., Julia, C., Méjean, C., Kesse-Guyot, E., Touvier, M., Fezeu, L. K., . . . Péneau, S. (2016). Impact of Different Front-of-Pack Nutrition Labels on Consumer Purchasing Intentions: A Randomized Controlled Trial. *Am J Prev Med, 50*(5), 627-636. doi:10.1016/j.amepre.2015.10.020

Egnell, M., Talati, Z., Hercberg, S., Pettigrew, S., & Julia, C. (2018). Objective Understanding of Front-of-Package Nutrition Labels: An International Comparative Experimental Study across 12 Countries. *Nutrients, 10*(10). doi:10.3390/nu10101542

Eldridge, S. M., Chan, C. L., Campbell, M. J., Bond, C. M., Hopewell, S., Thabane, L., & Lancaster, G. A. (2016). CONSORT 2010 statement: extension to randomised pilot and feasibility trials. *BMJ, 355*.

Elks, C. E., den Hoed, M., Zhao, J. H., Sharp, S. J., Wareham, N. J., Loos, R. J., & Ong, K. K. (2012). Variability in the heritability of body mass index: a systematic review and meta-regression. *Front Endocrinol (Lausanne), 3*, 29. doi:10.3389/fendo.2012.00029

Ericsson, K. A., & Simon, H. A. (1993). *Protocol Analysis: Verbal Reports as Data*. Cambridge,MA, USA,: The MIT Press.

European Public Health Alliance. (2019). What are 'food environments'? Retrieved from https://epha.org/what-are-food-environments/

Eyles, H., McLean, R., Neal, B., Jiang, Y., Doughty, R. N., McLean, R., & Ni Mhurchu, C. (2017). A salt-reduction smartphone app supports lower-salt food purchases for people with cardiovascular disease: findings from the SaltSwitch randomised controlled trial. *European journal of preventive cardiology, 24*(13), 1435-1444.

Falconer, C. L., Park, M. H., Croker, H., Kessel, A. S., Saxena, S., Viner, R. M., & Kinra, S. (2014). Can the relationship between ethnicity and obesity-related behaviours among school-aged children be explained by deprivation? A cross-sectional study. *BMJ Open, 4*(1), e003949. doi:10.1136/bmjopen-2013-003949

Fernandes, A. C., de Oliveira, R. C., Rodrigues, V. M., Fiates, G. M. R., & da Costa Proença, R. P. (2015). Perceptions of university students regarding calories, food healthiness, and the importance of calorie information in menu labelling. *Appetite, 91*, 173-178.

Fernandes, A. C., Rieger, D. K., & Proença, R. P. C. (2019). Perspective: Public Health Nutrition Policies Should Focus on Healthy Eating, Not on Calorie Counting, Even to Decrease Obesity. *Adv Nutr, 10*(4), 549-556. doi:10.1093/advances/nmz025

Fernández, J. R., & Shiver, M. D. (2004). Using genetic admixture to study the biology of obesity traits and to map genes in admixed populations. *Nutr Rev, 62*(7 Pt 2), S69-74. doi:10.1111/j.1753-4887.2004.tb00091.x

Ferrari, P., Friedenreich, C., & Matthews, C. E. (2007). The role of measurement error in estimating levels of physical activity. *American journal of epidemiology, 166*(7), 832-840.

Fields, S. (2004). The Fat of the Land: Do Agricultural Subsidies Foster Poor Health? *Environmental Health Perspectives, 112*(14), A820-A823. doi:10.1289/ehp.112-a820

Fitch, R. C., Harnack, L. J., Neumark-Sztainer, D. R., Story, M. T., French, S. A., Oakes, J. M., & Rydell, S. A. (2009). Providing calorie information on fast-food restaurant menu boards: consumer views. *Am J Health Promot, 24*(2), 129-132. doi:10.4278/ajhp.08031426

Forwood, S. E., Ahern, A. L., Marteau, T. M., & Jebb, S. A. (2015). Offering within-category food swaps to reduce energy density of food purchases: a study using an experimental online supermarket. *International Journal of Behavioral Nutrition and Physical Activity, 12*(1), 85. doi:10.1186/s12966-015-0241-1

Garnett, E. E., Balmford, A., Marteau, T. M., Pilling, M. A., & Sandbrook, C. (2021). Price of change: Does a small alteration to the price of meat and vegetarian options affect their sales? *Journal of Environmental Psychology, 75*, 101589.

Gatineau, M., & Mathrani, S. (2011). Ethnicity and obesity in the UK. *Perspectives in Public Health, 131*(4), 159-160. doi:10.1177/1757913911412478

Giesen, J. C. A. H., Geyskens, K., Goukens, C., & Havermans, R. C. (2013). Changing the default. How to promote healthier food choices. *Appetite, 71*, 475. doi:https://doi.org/10.1016/j.appet.2013.06.026

Giné, X., Karlan, D., & Zinman, J. (2010). Put your money where your butt is: a commitment contract for smoking cessation. *American Economic Journal: Applied Economics, 2*(4), 213-235.

Glynn, C. J., Huge, M. E., & Lunney, C. A. (2009). The Influence of Perceived Social Norms on College Students' Intention to Vote. *Political Communication, 26*(1), 48-64. doi:10.1080/10584600802622860

Goiana-da-Silva, F., Cruz, E. S. D., Miraldo, M., Calhau, C., Bento, A., Cruz, D., . . . Araújo, F. (2019). Front-of-pack labelling policies and the need for guidance. *Lancet Public Health, 4*(1), e15. doi:10.1016/s2468-2667(18)30256-1

Gonzalez-Nahm, S., Bhatti, A., Ames, M., Zaltz, D., & Benjamin Neelon, S. (2020). A Public Health Messaging Campaign to Reduce Caloric Intake: Feedback From Expert Stakeholders. *Journal of Nutrition Education and behavior, 52*. doi:10.1016/j.jneb.2020.02.018

Griffith, R., O'Connell, M., Smith, K., & Stroud, R. (2020). What's on the Menu? Policies to Reduce Young People's Sugar Consumption. *Fiscal Studies, 41*(1), 165-197. doi:https://doi.org/10.1111/1475-5890.12194

Grüne-Yanoff, T., & Hertwig, R. (2016). Nudge Versus Boost: How Coherent are Policy and Theory? *Minds and Machines, 26*(1), 149-183. doi:10.1007/s11023-015-9367-9

Grunert, K. G., Bolton, L. E., & Raats, M. M. (2012). Processing and acting on nutrition labeling on food: the state of knowledge and new directions for Transformative Consumer Research. *Transformative consumer research for personal and collective well-being*, 361-380.

Grunert, K. G., Fernández-Celemín, L., Wills, J. M., Storcksdieck genannt Bonsmann, S., & Nureeva, L. (2010). Use and understanding of nutrition information on food labels in six European countries. *Journal of Public Health, 18*(3), 261-277. doi:10.1007/s10389-009-0307-0

Grunert, K. G., & Wills, J. M. (2007). A review of European research on consumer response to nutrition information on food labels. *Journal of Public Health, 15*(5), 385-399. doi:10.1007/s10389-007-0101-9

Guan, Z., Lee, S., Cuddihy, E., & Ramey, J. (2006). *The validity of the stimulated retrospective think-aloud method as measured by eye tracking*. Paper presented at the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Montréal, Québec, Canada. https://doi.org/10.1145/1124772.1124961

Haines, M., Perkins, H., Richard, M., Rice, M., & Barker. (2005). A Guide to Marketing Social Norms for Health Promotion in Schools and Communities.

