Artificial Sweetener Consumption and Children’s Health: Key Considerations for Nutrition Policy

Allison C. Sylvetsky, PhD
Assistant Professor
Department of Exercise and Nutrition Sciences
Milken Institute School of Public Health
The George Washington University
Consequences of excess added sugar intake

Excess added sugar intake has negative impacts on health.

- Overweight and obesity
- Type 2 diabetes
- Non-alcoholic fatty liver disease
- Cardiovascular disease
- Dental caries

Sugar-sweetened beverages (SSBs) are the greatest contributors to added sugar intake in the US.

Malik VS et al., J Am Coll Cardiol, 2015
A can (12 FL OZ) of regular soda has about 150 CALORIES AND 10 TEASPOONS of added sugar.

STOP. RETHINK YOUR DRINK. GO ON GREEN.

Red - Drink Rarely, If At All
- Regular sodas
- Energy or sports drinks
- Fruit drinks

Yellow - Drink Occasionally
- Diet sodas
- Low-calorie, low-sugar drinks
- 100% juice

Green - Drink Plenty
- Water
- Seltzer water
- Skim or 1% milk

ARE YOU POURING ON THE POUNDS?
DON’T DRINK YOURSELF FAT.
Cut back on soda and other sugary beverages. Go with water, seltzer or low-fat milk instead.

HEALTHY KIDS ARE SWEET ENOUGH

Heart Healthy Tip: NO MORE THAN 1 Sugary Drink a Week
How many teaspoons of sugar in just one SMALL 8 OUNCE serving?

<table>
<thead>
<tr>
<th>Drink</th>
<th>Sugar (TSPS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WATER</td>
<td>0</td>
</tr>
<tr>
<td>SPORTS DRINK</td>
<td>4</td>
</tr>
<tr>
<td>SWEET TEA</td>
<td>6</td>
</tr>
<tr>
<td>SODA</td>
<td>6</td>
</tr>
<tr>
<td>LEMONADE</td>
<td>7</td>
</tr>
</tbody>
</table>

Learn more at heart.org/sugar

Source: USDA National Nutrient Database for Standard Reference Release 28
“We removed nearly 125,000 tons of added sugar through recipe changes in 2020.”

“About 36% of our beverage portfolio is low- or no-sugar.”
Reductions in sugar sales from soft drinks in the UK from 2015 to 2018

L. K. Bandy¹, P. Scarborough¹, R. A. Harrington¹, M. Rayner¹ and S. A. Jebb²

“The total volume sales of soft drinks that are subject to the soft drink industry levy (SDIL) fell by 50%, while the volume sales of low- and zero-sugar (<5 g/100 ml) drinks rose by 40%.”
“No meaningful changes in the quantities of nutrients of concern were observed. Our findings suggest little reformulation has occurred in Colombia in the absence of mandatory policies, except for the substitution of sugar with non-nutritive (artificial) sweeteners among beverages.”
Hankering for a Pepsi but looking to cut some calories? **Try the full cola taste of Pepsi Next made with 60% less sugar.** Love your Gatorade but not the calories? **Try G2 with the same electrolyte formula and 60% fewer calories.** Like to start your day with a glass of Tropicana Orange Juice but watching your waistline? **Try Trop50.** You get the picture. There’s a low calorie option for virtually every drink we make. The choice is yours.

https://www.pepsicobeveragefacts.com/home/caloriebalance
15 g added sugar + sucralose, acesulfame-potassium & aspartame

7 g added sugar + sucralose & acesulfame-potassium

10 g sugar + stevia leaf extract
Added sugars + artificial sweeteners

• Used Nielsen data to identify beverage brands that spent at least $100,000 in advertising and contain added sugar

• Excluded “children’s drinks,” which were previously reported.

• Many brands offered products that contained artificial sweeteners IN ADDITION to added sugars, including:
  • 88% of energy drinks,
  • 40% of iced teas,
  • 30% of fruit drink, sports drinks, and regular sodas
Proportion of household purchases with NNS

N = 39,300 households in 2002

N = 61,101 households in 2018

Dunford et al. JAND 2020
What about artificial sweeteners?

