Author’s response to reviews

Title: The negative impact of sugar-sweetened beverages on children's health: An update of the literature

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Author’s response to reviews:

Reviewer #1

This is a well written manuscript about an important topic. I have two concerns to be addressed before I believe that this paper is ready for publication.

1. This paper reports on updating the literature on SSB since a last review done in 2007. There is insufficient commentary on how the research findings have evolved since 2007. Are studies more sophisticated? Has the evidence regarding SSB and health been strengthened in the past decade?

We agree that our review did not have sufficient commentary on how research findings have evolved since 2007. To address this, we first restructured the introduction section to provide more background information on previous findings about the relationship between SSB consumption and health outcomes. We now state (pages 3 to 4):

“In light of the frequent consumption of SSBs among children and adolescents in the U.S., there has been an interest in critically examining associated health consequences. As a result, there has been a substantial rise in the number of studies investigating the health effects of SSBs over the past decade. Evidence has emerged linking SSB consumption to a number of health consequences among adults including weight gain [4, 5], cardiovascular risk factors (e.g., dyslipidemia) [6], insulin resistance and type 2 diabetes [7, 8] and non-alcoholic fatty liver disease [9]. Studies among children are more limited and have generally focused on weight gain [4] and dental caries [10], as well as insulin resistance to a lesser extent [11, 12]. An emerging body of research has also examined the association between caffeinated SSBs (e.g., energy drinks or colas) and caffeine-related health consequences including reduced sleep quality and headaches [13]. Given the growing number of studies assessing SSB-related health consequences, concise summaries of the evidence base are needed in order to inform policy and advocacy efforts focused on reducing SSB consumption.”
Next, we have added a section following the results titled “Summary of Evidence” in order to summarize the current evidence from our review and put it in the context of previous findings. We now state (page 12):

“Since the most recent relevant review was published on this topic in 2009, there has been a substantial increase in research examining the health consequences of SSB consumption among children and adolescents. For example, 227 studies indexed in PubMed were published on SSBs in 2017 compared to 16 studies published in 2007. Many more studies are now conducted exclusively on children and adolescents, while previous evidence was based on results found among adults. While the majority of this research is still cross-sectional (limiting the ability to make inferences about causality), the past decade has seen a growing number of longitudinal studies being implemented, as well as a smaller amount of intervention trials.”

2. The second issue is that there is not enough direction given to where the field needs to go. The authors mention a need to understand the mechanisms for how SSB affect health. Do you mean physiologically, behaviorally? What types of studies need to be done to clarify null or mixed results?

While our review did address future research needs, we agree with the reviewer that further clarity is needed to indicate direction on where the field needs to go. We have reworded this section to better articulate the major deficits in the current literature and what improvements can be made: We now state (pages 14 to 15):

“While there is a large and growing body of research examining the impact of SSBs on children’s health, important gaps remain. First, researchers should utilize more rigorous study designs (intervention trials, but also longitudinal studies) and move away from a reliance on cross-sectional studies. This will strengthen the evidence base and allow firmer conclusions to be made regarding the causal relationships between SSB consumption and negative health effects. Second, more consistency is needed in the definition of SSBs (specifying which beverages are included and what is a typical serving size) and measurement strategy (e.g., FFQ vs. 24-hour recall). Similarly, more uniformity is needed in assessing outcomes, particularly in the risk of overweight/obesity where studies vary considerably in the outcomes measured (e.g., BMI, BMI z-score, BMI percentile, overweight/obese status). Third, researchers should examine differences in health risks by subpopulations (e.g., race/ethnicity, socioeconomic status, age and gender) to determine if the intake of SSBs in particularly harmful in certain population subsets. While it is established the low-income and racial and ethnic minorities consume more SSBs, it is unclear the extent to which health consequences are magnified among these groups. This is important particularly for targeting interventions and policy approaches to reduce children’s SSB consumption. Better insights in these areas have the potential to inform real-world policies and recommendations that may greatly benefit children’s health. Finally, additional research is needed about a broader variety of caffeinated SSBs and their impact on children’s health. Energy and sport drink consumption is rising rapidly in the U.S. [13] and so studies examining the negative health effects of caffeinated SSB consumption are needed to inform future efforts to reduce consumption.”
Reviewer #2

This paper concerns an interesting topic, and is generally well-written. My comments are:

1. Page 3, lines 10-24: Please specify whether these numbers on obesity prevalence are in American children, or global estimates?

