**Background**

The average sugar intake of children in the UK is more than double recommended guidelines (PHE, 2018). This makes them the highest consumers of sugar of any age group in the UK (PHE, 2016, 2018), with the majority of children’s dietary sugar coming from sweetened drinks and confectionary items (PHE, 2015). Consuming high quantities of sugar is associated with consuming energy in excess of requirements, weight gain and obesity risk in children (Ludwig, Peterson, & Gortmaker, 2001; Cantoral et al., 2016; Della Torre, Keller, Depeyre, & Kruseman, 2016; SACN, 2015). In turn, this increases the risk of non-communicable diseases across the life course, such as heart disease, type 2 diabetes and some cancers (Butland et al., 2007; Biro & Wien, 2010). Amongst children in England, levels of overweight (including obesity) rise from 22.6% at age 4-5, to 34.3% at age 10-11 (Public Health England, 2020).

Schools are popular settings for measures to improve children’s diets due to the scope for reaching large numbers of children simultaneously (Brown & Summerbell, 2009). One example of a successful scheme is England’s School Food Plan, which introduced food-based standards for school meals in 2015, in replacement of the 2006 nutrient-based standards. (Dimbleby & Vincent, 2013).These standards aim to ensure that schoolchildren across the nation have access to nutritious meals, and to reduce the availability of energy-dense foods high in fat and sugar. The standards have raised the quality of meals provided by schools however no nationwide policies on home-packed lunches currently exist.

Studies comparing the nutritional content of packed lunches against school-provided lunches have revealed that packed lunches tend to be lower in nutritional quality (Rees, Richards, & Gregory, 2008; Evans, Cleghorn, Greenwood, & Cade, 2010a; Pearce, Wood, & Nelson, 2013; Evans, Mandl, Christian, & Cade, 2016) and provide a higher amount of sugar than school meals do (Rogers, Ness, Hebditch, Jones, & Emmett, 2007; Evans et al., 2010c). The gap between packed lunches and school meals has widened since the introduction of school food standards in 2006 (Evans et al., 2010a), with cross-sectional surveys finding that less than 2% of packed lunches meet either the 2006 nutrient-based or 2015 food-based standards for school meals (Evans, Greenwood, Thomas, & Cade, 2010b; Evans, Melia, Rippin, Hancock, & Cade, 2020). While it should be noted that the standards were developed specifically for improving the healthiness of school meals and not packed lunches, it is noteworthy that the vast majority of packed lunches contain items such as crisps, confectionery and sugary drinks, all of which are restricted in school-provided meals (Evans et al., 2010b; Evans et al., 2020).

It is therefore imperative that interventions are developed to improve the provision of healthy packed lunches for primary school children. Previous research has revealed that this can be challenging. For example, a randomised controlled trial (RCT) that tested a multi-component “SMART lunchbox” intervention (including providing parents with food-specific containers, wall charts and advice on encouraging children to eat more fruit and vegetables) which was implemented across 89 schools in the UK resulted in an 11% increase in vegetables and a 14% decrease in savoury snacks included within packed lunches, but did not reduce the inclusion of confectionery and sweetened drinks (Evans et al., 2010c). Another intervention using educational videos and incentives aimed at children found similarly small, yet positive, effects on parental provision and children’s consumption of fruit and vegetables over a 12-month period (Horne et al., 2009).

The small effects of these interventions should not be disregarded. Research has shown that relatively small, sustained behavioural changes can have a big cumulative impact: reducing energy consumption by just 30-100 calories a day would have a considerable effect on obesity levels (Hall et al., 2011). Nevertheless, to the authors’ knowledge, no intervention has yet been successful in reducing the sugar content of packed lunches.

The aim of this study was to therefore develop and test an intervention to improve the provision of healthier lunchboxes in the city of Derby, with a specific focus on sugar reduction. While a number of the intervention components from this study are similar to some of those included in the SMART lunchbox intervention (e.g., shopping lists, reward stickers etc.; Evans et al., 2010c), this intervention focused specifically on sugar reduction, including raising the salience of the sugar content in popular lunchbox foods and suggested food swaps. Rates of childhood overweight and obesity in Derby are higher than the national average, at 24.7% for 4-5 year-olds, and 37.2 for 10-11 year-olds (Public Health England, 2020). Given the state of packed lunches in UK schools, improving the nutrient content of these lunches could be an important step towards reducing childhood obesity rates in Derby. The study was registered on ClinicalTrials.gov (NCT03104777).

**Method**

**Participants and Design**

The study was a cluster randomised controlled trial with two arms (intervention and control). Clusters were formed at the school level. Invitation letters were sent to all primary schools in Derby (*n* = 57) of which 27 expressed interest in the trial. Two schools were excluded as they informed parents that photographs would be taken of packed lunches, thus violating the study protocol, and eight schools dropped out before the trial began. Seventeen schools were randomly allocated to the intervention (*n* = 8) and control groups (*n* = 9). Children in school years 3-6 (age 7 – 11 years) were included in the intervention as younger age groups were provided with free school meals (Education and Skills Funding Agency, 2019). It was estimated that there were 1,916 children having packed lunches across the schools (966 Control, 950 Intervention). Head teachers consented to participation on behalf of the school. Ethics approval was granted by the PHE Research Ethics and Governance Group (application reference R&D 275) and by the University of Derby Health and Social Care Ethics Committee.