Are they helpful or harmful for weight management and prevention of chronic disease?
Commonly used artificial sweeteners

- Sucralose
  - FDA approved as food additives
  - 600x
- Aspartame
  - 160-220x
- Acesulfame-K
  - 200x
- Saccharin
  - 300x
Common plant-based, non-caloric sweeteners

Stevia, Rebaudioside A  Monk Fruit (luo han guo)

Considered to be generally recognized as safe (GRAS)
I will collectively refer to them as “low-calorie sweeteners (LCS)”
Widespread presence of products with LCS

Sylvetsky, & Dietz 2014
Sylvetsky et al., Int. J Peds, 2014
Products with LCS marketed to children

Sylvetsky & Dietz, NEJM 2014; Sylvetsky et al. 2021 (in prep)
N= 1603 parents of young children through an online survey

In a randomized experiment, parents asked to indicate whether 8 popular children's drink products contained LCS after viewing:
• front-of-package alone or
• front-of-package plus nutrition/ingredient information.
LCS consumption in the United States

Demographic correlates of LCS consumption

• LCS intake more prevalent among:
  – Adults compared with children
  – Individuals who self-identify as non-Hispanic white
  – Individuals from higher SES households
  – Individuals of higher body mass index (BMI)
  – Individuals with diabetes

Sylvetsky & Rother Phys & Behavior 2016
Prevalence of consumption is underestimated

- Lack of consumer awareness about foods and beverages that contain LCS.
Prevalence of consumption is underestimated

- Challenges with food code groupings in dietary databases.

- EXAMPLE: FNDDS 2015-2016, Food code: 92530610
  - Main description: “Fruit juice drink, with high Vitamin C”
  - Additional food code description includes the following brands:

<table>
<thead>
<tr>
<th>No LCS</th>
<th>Sucralose</th>
<th>Sucralose + ace-K</th>
<th>Sucralose</th>
<th>No LCS</th>
</tr>
</thead>
</table>

Swithers, Welsh & Sylvetsky et al. Nutrients 2021
Consumption estimates are inherently flawed

- Lack of information regarding specific LCSs
- Manufacturers not required to indicate the amount per serving

Swithers, Welsh & Sylvetsky et al. Nutrients 2021
Purchases by type of LCS

Saccharin, aspartame
Stevia/RebA
Sucralose
Other LCS

Proportion of Households (%)

Foods and beverages

Dunford et al. JAND 2020
Purchases by type of LCS

- Saccharin, aspartame
- Stevia/RebA
- Sucralose
- Other LCS

Proportion of Households (%)

Dunford et al. JAND 2020
“It should be noted that replacing added sugars with low- and no-calorie sweeteners may reduce calorie intake in the short-term and aid in weight management, yet questions remain about their effectiveness as a long-term weight management strategy.”

“Low- and no-calorie sweeteners, which can also be called high-intensity sweeteners, are not recommended for children younger than age 2. Taste preferences are being formed during this time period, and infants and young children may develop preferences for overly sweet foods if introduced to very sweet foods during this timeframe.”
‘There is a **scarcity of long-term RCTs** of sufficient sample size and duration to adequately document the efficacy and safety of LCS beverages, particularly relative to SSBs, as a tool to help maintain energy balance, control cardiometabolic risk factors, and reduce risk of cardiovascular events. This **lack of evidence** does not mean that LCS beverages are or are not efficacious…Nonetheless, there is a dearth of evidence on the potential adverse effects of LCS beverages relative to potential benefits. On the basis of the available evidence, the writing group concluded that, at this time, **it is prudent to advise against prolonged consumption of LCS beverages by children.**’

Johnson et al. 2018 Circulation
HER 2019 Consensus Statement: SSBs and LCS beverages “not recommended” for children 0-5 years old.