Hall, K. D. (2018). Did the Food Environment Cause the Obesity Epidemic? *Obesity (Silver Spring), 26*(1), 11-13. doi:10.1002/oby.22073

Hall, K. D., Ayuketah, A., Brychta, R., Cai, H., Cassimatis, T., Chen, K. Y., . . . Zhou, M. (2019). Ultra-Processed Diets Cause Excess Calorie Intake and Weight Gain: An Inpatient Randomized Controlled Trial of Ad Libitum Food Intake. *Cell Metab, 30*(1), 67-77.e63. doi:10.1016/j.cmet.2019.05.008

Hall, K. D., Heymsfield, S. B., Kemnitz, J. W., Klein, S., Schoeller, D. A., & Speakman, J. R. (2012). Energy balance and its components: implications for body weight regulation. *Am J Clin Nutr, 95*(4), 989-994. doi:10.3945/ajcn.112.036350

Hall, K. D., Sacks, G., Chandramohan, D., Chow, C. C., Wang, Y. C., Gortmaker, S. L., & Swinburn, B. A. (2011). Quantification of the effect of energy imbalance on bodyweight. *The Lancet, 378*(9793), 826-837.

Halpern, S. D., French, B., Small, D. S., Saulsgiver, K., Harhay, M. O., Audrain-McGovern, J., . . . Volpp, K. G. (2015). Randomized trial of four financial-incentive programs for smoking cessation. *N Engl J Med, 372*, 2108-2117.

Harbers, M. C., Beulens, J. W., Rutters, F., de Boer, F., Gillebaart, M., Sluijs, I., & van der Schouw, Y. T. (2020). The effects of nudges on purchases, food choice, and energy intake or content of purchases in real-life food purchasing environments: a systematic review and evidence synthesis. *Nutrition journal, 19*(1), 1-27.

Harris, P. A., Taylor, R., Thielke, R., Payne, J., Gonzalez, N., & Conde, J. G. (2009). Research electronic data capture (REDCap)—A metadata-driven methodology and workflow process for providing translational research informatics support. *Journal of Biomedical Informatics, 42*(2), 377-381. doi:https://doi.org/10.1016/j.jbi.2008.08.010

Hartmann-Boyce, J., Bianchi, F., Piernas, C., Riches, S. P., Frie, K., Nourse, R., & Jebb, S. A. (2018). Grocery store interventions to change food purchasing behaviors: a systematic review of randomized controlled trials. *The American journal of clinical nutrition, 107*(6), 1004-1016.

Hashem, K. M., He, F. J., & MacGregor, G. A. (2018). Cross-sectional surveys of the amount of sugar, energy and caffeine in sugar-sweetened drinks marketed and consumed as energy drinks in the UK between 2015 and 2017: monitoring reformulation progress. *BMJ Open, 7*(12), e018136.

Hersey, J. C., Wohlgenant, K. C., Arsenault, J. E., Kosa, K. M., & Muth, M. K. (2013). Effects of front-of-package and shelf nutrition labeling systems on consumers. *Nutr Rev, 71*(1), 1-14. doi:10.1111/nure.12000

Higgins, E. T. (1996). VKnowledge Activation: Accessibility, Applicability, and Salience, V in E. Tory Higgins and Arie W. Kruglanski, eds. In E. E. Higgins & A. Kruglanski (Eds.), *Social Psychology: Handbook of Basic Principles*: Guilford.

Higgins, J. P., Altman, D. G., Gøtzsche, P. C., Jüni, P., Moher, D., Oxman, A. D., ... & Sterne, J. A. (2011). The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. *Bmj*, *343*, doi:10.1136/bmj.d5928

Higgs, S. (2015). Social norms and their influence on eating behaviours. *Appetite, 86*, 38-44. doi:10.1016/j.appet.2014.10.021

Hilbert, A., Rief, W., & Braehler, E. (2007). What determines public support of obesity prevention? *J Epidemiol Community Health, 61*(7), 585-590. doi:10.1136/jech.2006.050906

Hill, J. O. (2006). Understanding and Addressing the Epidemic of Obesity: An Energy Balance Perspective. *Endocrine Reviews, 27*(7), 750-761. doi:10.1210/er.2006-0032

Hill, J. O., Wyatt, H. R., Reed, G. W., & Peters, J. C. (2003). Obesity and the environment: where do we go from here? *Science, 299*(5608), 853-855. doi:10.1126/science.1079857

Hills, A. P., Byrne, N. M., Lindstrom, R., & Hill, J. O. (2013). 'Small changes' to diet and physical activity behaviors for weight management. *Obes Facts, 6*(3), 228-238. doi:10.1159/000345030

Hodge, J. M., Shah, R., McCullough, M. L., Gapstur, S. M., & Patel, A. V. (2020). Validation of self-reported height and weight in a large, nationwide cohort of U.S. adults. *PLoS One, 15*(4), e0231229. doi:10.1371/journal.pone.0231229

Hoffmann, T. C., Glasziou, P. P., Boutron, I., Milne, R., Perera, R., Moher, D., . . . Johnston, M. (2014). Better reporting of interventions: template for intervention description and replication (TIDieR) checklist and guide. *BMJ, 348*.

Hofmann, W., Friese, M., & Roefs, A. (2009). Three ways to resist temptation: The independent contributions of executive attention, inhibitory control, and affect regulation to the impulse control of eating behavior. *Journal of Experimental Social Psychology, 45*(2), 431-435.

Hollands, G., Bignardi, G., Johnston, M., Kelly, M., Ogilvie, D., Petticrew, M., . . . Sutton, S. (2017). The TIPPME intervention typology for changing environments to change behaviour. *Nature Human Behaviour, 1*, 0140. doi:10.1038/s41562-017-0140

Hollands, G. J., Shemilt, I., Marteau, T. M., Jebb, S. A., Lewis, H. B., Wei, Y., . . . Ogilvie, D. (2015). Portion, package or tableware size for changing selection and consumption of food, alcohol and tobacco. *Cochrane Database Syst Rev, 2015*(9), Cd011045. doi:10.1002/14651858.CD011045.pub2

Holt, E. (2011). Hungary to introduce broad range of fat taxes. *The Lancet, 378*(9793), 755. doi:10.1016/S0140-6736(11)61359-7

Horgen, K. B., & Brownell, K. D. (2002). Comparison of price change and health message interventions in promoting healthy food choices. *Health Psychol, 21*(5), 505-512. doi:10.1037//0278-6133.21.5.505

Huang, A., Barzi, F., Huxley, R., Denyer, G., Rohrlach, B., Jayne, K., & Neal, B. (2006). The effects on saturated fat purchases of providing internet shoppers with purchase-specific dietary advice: a randomised trial. *PLoS clinical trials, 1*(5), e22.

Hysong, S. J., Best, R. G., & Pugh, J. A. (2006). Audit and feedback and clinical practice guideline adherence: Making feedback actionable. *Implementation Science, 1*(1), 9. doi:10.1186/1748-5908-1-9

IBM Corp (2017). IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.

James, P., Seward, M. W., James O'Malley, A., Subramanian, S. V., & Block, J. P. (2017). Changes in the food environment over time: examining 40 years of data in the Framingham Heart Study. *International Journal of Behavioral Nutrition and Physical Activity, 14*(1), 84. doi:10.1186/s12966-017-0537-4

John, P. (2018). *How far to nudge?: Assessing behavioural public policy*. Cheltenham, UK: Edward Elgar Publishing.