We now specify that these numbers are specific to the United States (U.S.) (page 12):

“From 1976 to 2016, the prevalence of childhood obesity in the U.S. has nearly doubled in children ages 2 to 5 (from 5 percent to 13.9 percent), nearly tripled in children aged 6 to 11 (from 6.5 percent to 18.4 percent) and quadrupled in adolescents’ ages 12 to 19 (from 5 percent to 20.6 percent)”

2. Page 3, line 20: When and where is the "overall obesity prevalence" on 17%?

We now specify that this estimate is specific to children in the U.S. in 2015-2016. Please note: We have updated this number to reflect the CDC’s recent report on obesity which provides the 2015-2016 estimates, where we previously used 2014-2015 estimates (page 3):

“While there is some indication that childhood obesity rates may leveling in the U.S. [105], the overall prevalence of obesity among children in 2015-2016 was estimated at 18.5 percent [106], meaning it is still considerably higher than the Healthy People 2020 goal of 14.5 percent [107].

3. Page 3, line 35: Is the decline in SSB consumption observed in the US, or in other countries as well?

We now specify that we are referring to a leveling or decline in SSB consumption observed in the U.S. (page 3):

“There is evidence that consumption of SSBs has recently begun to decline in the U.S., with this decrease largely driven by fewer children consuming these beverages [2, 3].”

4. Page 4, line 9: When was this prior review conducted/published?

We now indicate that the prior review was published in 2009 (page 4):

“A previous review published in 2009 summarized many early studies on SSBs and children’s health [16]. Using a narrative review approach, we update the literature by reviewing more recent studies published up until 2017.”

5. Background section: I think the authors need to make it more clear why this review is important, and what it adds to the current knowledge. In addition, it should be more clear what the aims of this review are.
We agree that more information is needed in the introduction section provide background information on previous findings, why this review is important and what it adds to the current knowledge. We have now added the following section to the introduction (page 4):

“In light of the frequent consumption of SSBs among children and adolescents in the U.S., there has been an interest in critically examining associated health consequences. As a result, there has been a substantial rise in the number of studies investigating the health effects of SSBs over the past decade. Given this influx of studies, concise summaries of the evidence base are needed in order to inform policy and advocacy efforts focused on reducing SSB consumption.

This review aims to synthesize the existing evidence regarding the impact of SSB consumption on children’s health. Unlike previous reviews which have been limited in scope (e.g., focusing on a single outcome such as weight gain) [14, 15], this review summarizes evidence from cross-sectional, longitudinal and intervention studies on a broad range of health outcomes relevant to children including: obesity, insulin resistance, dental caries, and caffeine related effects. A previous review published in 2009 summarized many early studies on SSBs and children’s health [16]. Using a narrative review approach, we update the literature by reviewing more recent studies published up until 2017.”

6. Page 4, line 58: What do the authors mean with "new" data?

We have removed the phrase “new data” as this is not an important part of our methodology. This was referring to a small minority of studies which presented duplicative data (e.g., one paper described the effect of SSBs on insulin resistance alongside data of the effect of SSBs on obesity, but a separate paper by the same authors already reported data on the effect of SSBs on obesity so we would not include both articles since they presented the same data).

7. Page 5, lines 6-20: This information is indeed relevant, but I don't think it belongs in the results section, unless this is something that has been extracted from the review?

The reviewer is referring to the discussion of the mechanism through which SSBs can lead to overweight/obesity. We agree that this information is not best suited for the results section. We have removed it and incorporated it into a new “Summary of Results” section, which follows the results.

