The “Twinkie Defense”: the relationship between carbonated non-diet soft drinks and violence perpetration among Boston high school students

Sara J. Solnick (corresponding author)  
Department of Economics  
University of Vermont  
237 Old Mill  
94 University Place  
Burlington, VT 05405  
(802) 656-0183  
(802) 656-8405 fax  
Sara.Solnick@uvm.edu

David Hemenway  
Health Policy and Management  
Harvard School of Public Health  
Boston, MA, USA

Keywords: adolescent, aggression, violence, soda, soft drinks  
Word count: 2,368
Abstract:

Objectives: To investigate the association of carbonated non-diet soft drink consumption and violence perpetration in a sample of Boston adolescents.

Methods: In a survey of Boston public high schools, we asked how often respondents drank non-diet soft drinks and whether they had carried a weapon or engaged in physical violence with a peer. We used regression analysis to determine the role of soft drink consumption in these behaviors.

Results: Adolescents who drank more than 5 cans of soft drinks per week (nearly 30% of the sample) were significantly more likely to have carried a weapon and to have been violent with peers, family members, and dates (p < .01 for carrying a weapon and p < .001 for the three violence measures). Frequent soft drink consumption was associated with a 9 to 15 percentage point increase in the probability of engaging in aggressive actions, even after controlling for gender, age, race, body mass index, typical sleep patterns, tobacco use, alcohol use and having family dinners.

Conclusions: We found a significant and strong association between soft drinks and violence. There may be a direct cause-and-effect relationship, perhaps due to the sugar or caffeine content of soft drinks, or there may be other factors, unaccounted for in our analyses, that cause both high soft drink consumption and aggression.
**Introduction:**

In 1979, Dan White was tried for the assassinations of San Francisco city district Supervisor Harvey Milk and Mayor George Moscone. His lawyers argued that he had diminished capacity and was unable to premeditate his crime. Part of the evidence for his depressed and altered state of mind was that he had recently changed from a health-conscious diet to junk food and Coca-Cola. Although Twinkies, a popular packaged snack cake filled with cream, were mentioned only in passing during the trial, the legal argument became known as the “Twinkie Defense.” The defense was successful: White was convicted of voluntary manslaughter rather than homicide (Pogash 2003).

Although White’s lawyers never claimed that sugar led to his violent acts, studies since then have explored this possibility. High consumption of soft drinks, for example, has been found to correlate positively with poor mental health among Norwegian adolescents (Lien et al. 2006) and with increased individualism and decreased collectivism, social desirability and ability to understand emotions in a sample of American college students (Konrath 2011). A recent meta-analysis examined several purported pathways linking diet and anti-social behavior (Benton 2007). One possible explanation for an association between high sugar intake and aggressive behavior is that that consumption of sugary beverages is a response to abnormally low blood glucose levels, a physiologic state that has been linked with irritable and violent behavior (Benton 2007; DeWall et al. 2011). Another possibility is that soft drinks replace healthier whole foods in the diet, and that a deficiency of micro-nutrients can lead to violent behavior. Several studies found that supplementation of micro-nutrients can significantly decreased aggression, but this research remains in its initial stages (Benton 2007).

In this paper, we investigate the association of carbonated non-diet soft drink consumption and violence in a sample of Boston adolescents. We focus on whether non-diet soft drinks are linked with weapon carrying, and violence perpetration against siblings, dates and peers.
Methods:

The Boston Youth Survey (BYS) is a biennial paper-and-pencil survey of 9th-12th grade students in Boston public schools. Religious schools, private schools and other schools that are outside the Boston Public School system are not included. In 2008, all 31 eligible high schools were invited to participate; ineligible schools included those that served adults (e.g., “night” school), short-term schools (e.g., for students transitioning back to school following incarceration) and those that serve severely disabled youth. Twenty-two of the eligible schools participated in the survey (71%). The primary reason for school non-participation was scheduling difficulties (e.g., conflicts with mandatory standardized testing). There were no significant differences between participating and non-participating schools in terms of the race/ethnicity of the students, school dropout rates, and other readily measurable factors.