***Power Calculation***

As the sample size was determined by the number of children bringing packed lunches to participating schools, calculations were performed to estimate the minimum detectable effect size based on sample size estimates. The number of children bringing lunches in was estimated at 2779 (based on scoping data collected from 11 schools that agreed to participate in the trial). The desired power level was set at 80% and different estimates were calculated based on variations in expected sample sizes (ranging from 400 to 3000 children) and three different design effects to account for the cluster design of the trial (2.06, 3.65 and 5.66). The former two design effects were based on the two most applied intra-cluster correlations of .01 and .025. The latter value was the maximum permissible design effect for a sample size of 400 with a mean cluster size of 106 (estimated from scoping data).

These calculations revealed that for the design effect of 2.06, a given sample size of 2400 students and 80% power would allow the detection of an 8.2% reduction in the proportion of lunchboxes containing sugary snacks (assuming a base rate of approximately 50%; Evans et al., 2020). A design effect of 3.65 would allow the detection of an 11% reduction and a design effect of 5.66 would allow the detection of a 13% reduction.

**Randomisation**

Randomisation was undertaken by the researchers at Public Health England (PHE) in discussion and agreement with the PHE Statistics Unit. Blocked random allocation was used in order to balance the two trial arms with regards to (i) the number of pupils eating packed lunches and (ii) the percentage of children eligible for free school meals (FSM; used as a proxy measure of deprivation level). Schools were divided into approximately equal-sized blocks based on the number of children eating packed lunches, and a cut-off of 20% of pupils eligible for FSM as a way to categorise high-deprivation schools. Schools within each block were randomly allocated to the two trial arms on a 1:1 allocation ratio using random sorting. Randomisation was carried out using Stata v.13.

**Materials and Measures**

***School characteristics***

Data on various school characteristics (e.g., number of children per school year, number of children who bring packed lunches and school packed lunch policies to restrict certain food items) was obtained from telephone interviews with schools, Derby City Council and online resources (e.g., school websites) when necessary.

***Intervention materials***

Intervention materials were developed on the basis of a literature review and focus groups with parents (see supplementary file 1). The intervention consisted of a total of seven materials which were sent home to parents via the children’s book bags and lunchboxes in three bundles as per the Intervention Implementation Standard Operating Procedure (supplementary file 2). Ahead of the first bundle, a primer letter was sent to parents from the School Head Teacher, positively framed (e.g., “we hope you enjoy the suggested swaps”) with the aim to increase parental engagement, highlighting positive social norms regarding meals (e.g., “the majority of children choose to have school meals”), and explaining the materials they would receive in the coming weeks.

The first bundle contained (i) a spot the difference lunch box tag, designed to increase the salience of hidden sugars in lunch boxes by using simple, attractive images comparing the sugar content of standard packed lunch items versus healthier, lower-sugar alternative items with reference to the recommended guideline intake for children, and (ii) a handy swaps card highlighting small, simple and affordable healthier swaps (e.g., malt loaf in place of cake slices).

Bundle 2 included only one intervention component, a lunchbox mixer which suggested healthier alternatives for drinks, breaktime snacks, main lunch components, savoury sides and sweets snacks for parents to choose from.

Bundle 3 included three intervention components; (i) a packed lunch planner (with pen) that included space for parents to write healthy swap pledges, (ii) a shopping list pad (with a healthy swaps summary on the back) to encourage action planning and provide support for the implementation of intentions, and a (iii) a reward chart (with star stickers provided) to monitor progress and encourage the child’s involvement with making healthier choices.

The specific behaviour change techniques (BCTs) employed from the BCT taxonomy (Michie et al., 2013) are listed below in Table 1. The principles of EAST (make it Easy, Attractive, Social and Timely; Behavioural Insights Team, 2014) were also applied to intervention materials (see supplementary files 1 & 4)

*Table 1: Behaviour Change Techniques (BCTs) from the BCT taxonomy v.1 employed in the intervention materials*

|  |  |
| --- | --- |
| **Intervention Component** | **Behaviour Change Techniques** |
| First primer letter | * Credible source (sent from Head Teacher)
* Priming
* Information about health consequences (framed in terms of positive gains)
 |
| Spot the difference lunchbox tag | * Salience of consequences
* Behaviour substitution
* Adding objects to the environment
 |
| Handy swaps card | * Behaviour substitution
* Salience of consequences
* Adding objects to the environment
 |
| Lunchbox mixer | * Graded tasks (breaking lunches into individual components to be acted upon)
* Behaviour substitution
* Adding objects to the environment
 |
| Packed lunch planner | * Action planning
* Goal-setting (behaviour)
* Commitment
* Adding objects to the environment
 |
| Shopping list | * Graded tasks (breaking shopping into different food types)
* Action planning
* Prompts/cues
* Adding objects to the environment
 |
| Reward chart | * Prompts/cues
* Monitoring of behaviour
* Incentive/reward
* Goal-setting (behaviour)
* Adding objects to the environment
 |

***Packed lunch contents***

Data on packed lunch contents were collected from photographs taken by the researchers. Photographs were taken before the lunch break in order to ensure that complete contents were present. During data collection it became apparent that some schools allow children to take food from their lunchboxes at mid-morning break, meaning that some images may have been of incomplete contents; efforts were made to take photographs before the mid-morning break where possible. Efforts were also made to ensure that the researchers did not go into schools during “special” days (e.g., days schools advised more children opted for school dinners such as ‘fish and chip’ Fridays, school trips or event days) where the number and contents of children’s lunches may not be representative of a standard school day.