8. Page 5, lines 13-14: Something seems missing in the sentence

We have attempted to clarify the meaning of this sentence (pages 12-13):

“In other words, drinking calories in liquid form does not decrease hunger in the same way as solid food. Additionally, people do not sufficiently reduce their total energy intake to make up for the excess calories obtained from SSBs.”

9. Page 6, lines 22-24: Are the listed possible reasons for differences in results based on observations from the reviewed literature (e.g. observed differences in instruments used
to assess SSB consumption or weight gain)? If so, please specify what these differences include.

We have removed this section from the results as we did not feel it was most suitably placed there. In the new “Summary of Results” section, we have argued that researchers need more consistency in measurement to promote comparisons across studies. We now state (pages 14 to 15):

“Second, more consistency is needed in the definition of SSBs (specifying which beverages are included and what is a typical serving size) and measurement strategy (e.g., FFQ vs. 24-hour recall). Similarly, more uniformity is needed in assessing outcomes, particularly in the risk of overweight/obesity where studies vary considerably in the outcomes measured (e.g., BMI, BMI z-score, BMI percentile, overweight/obese status).”

10. Page 7, line 40: Many fewer than what?

We have clarified the text to state “a small number” instead of “many fewer” (page 7):

“A small number of intervention studies have examined SSB consumption and overweight and obesity risk among children [58-60].”

11. Page 8, lines 33-51: This section provides some of the information that I think is missing in the introduction. I think the manuscript would improve with more consistency on what is written under each "outcome-headline" - for example, on page 5 lines 6-20, the authors provide information on the mechanisms behind the investigated association (and no information on previous literature), whereas on page 8 lines 33-51 information on previous literature is provided (and no information on mechanisms).

We agree that the placement of this information regarding previous literature and mechanism is not appropriate in the results section and was not consistently reported for all studies. We have removed all discussion of previous literature and mechanisms from the results and moved it to the new section “Summary of Results” where we now summarize the results of our review, put them in context of previous findings and suggest potential mechanisms (pages 12-14).

12. Page 12, line 33: I think there is a typo ("with and attention....")

Thank you. We have removed “and” as it was a typo. The sentence now reads (page 12):

“One longitudinal study was conducted and it found evidence that increased energy drink consumption was associated with attention deficit/hyperactivity disorder inattention and hyperactivity at 16-month follow-up, but did not find evidence for associations with depression, panic and anxiety [95].”

13. Page 13, lines 8 and 40: What results from the review suggest that additional research on taste preferences is needed?
We have removed this mention of additional research on taste preferences being needed. This was leftover from a more expanded review conducted for the Robert Wood Johnson Foundation, which included the results of this review plus evidence on taste preferences and substitution of SSBs.

14. Conclusion: Based on the results of this review, do the authors think there is evidence or indications suggesting that intake of SSB is harmful in particular population subsets?

Evaluating subgroup differences was not a main aim of this study. Given the small number of studies, it was not possible to make meaningful overarching statements about the intake of SSBs being harmful in particular subsets. To address this gap in our review, we now suggest future research to examine differences in health risks associated with SSBs by subpopulations (page 15):

“Third, researchers should examine differences in health risks by subpopulations (e.g., race/ethnicity, socioeconomic status, age and gender) to determine if the intake of SSBs in particularly harmful in certain population subsets. While it is established the low-income and racial and ethnic minorities consume more SSBs, it is unclear the extent to which health consequences are magnified among these groups. This is important particularly for targeting interventions and policy approaches to reduce children’s SSB consumption. Better insights in these areas have the potential to inform real-world policies and recommendations that may greatly benefit children’s health.”

Reviewer #3

Title: The negative impact of sugar-sweetened beverages on children’s health: An update of the literature

1. General: The purpose of this manuscript, to provide an overview of the status of the current evidence of an association between the consumption of sugar-sweetened beverages and negative health outcomes among children, is a valuable one but I have some questions and some concerns. As written, the manuscript appears to focus on highlighting the evidence of an association rather than objectively evaluating the totality of it.

