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Parental norms and attitudes in Relation to Children's sugar consumption – A mediation analysis of the “Are You Too Sweet?” intervention study

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ABSTRACT

Parental influence on children's dietary behaviour makes parents an obvious target for prevention strategies with nutritional foci. Mediation analysis is considered a valuable tool for understanding the underlying mechanisms of influence in intervention studies aimed at implementing behaviour change strategies.

The present study used data from the multi-component cluster-randomised intervention “Are You Too Sweet?” with 153 Danish children (5–7 years) to explore mediating effects and role of parental determinants on added sugar intake in children.

A pre-and post-intervention questionnaire evaluated parental knowledge, practices, self-efficacy, norms, and attitudes. Children's dietary intake was estimated from a seven-day dietary record. Associations between children's added sugar intake and parental responses and changes in responses following the intervention were evaluated using linear mixed models. Exploring potential behaviour change pathways of the intervention was done using mediation analyses.

Children's reduction in added sugar consumption was partly mediated by changes in parental norms and attitudes regarding limiting sugar-rich foods and drinks to special occasions. Parental knowledge of guidelines on the intake of sugar-rich discretionary foods and drinks increased as an intervention effect but did not demonstrate a mediating effect. No significant changes or mediating effects were found in parental self-efficacy or practices.

The findings highlight parental norms and attitudes regarding restricting sugar-rich foods and drinks to special occasions as modifiable and a mediator for reducing added sugar intake in the “Are You Too Sweet?” intervention study.

Trial registration: Retrospectively registered at ISRCTN: ISRCTN10409779.

1. Introduction

The global consumption of added sugar by children is too high, leading to adverse health consequences such as increased risk of obesity and non-communicable diseases (EFSA Panel on Nutrition et al., 2022; Huang et al., 2023; Morenga et al., 2013; Vos et al., 2017). This risk is particularly evident concerning sugar-sweetened beverages (Mullee

et al., 2019; Risk Factor Collaboration and (NCD-RisC)., 2017). Consequently, the World Health Organization and the Nordic Nutrition Recommendations 2023 (NNR 2023) recommend to lower free sugar intake, including added sugar, to less than 10 % of the total energy consumption (E%) and preferably lower (Blomhoff et al., 2023; World Health Organization, 2015). The NNR from 2012 has focused on added sugar, which has therefore also been addressed in Danish dietary

Abbreviations: BMI, Body Mass Index; CFA, Confirmatory Factor Analysis; CI, Confidence interval; CSPQ, The Comprehensive Snack Parenting Questionnaire; E%, Percentage of total energy intake; IOTF, International Obesity Task Force; IQR, Inter quartile range; kJ, Kilojoule; OR, Odds ratio; RMSA, Root Mean Square error of Approximation; SCT, Social Cognitive Theory; SE, Standard error; TLI, Tucker Lewis Index.

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guidelines (Nordic Council of Ministries, 2012). Children's added sugar intake alone in five European countries has been reported as a mean of 11–17 E% (Azaïs-Braesco et al., 2017). Many foods and beverages representing sources of added sugar in children are characterised not only by their sugar content but also by having a high energy density and being nutrient-poor. The NNR states that increasing sugar intake leaves less room for healthy food choices rich in micronutrients, which is especially important for those with low energy intake, such as children (Blomhoff et al., 2023). In Western countries, children's primary sources of added sugar appear to be sugar-sweetened beverages, candies, cakes, and sweet snacks (EFSA Panel on Nutrition et al., 2022). A Danish qualitative study found that even though parents were aware of the importance of reducing added sugar, they had little comprehension of how much was too much (Iversen et al., 2011). In Denmark, dietary guidelines to set limits and definitions regarding energy-dense nutrient-poor (EDNP) food groups have been developed using nutrient profiling modelling (Biltoft-Jensen et al., 2022). EDNP foods are also communicated as discretionary foods and drinks, i.e. foods and drinks that are not necessary to provide the nutrients required by the body, and encompass cakes, sweets, chocolate, sweet bakery products, salty snacks, sweet drinks, and alcohol. Communicating specific foods might be a more consumer-specific target than nutrients, such as added sugar, as this approach is anticipated to be more comprehensible and actionable for the general public (Biltoft-Jensen et al., 2022).

Developing intervention programs and promoting a healthy diet in early childhood is essential to tackle childhood obesity and ensure optimal dietary habits during growth and development (Vargas-Garcia et al., 2017; World Health Organisation (WHO), 2017). In this context, gaining insight into the various factors influencing children's dietary habits is crucial. Physical and social environment and parenting practices are potentially modifiable factors influencing children's dietary behaviour (Scaglioni et al., 2018). Mediation analysis has been suggested as an informative tool to evaluate behaviour interventions and explore how interventions work, even in studies without an intervention effect (Bekelman et al., 2017; Cerin et al., 2009; O'Rourke & Mackinnon, 2018).

