

# Blueprint for halving obesity: rapid review

Calorie reformulation as an intervention for reducing obesity



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## Summary table

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<b>Title</b>	<a href="#">Calorie reformulation: a systematic review and meta-analysis examining the effect of manipulating food energy density on daily energy intake</a>
<b>Author and year</b>	Robinson et al. (2022)
<b>Type of study</b>	Systematic review and meta-analysis
<b>Outcome variable</b>	Reduction in energy take
<b>Treatment</b>	Low energy density foods in some of the meals
<b>Control</b>	Regular energy density foods across meals
<b>Magnitude of effect (Adults and children)</b>	-208.17kcal
<b>Magnitude of effect (Children)</b>	~ 225 to 338kcal [SMD = -0.713, 95%]*
<b>Compensation effects</b>	35kcal
<b>Effect after accounting for compensatory behaviour</b>	Adults = -160.29kcal Children = -173.25 to -260.26kcal

\*Calculated using SMD – kcal conversion charts in [Hollands et al. \(2015\)](#)

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# Rapid umbrella review

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## Background

According to [Hashem et al. \(2019\)](#), product reformulation are efforts to lower the 'unhealthy' components (eg, saturated fat, trans fats, sugar, salt) of products at the time of production without worsening the profile of other ingredients (eg, increasing calorie content). It is expected that the reformulated product would replace the existing product so that it doesn't rely on major behavioural changes by the consumers. In some cases, reformulation programmes such as the salt reduction programme and the soft drinks industry levy have been found to be successful.

## Objective

To summarise the best available evidence on the impact of calorie reformulation on energy intake or body weight or purchasing or consumption behaviour.

## Methods

We aimed to identify reviews that included quantitative research synthesis (ie, meta-analysis) of the effectiveness of reformulations on outcomes relevant to calorie consumption, energy intake, weight loss or obesity. If more than one review was identified that answered our research question, we aimed to identify the review that was reflective of the best evidence, based on (a) year published and (b) quality of review (judged by JBI checklist).

## Eligibility criteria

*Types of review.* To be eligible for inclusion, articles were required to use systematic review methodology (ie, use of systematic search and inclusion strategy to identify all available studies) with randomised control trials and include quantitative data synthesis (ie, meta-analysis) of multiple studies that examined the effect of portion size reduction on outcomes relevant to calorie consumption, energy intake, weight loss or obesity.

If the search did not identify any studies where a meta-analysis had been conducted, we intended to include reviews with narrative syntheses. We did not set inclusion criteria on the number or type of databases searched.

We selected a single review that best represented our research question. If more than one review was identified, we assessed the quality and selected the one with the highest rating (taking into account year of publication).

*Participants.* To be eligible for inclusion, articles could examine the effect of product reformulation on adults or children. We aimed to report the findings for children and adults in this report.

*Intervention.* Reviews were required to synthesise interventions that manipulated calorie content of food products consumed by an individual.

*Comparator.* The comparators were individuals who were exposed to a non-reformulated food product.

*Outcomes.* To be eligible for inclusion, reviews needed to include either clinical (eg, weight, BMI, % fat change) or behavioural outcomes (including, but not limited to: eating behaviour, food diaries). Reviews that only included measures of intentions/plans for future behaviour were excluded due to evidence of the gap between intended and actual eating behaviour.

## Information sources and article selection

The search strategy was designed to identify syntheses of research evidence such as systematic reviews between the year 2010 and the date of search. Initial keywords were identified via a scoping review of relevant papers and reports as well as via MEDLINE using the MeSH function. A search was performed in MEDLINE and the Cochrane Database of Systematic Reviews (see [appendix 1](#) for search strategy). We searched grey literature using Google Scholar and Google to identify relevant reports. The search was run in April 2023.

## Screening

Due to the rapid nature of the reviews, a single reviewer screened titles and abstracts and discussed any uncertainty with a second reviewer. For relevant

titles/abstracts, the full text was retrieved for full text review. One reviewer reviewed the full texts and discussed uncertainties with a second reviewer.

#### Assessment of methodological quality

All relevant reviews were critically appraised by two reviewers individually using the JBI Critical Appraisal Checklist for Systematic Reviews and Research Syntheses ([appendix 2](#)). We selected the highest quality and up-to-date review for data extraction. Suitability to our research question was also taken into account when selecting the final review for extraction.