We used passive consent procedures (i.e., students’ parents were required to return a signed form if they did not want their child to take the survey). Students were also permitted to decline to participate at any time before or during survey administration. The survey was designed to be able to be completed within a single 40-minute class period. Trained youth workers and others (e.g., researchers, graduate students, city employees) administered the survey during regular class time. The Harvard School of Public Health Office of Human Research Administration approved the study protocol.

Within participating schools, required humanities (e.g. English) classes were stratified by grade, and classrooms were then randomly selected for survey administration within each grade. About four classrooms per school were selected--in order to sample one classroom per grade for each school--or about 100-110 total students. In those schools with total enrollments of 100 or fewer, the entire school was sampled.

Of the 2,725 students who were selected for participation (i.e., who were enrolled in the selected classrooms), 69% (1878) answered the survey. The remaining students were absent on the day of the survey (n=724), declined to participate (n=99), or were not permitted to participate by their parents (n=24).

Our key independent variable for this study is consumption of regular (non-diet) carbonated soft drinks. Respondents were asked, “In the past seven days, how often did you drink soda¹?” They were specifically instructed not to include diet (artificially sweetened) soda. Intake was measured in cans (12 ounces or 355 milliliters), and respondents were told to count a 20 ounce

¹ “Soda” is the common term for carbonated soft drinks in the northeastern United States.
bottle (a commonly available serving size, equivalent to 590 milliliters) as two cans. Possible answers were: Never or less than 1 can, 1 can in the past 7 days, 2-4 cans in the past 7 days, 5-6 cans in the past 7 days, 1 can per day, 2 cans per day, 3 or more cans per day. Eight-six percent (1618) of survey respondents answered this question. For ease of exposition, in most analyses, we divided the sample into two groups: those who consumed up to 4 cans of soft drinks in the past 7 days and those who consumed 5 or more cans of soft drinks in the past 7 days. Just under thirty percent of respondents were classified as heavy consumers of soft drinks.

The purpose of this study was to investigate the effect of carbonated soft drink consumption on aggressive and violent behavior, which we measured in three ways: whether the respondent had (a) been violent towards other adolescents (not a date or a child in the family)\(^2\); (b) been violent towards another child in the family\(^3\) and (c) been violent toward someone in a dating relationship.\(^4\) We also examined whether the respondent had carried a knife or a gun anywhere in the past year.

The control variables included (a) gender, (b) age, (c) ethnicity, (d) body mass index (BMI),\(^5\) (e) any alcohol consumption in the past month; (f) any tobacco use in the past month; (g) any family dinners in the past week; (h) less than six hours of sleep on an average school night.

T-tests and chi-square tests of association were used in bivariate comparisons and multivariate logistical regression techniques in multivariate analyses to determine risk factors. Robust variance estimators were employed to account for non-independent responses from students at the same school (Williams 2000). We used step-wise procedures to eliminate independent variables that were not significant in any of the multivariate regressions.

\(^2\) In the past 30 days, respondent got into a physical fight with another child (not someone in the respondent’s family or someone the respondent had dated) or pushed, shoved, slapped, hit, punched, kicked or choked him or her or attacked or threatened the other child with a weapon.

\(^3\) In the past 30 days, respondent got into a physical fight with another child in his or her family or pushed, shoved, slapped, hit, punched, kicked or choked him or her or attacked or threatened the other child with a weapon. These analyses were restricted to respondents who had another child in their family.

\(^4\) In the past 30 days, respondent got into a physical fight with someone they were or had been dating or pushed, shoved, slapped, hit, punched, kicked or choked him or her. These analyses were restricted to respondents who were or had been in a dating relationship during that time.

\(^5\) Respondents were asked their height in inches and their weight in pounds, and these values were used to calculate body mass index.
Results:

Across the sample, 29.8% of respondents reported drinking more than 5 cans of non-diet soft drinks per week (Table 1). Body mass index (BMI) for the frequent soft drink consumers was not significantly higher than for those who consumed less. The students ranged from 14 to 18 years old, with less than 5% being older or younger. Gender and age were very similar across the two categories. Half (50%) of respondents were black or multi-racial, 33% were Hispanic, 9% were white and 8% were Asian. Asians were the only group to show significant differences in soft drink consumption: they were much less likely than other races to drink more than 5 cans of soft drinks per week.