All pre-packaged items (including empty packages) were removed from the lunchboxes and placed on a tray so that all brands and product names were visible and identifiable. Researchers wore clean, disposable gloves during this process, and trays were wiped with anti-bacterial wipes between each lunchbox. Other items (e.g., loose food, foil-wrapped items, plastic container boxes) were left inside the lunchbox, which was placed on the same tray and opened up so that these items were also visible from inside the lunchbox. Any identifiable information (e.g., child’s name/address) was covered by post-it notes, and another post-it note was placed on the tray displaying an anonymous reference code which allowed the researchers to identify the school number, the year group and the photo number. A photograph of this set-up was taken and the items were returned to the lunchbox. Photos were taken both before the intervention (baseline), a few weeks after the last bundle had been sent home (post-intervention) and three months later (follow-up). Data collection occurred once per school at each time-point. A data collection protocol set out all the steps and all researchers were familiar with this before attending the school (see supplementary file 2).

Photos of lunchboxes were coded independently by researchers at the University of Derby. If an item was pre-packaged, the brand, product name and flavour were coded where possible. Items that had not been pre-packaged but were still identifiable were coded with basic descriptions (e.g., “apple”, “digestive biscuits”). Items that had not been pre-packaged but were not identifiable (i.e., because they had been wrapped in foil) were coded as “unidentifiable”. Where coders felt it was appropriate, additional details were noted down to aid the identification of items (e.g., when searching for nutritional information in existing databases). A database was created listing each product observed in each lunchbox (including unidentifiable items) and where possible, the nutritional information per 100 g/ml of that product for kJ, kcal, salt, sugar, fat, saturated fat, protein and fibre. Nutritional information was derived from existing databases (primarily the Brandbank database), supermarket and product websites, and from photos of packaging.

It was not possible to blind those collecting data from school allocation as these researchers were also involved in implementation of the intervention, however those coding the contents of lunchboxes were all blind to study allocation.

***Parent survey***

A post-intervention cross-sectional online parental survey using Qualtrics was designed to explore parents’ self-reported capability, opportunity and motivation to prepare and provide healthier packed lunches. Letters with a link and a QR code to the survey were provided to schools to distribute to parents of children in Years 3 – 6 who ate a packed lunch at least once per week. Paper copies were available to parents on request.

The questionnaire was designed to capture various influences on behaviour according to the COM-B model (Michie, Van Stralen, & West, 2011). Questions were designed to link closely to the intervention materials (e.g., testing the knowledge of specific information provided in the materials in order to see if this was higher in the intervention group) and captured the following domains based partly on the Theoretical Domains Framework (Cane, O’Connor, & Michie, 2012): Capability (with subscales for Knowledge and Memory Attention & Decision Processes), Opportunity (with subscales for Environmental and Social Influences), and Motivation (with subscales for Role & Identity, Beliefs Capability, Beliefs Consequences, and Emotion). Examples of items are included in Table 2, and the complete list of final questionnaire items included in the analysis are listed in supplementary file 3.

*Table 2: Examples of survey items for each COM-B component and domain*

|  |  |  |
| --- | --- | --- |
| COM-B | Domain | Example Item |
| Capability | Knowledge | I do not know which foods in my child’s packed lunch contain added sugar (R) |
|  | Memory, Attention & Decision Processes | Sometimes I forget what healthier swaps I could make (R) |
| Opportunity | Environmental Influences | I cannot afford to provide healthier options in my child’s packed lunch (R) |
|  | Social Influences | Most parents provide a packed lunch that contains a sweet treat or sugary drink (R) |
| Motivation | Role & Identity | It is important as a parent to provide a healthy lunch for my child |
|  | Beliefs Capability | I would find it hard to persuade my child to try or take healthier options in their packed lunch (R) |
|  | Beliefs Consequences | What a child eats can have an impact on their health and wellbeing |
|  | Emotion | I worry that my child consumes too much sugar |

*(R) indicates reversed items*

As these questionnaire scales were developed specifically for this project (and therefore had not validated in advance), principal axis factoring with oblimin rotation was used to group the parental survey items together and reduce the number of variables tested. The Kaiser-Meyer-Olkin measure verified that the sample was adequate for factor analysis (KMO = 0.76), and a total of seven factors had eigenvalues higher than Kaiser’s criterion of one. The scree plot was ambiguous and demonstrated inflections at the second and fourth factor. A solution of three-factors was decided upon as (i) we expected three factors to match the COM-B model upon which the survey was developed, and (ii) the scree plot demonstrated a sharp drop-off after the third factor, with the top three factors being the only ones to have eigenvalues above two. These three factors explained 39.88% of the variance in the survey answers.

The survey items did not load onto factors according to COM-B as expected; however, the first factor could be interpreted as representing negative emotional responses and difficulties associated with packing a healthy lunch (Automatic Motivation, Psychological Capability, Physical Capability), the second factor could be interpreted as the Social Opportunity for packing a healthy lunch, and the third factor could be interpreted as Motivation and Knowledge for packing a healthy lunch (Reflective Motivation, Psychological Capability; see supplementary file 3 for factor loadings and questionnaire items). Cronbach’s alpha was used to test the reliability of these scales, and was found to be high for each set of items (alpha = .867, .738 and .786 for each scale respectively). Three questionnaire items assessing parental knowledge were analysed separately; a knowledge score was calculated based on parents’ responses to these questions.

The survey also asked parents to provide demographic information for themselves (e.g. gender, age range, ethnicity, highest educational attainment) and information relating to the study site and the year group and gender of any child(ren) attending the school in the intervention year groups (3-6). Further questions were added to the survey for parents in the intervention group, to assess responses to the intervention materials. Parents were offered the chance to enter a prize draw to win vouchers as an incentive for participation, two prizes of £25 and one prize of £50.