The primary aim of this paper is to explore data from the "Are You Too Sweet?" intervention to investigate whether parental determinants mediate changes in children's added sugar consumption. In addition, it is explored whether parental determinants mediate changes in intake of sugar-rich discretionary foods and drinks. It is hypothesised that the intervention, delivered within a framework based on Social Cognitive Theory (SCT), can change one or more aspects (constructs) of parental behaviour, which in turn can mediate a potential change in children's diet. Further, exploring both mediated changes in children's intake of added sugar and sugar-rich discretionary foods and drinks, can give insight into how to communicate the guidelines as servings and discretionary choices.

2. Materials and Methods

2.1. Study design

The current study uses data from the "Are You Too Sweet?" intervention study (Bestle et al., 2020, 2024). The intervention study was designed as a 3.5-month multicomponent, two-armed, parallel, cluster-randomised trial. The trial was conducted between September 2020 and March 2021 in the Danish municipality of Hvidovre. The municipality was chosen because it is close to the national mean for socio-economic status level in Denmark. All parent participants gave written consent after written and oral information about the study.

The study's main outcomes have been reported previously (Bestle et al., 2024). In short, the study found no significant effects on the summarised group of discretionary foods and drinks, while discretionary drinks alone decreased significantly by 41 %. Furthermore, subgroup analyses on parental educational level showed a significant decrease of

added sugar by -2.9 E% for children of parents with lower parental education levels (Bestle et al., 2024).

2.2. Population sample and randomisation

Parents of children (5–7 years) starting at six different schools were invited before the beginning of the school year to participate in the intervention in the autumn after school start along with their children. The collaborating municipality selected six schools for the intervention based on feasibility, ensuring representation of areas with diverse socio-economic characteristics to include more and less resourceful families. The schools were randomised to either intervention or control group, with an initial plan for a balanced design of three schools in each group. However, many families reconsidered their participation, likely due to the COVID-19 lockdown and delays between initial contact and the interviews. As a result, because of the high dropout rate before the study began, four schools were randomised to the intervention group, while only two were randomised to the control group, to ensure a sufficient number of families in the intervention group. Due to the nature of the study, the intervention was not blinded. However, participants were first informed whether they belonged to the intervention or control group after collecting baseline measures. Families were enrolled continuously over a six week period, depending on their scheduled appointment with the school health nurse. All children planning to start at one of the schools were eligible for participation and there were no exclusion criterias.

2.3. The "Are You Too Sweet?" intervention

The development, design, and materials of the "Are You Too Sweet?" intervention have been described in detail elsewhere (Bestle et al., 2020). In short, the intervention "Are You Too Sweet?" built on current practice of offering Danish school starters and their parents a consultation with a school health nurse. The intervention aimed at increasing the awareness regarding guidelines for the maximum intake of sugar-rich discretionary foods and drinks by several intervention components. The principles of Social Cognitive Theory (SCT) guided the development of the intervention framework, components, and materials. The SCT target individual behaviour changes within a social context, emphasising factors such as expectations, knowledge, behavioural capability, observational learning, social and structural impediments, and self-efficacy as central concepts (Bandura, 2004). A sugar-rich food screener (Cramer-Nielsen et al., 2022), self-administered by the parents to register the intake of the child's intake the week before the school health nurse consultation, enabled the school health nurse to provide individualised guidance supporting the theoretical constructs expectation and knowledge. Further, the intervention families were given a take-home box containing an inspirational booklet with strategies to reduce sugar-rich discretionary foods and drinks, a card game with stickers for an AR app for download, a sticker board to illustrate guidelines, a children's book, local "activity suggestions, and public swimming pool tickets. These materials aimed to support the families' behavioural capabilities, expectations, and self-efficacy, limit social and structural impediments, and increase alternative activities and engage families. Intervention parents were also invited to a closed Facebook group used to provide parents with information and reminders of the project during the intervention period and as an opportunity to build peer-to-peer support among the participating families. Families in the control group received standard consultation at the school health nurses, but with new consultation materials on thriving, physical activity and overall diet (Bestle et al., 2020; (Christensen et al., 2022a).

2.4. Dietary intake data

Parents were instructed to register their children's diet in an online validated dietary record for seven consecutive days beginning the day

after the introduction meeting for each family (Biltoft-Jensen et al., 2013). The daily registration consisted of three main meals and additional three in-between meals. Participants could search for foods and drinks and choose the amount eaten from 1 to 4 pictures of the food/drink. Recording of open-ended answers was also possible. At the end of each day, parents were asked if they forgot to record any sweets or chocolate and if the child had any dietary supplements. Intake of food items, energy, nutrients, and added sugar were calculated for each participant using the software system General Intake Estimation System (GIES) version 1.000.i6 and the Danish Food Composition Databank version 7.0, both developed at the National Food Institute, Technical University of Denmark. At least four days, including one weekend day and three weekdays, were required to be logged for the participating child to be considered valid and included in the analysis.

This study focused on added sugar as the nutrient of interest. Added sugar intake exhibited less variation and a more normal distribution in the dataset compared to sugar-rich discretionary foods and drinks, enabling a more robust analysis. Since children's primary sources of added sugar are sugar-rich foods and drinks, which are a key focus of the intervention, we also report a mediation analysis using these foods and drinks as outcomes.