#### Data extraction

The JBI Data Extraction Form for Review for Systematic Reviews and Research Syntheses was used for data extraction for the final included review. Extracted characteristics included:

- Review characteristics: author/year, objectives, participants (characteristics, total number), setting/context, interventions of interest, date range of included studies, detailed description of the included studies (number/type/country of origin), appraisal instrument and rating, type of review/method of analyses and outcomes.
- Results: findings of the review and comments.

## Results

[Robinson et al. \(2022\)](#) conducted a systematic review and meta-analysis of studies that have examined the impact of reducing energy density of served food on daily energy intake. In addition, the review also aimed to understand moderators of the effect that altering energy density has on energy intake and its effects on body weight.

#### What studies did the review include?

The review included articles if they reported human participant studies that:

- Used a within-subjects/repeated measures design or a between-subjects design. Some studies required participants to consume a meal/food in full (eg, consumption of a set amount of energy density manipulated food) and these designs were eligible. Studies that 'crossed' energy density manipulations with another experimental factor (eg, manipulation of both energy density of food and portion sizes in the same study) were eligible. For studies that did not manipulate energy density of all meals/foods, studies were required to measure and report energy intake at that meal(s) that energy density was manipulated for in order to be eligible.
- Manipulated the energy density of food products or meals served to participants. Studies were included that manipulated the energy density of a minimum of one food/meal, and studies that manipulated energy density of up to all foods/meals served across the day were eligible. However, if energy density of only beverages were altered, then they were not eligible.
- Measured energy intake for a minimum of one day. The measurements were expected to be objective. The studies could be set in real-world or laboratory settings.

The risk of bias was assessed as low for the studies included.

## What were the systematic review methods?

The authors searched electronic databases such as PsycINFO, PubMed and Scopus (from date of inception) during September to October 2020. The reference lists of all eligible papers were searched and the authors also contacted the authors of the studies to enquire about other studies to be included. In addition, grey literature was searched in the OSF and NutriXiv databases. Article eligibility for inclusion was independently carried out by two authors. In addition, another author was engaged in snowballing and grey literature searches. Discrepancies were discussed and resolved with a third author. The first searches were run in September to October 2020 and a second search was run in October 2021 to include more recently published literature.

## What did the review find?

This is a non-exhaustive summary of the review findings. Please see the [original article](#) for more detail missing here. Sixty-nine studies were included in this review covering portion size manipulations on food products.

A meta-analysis of 31 eligible studies were included in the review and meta-analysis. Studies were mainly from the US, Europe and Singapore. The multi-level analysis of 90 effect sizes from 31 studies was found to have a large effect of energy density on daily energy intake (SMD = -1.002, 95% CI: -0.745 to -1.266). Sensitivity analysis also found the results to be statistically significant. Further, subgroup analyses for adults (57 effects) found statistically significant effect size (SMD = -0.892, 95% CI: -1.039 to -0.746). Similar analyses for children (five effects) found statistically significant effects (SMD = -0.713, 95% CI: -0.521 to -0.905).

Subgroup analyses of studies manipulating energy density of all foods/meals found a large statistically significant effect on daily energy intake (-855.85kcal, 95% CI: -616.18 to -1095.52). This was mainly due to some large outliers. Analysis after removing the outliers found that the effect reduced slightly (-709.01kcal, 95% CI: -602.04 to -815.97), however with narrower upper and lower limits of the confidence interval. The kcals indicated is the difference in total energy intake between participants on high energy density meals versus those on low energy density meals.

Further, subgroup analyses limited to studies not manipulating energy density of all foods/meals (but of some) found a large statistically significant difference between high and low energy density at -237.84kcal, 95% CI: -148.13 to -327.54. On removing outliers, the effect was still large at -208.17, 95% CI: -160.00 to -256.37. These studies further suggested that for every 100 fewer kcals of food served to participants (due to reduced energy density), daily energy intake was reduced by approximately 77kcals, accounting for any compensatory effects, through ad-libitum energy intake.

Across five studies, weight loss was found to be greater in lower compared to higher energy dense foods, however, this difference in weight was not statistically significant (-0.69kg, 95% CI: -1.43 to 0.04).