**Procedure**

Baseline data collection of lunch box contents occurred during October and November 2016. Control schools received no intervention materials. In intervention schools, an initial letter informing parents that schools would be participating in a healthy food initiative was sent out before the Christmas holidays and was addressed from the headteacher (apart from in two schools where it was requested that the letter came from PHE). The three bundles of materials (outlined above) were sent out over a 4-week period in the new term. Post-intervention lunchbox data collection occurred in the weeks following the delivery of the final bundle, and follow-up lunchbox data collection was conducted three months later. All parents of children who usually take a packed lunch at least one-day per week in participating trial schools were invited to participate in the online survey once follow up data collection had taken place.

**Outcomes**

The primary outcomes for this study were (i) presence of sugary snacks and (ii) presence of sugary desserts in lunchboxes. Secondary outcomes were the presence of (i) crisps, (ii) fruit and vegetables, (iii) sugary drinks and (iv) swap items (i.e., healthier alternatives suggested in intervention materials) in lunchboxes. All of these variables were explored as both the proportion of lunchboxes containing these items, and the mean number of items per lunchbox. Sugary drinks was listed as a secondary outcome instead of a primary outcome due to concerns raised during pilot work that identifying the presence of sugary drinks was difficult (i.e., due to branded bottles being reused and filled with other drink types). As a result, the main focus to assess sugar reduction was on sugary snacks and desserts. A final secondary outcome measure was (v) total sugar content of lunchbox.

**Analyses**

The data were aggregated across lunchboxes. Multilevel modelling was conducted to account for a data structure of lunchboxes nested within school years nested within schools. This was conducted in R using the lme4 package. Analyses were conducted on data from the post-intervention time point, with three-month follow-up analyses only being consulted when significant intervention effects emerged on immediate post-intervention outcomes.

 Unadjusted models contained only the effects of the intervention and baseline estimates for that outcome. Due to the nature of data collection, it was not possible to link specific lunchboxes across time points. As a result, baseline estimates in this case were given as the average score for the relevant school year at the relevant school (as this was the closest level of identification possible for each lunchbox).

Adjusted models contained additional school-level factors (presence of a packed lunch policy, Index of Multiple Deprivation [IMD] for school post code, number of children with English as an Additional Language [EAL] at the school). Further exploratory models also contained interaction effects between intervention group and IMD to see whether the effect of the intervention differed according to deprivation status. Results from adjusted models are presented for all outcomes, except in cases where the exploratory model (which contained an additional interaction term between the intervention and IMD) was found to be a significantly better fit, as indicated in the text. A Bonferroni correction for multiple comparisons was applied to the standard critical p value (p = .050) by dividing it by the number of outcomes.

 The two intervention arms were compared on the survey knowledge score and the factors extracted from the principal axis factor analysis (see above) using t-tests. The comments from the surveys were analysed using a thematic analysis approach, with an aim to answering the following questions: (i) what are the barriers and facilitators to parents packing a healthy lunchbox in this sample and (ii) how, if at all, have the intervention resources supported parents in packing healthy lunchboxes?

**Results**

**Preliminary Analyses**

Randomisation checks revealed that the two arms did not differ significantly with regards to the school-level characteristics of (i) presence of a packed lunch policy, (ii) school size (number of pupils in school), (iii) IMD, (iv) proportion of pupils receiving FSM and (v) proportion of EAL pupils. It is worth noting that almost half of Control schools had a packed lunch policy in place, while no Intervention schools did (although as noted, this difference was not statistically significant; Table 3).

*Table 3: Baseline characteristics of schools and randomisation checks.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Intervention | Control | Test statistic | *p* |
| Packed lunch policy | 0% | 44% | χ2(1) = 4.65 | .082 |
| Number of pupils in school | 377.63 (129.58) | 391.67 (143.88) | *t* (15) = 0.210 | .836 |
| IMD | 26.11 (16.03) | 26.56 (16.68) | *t* (15) = 0.057 | .956 |
| % FSM pupils | 12.88 (10.45) | 12.33 ( 9.29) | *t* (15) = -0.113 | .911 |
| % EAL pupils | 15.75 ( 8.45) | 25.44 (25.28) | *t* (15) = 1.031 | .319 |

In total, 5,147 photos of lunchboxes were collected across the three time-points (pre intervention = 1,708; post intervention = 1,707; three-month follow up = 1,732; Figure 1). All lunchboxes were included in analyses. Krippendorff’s alpha and Fleiss Kappa were calculated to assess reliability of coding the subcategory and product names of items in photos. The highest level of agreement was found for coding items into subcategories, for which there were 33 different options and the Krippendorff’s alpha was 0.617 and the Fleiss Kappa 0.608. This can be considered as moderate agreement between coders. Reliability dropped for coding product names (for which 245 options were possible) with a Krippendorff’s alpha of 0.477 and a Fleiss Kappa of 0.476, however this also indicates moderate agreement.

*Figure 1: CONSORT flow-chart detailing numbers of participating schools and photographed lunchboxes*



For the outcomes of sugary drinks and crisps in lunchboxes, over 99% of the values were either 0 or 1, rendering these variables effectively binary. Therefore, the presence of both of these items was explored in analyses but the number of these items per lunchbox were not. The final number of outcome variables explored was 11, resulting in a Bonferroni-adjusted p value of .0045.

**Primary Outcomes**

 Immediately post-intervention, baseline estimates were a significant predictor of presence (*b* = 1.61, *SE* = 0.45, *z* = 3.60, *p* < .001) and number (*b* = 0.36, *SE* = 0.10, *t* = 3.74, *p* < .001) of sugary snacks, and presence (*b* = 1.94, *SE* = 0.52, *z* = 3.75, *p* < .001) and number[[1]](#footnote-2) of sugary desserts in lunchboxes (*b* = 0.35, *SE* = 0.12, *t* = 2.99, *p* = .003). No other significant effects or interactions were observed.