2.5. Questionnaire instrument construction

One parent of each participating child (the same parent both times) was asked to complete a questionnaire on a tablet using Lime Survey at both baseline and follow-up center visit. As SCT guided the "Are You Too Sweet?" intervention, the questionnaire aimed to measure changes in constructs within the SCT framework. Theories of parenting practices, norms, and attitudes were used to reflect the concepts of behavioural capability, observational learning, and social and structural impediments from the SCT (Bestle et al., 2020). The questionnaire was inspired by two previously validated questionnaires, designed to reflect domains regarding parenting practices and family food self-efficacy, i.e. the Comprehensive Snack Parenting Questionnaire (CSPQ) by Gevers et al. and the Swedish parental self-efficacy instrument by Bohman et al., respectively (Bohman et al., 2014; Gevers et al., 2018). The questions were translated into Danish by two independent translators. Additional questions were developed when previously validated questionnaires could not be found. The complete questionnaire developed for the intervention thus consisted of previously validated questions (Q22-Q24 and Q28-Q35) and newly developed questions (items Q1-Q21 and Q25-Q27).

Eight questions from the Comprehensive Snack Parenting Questionnaire (CSPQ) (Gevers et al., 2018) were used to measure parental practices that could explain child snacking behaviour, focusing on sugar-rich foods and drinks. The questions on parental practices were kept as single items, as only part of the CSPQ was used, which originally comprised several more constructs than those described in this paper. The multi-item parts of the questionnaire consisted of six a priori constructs (scales) with a total of 34 items. First, "expectations" were measured by assessing the parent's motivation to change their child's sweet-eating habits, asking whether they would like to change their children's habits and if they were satisfied with their child's current food habits. Secondly, knowledge was measured as knowing the guidelines for sugar-rich discretionary foods and drinks for 4–6- and 7–9-year-old children, respectively. Third, measures of norms and attitudes comprised ten items inspired by qualitative research on Danish children and snacking habits and classifying sugar-rich foods and drinks for special occasions rather than everyday use (Husby et al., 2009; Iversen et al., 2011). The fourth construct measured social support in terms of feeling supported to eat healthily and provide the child with healthy food. The fifth construct, perceived barriers, assessed difficulties in setting limits for the child's unhealthy eating (Iversen et al., 2011). Finally, the sixth construct measured self-efficacy by both food-related issues adopted from a Swedish, validated questionnaire by Bohman

et al. (Bohman et al., 2014), and family-related items, developed to capture a more general self-efficacy of family dynamics, constructed by guidelines of Bandura (Bandura, 2006).

Face validation of the entire questionnaire was done by conducting individual think-aloud interviews with one male and five female parents of at least one child in the age group 5–9 years, recruited through social network sampling. Revisions were made in cases questions were unclear or misunderstood. Next, field-testing of the online questionnaire was performed among 26 parents of a child aged 4–9 years, recruited through social media and network, to ensure feasibility and evaluate time requirements. Only minor typographical revisions were made after the field test, and the time requirements were deemed acceptable (approximately 20 min).

For the knowledge category, four response options were provided, with one designated as the correct answer. Subsequently, answers were coded as either right or wrong. Self-efficacy responses were measured on a scale from 1 to 10. Responses from the rest of the questions were categorised on a five-point Likert scale ranging from 1 (*very much disagree*) to 5 (*very much agree*) or from 1 (*very difficult*) to 5 (*not at all difficult*). The questionnaire was translated from Danish to English for use in this paper (Supplementary Table A1).

2.6. Statistical analysis – Questionnaire

Descriptive summaries of the questionnaire items were performed to examine distribution and floor and ceiling effects to explore potential issues regarding scale precision and sensitivity to detect changes. The full questionnaire and descriptive summaries are presented in Supplementary Table A1.

Confirmatory Factor Analysis (CFA) was conducted to ensure the validity of the underlying constructs (factors) of multi-item questions. The analysis was carried out using the R package Lavaan (Rosseel, 2012). The Tucker Lewis Index (TLI) and the Root Mean Square error of Approximation (RMSEA) were reported to evaluate the CFA. A TLI close to or above 0.95 is considered a very good fit, but close to 0.9 can be regarded as acceptable (Byrne, 1994). A low RMSEA is desired; close to 0.05 represents a good fit, while measures up to 0.1 are considered acceptable (Fayers & Machin, 2013).

Cronbach's α was calculated within each construct using the R package, psych (Revelle & Revelle, 2015) to assess internal consistency. A Cronbach's α above 0.7 is considered acceptable for psychometric measures (Fayers & Machin, 2013). In cases where model fit was poor, the number of constructs were adjusted (either reduced or increased) as needed. Items with poor correlation to the underlying construct were either discarded if deemed invalid or retained as single items if considered valuable for the study's purpose.