John, P., & Stoker, G. (2019). Rethinking the Role of Experts and Expertise in Behavioural Public Policy. *Policy & Politics, 47*. doi:10.1332/030557319X15526371698257

Jones, A., Neal, B., Reeve, B., Ni Mhurchu, C., & Thow, A. M. (2019). Front-of-pack nutrition labelling to promote healthier diets: current practice and opportunities to strengthen regulation worldwide. *BMJ Glob Health, 4*(6), e001882. doi:10.1136/bmjgh-2019-001882

Jones, C. S. (2010). Encouraging healthy eating at restaurants: More themes uncovered through focus group research. *Services Marketing Quarterly, 31*(4), 448-465.

Jung, J. Y., & Mellers, B. A. (2016). American attitudes toward nudges. *Judgment & Decision Making, 11*(1), 62–74.

Just, D., & Price, J. (2013). Default options, incentives and food choices: evidence from elementary-school children. *Public Health Nutr, 16*(12), 2281-2288. doi:10.1017/s1368980013001468

Kahneman, D. (2012). Thinking, fast and slow. London: Penguin Books.

Kantar World Panel UK. (2015). *Sugar Reduction: The evidence for action Annexe 4: An analysis of the role of price promotions on the household purchases of food and drinks high in sugar.* Retrieved from London:

Khan, U., & Dhar, R. (2006). Licensing Effect in Consumer Choice. *Journal of Marketing Research, 43*(2), 259-266. doi:10.1509/jmkr.43.2.259

Kirk, S. F., Penney, T. L., & McHugh, T. L. (2010). Characterizing the obesogenic environment: the state of the evidence with directions for future research. *Obesity reviews, 11*(2), 109-117.

Kivetz, Y., & Tyler, T. R. (2007). Tomorrow I'll be me: The effect of time perspective on the activation of idealistic versus pragmatic selves. *Organizational behavior and human decision processes, 102*(2), 193-211.

Kottke, T. E., Pronk, N. P., Katz, A. S., Tillema, J. O., & Flottemesch, T. J. (2013). The Effect of Price Reduction on Salad Bar Purchases at a Corporate Cafeteria *Prevent. Chronic Dis, 10*, 25. doi:10.5888/pcd10.120214

Kourouniotis, S., Keast, R. S. J., Riddell, L. J., Lacy, K., Thorpe, M. G., & Cicerale, S. (2016). The importance of taste on dietary choice, behaviour and intake in a group of young adults. *Appetite, 103*, 1-7. doi:10.1016/j.appet.2016.03.015

Koutoukidis, D. A., Jebb, S. A., Ordóñez-Mena, J. M., Noreik, M., Tsiountsioura, M., Kennedy, S., . . . Piernas, C. (2019). Prominent positioning and food swaps are effective interventions to reduce the saturated fat content of the shopping basket in an experimental online supermarket: a randomized controlled trial. *International Journal of Behavioral Nutrition and Physical Activity, 16*(1), 50. doi:10.1186/s12966-019-0810-9

Kronenfeld, L. W., Reba-Harrelson, L., Von Holle, A., Reyes, M. L., & Bulik, C. M. (2010). Ethnic and racial differences in body size perception and satisfaction. *Body Image, 7*(2), 131-136. doi:10.1016/j.bodyim.2009.11.002

Laibson, D. (1997). Golden eggs and hyperbolic discounting. *The Quarterly Journal of Economics, 112*(2), 443-478.

Lando, A. M., & Labiner-Wolfe, J. (2007). Helping consumers make more healthful food choices: consumer views on modifying food labels and providing point-of-purchase nutrition information at quick-service restaurants. *Journal of Nutrition Education and behavior, 39*(3), 157-163.

Larsen, B., Micucci, S., Hartman, S. J., & Ramos, G. (2020). Feasibility and Acceptability of a Counseling- and mHealth-Based Physical Activity Intervention for Pregnant Women With Diabetes: The Fit for Two Pilot Study. *JMIR Mhealth Uhealth, 8*(10), e18915. doi:10.2196/18915

Lassale, C., Péneau, S., Touvier, M., Julia, C., Galan, P., Hercberg, S., & Kesse-Guyot, E. (2013). Validity of Web-Based Self-Reported Weight and Height: Results of the Nutrinet-Santé Study. *J Med Internet Res, 15*(8), e152. doi:10.2196/jmir.2575

Lassen, A. D., Fagt, S., Lennernäs, M., Nyberg, M., Haapalar, I., Thorsen, A. V., ... & Beck, A. M. (2018). The impact of worksite interventions promoting healthier food and/or physical activity habits among employees working 'around the clock'hours: A systematic review. *Food & nutrition research*, *62*.

Lassen, A. D., Thorsen, A. V., Sommer, H. M., Fagt, S., Trolle, E., Biltoft-Jensen, A., & Tetens, I. (2011). Improving the diet of employees at blue-collar worksites: results from the 'Food at Work' intervention study. *Public health nutrition, 14*(6), 965-974. doi:10.1017/S1368980010003447

Lean, M., Lara, J., & Hill, J. O. (2006). Strategies for preventing obesity. *BMJ, 333*(7575), 959-962. doi:10.1136/bmj.333.7575.959

Lee, Y. M., & Sozen, E. (2020). Explaining consumers' intention to use menu labels: a structural equation modeling analysis. *British Food Journal, 122*(4), 1068-1084. doi:10.1108/BFJ-07-2019-0570

Lhachimi, S. K., Bala, M. M., & Vanagas, G. (2016). Evidence-Based Public Health. *Biomed Res Int, 2016*, 5681409. doi:10.1155/2016/5681409

Li, G., Taljaard, M., Van den Heuvel, E. R., Levine, M. A., Cook, D. J., Wells, G. A., . . . Thabane, L. (2017). An introduction to multiplicity issues in clinical trials: the what, why, when and how. *International journal of epidemiology*.

Liberman, N., & Trope, Y. (2003). Construal level theory of intertemporal judgment and decision. In *Time and decision: Economic and psychological perspectives on intertemporal choice.* (pp. 245-276). New York, NY, US: Russell Sage Foundation.

Library Archive Service (2018). Removing Duplicates from EndNote Library Retrieved from https://blogs.lshtm.ac.uk/library/2018/12/07/removing-duplicates-from-an-endnote-library/

Littlewood, J. A., Lourenço, S., Iversen, C. L., & Hansen, G. L. (2016). Menu labelling is effective in reducing energy ordered and consumed: a systematic review and meta-analysis of recent studies. *Public health nutrition, 19*(12), 2106-2121.

Liu, J. L., Han, B., & Cohen, D. A. (2015). Associations between eating occasions and places of consumption among adults. *Appetite, 87*, 199-204. doi:10.1016/j.appet.2014.12.217

Loewenstein, G. (1996). Out of control: Visceral influences on behavior. *Organizational behavior and human decision processes, 65*(3), 272-292.

Loewenstein, G. (2000). Emotions in economic theory and economic behavior. *American economic review*, *90*(2), 426-432.

Machín, L., Aschemann-Witzel, J., Curutchet, M. R., Giménez, A., & Ares, G. (2018). Does front-of-pack nutrition information improve consumer ability to make healthful choices? Performance of warnings and the traffic light system in a simulated shopping experiment. *Appetite, 121*, 55-62.