*Table 4: Descriptive statistics (% of lunchboxes containing for presence, and mean and standard deviation per lunchbox for number) and intervention effects for the primary outcome measures of sugary snacks and chilled sugary desserts.*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Outcome | Time Point | Int. | Cont. | *b* (Int.) | *SE* (Int.) | *z/t*(Int.) | *p* (Int.) |
| Sugary Snacks |  |  |  |  |  |  |
|  Presence (%) | Baseline | 71.19 | 66.16 |  |  |  |  |
|  | Post-Int. | 69.00 | 64.11 | 0.016 | 0.12 | 0.13 | .896 |
|  | Follow-Up | 67.49 | 62.04 | n/a | n/a | n/a | n/a |
|  Number  (M (SD)) | Baseline | 0.95 (0.82) | 0.86 (0.83) |  |  |  |  |
| Post-Int. | 0.91 (0.80) | 0.84 (0.80) | 0.02 | 0.05 | 0.46 | .652 |
|  | Follow-Up | 0.89 (0.84) | 0.83 (0.82) | n/a | n/a | n/a | n/a |
| Chilled Sugary Desserts |  |  |  |  |  |  |
|  Presence (%) | Baseline | 48.05 | 44.96 |  |  |  |  |
|  | Post-Int. | 50.06 | 39.91 | 0.22 | 0.14 | 1.63 | .102 |
|  | Follow-Up | 46.34 | 42.87 | n/a | n/a | n/a | n/a |
|  Number  (M (SD)) | Baseline | 0.52 (0.57) | 0.51 (0.60) |  |  |  |  |
| Post-Int. | 0.55 (0.60) | 0.43 (0.56) | 0.07 | 0.03 | 2.09 | .050 |
|  | Follow-Up | 0.52 (0.61) | 0.46 (0.57) | n/a | n/a | n/a | n/a |

M = mean, SD = standard deviation, Int. = intervention. Critical adjusted p value = .0045. N/a indicates that follow-up analyses were not consulted due to lack of significant effects at the immediate post-intervention time point.

**Secondary Outcomes**

For the outcomes of crisps (presence), sugary drinks (presence), fruit and vegetables (presence and number), and swap items (number), baseline estimates significantly predicted post-intervention outcomes. Number of swap items in lunches was significantly higher in the Intervention group at post-intervention (*b* = 0.23, *SE* = 0.06, *t* = 3.71, *p* < .001), but this effect was not sustained at follow-up (*p* = .507).

Presence of sugary drinks was positively related to number of EAL pupils at the school (*b* = 0.40, *SE* = 0.13, *t* = 3.01, *p* = .003), and presence of swap items was predicted by packed lunch policy (*b* = 0.29, *SE* = 0.10, *t* = 2.97, *p* = .003). No other significant effects were observed.

**Parental Survey**

 In total, 1916 survey invitations were delivered to schools (based on the numbers of children having packed lunches, without taking siblings into account) and 123 surveys were returned (70 from Control parents and 53 from Intervention parents). Once incomplete responses were removed, a total of 102 surveys were retained for analysis (59 Control, 43 Intervention). Respondents to the survey were predominately female (85.3%), white (79.4%), aged between 35 - 44 years (53.9%), and educated to degree level or above (54.9%).

Respondents reported having between 1 and 3 children in school years 3-6 (*M* =1.18, *SD*= .44). Respondents with more than one child at the school in years 3-6 were asked to consider one of these children when responding to the survey. The responses received related to children across years 3–6 with approximately 12% in year 3, 30% in year 4, 32% in year 5 and 24% in year 6. There were slightly more responses relating to male children than female children (57% and 43% respectively). The number of days these children took a packed lunch to school ranged from 1-day per week to 5-days per week, with the mean number of days being 4.03 (*SD*=1.32), and the majority (56.9%) of children taking a packed lunch every day.

 **Questionnaire items.** There was no evidence of differences in scores between trial arms on the three factors (all *p* > .180). The trial arms also did not significantly differ on knowledge score (*p* = .386).

 **Parent comments.** In terms of answering the first research question pertaining to barriers and facilitators to packing a healthy lunch, parents’ comments could be categorised into three domains: (i) those associated with the child, (ii) those associated with the parents’ perceptions of the health of the child and the family as a whole, and (iii) those associated with the food environment (both within the school and in everyday life).

 ***Barriers and facilitators associated with the child.*** Many parents described their children as fussy eaters, and parents emphasised that they would rather provide a lunch that their child would eat than providing them with a disliked lunch that would not be eaten and result in hunger.

*It's not about putting healthy things in a packed lunch, it's about making sure there is things my child will eat rather than going hungry. I try to add healthy snacks, but my child is fussy and won't eat salad or fruit. [Intervention Group]*

*The problem is that my son won't even attempt to try the options suggested for healthy lunch boxes. [Intervention Group]*

Sometimes children’s food fussiness was also described as originating from children desiring to have lunches that were similar to those of their friends. The school environment itself was frequently identified as a barrier to healthy eating, as discussed further below.

*Tried giving them a hot pasta dish or similar in a thermos but they don't like that either and I think that's because it's different to their friends [Control Group]*

*I usually try to make her have healthier choices, but as other children usually take chocolate, cakes and sugary drinks I have to add them to her lunch every now and then. [Control Group]*

Some parents also emphasised the autonomy of their children in choosing their own lunches. Sometimes this was described as a behaviour that parents supported (e.g., preferring their children to have a lunch that they would eat) whereas other parents described it as a behaviour that undermined their own control over their child’s diet (e.g., if their child would obtain preferred foods anyway).