AAP 2019 Policy Statement: “Not only are more children and adolescents consuming NNSs, but they are also consuming a larger quantity of NNSs in the absence of strong scientific evidence to refute or support the safety of these agents…. The long-term safety of NNSs in childhood has not been assessed in humans.”
Reformulation of products to contain LCS

Analysis of ~1500 products from 19 supermarkets from Dec 2018-Oct 2019

55% contained at least one LCS

100% of flavored waters; 99% of powdered juices, 98% of flavored milks

“The fact that there are no LCS-free alternatives for certain food categories, especially for children, is worrying.”
Guidance highlights uncertainty…

What do we know about whether LCS are helpful or harmful for weight management and prevention of chronic disease?
LCS vs sugar in randomized controlled trials

N= 29 parallel-arm RCTs

Included children and adults

2267 participants

Results show favorable effect of LCS vs sugar

Reduction of ~1.06 kg

Rogers & Appleton, Int J Obes 2021
Cohort studies tell a different story

<table>
<thead>
<tr>
<th></th>
<th>No of studies</th>
<th>No of participants</th>
<th>No of cases</th>
<th>Relative risk (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Obesity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SSBs</td>
<td>7</td>
<td>56,579</td>
<td>11,821</td>
<td>1.12 (1.05-1.19)</td>
</tr>
<tr>
<td>LCSBs</td>
<td>5</td>
<td>22,390</td>
<td>2,436</td>
<td>1.21 (1.09-1.35)</td>
</tr>
<tr>
<td><strong>T2DM</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SSBs</td>
<td>19</td>
<td>1,010,392</td>
<td>34,788</td>
<td>1.19 (1.13-1.25)</td>
</tr>
<tr>
<td>LCSBs</td>
<td>12</td>
<td>657,068</td>
<td>23,152</td>
<td>1.15 (1.05-1.26)</td>
</tr>
<tr>
<td><strong>Hypertension</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SSBs</td>
<td>6</td>
<td>311,916</td>
<td>80,426</td>
<td>1.10 (1.06-1.14)</td>
</tr>
<tr>
<td>LCSBs</td>
<td>5</td>
<td>293,262</td>
<td>78,356</td>
<td>1.08 (1.06-1.10)</td>
</tr>
<tr>
<td><strong>All-cause mortality</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SSBs</td>
<td>8</td>
<td>768,083</td>
<td>113,321</td>
<td>1.04 (1.01-1.07)</td>
</tr>
<tr>
<td>LCSBs</td>
<td>4</td>
<td>665,221</td>
<td>104,520</td>
<td>1.06 (1.02-1.10)</td>
</tr>
</tbody>
</table>

Qin et al. Eur J Epid. 2020

**Per 1 serving (250 mL) of LCS beverages per day**
7% higher CVD risk per 1 serv of LCSBs/day

### Risk of CVD per 1 serving (250 mL) of LCS beverages per day

<table>
<thead>
<tr>
<th>Study</th>
<th>Outcome</th>
<th>Case/ total</th>
<th>Follow-up (year)</th>
<th>RR (95% CI)</th>
<th>Weight (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CHD</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rahmani 2019 (16)</td>
<td>CHD</td>
<td>3,618/81,714</td>
<td>11.9</td>
<td>1.09 (1.03, 1.15)</td>
<td>28.47</td>
</tr>
<tr>
<td>Gardener 2012 (23)</td>
<td>MI</td>
<td>155/2,564</td>
<td>9.8</td>
<td>1.32 (0.94, 1.86)</td>
<td>0.63</td>
</tr>
<tr>
<td>Koning 2012 (11)</td>
<td>CHD</td>
<td>3,683/42,883</td>
<td>22</td>
<td>1.00 (0.92, 1.09)</td>
<td>10.27</td>
</tr>
<tr>
<td>Fung 2009 (25)</td>
<td>CHD</td>
<td>3,105/88,520</td>
<td>24</td>
<td>1.06 (1.00, 1.13)</td>
<td>19.23</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td></td>
<td></td>
<td></td>
<td>1.06 (1.02, 1.11)</td>
<td>58.61</td>
</tr>
<tr>
<td><strong>Stroke</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rahmani 2019 (16)</td>
<td>Stroke</td>
<td>2,838/81,714</td>
<td>11.9</td>
<td>1.07 (1.00, 1.13)</td>
<td>20.25</td>
</tr>
<tr>
<td>Pase 2017 (10)</td>
<td>Stroke</td>
<td>70/2,137</td>
<td>10</td>
<td>1.32 (0.83, 2.07)</td>
<td>0.36</td>
</tr>
<tr>
<td>Bernstein (HPFS) 2012 (48)</td>
<td>Stroke</td>
<td>1,416/43,371</td>
<td>22</td>
<td>1.07 (0.96, 1.20)</td>
<td>5.87</td>
</tr>
<tr>
<td>Bernstein (NHS) 2012 (48)</td>
<td>Stroke</td>
<td>2,938/84,085</td>
<td>28</td>
<td>1.11 (1.04, 1.20)</td>
<td>14.24</td>
</tr>
<tr>
<td>Gardener 2012 (23)</td>
<td>Stroke</td>
<td>328/2,564</td>
<td>9.8</td>
<td>1.17 (0.84, 1.62)</td>
<td>0.68</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td></td>
<td></td>
<td></td>
<td>1.09 (1.04, 1.13)</td>
<td>41.39</td>
</tr>
<tr>
<td><strong>Overall</strong></td>
<td></td>
<td></td>
<td></td>
<td>1.07 (1.05, 1.10)</td>
<td>100.00</td>
</tr>
</tbody>
</table>