As addressed in the comment #1 to Reviewer #1, we have added a section following the results titled “Summary of Evidence” in order to summarize the current evidence from our review and put it in the context of previous findings (pages 12 to 14). We believe that this enables an objective evaluation of the totality of the evidence, rather than a focus on specific associations.

In addition, it is unclear why/how the specific SSB-associated health outcomes were selected. What about other outcomes that have also been associated with SSB consumption, eg. non-alcoholic fatty liver disease? dyslipidemia?
This review was not meant to be an exhaustive overview of all SSB-associated health outcomes. Instead, we chose 4 areas that we believed were most relevant to children’s health and are well-supported in the literature. Additionally, much of the literature examining SSBs has been conducted on adults, whereas we wanted to focus our review on evidence conducted exclusively among children. We have attempted to provide more background information to justify our choice (page 3):

“In the past decade, evidence has emerged linking SSB consumption to a number of health consequences among adults including weight gain [4, 5], cardiovascular risk factors (e.g., dyslipidemia) [6], insulin resistance and type 2 diabetes [7, 8] and non-alcoholic fatty liver disease [9]. Studies among children are more limited and have generally focused on weight gain [4] and dental caries [10], as well as insulin resistance to a lesser extent [11, 12]. An emerging body of research has also examined the association between caffeinated SSBs (e.g., energy drinks or colas) and caffeine-related health consequences including reduced sleep quality or headaches [13].”

Additionally, we now acknowledge our narrow scope as a limitation (page 15):

“First, it only focuses on four main health effects associated with SSB consumption and does not address other potential consequences which have been documented among consumers of SSBs (e.g., hyperlipidemia, non-alcoholic fatty liver disease).”

2. Abstract. Background. I don’t believe that the Dietary Guidelines have a "recommended amount set" for sugar-sweetened beverage intake.

We are referring to the recommended limit for added sugar. However, the reviewer is correct that there is no recommended amount of SSBs set by the 2015-2020 DGAs and so we have removed this from the abstract and background.

3. It is unclear how the determination was made that the "...strongest support" was for "overweight/obesity". How as strongest assessed? Number of studies? Strength of associations? Fewer conflicting studies?

Given that this is a narrative review, we did not incorporate any formal quality assessment or strength of evidence evaluation. Overweight/obesity and dental caries had the strongest support because they had the most number of studies (including cross-sectional, longitudinal and intervention) reporting consistently positive results. We have clarified this in the text and now state (page 12):

“The findings of this review confirm that there is clear and consistent evidence that the consumption of SSBs heightens obesity risk among children and adolescents. Although a formal quality assessment or strength of evidence evaluation was not conducted, the vast majority of cross-sectional, longitudinal and intervention studies find strong evidence for a positive relationship in all or part of their study population.”
4. Page 3. Background. The only background information presented as an introduction relates to SSBs and obesity. No information to justify the importance of the other outcomes, or of examining associations with caffeine, is presented.

We have restructured the introduction to shift the focus away from obesity. We now start by discussing SSBs and trends in the U.S., then introduce evidence on related health consequences.

5. Methods. Why was a publication date of Jan 2007 chosen as the cut-off for study inclusion?

This was chosen as the cut-off to follow-up a previous review published in 2009. We now state (page 5):

“We selected 2007 as the start date because the most recent relevant review [16] included studies published prior to this.”

6. Methods. What is the significance of including OECD countries only?

This was decided in order to promote the generalizability of results. Very few studies on SSBs have been published in non-OECD countries and our decision to exclude them is in line with previous reviews. We now state (page 5):

“We limited our scope to high-income countries to promote generalizability of results.”

7. Results. The background information provided as the first paragraph in the Results section appears out of place.

We agree that the placement of this background information regarding previous literature and mechanism is not appropriate in the results section. We have removed it from the results and moved it to the new section “Summary of Results” where we now summarize the results of our review, put them in context of previous findings and suggest potential mechanisms (pages 12-14).