*They get what they ask for in their packed lunch, I would rather they eat at lunch and not spend the afternoon hungry. [Control Group]*

*Even if I give my son food he will then go and get whatever he wants to take anyway [Control Group]*

***Barriers and facilitators associated with parental perceptions.*** Some parents appeared to be unreceptive to sugar reduction messages due to perceptions that their child and family were already healthy and therefore did not need to make any adjustments to their lifestyle. It is not possible to ascertain whether or not these families were in fact consuming below the recommended level of sugar, however this theme is described here as a potential barrier to packing a healthier lunch (i.e., for lack of motivation or possibly lack of awareness of need to). Parents sometimes discussed not being overweight as an indicator that they did not need to make changes to their diet or lifestyle, whereas others indicated that their child already had healthy tastes and therefore they did not need to worry about providing healthier lunches.

*My whole family is far from being fat and has good oral hygiene. I see no reason to limit sugar in our diet [Intervention Group]*

*Have a hungry child who enjoys good wholesome food for breakfast and tea so don’t worry about what he eats for lunch. He’s not fussy so it’s easy to give healthier things. [Intervention Group]*

A common theme was the idea that the child’s other activities (e.g., sports) compensated for any sugary foods that they might be eating. Parents indicated that they were not worried about their child eating sugary foods as this would be balanced out (or even necessary) after participating in physical activity.

*I don't appreciate being told they cannot have the sweet option when I am paying for it. My son exercises 6 days a week. [Control Group]*

*I believe in everything in moderation so one thing is fine in my mind. My daughter is borderline underweight and is extremely active participating in a number of sports doing way over recommended activity levels […] In her case I have no problem if her sugar intake was a little higher than an inactive overweight child. I understand she is the exception by today's standards. [Intervention Group]*

Finally, another theme that emerged was the belief that parents should be the ones to decide the contents of their children’s packed lunch and that outside intervention was not appropriate.

*I feel that packed lunches are parent choices and therefore it's content should be parent decisions. […] If we wanted state control of what my child eats he'd have school dinners more and probably be even thinner than he is now as he wouldn't eat them. [Control Group]*

*Making all people feel shameful about eating certain foodstuffs when it has no negative effect on them is callous and I personally am getting fed up with all the preaching. [Intervention Group]*

***Barriers and facilitators associated with the environment.*** The school environment was cited as being an influential factor in whether or not parents could provide a healthy lunch for their child. Some comments captured elements of the practicality of providing healthy lunches due to lunchbox storage facilities.

*School provide refrigeration store for boxes which helps keep fresh foods better. [Control Group]*

*Unable to provide certain foods due to the fact that they are unable to keep their lunchboxes in a cool location. The lunchboxes tend to get warm which can ruin certain foods. [Intervention Group]*

Other comments focused more on the difficulties associated with providing a healthy lunch when the foods available in schools themselves were often high in sugar.

*I would give them school dinners every day except that they would then have a pudding every day!!!. [Control Group]*

*I find it annoying that my child is not allowed to take anything with chocolate in as a snack e.g. a homemade lower sugar flapjack made with honey and nuts when "healthy" but high sugar snacks are sold in the tuck shop e.g. fruit flakes or toffee popcorn!! I think school staff need some education on sugar contents... [Intervention Group]*

Similar comments were made about the availability and accessibility of healthy versus sugary foods in the wider “every day” environment that families find themselves in, with some citing issues of affordability and others stating that it was difficult to find healthier foods in the shops, particularly when information was seen to be conflicting.

*Healthy food is often very expensive compared to sugary food which is unfair when we are all being told to eat healthier [Control Group]*

*I think that is hard to know what is good for the children we choose cereal bars and fruit etc. but then told these are not good due to the amount of sugar in them!! [Intervention Group]*

***Reception of Intervention Materials.*** With regards to answering the second research question regarding how (if at all) the intervention materials supported parents in packing healthier packed lunches, it was found that the majority of comments from intervention parents indicated that the materials were not helpful. A couple of parents commented that the materials were helpful but no deep understanding of how exactly the materials had helped could be extracted.

*It was informative and worth reading and considering although in our case it has only made a small difference to what we buy. Simply because there were only little tweaks needed to our daughter pack lunch as it was already healthy and suitable for her needs. [Intervention Group]*

The remaining comments could be split into two themes; (i) materials were unhelpful due to reinforcing existing knowledge and (ii) materials were unhelpful due to reactance against messages. Some parents commented that the materials were not useful as they only communicated information that was already known to them. However, parents suggested that the materials had value for other families, and that they were also useful for reassuring parents that they were already providing healthy lunches.

*I don't personally need them, I am very conscious of my child having a healthy diet & I always plan meals & shopping accordingly.[Intervention Group]*

*I could see the purpose of the materials and read them all, but they didn't tell me anything I didn't already know and didn't change what I put in my child's lunchbox. However, they were useful in reinforcing that I was putting the right sort of foods into my child's lunchbox, but there were quite a lot of materials that I'm afraid ended up in the bin [Intervention Group]*

Other comments were indicative of parents displaying psychological reactance against the messages included in the intervention materials. These parents felt that the messages were inappropriate and their comments indicated that the materials elicited negative emotions such as anger and shame.

*They went straight in the bin. I am fed up of being told what to feed my child. I would rather give her a lunch I know she will eat than pack a lunchbox fool of 'healthy' items destined for the bin. Food ain't healthy if ain't eaten. [Intervention Group]*

*I cannot be doing with the anti -sugar brigade it alienates the sensible people who already know how to be healthy in a realistic way (and enjoy life at the same time). [Intervention Group]*

**Discussion**

The purpose of this RCT was to see whether behaviourally-informed intervention materials for families could be effective in reducing the sugar content of children’s packed lunches. There was insufficient evidence for an effect of the intervention on any of the primary outcomes (presence and number of sugary snacks and sugary desserts in lunchboxes). There was also very little evidence that the intervention influenced secondary outcomes. The number of healthier alternative foods suggested in the intervention materials (“swap items”) was higher in the intervention group at the post-intervention time point, but this was not maintained at three-month follow-up.