The initial CFA on the questionnaire's six hypothesised latent constructs (factors) showed a TLI at 0.58 and an RMSEA at 0.09 (not shown in tables). The knowledge items showed poor correlation and were kept as single items on recommendations for children 4–6 years and 7–9 years old, respectively. Two constructs were further split into four: Expectations were divided into two constructs focusing on the desire for change in sugar-rich foods (F1) and sugar-rich drinks (F2). Similarly, self-efficacy were separated into food-specific self-efficacy (F6) and family-specific self-efficacy (F7). Questions Q5, Q8, and Q18 were discarded from further analysis (Table A1). The final model consisted of seven constructs (factors) derived from 22 questions, supplemented by 10 single-item questions. The fitted CFA showed a TLI at 0.877 and RMSEA at 0.041, and final latent constructs with a range of Cronbach's α at 0.67 for perceived barriers (F5) to 0.92 for desire for change in sugar-rich drinks (F2) (Supplementary Table A2). Further analyses and results are based on summary scores for items within these constructs.

2.7. Statistical analysis – Mediation analysis

A complete-case mediation analysis was conducted to elucidate the

behaviour change pathways within the intervention that may have influenced the reduction of added sugar intake. The pathway of interest in the current study is illustrated in Fig. 1. The direct effect of the intervention on the outcome (child intake of added sugar) is described by τ . The effect of the intervention on a potential mediator (parental responses in the questionnaire) is represented by α , and the effect of the mediator on the outcome is denoted by β . The indirect effect through a potential mediator label is labeled as $\alpha\beta$.

The direct effects on child intake of added sugar, path τ , can be described as the intervention effect on child intake of added sugar adjusted for potential mediators. The total effect has been reported previously (Bestle et al., 2024). The direct effect, path τ , is shown in Fig. 1 to illustrate hypothetical pathways but will not be reported.

The analysis follows a stepwise process, where both paths α , β , and $\alpha\beta$, are of interest in the current study. First, linear mixed models were used to investigate associations between questionnaire responses and child intake of added sugar adjusted for intervention (group and time), an association which we label β . The same statistical analyses were performed with discretionary food and drinks summarised and drinks alone as outcome variables. Secondly, linear mixed models were used to investigate the intervention effects on questionnaire responses: parental determinants (path α). An intervention effect was reported when there was a significant interaction effect of time and group.

Finally, mediation analyses, path $\alpha\beta$, were performed using the R package, mediation (Tofighi & MacKinnon, 2011). Mixed linear models were used as input models, including interaction terms between time, group, and mediator, describing that the mediator could moderate the intervention effect on added sugar and sugar-rich discretionary foods and drinks. Mediation analysis with the summarised group of sugar-rich discretionary foods and drinks is presented as a supplementary analysis.

All models were adjusted for parental educational level, child sex, child BMI as fixed effects, and participant as random effects. Results of the mediation analysis were presented as the indirect effect of the intervention through the mediator, together with the proportion mediated in %. All data processing and statistical analysis were performed using R version 4.2.2. A p-value < 0.05 was considered statistically significant.

3. Results

3.1. Participants

Summary characteristics of participating parents and children at baseline are presented in Table 1. There were no significant differences

Table 1

Summary characteristics at baseline of parents who responded to the questionnaire, household of the child, and participating children.

	Intervention group (n = 92)	Control group (n = 57)
Parent (responder)		
Sex; females, %	79 %	79 %
Education; >14 y, %*	51 % ^a	74 % ^b
Ethnicity (maternal); Danish, %	92 %	93 %
Child		
Age; mean (SD)	6.4 (0.3)	6.4 (0.3)
Sex; females, %	53 %	47 %
Weight status, IOTF; overweight or obese, %	15 %	9 %
Baseline intake of added sugar in E %, mean (sd)**	8.1 (4.3)	8.5 (3.5)
Baseline intake of discretionary energy kJ/d, median (IQR)**	930 (602; 1347)	1101 (702; 1357)
Baseline intake of total energy kJ/d, mean (sd)	5868 (1312)	5863 (1128)
Household		
Number of siblings; ≥ 1 , %	88 %	91 %
Family Type; parents living together, %	85 %	91 %

IOTF: International Obesity Taskforce (cut-offs). * Significantly different between groups by Student's T-test. ** Dietary data from 87 and 54 respectively.

in characteristics between the two groups, except for educational level, where a higher proportion of parents in the control group had a bachelor's degree or higher than the intervention group ($p < 0.05$). Most responding parents were female across the sample. At baseline, children's mean intakes of added sugar was 8.1 E% in the intervention group and 8.5 E% in the control groups, as a percentage of their daily energy consumption. Across the sample, about one third of the participating children had an estimated added sugar intake above 10 E%. For added sugar intake above 5 E%, this was applied to 75 % and 84 % in the intervention and control groups, respectively. Across the entire sample, 79 % of added sugar intake came from discretionary foods and drinks.