Malik, V. S., Popkin, B. M., Bray, G. A., Després, J.-P., & Hu, F. B. (2010). Sugar-sweetened beverages, obesity, type 2 diabetes mellitus, and cardiovascular disease risk. *Circulation, 121*(11), 1356-1364.

Mantzari, E., Vasiljevic, M., Turney, I., Pilling, M., & Marteau, T. (2018). Impact of warning labels on sugar-sweetened beverages on parental selection: An online experimental study. *Prev Med Rep, 12*, 259-267. doi:10.1016/j.pmedr.2018.10.016

Marteau, T. M., Hollands, G. J., Shemilt, I., & Jebb, S. A. (2015). Downsizing: policy options to reduce portion sizes to help tackle obesity. *BMJ, 351*, h5863. doi:10.1136/bmj.h5863

Marty, L., Cook, B., Piernas, C., Jebb, S. A., & Robinson, E. (2020). Effects of labelling and increasing the proportion of lower-energy density products on online food shopping: a randomised control trial in high-and low-socioeconomic position participants. *Nutrients, 12*(12), 3618.

Masic, U., Christiansen, P., & Boyland, E. (2017). The influence of calorie and physical activity labelling on snack and beverage choices. *Appetite, 112*, 52-58.

Matthiessen, J., Fagt, S., Biltoft-Jensen, A., Beck, A. M., & Ovesen, L. (2003). Size makes a difference. *Public Health Nutr, 6*(1), 65-72. doi:10.1079/phn2002361

McCrory, M. A., Harbaugh, A. G., Appeadu, S., & Roberts, S. B. (2019). Fast-Food Offerings in the United States in 1986, 1991, and 2016 Show Large Increases in Food Variety, Portion Size, Dietary Energy, and Selected Micronutrients. *J Acad Nutr Diet, 119*(6), 923-933. doi:10.1016/j.jand.2018.12.004

McGeown, L. (2019). The calorie counter-intuitive effect of restaurant menu calorie labelling. *Canadian Journal of Public Health, 110*(6), 816-820.

McLaren, L. (2007). Socioeconomic status and obesity. *Epidemiol Rev, 29*, 29-48. doi:10.1093/epirev/mxm001

Mhurchu, C. N., Eyles, H., & Choi, Y. H. (2017). Effects of a Voluntary Front-of-Pack Nutrition Labelling System on Packaged Food Reformulation: The Health Star Rating System in New Zealand. *Nutrients, 9*(8). doi:10.3390/nu9080918

Michie, S., Van Stralen, M. M., & West, R. (2011). The behaviour change wheel: a new method for characterising and designing behaviour change interventions. *Implementation Science, 6*(1), 1-12.

Migliavada, R., Ricci, F. Z., & Torri, L. (2021). A three-year longitudinal study on the use of pre-ordering in a university canteen. *Appetite, 163*, 105203. doi:https://doi.org/10.1016/j.appet.2021.105203

Miller, G. F., Gupta, S., Kropp, J. D., Grogan, K. A., & Mathews, A. (2016). The effects of pre-ordering and behavioral nudges on National School Lunch Program participants' food item selection. *Journal of economic psychology, 55*, 4-16.

Min, J., Chiu, D. T., & Wang, Y. (2013). Variation in the heritability of body mass index based on diverse twin studies: a systematic review. *Obes Rev, 14*(11), 871-882. doi:10.1111/obr.12065

Monteiro, C. A. (2009). Nutrition and health. The issue is not food, nor nutrients, so much as processing. *Public health nutrition, 12*(5), 729-731. doi:10.1017/S1368980009005291

Monteiro, C. A., Moubarac, J. C., Cannon, G., Ng, S. W., & Popkin, B. (2013). Ultra-processed products are becoming dominant in the global food system. *Obes Rev, 14 Suppl 2*, 21-28. doi:10.1111/obr.12107

Mørk, T., Grunert, K. G., Fenger, M., Juhl, H. J., & Tsalis, G. (2017). An analysis of the effects of a campaign supporting use of a health symbol on food sales and shopping behaviour of consumers. *BMC public health, 17*(1), 239. doi:10.1186/s12889-017-4149-3

Munson, J., Tiropanis, T., & Lowe, M. (2017). *Online grocery shopping: Identifying change in consumption practices.* Paper presented at the International Conference on Internet Science.

Naicker, A., Shrestha, A., Joshi, C., Willett, W., & Spiegelman, D. (2021). Workplace cafeteria and other multicomponent interventions to promote healthy eating among adults: A systematic review. *Preventive medicine reports*, 101333.

Nakamura, R., Suhrcke, M., Jebb, S. A., Pechey, R., Almiron-Roig, E., & Marteau, T. M. (2015). Price promotions on healthier compared with less healthy foods: a hierarchical regression analysis of the impact on sales and social patterning of responses to promotions in Great Britain. *Am J Clin Nutr, 101*(4), 808-816. doi:10.3945/ajcn.114.094227

National Food Strategy (2021). *The National Food Strategy. An Independent Review for Government - The Evidence*. Retrieved from https://www.nationalfoodstrategy.org/

National Health Service (NHS) Digital. (2021). Statistics on obesity, physical activity and diet, England 2021. Retrieved from https://digital.nhs.uk/data-and-

information/publications/statistical/statisticson-obesity-physical-activity-and-diet/england-2021

Neuman, N., Persson Osowski, C., Mattsson Sydner, Y., & Fjellström, C. (2014). Swedish students' interpretations of food symbols and their perceptions of healthy eating. An exploratory study. *Appetite, 82*, 29-35. doi:10.1016/j.appet.2014.07.003

Newton, S., Braithwaite, D., & Akinyemiju, T. F. (2017). Socio-economic status over the life course and obesity: Systematic review and meta-analysis. *PLoS One, 12*(5), e0177151. doi:10.1371/journal.pone.0177151

Nielsen, J., Clemmensen, T., & Yssing, C. (2002). *Getting access to what goes on in people's heads? reflections on the think-aloud technique*. Paper presented at the Proceedings of the second Nordic conference on Human-computer interaction, Aarhus, Denmark. https://doi.org/10.1145/572020.572033

O'Donoghue, T., & Rabin, M. (1999). Doing It Now or Later. *American Economic Review, 89*(1), 103-124. doi:10.1257/aer.89.1.103

O'Hara, B. J., Grunseit, A., Phongsavan, P., Bellew, W., Briggs, M., & Bauman, A. E. (2016). Impact of the swap it, don't stop it Australian national mass media campaign on promoting small changes to lifestyle behaviors. *Journal of health communication, 21*(12), 1276-1285.

Ocado. (2016). Annual Report 2015. Retrieved from https://www.annualreports.com/HostedData/AnnualReportArchive/O/LSE_OCDO_2016.pdf

OECD. (2011). *Education at a Glance 2016: OECD Indicators*. Retrieved from http://dx.doi.org/10.1787/eag-2011-en

Office for National Statistics. (2010). 'Average' Briton highlighted on UN World Statistics Day. Retrieved from https://www.ons.gov.uk/aboutus/transparencyandgovernance/freedomofinformationfoi/theaveragebriton

Office for National Statistics. (2011). Population of England and Wales. . Retrieved from https://www.ethnicity-facts-figures.service.gov.uk/uk-population-by-ethnicity/national-and-regional-populations/population-of-england-and-wales/latest

Office for National Statistics. (2017). The Average Briton: Income. Retrieved from https://www.ons.gov.uk/aboutus/transparencyandgovernance/freedomofinformationfoi/theaveragebriton

Office for National Statistics. (2018). *UK business: activity, size and location*.