*NOTE: Weights are from random-effects analysis*

Overall RR 1.07 for LCSBs; Overall RR 1.08 for SSBs

Very few RCTs have focused on cardiometabolic outcomes other than weight or adiposity.

The vast majority have been conducted in healthy individuals.

The vast majority have been conducted in adults.
How to explain discrepant findings?

Developing obesity, being overweight, already at risk for cardiometabolic disease
Discrepant results: behavioral mechanisms

Real-life
- Unaware of LCS use
- No behavioral support/weight loss diet
- Low cognitive engagement
- Substitution vs. addition?
- LCS from many sources

RCT
- Knowledge of LCS consumption
- Intensive behavioral support
- High cognitive engagement
- Diet beverages/capsules
- Relatively short timeframe

Sylvetsky et al. Reviews in Endocrinology and Metabolic Disorders 2017
LCS and health: biological mechanisms

- Sweet-taste receptor mediated changes in glucose and insulin
- Increased adipogenesis, disturbance of pathways in adipose
- Alterations in gut microbiota
- Impaired predictive relationship between sweet taste and calories
- Change in taste preferences, dietary patterns

DIET

Cardiometabolic Risk Factors
Summary: what we know

• Presence of LCS in the food supply has increased, especially in products that also contain added sugars.

• LCS consumption has increased in the US and worldwide, particularly among children.

• Discrepant findings of RCTs vs. observational studies of LCS effects on body weight and cardiometabolic outcomes

• 1:1 replacement of SSBs with diet beverages may be effective for weight loss strategy in adults who frequently consume SSBs.

• LCS induce metabolic derangements in rodents, but unclear relevance to human consumption.
Summary: what we don’t know

- Scarcity of RCTs on metabolic outcomes other than weight
- Difficult to disentangle effects due to specific LCS
- Very limited research on metabolic effects of stevia
- Little known about real-life consumption patterns/effects of LCS from sources other than diet beverages
- Most studies conducted in healthy individuals
- Extremely limited research in children and adolescents
- Early life/intergenerational exposure not well understood
Implications for nutrition research & policy

• Change regulation of front of package claims to support informed consumer decision making.

• Consider label calling attention to LCS in products marketed directly to children.

• Restrict advertising of both SSBs and LCSBs to youth.

• Require manufacturers to disclose the amount of LCS in order to estimate LCS exposure.

• Update dietary databases to accurately reflect presence of LCS in foods and beverages.
Implications for sugar reduction messaging

• Water and unsweetened beverages are best!

• Beverages with LCS may offer a weight management option among adults who consume SSBs, if used carefully.

• Efforts to reduce added sugar in foods should focus on reducing sweetness and choosing healthier options, rather than adding LCS.

• LCS should not be used in products marketed to children.
THANK YOU!