3.2. Associations between added sugar intake and parental responses as proposed mediator: β

Children's added sugar intake was positively associated with the proposed mediators: Desire for change in sugar-rich foods (F1, $p = 0.001$) and in sugar-rich drinks (F2, $p < 0.001$), and perceived barriers (F5, $p = 0.007$) (Table 2). These constructs were also associated with

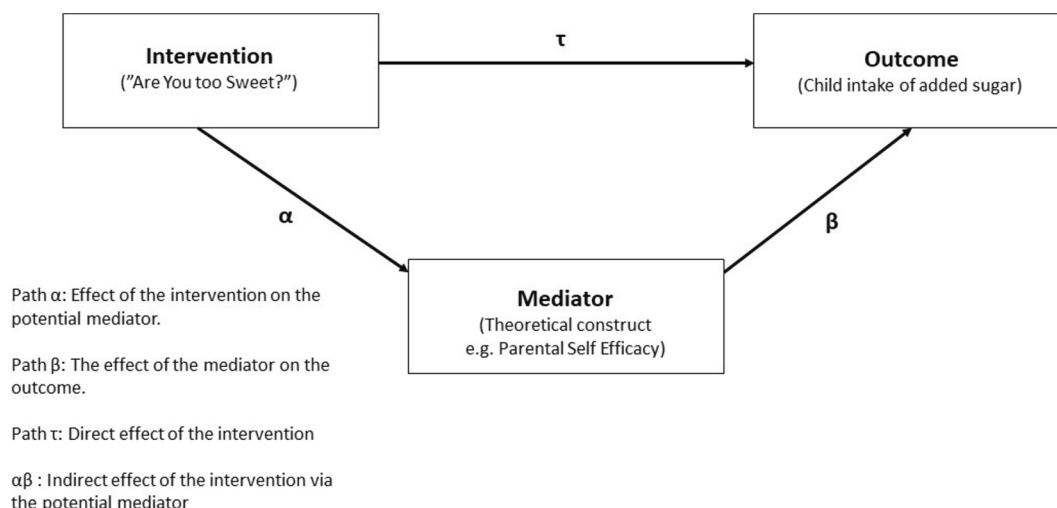


Fig. 1. Potential pathway of the effect of the intervention on child intake of added sugar through the potential mediator of parental response.

Table 2

Change in proposed mediator (parental response) after intervention period compared to control group (α); Associations between proposed mediator and added sugar intake adjusted for the intervention (β); mediation analysis showing the indirect effect of the intervention compared to the control group on child intake of added sugar, through the proposed mediator ($\alpha\beta$).

Variable	Association of mediator on outcome β			Changes in responses α			Indirect effects of intervention through mediator $\alpha\beta$					
	Coefficient	95 % CI	P	Coefficient	95 % CI	P	Coefficient	95 % CI	P	Prop. med. (%)	95 % CI	
<i>Expectations</i>												
F1 Desire for change in sugar-rich foods	0.43	0.17;0.69	0.001	-0.22	-0.73;0.29	0.394	0.03	-0.11;0.16	0.680			
F2 Desire for change in sugar-rich drinks	0.43	0.2;0.65	< 0.001	-0.21	-0.89;0.46	0.530	-0.06	-0.23;0.09	0.424			
<i>Knowledge</i>												
Q6: [...] recommended for a 4-6 [...]	0.55	-0.31;1.41	0.213	1.18	0.05;2.37	0.045	0.04	-0.14;0.25	0.659			
Q7: [...] recommended for a 7-9 [...]	-0.08	-0.92;0.77	0.860	1.14	0.01;2.36	0.054	-0.03	-0.24;0.18	0.790			
<i>Norms and attitudes</i>												
F3 For special occasions	-0.18	-0.3;-0.05	0.005	1.50	0.38;2.62	0.009	-0.19	-0.38;-0.03	0.012	14.5	2.4;39.2	
<i>Social and structural impediments</i>												
F4 Social support	-0.4	-0.71;-0.09	0.012	-0.06	-0.49;0.37	0.779	-0.07	-0.21;0.03	0.19			
F5 Perceived barriers	0.27	0.07;0.46	0.007	-0.20	-0.87;0.46	0.546	-0.06	-0.2;0.03	0.24			
<i>Self-efficacy</i>												
F6 Food specific self-efficacy	-0.12	-0.26;0.01	0.065	-0.31	-1.39;0.77	0.574	-0.02	-0.14;0.07	0.63			
F7 Family specific self-efficacy	-0.11	-0.22;-0.01	0.034	-1.16	-2.56;0.25	0.106	-0.05	-0.19;0.05	0.37			
<i>Parental practice</i>												
Q28: I limit the availability [...]	-0.5	-0.94;-0.06	0.027	0.20	-0.1;0.49	0.186	-0.03	-0.14;0.07	0.555			
Q29: I give [...] feel better [...]	0.39	-0.11;0.88	0.129	-0.20	-0.49;0.08	0.159	-0.04	-0.15;0.05	0.409			
Q30: I consciously refrain [...]	-0.1	-0.51;0.31	0.628	0.16	-0.19;0.52	0.367	0.02	-0.06;0.11	0.718			
Q31: [...] sweet treats to reward [...]	0.06	-0.37;0.5	0.78	-0.03	-0.38;0.32	0.861	0	-0.05;0.08	0.926			
Q32: [...] easy access to healthy foods	-0.28	-0.88;0.31	0.348	-0.03	-0.28;0.22	0.81	-0.02	-0.12;0.07	0.687			
Q33: I teach [...] about food	-0.11	-0.7;0.48	0.712	-0.10	-0.38;0.18	0.474	0	-0.08;0.09	0.972			
Q34: I involve [...] in food-related activities	-0.2	-0.77;0.36	0.476	-0.04	-0.31;0.24	0.796	-0.07	-0.24;0.08	0.362			
Q35: I monitor [...]	-0.33	-0.89;0.24	0.262	-0.13	-0.42;0.16	0.373	0.04	-0.1;0.2	0.501			