Ohlhausen, P., & Langen, N. (2019). *Variety-seeking meal choice in business canteens.* Paper presented at the 168th EAAE Seminar Behavioural Perspectives in Agricultural Economics and Management, Uppsala, Sweden.

Omnico Group. (2019). Corporate Catering Barometer #2. Retrieved from https://cdn2.hubspot.net/hubfs/5898474/Omnico-Corporate-Catering-Barometer-2019.pdf

Ouzzani, M., Hammady, H., Fedorowicz, Z., & Elmagarmid, A. (2016). Rayyan—a web and mobile app for systematic reviews. *Systematic Reviews, 5*(1), 210. doi:10.1186/s13643-016-0384-4

Palan, S., & Schitter, C. (2018). Prolific.ac—A subject pool for online experiments. *Journal of Behavioral and Experimental Finance, 17*, 22-27. doi:https://doi.org/10.1016/j.jbef.2017.12.004

Palinkas, L. A., Horwitz, S. M., Green, C. A., Wisdom, J. P., Duan, N., & Hoagwood, K. (2015). Purposeful sampling for qualitative data collection and analysis in mixed method implementation research. *Administration and policy in mental health and mental health services research, 42*(5), 533-544.

Palsola, M., Renko, E., Kostamo, K., Lorencatto, F., & Hankonen, N. (2020). Thematic analysis of acceptability and fidelity of engagement for behaviour change interventions: The Let's Move It intervention interview study. *British Journal of Health Psychology, 25*(3), 772-789.

Payne Riches, S., Aveyard, P., Piernas, C., Rayner, M., & Jebb, S. A. (2019). Optimising swaps to reduce the salt content of food purchases in a virtual online supermarket: A randomised controlled trial. *Appetite, 133*, 378-386. doi:10.1016/j.appet.2018.11.028

Pechey, E., Clarke, N., Mantzari, E., Blackwell, A. K. M., De-Loyde, K., Morris, R. W., . . . Hollands, G. J. (2020). Image-and-text health warning labels on alcohol and food: potential effectiveness and acceptability. *BMC public health, 20*(1), 376. doi:10.1186/s12889-020-8403-8

Peer, E., Brandimarte, L., Samat, S., & Acquisti, A. (2017). Beyond the Turk: Alternative platforms for crowdsourcing behavioral research. *Journal of Experimental Social Psychology, 70*, 153-163.

Pell, D., Penney, T., Hammond, D., Vanderlee, L., White, M., & Adams, J. (2019). Support for, and perceived effectiveness of, the UK soft drinks industry levy among UK adults: cross-sectional analysis of the International Food Policy Study. *BMJ Open, 9*(3), e026698.

Perski, O., Blandford, A., Ubhi, H. K., West, R., & Michie, S. (2017). Smokers' and drinkers' choice of smartphone applications and expectations of engagement: A think aloud and interview study. *BMC medical informatics and decision making, 17*(1), 1-14.

Peters, M. D., Godfrey, C. M., Khalil, H., McInerney, P., Parker, D., & Soares, C. B. (2015). Guidance for conducting systematic scoping reviews. *Int J Evid Based Healthc, 13*(3), 141-146. doi:10.1097/xeb.0000000000000050

Peters, M. D. J., Marnie, C., Tricco, A. C., Pollock, D., Munn, Z., Alexander, L., . . . Khalil, H. (2020). Updated methodological guidance for the conduct of scoping reviews. *JBI Evid Synth, 18*(10), 2119-2126. doi:10.11124/jbies-20-00167

Physical Activity Health Alliance. (2012). Scottish Physical Activity Screening Question (Scot-PASQ). Retrieved from http://www.healthscotland.scot/health-topics/physical-activity/screening-for-physical-activity-levels-using-scot-pasq

Piernas, C., Cook, B., Stevens, R., Stewart, C., Hollowell, J., Scarborough, P., & Jebb, S. A. (2021). Estimating the effect of moving meat-free products to the meat aisle on sales of meat and meat-free products: A non-randomised controlled intervention study in a large UK supermarket chain. *PLoS Med, 18*(7), e1003715. doi:10.1371/journal.pmed.1003715

Poelman, M. P., Eyles, H., Dunford, E., Schermel, A., L'Abbe, M. R., Neal, B., . . . Ni Mhurchu, C. (2016). Package size and manufacturer-recommended serving size of sweet beverages: a cross-sectional study across four high-income countries. *Public health nutrition, 19*(6), 1008-1016. doi:10.1017/S1368980015001974

Policastro, P., Palm, T., Schwartz, J., & Chapman, G. (2017). Targeted Calorie Message Promotes Healthy Beverage Consumption Better than Charity Incentive. *Obesity (Silver Spring), 25*(8), 1428-1434. doi:10.1002/oby.21885

Prestwich, A., Conner, M. T., Lawton, R. J., Ward, J. K., Ayres, K., & McEachan, R. R. (2012). Randomized controlled trial of collaborative implementation intentions targeting working adults' physical activity. *Health Psychology, 31*(4), 486.

Provencher, V., Polivy, J., & Herman, C. P. (2009). Perceived healthiness of food. If it's healthy, you can eat more!. *Appetite*, *52*(2), 340-344.

Public Health England. (2017). *Health matters: obesity and the food environment*. Retrieved from London: www.gov.uk/government/publications/health-matters-obesity-andthe-food-environment

Public Health England. (2018a). Calorie reduction: The scope and ambition for action. Retrieved from

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/800675/Calories_Evidence_Document.pdf

Public Health England. (2018b). *Obesity and the environment Density of fast food outlets.* Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/741555/Fast_Food_map.pdf

Public Health England. (2018c). Plans to cut excess calorie consumption unveiled [Press release]. Retrieved from https://www.gov.uk/government/news/plans-to-cut-excess-calorie-consumption-unveiled

Public Health England (2021). Better Health Campaign. Phase 1: Evaluation of the NHS Weight Loss Plan app. Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1013453/Evaluation_of_the_NHS_App_PHE_Report_25Aug2020.pdf

Purcell, K., Sumithran, P., Prendergast, L. A., Bouniu, C. J., Delbridge, E., & Proietto, J. (2014). The effect of rate of weight loss on long-term weight management: a randomised controlled trial. *The Lancet Diabetes & Endocrinology*, *2*(12), 954-962.

QSR International Pty Ltd. (2020) NVivo (released in March 2020), https://www.qsrinternational.com/nvivo-qualitative-data-analysis-software/home

Quintiliani, L., Poulsen, S., & Sorensen, G. (2010). Healthy Eating Strategies in the Workplace. *Int J Workplace Health Manag, 3*(3), 182-196. doi:10.1108/17538351011078929

Raghunathan, R., Naylor, R. W., & Hoyer, W. D. (2006). The Unhealthy = Tasty Intuition and Its Effects on Taste Inferences, Enjoyment, and Choice of Food Products. *Journal of Marketing, 70*(4), 170-184. doi:10.1509/jmkg.70.4.170

Raleigh, V., & Holmes, J. (2021). The health of people from ethnic minority groups in England. *King's Fund*.