The limitation of the review is that the included studies were short duration (one to 14 days). The review also found that the effect of energy density was smaller in longer studies but this observation was not statistically significant.



Table 1: Characteristics of Robinson et al. (2022) meta-analysis

Total number of studies	Total sample size	Country (number of studies)	Age range	Intervention and comparison	Magnitude of effect in SD (95% CI)	Magnitude of effect in terms of calorie intake (per person/per day)	Quality of evidence (GRADE) <sup>1</sup>
31	1,086	US, Europe, Singapore	Adults and children	Intervention: low energy density foods in one or more of the meals Comparison: high/regular energy density foods across all meals	SMD = -1.002, 95% CI: -0.745 to -1.266	Not reported	Not reported
57 effects	n/a	US, Europe, Singapore	Adults	Intervention: low energy density foods in one or more of the meals Comparison: high/regular energy density foods across all meals	SMD = -0.892, 95% CI: -1.039 to -0.746	Not reported	Not reported

<sup>1</sup> \*GRADE = Grading of Recommendations, Assessment, Development and Evaluations

5 effects	n/a	US, Europe, Singapore	Children	Intervention: low energy density foods in one or more of the meals Comparison: high/regular energy density foods across all meals	(SMD = -0.713, 95% CI: -0.521 to -0.905	Not reported	Not reported
16	n/a	US, Europe, Singapore	Adults and children	Intervention: low energy density foods in all the meals Comparison: regular/high energy density foods in all the meals	Not reported	Difference in energy intake: -855.85kcal, 95% CI: -616.18 to -1095.52 Difference in energy intake (w/o outliers): -709.01kcal, 95% CI: -602.04 to -815.97	Not reported
37	n/a	US, Europe, Singapore	Adults and children	Intervention: low energy density foods in some of the meals Comparison: regular/high energy density foods across meals	Not reported	Difference in energy intake: -237.84kcal, 95% CI: -148.13 to -327.54 Difference in energy intake (w/o outliers): -208.17kcal, 95% CI: -160.00 to -256.37	Not reported

## Appendices

### Appendix 1: Search strategy

What is the effect of positioning or placement interventions (of food products) on 'purchasing behaviour' or 'eating behaviour' or 'energy intake' or 'weight loss' among adults and children?

No.	Concept	PubMed search terms
1	Reformulation	"Food reformulation"[tiab] OR "Reformulation"[tiab] OR "Food, Formulated"[Mesh]
2	Weight loss and obesity	"Weight Loss"[Mesh] OR "Obesity"[Mesh] OR "obesity"[tiab] OR "overweight"[tiab] OR "over-weight"[tiab]
3	Calorie	"Energy Intake"[Mesh] OR "Calorie consumption" [tiab] OR "Calories consumed" [tiab] OR Calories [tiab] OR "Calorie intake" [tiab] OR "Caloric intake" [tiab] OR "Energy" [tiab] OR "Energy Intake" [tiab]
4	Eating behaviour	"Food consumed" [tiab] OR "Feeding Behavior"[Mesh] OR "Feeding Behavior*" [tiab] OR "Eating rate"[tiab] OR "Dietary intake" [tiab] OR "Diet"[Mesh] OR "Food preferences"[Mesh] OR "Consumer Behavior"[Mesh] OR "eating behaviour" [tiab] OR "consumption" [tiab]
5	Purchasing behaviour	"Purchas*" [tiab] OR "Purchasing behavior*" [tiab] OR "buying" [tiab]
6	Systematic review	"systematic review" [tiab] OR "systematic*" [tiab] OR "meta-analys*" [tiab] OR "narrative synthes*" [tiab]
7	Full search	(#1) AND (#2 OR #3 OR #4 OR #5) AND #6

## Appendix 2: JBI Data Extraction Form for Review for Systematic Reviews and Research Syntheses

Study details
Author/year
Objectives
Participants (characteristics/total number)
Setting/context
Description of interventions/phenomena of interest
Search details
Sources searched
Range (years) of included studies
Number of studies included <i>I</i>
Types of studies included
Country of origin of included studies
Appraisal
Appraisal instruments used
Appraisal rating
Analysis
Method of analysis
Outcome assessed
Results/findings
Significance/direction
Heterogeneity
Comments