95% CI: 95% confidence interval. Prop. med.: Proportion mediated.

child intake of sugar-rich discretionary foods and drinks (Supplementary Table A3). Further, added sugar intake was observed to be negatively associated with the constructs for special occasions, social support, and family-specific self-efficacy (F3 ($p = 0.005$), F4 ($p = 0.012$), and F7 ($p = 0.034$), Table 2). The Impacts of F5-F6 on either analysis were not supported by the data. Limiting the availability of sweet treats and drinks (Q28) was associated with lower child intake of added sugar ($p = 0.027$), but the remaining questions relating to parental practices were not (Q29-35). No association was observed between knowledge of the new guidelines (Q6 and Q7, Table 2) and children's added sugar intake.

3.3. Intervention effects on proposed mediator: α

After the intervention, the knowledge about guidelines (Q6 and Q7, $p = 0.045$ and 0.054 , respectively) increased compared to the control group, although borderline significant. Further, within norms and attitudes, parental agreement about sugar-rich discretionary foods and drinks to be limited to special occasions, increased compared to the control group (F3, $p = 0.009$, Table 2). No other parental responses changed significantly compared to the control group after the intervention.

3.4. Mediation analysis: $\alpha\beta$

In the mediation analysis, a significant indirect effect of the intervention on a lower added sugar intake was found, mediated by a change in the perception of sugar-rich discretionary foods as being reserved for

special occasions (F3, $p = 0.012$, Table 2). However, no significant mediating effects were observed for parental knowledge, parental practices, self-efficacy, or social support. Additionally, no mediating effects from any proposed mediators were found for the combined group of sugar-rich discretionary foods and drinks (Supplementary Table A3).

4. Discussion

This study explored questionnaire data from the "Are You Too Sweet?" intervention to investigate potential parental determinants as mediators for changes in children's added sugar consumption. A significant shift in parental norms and attitudes was observed due to the intervention; parents in the intervention group increased agreement of limiting sugar-rich discretionary foods and drinks for special occasions (F3), which was also shown to mediate part of an intervention effect with regards to reducing child intake of added sugar.

While the intervention group demonstrated a borderline increase in knowledge of the new guidelines for sugar-rich discretionary foods and drinks (F1 and F2), this did not appear to mediate the intervention effect on the children's added sugar intake. The qualitative evaluation of the intervention revealed that several parents found the registration and use of the sugar-rich food screener (a component of the intervention) to be an eye-opener. Moreover, they were surprised to find the guidelines more restrictive than expected, which may have increased awareness of the need to reduce sugar-rich discretionary foods and drinks (Christensen et al., 2022a,b). Several parents reported that they made changes regarding what they described as everyday treats without

necessarily adhering to the guidelines in a strict manner (Christensen et al., 2022a,b). The guidelines might have indirectly impacted norms and attitudes by fostering a parental understanding of the value of limiting sugar-rich discretionary foods and drinks to special occasions (Christensen et al., 2022a).

To our knowledge, only a few intervention studies have examined parental mediators of children's dietary behaviors (Cerin et al., 2009; Lambrinou et al., 2019; Lehto et al., 2022; Wyse et al., 2015). In contrast to our study, a Finnish study with children aged 3–6 years found that parental norms – defined as the parents' normative view on a suitable amount of fruits and vegetables – mediated the intervention's effect of increased consumption of these foods, but not on "sugary everyday foods", "sugary treats", or sugar-sweetened beverage consumption (Lehto et al., 2022). However, the study supports the conclusions that normative views can act as mediators.

The ToyBox intervention study, a large-scale European study among pre-schoolers by Lambrinou et al., found that children's attitudes towards fruits and vegetables mediated the intervention's effect on fruit, vegetable, and snack consumption. Parental rule-setting – such as limiting snacking to certain occasions – also mediated a reduction in unhealthy snack intake (Lambrinou et al., 2019). This rule-setting practice aligns with our findings, where limiting unhealthy snacking to special occasions played a similar role. Additionally, parental knowledge of snacking recommendations mediated some of the intervention's effect in their study (Lambrinou et al., 2019). In contrast, a recent Norwegian intervention study with the aim of promoting a higher fruit and vegetable consumption among adolescents, could not find explanation by targeted determinants of an increased fruit and vegetable consumption through mediation analysis (Daas et al., 2024). Similarly, the mediation analysis in our study only partially explained the intervention's effects. This underscores the complexity of behaviour change pathways, and that measuring a wide range of potential determinants might be essential to clarify mechanisms of behaviour change in interventions.