Ramasamy, A., Laliberté, F., Aktavoukian, S. A., Lejeune, D., DerSarkissian, M., Cavanaugh, C., . . . Duh, M. S. (2019). Direct and Indirect Cost of Obesity Among the Privately Insured in the United States: A Focus on the Impact by Type of Industry. *J Occup Environ Med, 61*(11), 877-886. doi:10.1097/jom.0000000000001693

Rauber, F., Steele, E. M., Louzada, M., Millett, C., Monteiro, C. A., & Levy, R. B. (2020). Ultra-processed food consumption and indicators of obesity in the United Kingdom population (2008-2016). *PLoS One, 15*(5), e0232676. doi:10.1371/journal.pone.0232676

Read, D., & Van Leeuwen, B. (1998). Predicting hunger: The effects of appetite and delay on choice. *Organizational behavior and human decision processes, 76*(2), 189-205.

Reimann, M., Bechara, A., & MacInnis, D. (2015). Leveraging the happy meal effect: Substituting food with modest nonfood incentives decreases portion size choice. *J Exp Psychol Appl, 21*(3), 276-286. doi:10.1037/xap0000054

Review Manager (RevMan) (2020) [Computer program]. Version 5.4, The Cochrane Collaboration, 2020.

Reynolds, J. P., Ventsel, M., Kosīte, D., Rigby Dames, B., Brocklebank, L., Masterton, S., . . . Hollands, G. J. (2021). Impact of decreasing the proportion of higher energy foods and reducing portion sizes on food purchased in worksite cafeterias: A stepped-wedge randomised controlled trial. *PLoS medicine, 18*(9), e1003743.

Roberto, C. A., & Khandpur, N. (2014). Improving the design of nutrition labels to promote healthier food choices and reasonable portion sizes. *Int J Obes (Lond), 38 Suppl 1*(Suppl 1), S25-33. doi:10.1038/ijo.2014.86

Robinson, E., Jones, A., Whitelock, V., Mead, B. R., & Haynes, A. (2018). (Over)eating out at major UK restaurant chains: observational study of energy content of main meals. *BMJ, 363*, k4982. doi:10.1136/bmj.k4982

Robinson, M. R., English, G., Moser, G., Lloyd-Jones, L. R., Triplett, M. A., Zhu, Z., . . . Visscher, P. M. (2017). Genotype-covariate interaction effects and the heritability of adult body mass index. *Nat Genet, 49*(8), 1174-1181. doi:10.1038/ng.3912

Rodearmel, S. J., Wyatt, H. R., Stroebele, N., Smith, S. M., Ogden, L. G., & Hill, J. O. (2007). Small changes in dietary sugar and physical activity as an approach to preventing excessive weight gain: the America on the Move family study. *Pediatrics, 120*(4), e869-e879.

Rodgers, A., Woodward, A., Swinburn, B., & Dietz, W. H. (2018). Prevalence trends tell us what did not precipitate the US obesity epidemic. *The Lancet Public Health, 3*(4), e162-e163.

Romieu, I., Dossus, L., Barquera, S., Blottière, H. M., Franks, P. W., Gunter, M., . . . Willett, W. C. (2017). Energy balance and obesity: what are the main drivers? *Cancer Causes Control, 28*(3), 247-258. doi:10.1007/s10552-017-0869-z

Roser, M., & Ritchie, H. (2017). Obesity; Our World Data. *Published online at OurWorldInData.org*.

Royal Society for Public Health (2016). Introducing “activity equivalent” calorie labelling to tackle obesity. Retrieved from https://www.rsph.org.uk/static/uploaded/26deda5b-b3b7-4b15-a11bea931dabf041.pdf

Royer, H., Stehr, M., & Sydnor, J. (2015). Incentives, commitments, and habit formation in exercise: evidence from a field experiment with workers at a fortune-500 company. *American Economic Journal: Applied Economics, 7*(3), 51-84.

RStudio Team (2020). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/.

Sacks, F. M., Svetkey, L. P., Vollmer, W. M., Appel, L. J., Bray, G. A., Harsha, D., . . . Simons-Morton, D. G. (2001). Effects on blood pressure of reduced dietary sodium and the Dietary Approaches to Stop Hypertension (DASH) diet. *New England journal of medicine, 344*(1), 3-10.

Saghaei, M. (2011). An overview of randomization and minimization programs for randomized clinical trials. *Journal of medical signals and sensors, 1*(1), 55.

Salvatore, D. (2008). *Microeconomics: theory and applications* (5 ed.). OUP Catalogue: Oxford University Press,.

Sarwer, D. B., & Polonsky, H. M. (2016). The Psychosocial Burden of Obesity. *Endocrinology and metabolism clinics of North America, 45*(3), 677-688. doi:10.1016/j.ecl.2016.04.016

Savani, M. M. (2018). The effects of a commitment device on health outcomes: Reputational commitment and weight loss in an online experiment. *International Journal of Applied Behavioral Economics (IJABE), 7*(4), 1-20.

Schaumberg, K., & Anderson, D. (2016). Dietary restraint and weight loss as risk factors for eating pathology. *Eating behaviors, 23*, 97-103. doi:https://doi.org/10.1016/j.eatbeh.2016.08.009

Schelling, T. C. (1984). Self-command in practice, in policy, and in a theory of rational choice. *The American Economic Review, 74*(2), 1-11.

Schwartz, J., Mochon, D., Wyper, L., Maroba, J., Patel, D., & Ariely, D. (2014). Healthier by precommitment. *Psychol Sci, 25*(2), 538-546. doi:10.1177/0956797613510950

Schwartz, J., Riis, J., Elbel, B., & Ariely, D. (2012). Inviting consumers to downsize fast-food portions significantly reduces calorie consumption. *Health Affairs*, *31*(2), 399-407.

Sekhon, M., Cartwright, M., & Francis, J. J. (2017). Acceptability of healthcare interventions: an overview of reviews and development of a theoretical framework. *BMC health services research, 17*(1), 88. doi:10.1186/s12913-017-2031-8

Shangguan, S., Afshin, A., Shulkin, M., Ma, W., Marsden, D., Smith, J., . . . Imamura, F. (2019). A meta-analysis of food labeling effects on consumer diet behaviors and industry practices. *American journal of preventive medicine, 56*(2), 300-314.

Sharma, S., Wagle, A., Sucher, K., & Bugwadia, N. (2011). Impact of point of selection nutrition information on meal choices at a table-service restaurant. *Journal of foodservice business research, 14*(2), 146-161.

Sharma, S. V., Paolicelli, C. W., Jyothi, V., Baun, W., Perkison, B., Phipps, M., . . . Alfaro, V. (2016). Evaluation of worksite policies and practices promoting nutrition and physical activity among hospital workers. *International Journal of Workplace Health Management*.

Silventoinen, K., Rokholm, B., Kaprio, J., & Sørensen, T. I. (2010). The genetic and environmental influences on childhood obesity: a systematic review of twin and adoption studies. *Int J Obes (Lond), 34*(1), 29-40. doi:10.1038/ijo.2009.177

Simons, D., De Bourdeaudhuij, I., Clarys, P., De Cocker, K., Vandelanotte, C., & Deforche, B. (2018). A Smartphone App to Promote an Active Lifestyle in Lower-Educated Working Young Adults: Development, Usability, Acceptability, and Feasibility Study. *JMIR Mhealth Uhealth, 6*(2), e44. doi:10.2196/mhealth.8287

Sinclair, S. E., Cooper, M., & Mansfield, E. D. (2014). The influence of menu labeling on calories selected or consumed: a systematic review and meta-analysis. *Journal of the Academy of Nutrition and Dietetics, 114*(9), 1375-1388. e1315.

Smith, K. (2013). *Beyond evidence based policy in public health: The interplay of ideas*: Springer.