We explored whether high soft drink consumption was associated with other behaviors that might indicate trouble. Over one-third of respondents did not have dinner with their family even once in the preceding seven days, but this proportion did not differ by soft drink consumption. Heavy consumers of soft drinks were no more likely to get insufficient sleep (less than six hours on average school nights). However, respondents who drank a lot of soft drinks were significantly more likely both to have used alcohol and to have used tobacco at least once in the previous thirty days. The frequent consumers of soft drinks were much more likely to have carried a gun or knife and to have been violent with (a) a sibling, (b) a person they were dating or (c) another young person who was neither a family member nor a romantic partner. These findings also appear when soft drink consumption was divided into four levels of frequency rather than two, suggesting a “dose-response” relationship (Table 2).

Multivariate analysis revealed that soft drinks were an important explanatory variable for our measures of violence and aggression even when other behaviors were included in the analysis (Table 3). Consumption of high quantities of soft drinks resulted in a 9 to 15 percentage point increase in the probability of engaging in the aggressive actions (Table 4). The impact of high soft drink consumption on violence was similar in magnitude to the impact of using tobacco or using alcohol, but the influence of soft drink consumption on the probability of carrying a weapon, while significant, was not as strong as the influence of alcohol or tobacco consumption.

In addition to defining soft drink consumption into two categories—high and low—we also tested regression models in which consumption was measured in estimated number of cans per week\(^6\). The results were virtually identical (not shown).

\(^6\) “Never or less than 1 can” = 0 cans, “1 can in the past 7 days” = 1 can, “2-4 cans in the past 7 days” = 3 cans, “5-6 cans in the past 7 days” = 5.5 cans, “1 can per day” = 7 cans, “2 cans per day” = 14 cans, “3 or more cans per day” = 21 cans
Discussion:

We find that among Boston high school students, drinking more soft drinks is associated with engaging in violent behavior in a variety of contexts, even when controlling for BMI, nightly sleep, demographics and behaviors such as alcohol and tobacco use, and eating dinner with the family. The influence of soft drink consumption on violence appears to be a “dose-response” relationship, with effects visible at low levels of consumption and increasing with greater consumption. Even among respondents who drink alcohol and smoke cigarettes, those who drink more than five cans of soft drinks per week are significantly more likely to be violent than those who drink fewer soft drinks.

We do not know the reason for the association between soft drinks and the perpetration of violence. A direct cause-and-effect relationship between soft drink consumption and aggression is one possibility. Diet can affect aggression (Benton 2007), and soft drinks have various ingredients, including carbonated water, high fructose corn syrup, aspartame, sodium benzoate, phosphoric or citric acid, and often caffeine, any of which might affect behavior. Of the top ten varieties of soft drinks, which together comprise 66% of the total U.S. market, only two, amounting to 7% of the total market, are caffeine-free (Beverage Digest 2011). Hence we expect that caffeine is present in most of the soft drinks consumed by respondents.

The two ingredients in soft drinks that have sometimes been associated with aggression are caffeine and sugar. The evidence about both is mixed. For example, high caffeine consumption was associated with aggressive behavior in a sample of adolescents largely drawn from a clinics focusing on psychiatric disorders and risk-taking (Martin et al. 2008), but a recent, thorough review of the effects of caffeine on young people does not even mention aggression (Seifert et al. 2011), while another cites only the 2008 Martin study (Temple 2009). Similarly, sugar has been linked with aggression in some studies (Schoenthaler 1983a; Schoenthaler 1983b; Lien et al. 2006), but the evidence of a direct impact of sugar on behavior may be weaker than popularly believed (Wolraich et al. 1995; Benton 2008).

It is possible that an underlying organic factor, such as low blood sugar, may lead to both high soft drink consumption and aggressive behavior. In addition, soft drink consumption is associated with many behavioral variables that are associated with violence. Our study controls for a variety of factors that have been linked with youth violence, including alcohol and tobacco use (e.g., Orpinas et al. 1995; Valois et al. 1995; Rudatsikira et al. 2007; Rudatsikira, Muula & Siziya 2008; Shetgiri et al. 2010), sleep (Ireland & Culpin 2006) and family dinners (Sen 2010; Yen et al. 2010). However, there are many other potential confounders that we could not control for, such as family income and other parenting practices.