A Danish qualitative study found that sugar-rich foods functioned as markers of special social occasions in children with a healthier eating pattern, in contrast to children with a less healthy eating pattern who consumed these foods more regularly and perceived them as everyday treats (Husby et al., 2009). As an example of describing norms and attitudes, qualitative studies have found that parents' and children's opinions regarding the role of sugar-rich foods and drinks can be categorised depending on the situation (Adams & Savage, 2017; Christensen et al., 2022a,b; McCafferty et al., 2019).

Evidence from previous research supports the idea that normative beliefs are an essential factor in shaping children's dietary behaviors, and it is worth further investigating e.g. how and to what extent these normative beliefs can be modified through interventions. However, the complexity of behavior change underscores the need for a comprehensive approach considering a wide range of potential determinants.

We did not find associations between the parental practices of using unhealthy food as comfort or reward, modelling, involvement, or teaching (Q29-Q35) and children's intake of added sugar in our study. In contrast, several other studies have highlighted instrumental and emotional feeding, such as rewarding or comforting with food, as undesired parenting practices (Davison et al., 2015; Gevers et al., 2015; Sleddens et al., 2010; Ventura & Birch, 2008). A review and meta-analysis by Yee et al. (2017), which examined 88 studies on this topic, found that parental use of food as a reward was associated with unhealthy food consumption in six out of nine studies. Additionally, parental role modelling was associated with children's dietary behaviours in most studies (Yee et al., 2017). Interestingly, our findings might suggest that these practices are less relevant within the population sample of our study. While the absence of associations could be due to limited sensitivity in the questionnaire, it is also possible that norms and attitudes, which frame parental practices and behaviors, play a more significant role in determining children's intake of added sugar in this

context.

Despite the strengths of using mediation analysis to evaluate interventions, this study faced several limitations. Notably, only a small part of the effect was influenced by this construct. This could be due to a lack of sensitivity in the questionnaire or to mechanisms not measured in the study. A limitation of our study is the degree of validity of the questionnaire. A pre-validation, including a test–retest of the entire questionnaire, might have strengthened the methodology. Furthermore, it is a limitation that responses, especially for self-efficacy measures, showed ceiling effects, which might raise questions about whether the variance of true self-efficacy in the sample population was captured. A floor/ceiling effect below 15 % has been defined as optimal (McHorney & Tarlov, 1995). On the other hand, the responses might reflect a truly high self-efficacy in the sample. Moreover, single-item responses should be interpreted with particular care, as the validation process of those in this study focused solely on face validity during questionnaire testing.

Another limitation of the questionnaire is that, as it might contain normative elements, responses are susceptible to social desirability bias. Additionally, criterion validity, ensuring that latent constructs held the same meaning across different sub-groups in the sample, could have been addressed by conducting an invariance test of the questionnaire. Non-invariance between parents with different educational levels, between mothers or fathers, or parents from different ethnic groups might have biased the interpretation of results (Guenole & Brown, 2014). However, the subgroups in the sample were too small to conduct a valid invariance test. The lack of an invariance analysis might be mitigated in this study, as the change from the intervention was of interest, and the mediation analysis was controlled for parental education level. It is important to underscore that potential non-invariance might bias the interpretation and generalizability of the mediating effect of the construct. Only few validation studies on parental feeding practices report invariance analysis (Morris et al., 2023).

Although face validity was tested before the study, some parents might still have difficulty answering certain questions, and responses might be relative depending on cultural norms. For example, the perception of what it means to limit availability might differ across families. However, while recognising that the interpretation of questionnaire data should be done carefully and considering the validity, a strength of this study is that validation by CFA analysis showed overall acceptable results while also allowing a more explorative approach to emphasise new dimensions of parental behaviour related to normative beliefs. Nonetheless, the acceptability rate of the RMSEA and TLI in the questionnaire validation remains debatable, and a higher TLI would have been desirable. Using explorative factor analysis with a larger sample size could have strengthened the validation and revealed aspects related to potential mediators. A theoretical gap in measuring potential mediators is also a limitation of our study. First, the construct *expectations* was interpreted as motivation for change in our study, though some parents may have lacked information about the health consequences for their children. Secondly, measuring the construct of *knowledge* might also need clarity, as it only encompasses the maximum number of servings recommended. Although the knowledge of the guidelines increased, this might not represent the decisive dimension. A more comprehensive analysis of the complex interactions of dimensions, such as expectations, motivation, and knowledge related to awareness of child intake of sugar-rich foods and drinks, might have contributed to a better understanding of behaviour change pathways. Multiple mediation analysis and structural equation modelling have previously been used in more complex analyses of behaviour change pathways (Gray et al., 2016), although with larger sample sizes than those used in this study.

Using dietary registration might have affected parents' awareness of their children's consumption. Potentially the data from the dietary registration may be impacted by social desirability bias, and perhaps by more or less conscious changed habits the week of dietary registration. This raises the possibility of overestimation the impact of the

intervention.