Social Metrics Commission. (2019). Measuring poverty. Retrieved from https://socialmetricscommission.org.uk/wp-content/uploads/2019/07/SMC_measuring-poverty-201908_full-report.pdf

Spiegelman, B. M., & Flier, J. S. (2001). Obesity and the regulation of energy balance. *Cell, 104*(4), 531-543. doi:10.1016/s0092-8674(01)00240-9

Stata Corp (2019). *Stata Statistical Software: Release 16*. College Station, TX: StataCorp LLC.

Statistica. (2019). Most Popular Crisps and Savoury Snacks in the United Kingdom. . Retrieved from https://www.statista.com/statistics/324174/most-popular-crisps-and-savoury-snack-brands-in-the-united-kingdom-uk/

Steenhuis, I., & Poelman, M. (2017). Portion Size: Latest Developments and Interventions. *Curr Obes Rep, 6*(1), 10-17. doi:10.1007/s13679-017-0239-x

Steenhuis, I. H., Leeuwis, F. H., & Vermeer, W. M. (2010). Small, medium, large or supersize: trends in food portion sizes in The Netherlands. *Public Health Nutr, 13*(6), 852-857. doi:10.1017/s1368980009992011

Stefano, F., Borsci, S., & Stamerra, G. (2010). Web usability evaluation with screen reader users: implementation of the partial concurrent thinking aloud technique. *Cognitive processing, 11*(3), 263-272.

Stice, E., Shaw, H., & Nemeroff, C. (1998). Dual Pathway Model of Bulimia Nervosa: Longitudinal Support for Dietary Restraint and Affect-Regulation Mechanisms. *Journal of Social and Clinical Psychology, 17*(2), 129-149. doi:10.1521/jscp.1998.17.2.129

Stites, S. D., Singletary, S. B., Menasha, A., Cooblall, C., Hantula, D., Axelrod, S., . . . Phipps, E. J. (2015). Pre-ordering lunch at work. Results of the what to eat for lunch study. *Appetite, 84*, 88-97.

Stok, F. M., de Ridder, D. T., de Vet, E., Nureeva, L., Luszczynska, A., Wardle, J., . . . De Wit, J. B. (2015). Hungry for an intervention? Adolescents' ratings of acceptability of eating-related intervention strategies. *BMC public health, 16*(1), 1-8.

Stroebele, N., De Castro, J. M., Stuht, J., Catenacci, V., Wyatt, H. R., & Hill, J. O. (2009). A small-changes approach reduces energy intake in free-living humans. *Journal of the American College of Nutrition, 28*(1), 63-68.

Stubbs, R. J., Hughes, D. A., Johnstone, A. M., Rowley, E., Reid, C., Elia, M., . . . Blundell, J. E. (2000). The use of visual analogue scales to assess motivation to eat in human subjects: a review of their reliability and validity with an evaluation of new hand-held computerized systems for temporal tracking of appetite ratings. *British Journal of Nutrition, 84*(4), 405-415. doi:10.1017/S0007114500001719

Swartz, J. J., Dowray, S., Braxton, D., Mihas, P., & Viera, A. J. (2013). Simplifying healthful choices: a qualitative study of a physical activity based nutrition label format. *Nutrition journal, 12*(1), 1-9.

Swinburn, B., Egger, G., & Raza, F. (1999). Dissecting obesogenic environments: the development and application of a framework for identifying and prioritizing environmental interventions for obesity. *Prev Med, 29*(6 Pt 1), 563-570. doi:10.1006/pmed.1999.0585

Swinburn, B. A., Kraak, V. I., Allender, S., Atkins, V. J., Baker, P. I., Bogard, J. R., . . . Dietz, W. H. (2019). The Global Syndemic of Obesity, Undernutrition, and Climate Change: The Lancet Commission report. *The Lancet, 393*(10173), 791-846. doi:http://dx.doi.org/10.1016/S0140-6736(18)32822-8

Swinburn, B. A., Sacks, G., Hall, K. D., McPherson, K., Finegood, D. T., Moodie, M. L., & Gortmaker, S. L. (2011). The global obesity pandemic: shaped by global drivers and local environments. *The Lancet, 378*(9793), 804-814.

Tang, J., Abraham, C., Greaves, C., & Yates, T. (2014). Self-directed interventions to promote weight loss: a systematic review of reviews. *J Med Internet Res, 16*(2), e58. doi:10.2196/jmir.2857

Tashakkori, A., & Creswell, J. (2007). Editorial: The New Era of Mixed Methods. *Journal of Mixed Methods Research, 1*, 3-7. doi:10.1177/2345678906293042

Thaler, R. (1981). Some empirical evidence on dynamic inconsistency. *Economics letters, 8*(3), 201-207.

Thaler, R. H., & Sunstein, C. R. (2008). *Nudge: Improving decisions about health, wealth, and happiness*. New Haven, CT, US: Yale University Press.

The GBD 2015 Obesity Collaborators. (2017). Health Effects of Overweight and Obesity in 195 Countries over 25 Years. *New England journal of medicine, 377*(1), 13-27. doi:10.1056/NEJMoa1614362

Trendel, O., & Werle, C. O. (2016). Distinguishing the affective and cognitive bases of implicit attitudes to improve prediction of food choices. *Appetite, 104*, 33-43. doi:10.1016/j.appet.2015.10.005

Trope, Y., & Liberman, N. (2000). Temporal construal and time-dependent changes in preference. *Journal of personality and social psychology, 79*(6), 876.

Trudel-Guy, C., Bédard, A., Corneau, L., Bélanger-Gravel, A., Desroches, S., Bégin, C., . . . Lemieux, S. (2019). Impact of pleasure-oriented messages on food choices: is it more effective than traditional health-oriented messages to promote healthy eating? *Appetite, 143*, 104392. doi:10.1016/j.appet.2019.104392

UK Government (2021). New advertising rules to help tackle childhood obesity. Retrieved from https://www.gov.uk/government/news/new-advertising-rules-to-help-tackle-childhood-obesity

van der Bend, D. L., Jansen, L., van der Velde, G., & Blok, V. (2020). The influence of a front-of-pack nutrition label on product reformulation: A ten-year evaluation of the Dutch Choices programme. *Food chemistry: X, 6*, 100086.

Van Rookhuijzen, M., De Vet, E., & Adriaanse, M. A. (2021). The Effects of Nudges: One-Shot Only? Exploring the Temporal Spillover Effects of a Default Nudge. *Frontiers in Psychology, 12*.

van Strien, T., Frijters, J. E. R., van Staveren, W. A., Defares, P. B., & Deurenberg, P. (1986). The predictive validity of the Dutch Restrained Eating Scale. *International Journal of Eating Disorders, 5*(4), 747-755. doi:https://doi.org/10.1002/1098-108X(198605)5:4<747::AID-EAT2260050413>3.0.CO;2-6

van Teijlingen, E. R., & Hundley, V. (2001). The importance of pilot studies. *Social Research Update, 35*.

Vandevijvere, S., Chow, C. C., Hall, K. D., Umali, E., & Swinburn, B. A. (2015). Increased food energy supply as a major driver of the obesity epidemic: a global analysis. *Bulletin of the World Health Organization, 93*, 446-456.

VanEpps, E. M., Downs, J. S., & Loewenstein, G. (2016a). Advance ordering for healthier eating? Field experiments on the relationship between the meal order–consumption time delay and meal content. *Journal of Marketing Research, 53*(3), 369-380.