The findings on sugar reduction are in keeping with other trials of interventions to reduce confectionery and sweetened drinks in lunchboxes (Nathan et al., 2019) such as the SMART lunchbox intervention (although it should be noted that the SMART lunchbox intervention successfully increased fruit and vegetable provision in lunchboxes; Evans et al., 2010c). A recent systematic review identified only one intervention that successfully reduced sugary, “discretionary” foods (e.g., confectionery) packed in children’s lunchboxes (Nathan et al., 2019). This intervention included many components that were delivered to parents, children and the wider school organisation (Roberts-Gray et al., 2016).

 There was also insufficient evidence for intervention effectiveness on the outcomes of the parental survey, which was designed with an aim to capture any post-intervention differences in parents’ capability, opportunity or motivation to pack healthier lunches. This is unsurprising given that no behavioural impacts of the intervention were observed. In addition, fewer than 10% of surveys were returned, and it is likely that these survey responses represent a self-selected and unrepresentative sample. Although the psychological mechanisms underpinning the lack of change cannot be inferred from the survey responses, parents’ comments on the survey illustrated a number of reasons why no change was observed; intervention group parents who left feedback about the materials either commented that the intervention materials were not helpful due to them reinforcing knowledge that they already held, or communicated displeasure and anger at being told what to do. These responses clearly illustrate two very different reasons for parents not modifying the contents of children’s lunchboxes: one because the lunches were already (perceived to be) of a healthy standard and the other because parents rejected the sugar reduction messages of the intervention materials.

 The former response type could indicate that the null effects observed here may have been driven by optimism bias among parents. Evidence suggests that parents are more likely to evaluate the risks of obesity as an issue for other children rather than their own child (Wright et al., 2017). Some comments spoke directly to this theory, for example when parents pointed to their child’s higher-than-average activity levels as an explanation for why the information was not relevant to their family. Alternatively, it is possible that children’s diets were not as healthy as parents perceived them to be, either due to inaccuracies in recall (Burrows et al., 2013) or due to differences in what parents believe a healthy diet is versus a public health perspective (Lopez-Dicastillo, Grande, & Callery, 2010). However, without fully being able to assess the healthiness of the children’s diets in these families, it is not possible (nor would it be fair) to assume that optimism bias drove the null effects in this study.

The latter response type is indicative of psychological reactance which can arise when a threat to personal freedom is perceived (Brehm & Brehm, 2013). As was reflected in some of the survey comments in this study, parents value their responsibility and role in deciding what is packed in their children’s lunchboxes (O'Rourke, Shwed, Bruner, & Ferguson, 2020) but must also balance this parental control against the needs and preferences of their children, and the overarching priority that the lunch actually be eaten by the child (Ensaff, Bunting, & O'Mahony, 2018). Within this context of juggling multiple priorities, parents may feel threatened by sugar reduction messages, particularly when messages about confectionery items in packed lunches are perceived to be unfair against the context of puddings being provided in school meals (Ensaff et al., 2018). While the current study aimed to develop an intervention that would support parents to overcome the barriers associated with packing a lunchbox that was lower in sugar (i.e., by conducting a literature review and testing materials with a focus group of parents), it is clear that further work is needed to understand what support parents need, and which suggestions and messages they would be receptive to. Another potential avenue could be to encourage greater uptake of school meals which have been shown to be higher in nutritional quality than packed lunches (Rees et al., 2008; Evans et al., 2010a; Pearce et al., 2013; Evans et al., 2016); one randomised controlled trial found that overall dietary intake was improved at the food and nutrient-level when Danish schoolchildren ate school meals compared to home-prepared lunchboxes (Andersen et al., 2014). However, some parents choose packed lunches from home as a way of ensuring that their child receives a lunch that they like and will eat (Ensaff et al., 2018), meaning that this approach also carries similar challenges.

Comments from parents at all schools (regardless of trial arm) also revealed a number of barriers to packing healthy lunches, with child fussiness and accessibility of healthy foods within school and retail environments emerging as common themes. While this trial did aim to involve children in the intervention (e.g., with reward charts and star stickers), perhaps effectiveness would have been greater had it employed more behaviour change techniques targeting children directly. As noted, the intervention that successfully reduced discretionary foods in lunchboxes consisted of multiple components that targeted children and the wider school environment as well as parents (Roberts-Gray et al., 2016). Furthermore, recent analysis of trends in lunchbox contents over the past decade has revealed reductions in non-milk extrinsic sugars, which could be due to environmental interventions such as the reduction in portion sizes of chilled sugary desserts (Evans et al., 2020). The importance of the environment is captured by many models of health psychology (e.g., Michie et al., 2011), and future interventions and policies aiming to improve the diets of children should consider this wider food environment (both physical and social) when seeking to support families in healthy decision-making.

 The strengths of this study include the testing of an intervention that was developed on the basis of a review of the barriers and facilitators to parents packing a healthy lunch for their children. By aiming to target behavioural barriers that have already been identified in the scientific literature (rather than simply providing information and aiming to educate individuals on the behaviour in question) it is more likely that interventions will be effective. The intervention was also designed with parents and children in mind (e.g., information was presented in a simple and child-friendly format, and reward stickers and a reward chart were supplied to increase child engagement). Interventions that involve the whole family in behaviour change are often more effective than those targeting parents or children alone (NICE, 2015), indicating another potential strength of this study (although it should be noted that with only limited survey data on how families received and used the intervention materials, it is uncertain whether all of the proposed intervention components and behaviour change techniques were delivered as intended).