Another limitation to the study was that only six schools were included, and only two schools in the control group, leading to a potential risk of baseline imbalances and confounding. Therefore, the analyses were adjusted for several potential confounders, while residual confounding might still bias of the results. However, at baseline, significant imbalances were only found for parental educational level. A risk of social desirability bias is also present in the dietary record, both at baseline, but perhaps even more at follow-up, where intervention families had been presented with recommendations.

Finally, added sugar was employed as a nutrient proxy to represent sugar-rich discretionary food and drinks in the present study. This approach strengthened the analysis, ensuring greater accuracy and reliability of the results. However, as analysis with discretionary foods and drinks as an outcome for the mediating analysis could not confirm these results, interpretation should be made with caution, and more studies are needed to support the findings. Moreover, research on how discretionary servings are understood among families compared to communicating added sugar might help to shape best practices. If families attempted to replace unhealthy snacks with healthier options or changing recipes, it might not have been observed in the intervention. Further, the communication of 'sweet' might have impacted sugar use to larger extend than it impacted other discretionary choices. Finding the most effective communication strategies for reducing energy-dense foods and drinks, as well as added sugar, is a relevant issue for future studies.

A strength of this study is that we have combined data from a questionnaire and food dietary records to explore the underlying mechanisms of influence of the intervention in more depth. Mediation analysis can evaluate theoretical approaches and determine effective strategies in health-promoting behaviour change interventions by suggesting causal pathways. Identifying potentially modifiable behaviours is vital for developing effective health-promoting strategies. By focusing on behaviours that can be changed, interventions can be designed to be more cost-effective (Scaglioni et al., 2018). The theoretical approach and the wide range of investigated mediators contribute to identifying causal pathways influencing children's added sugar intake. The construct validation in the present study suggests that parents' normative beliefs, as occasions for allowing children discretionary foods and drinks, which were inspired by qualitative studies, can be used in a questionnaire (Christensen et al., 2022a,b; Husby, Heitmann, & O'Doherty Jensen, 2009). However, more uniform and validated measures of potential mediators are needed to compare the findings across studies, a need that has been stressed (Bekelman et al., 2017).

5. Conclusion

In conclusion, this study delved into the relationship between children's added sugar intake and parental determinants within the framework of the "Are You Too Sweet?" intervention. Notably, a significant shift in parental norms and attitudes was observed post-intervention regarding the limitation of sugar-rich discretionary foods and drinks for special occasions, which in turn partially mediated the intervention's effect on reducing child intake of added sugar. This study could not detect the effects of the intervention on parent-reported self-efficacy nor identify self-efficacy as a mediator. Specific changes in knowledge or practices alone could also not be proven to mediate these behaviour changes. Future studies need more uniform and validated measures of potential mediators, including considerations of more complex interaction pathways.

While shedding light on various parental determinants for children's dietary behaviours, this study highlight that normative dimensions are worth exploring. Given the potential of normative beliefs to act as powerful mediators, future interventions should focus on exploring how these beliefs can be more effectively modified. This may involve not only addressing parental norms but also incorporating a broader range of

influences, such as social and environmental factors. For instance, communicating and visualising a more appropriate number of servings may change parents' normative understanding of when sugar-rich foods and drinks should be provided. Furthermore, understanding how long-term changes in norms can be sustained beyond the intervention period will be crucial for designing more effective public health strategies aimed at reducing children's added sugar intake. Although more rigorous methodology and deeper theoretical insights are needed to confirm measures of norms and attitudes, these findings can hopefully inspire new important targets for health promotion strategies or policy implementation.

6. Ethics approval and consent to participate

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved by The Ethics Committee for the Capital Region, Denmark (journal-no.: H-20036402). Written informed consent was obtained from all subjects.

Author contributions:

Conceptualisation of intervention design and materials, A.P.B.-J., J. M., E.T., S.M.S.B., A.D.L., and B.J.C., Development and field test of questionnaire: S.M.S.B., Data collection: S.M.S.B, B.J.C. Data preparation and statistical analysis, S.M.S.B. Statistical support; A.S., Original draft preparation; S.M.S.B.; Review and editing, E.T, A.D.L., B.J.C., A.P. B.-J., J.M and A.S.; funding acquisition, A.P.B.-J. All authors have read and agreed to the published version of the manuscript.

CRedit authorship contribution statement

Sidse Marie Sidenius Bestle: Writing – original draft, Investigation, Formal analysis, Conceptualization. **Ellen Trolle:** Writing – review & editing, Supervision. **Anja Pia Bilot-Jensen:** Writing – review & editing, Resources, Project administration, Funding acquisition, Conceptualization. **Bodil Just Christensen:** Writing – review & editing, Investigation. **Jeppe Matthiessen:** Writing – review & editing. **Anders Stockmarr:** Supervision. **Anne Dahl Lassen:** Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Anja Pia Bilot-Jensen reports financial support was provided by Nordea-fonden. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper..

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.foodqual.2024.105353>.

Data availability

Data will be made available on request.

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