8. More of a discussion of the limitations of the existing evidence would be helpful. How consistent were the methods used, eg. the definition of SSBs, and the way in which insulin resistance was assessed? What are the strengths and weaknesses of the evidence for each the outcomes?

We have added a more thorough discussion of the limitations of existing studies to the new “Summary of Results” section (pages 14 to 15):

“How consistent were the methods used, eg. the definition of SSBs, and the way in which insulin resistance was assessed? What are the strengths and weaknesses of the evidence for each the outcomes?

While there is a large and growing body of research examining the impact of SSBs on children’s health, important gaps remain. First, researchers should utilize more rigorous study designs (intervention trials, but also longitudinal studies) and move away from a reliance on cross-sectional studies. This will strengthen the evidence base and allow firmer conclusions to be made regarding the causal relationships between SSB consumption and negative health effects.
Second, more consistency is needed in the definition of SSBs (specifying which beverages are included and what is a typical serving size) and measurement strategy (e.g., FFQ vs. 24-hour recall). Similarly, more uniformity is needed in assessing outcomes, particularly in the risk of overweight/obesity where studies vary considerably in the outcomes measured (e.g., BMI, BMI z-score, BMI percentile, overweight/obese status). Third, researchers should examine differences in health risks by subpopulations (e.g., race/ethnicity, socioeconomic status, age and gender) to determine if the intake of SSBs in particularly harmful in certain population subsets. While it is established the low-income and racial and ethnic minorities consume more SSBs, it is unclear the extent to which health consequences are magnified among these groups. This is important particularly for targeting interventions and policy approaches to reduce children’s SSB consumption. Better insights in these areas have the potential to inform real-world policies and recommendations that may greatly benefit children’s health. Finally, additional research is needed about a broader variety of caffeinated SSBs and their impact on children’s health. Energy and sport drink consumption is rising rapidly in the U.S. [13] and so studies examining the negative health effects of caffeinated SSB consumption are needed to inform future efforts to reduce consumption.”

9. What are the limitations of this review?

We have added a section to the new “Summary of Results” section discussing limitations of the current review (page 15):

“This review has several limitations. First, it only focuses on four main health effects associated with SSB consumption and does not address other potential consequences which have been documented among consumers of SSBs (e.g., hyperlipidemia, non-alcoholic fatty liver disease). Second, our conclusions for a particular health consequence did not include a formal strength of evidence assessment and was limited to an informal evaluation of consistency and lack of conflicting studies. Third, article screening was not done in duplicate, although all included articles were confirmed by a second reviewer.”

10. Conclusion. The conclusion should focus more on the conclusion that can be drawn from the review itself. While it may be true that more research is needed about substitution and taste preference, that is not a determination that can be made from this review. What are the important limitations/gaps of the current evidence in regards to the link between consumption and the specified health outcomes.

We have restructured our conclusion to focus more on conclusions that can be drawn from the review itself. We now state (page 15 to 16):

“This review provides clear and consistent evidence that consumption of SSBs increases obesity risk and dental caries, with emerging evidence supporting the negative impact of SSBs on insulin resistance and caffeine-related effects. In general, the strength of evidence for all four health consequences could be improved through the implementation of more longitudinal and intervention studies, moving away from a reliance on the cross-sectional design. Additionally, more consistency is needed from studies in the measurement of exposures (e.g., standardized measurement and definition of SSBs) and outcomes (e.g., assessment of weight-related
outcomes) to create a stronger evidence base. Future research should examine low-income and racial/ethnic minority subgroups in order to determine if differences in health risks associated with SSBs exist. Although SSB consumption has declined in the last 15 years, SSB consumption still remains high (61% of children consume at least one SSB per day) and is particularly high among low-income and racial and ethnic minorities. The vast majority of the available literature suggests that reducing SSB consumption would improve children’s health.”

Minor

11. It would be helpful if the numbers for references were presented in numerical order.

We have fixed this issue in Endnote and references are now presented in numerical order.