VanEpps, E. M., Downs, J. S., & Loewenstein, G. (2016b). Calorie label formats: using numeric and traffic light calorie labels to reduce lunch calories. *Journal of Public Policy & Marketing, 35*(1), 26-36.

VanEpps, E. M., & Roberto, C. A. (2016c). The Influence of Sugar-Sweetened Beverage Warnings: A Randomized Trial of Adolescents' Choices and Beliefs. *Am J Prev Med, 51*(5), 664-672. doi:10.1016/j.amepre.2016.07.010

Vasiljevic, M., Cartwright, E., Pilling, M., Lee, M.-M., Bignardi, G., Pechey, R., . . . Marteau, T. M. (2018). Impact of calorie labelling in worksite cafeterias: a stepped wedge randomised controlled pilot trial. *International Journal of Behavioral Nutrition and Physical Activity, 15*(1), 41. doi:10.1186/s12966-018-0671-7

Vecchio, R., & Cavallo, C. (2019). Increasing healthy food choices through nudges: A systematic review. *Food Quality and Preference, 78*, 103714.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. MIS quarterly, 425-478.

Viera, A. J., Gizlice, Z., Tuttle, L., Olsson, E., Gras-Najjar, J., Hales, D., . . . Ammerman, A. (2019). Effect of calories-only vs physical activity calorie expenditure labeling on lunch calories purchased in worksite cafeterias. *BMC public health, 19*(1), 1-7.

Vincent, S., & O'Mahoney, J. (2018). Critical Realism and Qualitative Research: An Introductory Overview. In C. C. Cassell, A; Grady, G (Ed.), *The sage handbook of qualitative business and management research methods* (Vol. 1, pp. 201-216). London: Sage.

Vyth, E. L., Steenhuis, I. H., Roodenburg, A. J., Brug, J., & Seidell, J. C. (2010). Front-of-pack nutrition label stimulates healthier product development: a quantitative analysis. *Int J Behav Nutr Phys Act, 7*, 65. doi:10.1186/1479-5868-7-65

Waterlander, W. E., Jiang, Y., Nghiem, N., Eyles, H., Wilson, N., Cleghorn, C., . . . Blakely, T. (2019). The effect of food price changes on consumer purchases: a randomised

experiment. *The Lancet Public Health, 4*(8), e394-e405. doi:https://doi.org/10.1016/S2468-2667(19)30105-7

Whitehead, A. L., Julious, S. A., Cooper, C. L., & Campbell, M. J. (2016). Estimating the sample size for a pilot randomised trial to minimise the overall trial sample size for the external pilot and main trial for a continuous outcome variable. *Stat Methods Med Res, 25*(3), 1057-1073. doi:10.1177/0962280215588241

Whitehead, M. (2007). A typology of actions to tackle social inequalities in health. *Journal of Epidemiology & Community Health, 61*(6), 473-478.

Whitton, C., Nicholson, S. K., Roberts, C., Prynne, C. J., Pot, G. K., Olson, A., . . . Bates, B. (2011). National Diet and Nutrition Survey: UK food consumption and nutrient intakes from the first year of the rolling programme and comparisons with previous surveys. *British Journal of Nutrition, 106*(12), 1899-1914.

Williams, D. R., Priest, N., & Anderson, N. B. (2016). Understanding associations among race, socioeconomic status, and health: Patterns and prospects. *Health Psychol, 35*(4), 407-411. doi:10.1037/hea0000242

Williams, S. L., & Mummery, K. W. (2013). Characteristics of consumers using 'better for you' front-of-pack food labelling schemes - an example from the Australian Heart Foundation Tick. *Public Health Nutr, 16*(12), 2265-2272. doi:10.1017/s1368980012005113

Wilson, A. L., Buckley, E., Buckley, J. D., & Bogomolova, S. (2016). Nudging healthier food and beverage choices through salience and priming. Evidence from a systematic review. *Food Quality and Preference, 51*, 47-64.

Wilson, T. D., & Gilbert, D. T. (2003). Affective Forecasting. In *Advances in Experimental Social Psychology* (Vol. 35, pp. 345-411): Academic Press.

Winett, R. A., Moore, J. F., Wagner, J. L., Hite, L. A., Leahy, M., Neubauer, T. E., . . . Mundy, L. L. (1991). Altering shoppers'supermarket purchases to fit nutritional guidelines: an interactive information system. *Journal of Applied Behavior Analysis, 24*(1), 95-105. doi:https://doi.org/10.1901/jaba.1991.24-95

Wing, R. R., & Group, t. L. A. R. (2021). Does Lifestyle Intervention Improve Health of Adults with Overweight/Obesity and Type 2 Diabetes? Findings from the Look AHEAD Randomized Trial. *Obesity, 29*(8), 1246-1258. doi:https://doi.org/10.1002/oby.23158

Wolfenden, L., Kingsland, M., Rowland, B. C., Dodds, P., Gillham, K., Yoong, S. L., . . . Wiggers, J. (2015). Improving availability, promotion and purchase of fruit and vegetable and non sugar-sweetened drink products at community sporting clubs: a randomised trial. *International Journal of Behavioral Nutrition and Physical Activity, 12*(1), 1-10.

World Health Organization. (2008). *Closing the gap in a generation: health equity through action on the social determinants of health: Commission on Social Determinants of Health final report*: WHO Commission on Social Determinants of Health.

World Health Organisation. (2014). Global nutrition targets 2025: childhood overweight policy brief (WHO/NMH/NHD/14.6). In. Geneva: World Health Organization.

World Health Organisation. (2021a). Defining Adult Overweight & Obesity. Retrieved from https://www.who.int/health-topics/obesity#tab=tab_1

World Health Organization. (2021b). Obesity and overweight. Retrieved from https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight

Wrieden, W. L., & Levy, L. B. (2016). 'Change4Life Smart Swaps': quasi-experimental evaluation of a natural experiment. *Public health nutrition, 19*(13), 2388-2392.

Wright, A., Smith, K. E., & Hellowell, M. (2017). Policy lessons from health taxes: a systematic review of empirical studies. *BMC public health, 17*(1), 583. doi:10.1186/s12889-017-4497-z

Wyse, R., Delaney, T., Stacey, F., Zoetemeyer, R., Lecathelinais, C., Lamont, H., . . . Wolfenden, L. (2021). Effectiveness of a Multistrategy Behavioral Intervention to Increase the Nutritional Quality of Primary School Students' Web-Based Canteen Lunch Orders (Click & Crunch): Cluster Randomized Controlled Trial. *Journal of Medical Internet Research, 23*(9).

Yengo, L., Sidorenko, J., Kemper, K. E., Zheng, Z., Wood, A. R., Weedon, M. N., . . . Visscher, P. M. (2018). Meta-analysis of genome-wide association studies for height and body mass index in ~700000 individuals of European ancestry. *Hum Mol Genet, 27*(20), 3641-3649. doi:10.1093/hmg/ddy271

YouGov. (2019). Popular Confectionaries in the UK Retrieved from https://yougov.co.uk/ratings/food/popularity/confectionaries/all

Zlatevska, N., Dubelaar, C., & Holden, S. S. (2014). Sizing up the Effect of Portion Size on Consumption: A Meta-Analytic Review. *Journal of Marketing, 78*(3), 140-154. doi:10.1509/jm.12.0303

Zlatevska, N., Neumann, N., & Dubelaar, C. (2018). Mandatory calorie disclosure: a comprehensive analysis of its effect on consumers and retailers. *Journal of retailing, 94*(1), 89-101.