A further strength is that this trial focused on an objective behavioural outcome rather than relying on self-report data, which can often be compromised by individuals’ wish to provide socially desirable answers (van de Mortel, 2008). Parents were not informed at any point that lunchbox contents would be observed, as informing people that their behaviour will be monitored is a recognised behaviour change technique (Michie et al., 2013) which could have influenced the foods that parents packed for their children’s lunches and affected subsequent estimates of the efficacy of the intervention. This method carries potential ethical issues, as parents were not given the opportunity to opt-out of the study. A number of measures were put in place to limit the potential for adverse effects such as parental distress or reactance, including seeking consent from head teachers on behalf of the school, making efforts to ensure that parents were not informed of these observations at any point, and specifically choosing to not collect any identifying information that could link lunchbox observations to individuals.

 However, there were a number of limitations. Firstly, although the research team was closely involved in implementing the intervention in schools, it is not possible to know how many parents received and looked at the materials from their children’s lunchboxes/book bags. It is therefore not possible to closely evaluate the fidelity of the intervention’s implementation. Such a question could have been evaluated through the parental survey however, as has already been acknowledged, the response rate for this was very low. It could be argued that such low response rates were a result of survey invitations being sent in paper (and not digital) form. Many schools now communicate to parents in digital formats such as text messages and email, and a recent feasibility trial found preliminary evidence that communicating with parents via a smartphone app could improve the provision of healthy lunchboxes in primary schools (Sutherland et al., 2019). In the case of the survey, sending the link via digital channels could have made it easier for parents to access the survey (i.e., simply clicking and responding on their smartphone/computer rather than needing to type a link or scan the QR code from the paper copy). However, the paper format for invitations was chosen after consultation with participating schools over the most effective method of communicating with parents.

Secondly, if a food type was not identified in photographs of lunchboxes, it was presumed to be absent in analyses. However, it is highly likely that food types of interest were present but not identifiable in some lunchboxes (e.g., due to being wrapped in foil). This was also an issue when identifying presence of sugary drinks in lunches, as many lunches contained branded bottles that had clearly been reused. This limits our ability to fully analyse the contents of lunchboxes in this trial and the results should be interpreted with this caveat in mind. A related measurement issue is the fact that the study only measured the foods offered to children but did not assess which foods were actually consumed by children. While supporting parents to provide healthy lunchboxes for their children is important, children’s actual consumption of those lunches is key to sugar reduction aims. Indeed, the discrepancy between parental provision and child consumption of lunches was highlighted by some parents in the survey comments.

In addition, the design of the study precluded our ability to assess individual change over time, and the contribution of individual-level demographic characteristics to such change. As noted, parents and children were not aware that photographs of lunchboxes would be taken, meaning that it was not possible to obtain consent to examine this individual-level data. This compromise was made in order to improve ecological validity by reducing the likelihood that families would adjust the content of lunchboxes due to the prospect of the photographs (monitoring of behaviour by others is listed as a technique in the BCT taxonomy, Michie et al., 2013, but was not part of the intervention discussed here).

Other limitations include lack of blinding due to those delivering the intervention also being involved in data collection (although those involved in coding the lunchbox photos were blind to study allocation), and an imbalance between the trial arms in terms of the number of schools with packed lunch policies. Future trials could consider adding the presence of a packed lunch policy into the stratification process at randomisation to ensure that trial arms are better balanced on this characteristic.

Finally, although intervention development occurred on the basis of a literature review and involved a focus group of parents, the parent survey revealed that the materials were not always well received and led to psychological reactance among some parents, which will likely have reduced the effectiveness of the intervention. While this trial took place in a narrow geographical location in the UK, there is no reason to suspect that these findings would not be replicated in other locations within the UK. Future work should investigate which groups of people respond positively or negatively to such interventions and ensure that any future interventions are designed alongside representative samples of the target population, in order to ensure that materials and services meet their needs and expectations. This is important as childhood obesity rates vary between ethnic groups, with higher rates among children of Asian and black ethnicity compared to children of white ethnicity (dependent on age and gender; PHE, 2019). However, the majority of childhood obesity prevention interventions in the UK have been developed for the white ethnic group (Maynard, Baker, Rawlins, Anderson, & Harding, 2009) despite evidence that barriers to healthier diets are likely to vary between ethnic groups, in part due to different cultural needs and traditional practices (Rawlins, Baker, Maynard, & Harding, 2013). Future studies should ensure that intervention materials present meal and snack options that are acceptable and relevant to people of different ethnic groups, and should expand on the present study by recording school ethnicity data (where available) to better understand who these interventions work for.

To conclude, this RCT revealed limited effects of an intervention to improve the provision of healthier lunchboxes based on a behavioural insights approach. While the number of suggested healthy swap items was higher in intervention lunchboxes immediately following the trial, this was not sustained to three-month follow-up and there was insufficient evidence for change on other outcomes. Providing educational materials and activities may not be sufficient to change behaviour, even when multiple behaviour change techniques have been incorporated. Future research should explore ways in which behavioural science can be used to support families to provide healthier packed lunches for primary school children.

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1. For the outcome of number of sugary desserts, the exploratory adjusted model (i.e., the model containing the interaction between intervention group and IMD) was a significantly better fit of the data than the standard adjusted model (χ2(1) = 3.89, p = .049). The exploratory adjusted model is therefore reported for this variable, and the adjusted model is reported for all other outcomes. [↑](#footnote-ref-2)