Our study has various additional limitations. First, the data are based on self-report. However, we have no reason to expect respondents either to exaggerate or to downplay their consumption of soft drinks. Moreover, we have no a priori reason to expect that students who consume high
quantities of soft drinks are any more likely to exaggerate their actual violent behavior than are students with low or no soft drink consumption.

Second, we have limited information about the type of soft drinks consumed by respondents. We do not know, for example, whether or not they were caffeinated. Subsequent surveys should determine more about the soft drinks consumed. Third, we have no other information about the diet of the students, so we do not know if the “empty calories” of soft drinks may be replacing important nutrients in our sample. Finally, our findings, which deal only with largely black and Hispanic high school students from Boston public schools, may not be generalizable to other populations.

Our principal results are that, for Boston high school students, there is a strong, significant association between carbonated non-diet soft drink consumption and the perpetration of violence against siblings, against peers and against dates. Prior literature on this relationship is limited. We also find a strong association between soft drink consumption and carrying weapons. To the best of our knowledge, no prior study examined this relation. On the other hand, we find no support for a connection between soft drink consumption and BMI; the literature on this association is more extensive, but results are mixed (Malik et al. 2006; Gibson 2008; Wolff & Dansinger 2008)

Our finding of a connection between soft drink and violence was an incidental result; soft drink consumption is rarely included in violence surveys. Even if soft drinks are only a marker for violence rather than on the causal pathway, they may be a highly useful marker since, at least in our study, the association between soft drink consumption and violence is not only significant, but also strong and additive to that of both alcohol and tobacco use. In addition, like those variables, soft drink consumption can be readily determined with simple questions. Further research on this issue is warranted.

A review of the relationship between alcohol and crime concluded that alcohol is part of a high-risk lifestyle that also involves illegal drugs and possibly other forms of delinquency. The authors concluded that “it may be beneficial to encourage youth to drink sensibly by using pricing and tax policies to encourage soft drink consumption” (Sumner & Parker 1995, abstract). Our findings suggest that policies to encourage soft drink consumption may be a mistake.

What is already known on this subject
- Diet can affect behavior.
- High consumption of soft drinks in particular has been linked with poor mental health among adolescents in Norway.

What this study adds
- A sample of 1,878 Boston high school students was asked about carbonated non-diet soft drink consumption and about aggressive behavior in various contexts.
- Control variables include gender, age, ethnicity, body mass index, use of alcohol or tobacco, frequency of family dinners and hours of sleep on an average school night.
- Soft drink consumption was strongly and significantly associated with carrying a weapon and with the perpetration of violence against siblings, against peers and against dates.
Statement of contributorship:

David Hemenway was largely responsible for conception and design and acquisition of data. Sara Solnick was not involved in that phase of the project. Sara Solnick conducted the statistical analyses. Both authors participated in analysis and interpretation of data, drafting and revising the article for important intellectual content and both shared final approval of the version to be published.
References:


Beverage Digest, “Special Issue: Top-10 CSD Results for 2010,” 59 (March 17, 2011).


Konrath S, unpublished data, Research Center for Group Dynamics, University of Michigan, 2011.


Temple JL, “Caffeine Use in Children: What we know, what we have left to learn, and why we should worry,” *Neuroscience and Biobehavioral Reviews*, 33 (2009) 793–806.


Table 1: Descriptive Statistics

<table>
<thead>
<tr>
<th></th>
<th>Soft Drink Consumption in past 7 days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All</td>
</tr>
<tr>
<td>Overall</td>
<td>100%</td>
</tr>
<tr>
<td>BMI (mean)</td>
<td>24.0</td>
</tr>
<tr>
<td>Female</td>
<td>54.3%</td>
</tr>
<tr>
<td>Age (mean)</td>
<td>16.3</td>
</tr>
<tr>
<td>Asian</td>
<td>8.2%</td>
</tr>
<tr>
<td>No family dinner</td>
<td>35.9%</td>
</tr>
<tr>
<td>&lt;6 Hours Sleep</td>
<td>24.6%</td>
</tr>
<tr>
<td>Alcohol Use</td>
<td>37.5%</td>
</tr>
<tr>
<td>Tobacco Use</td>
<td>12.2%</td>
</tr>
<tr>
<td>Carried gun or knife</td>
<td>30.8%</td>
</tr>
<tr>
<td>Violent toward peers</td>
<td>44.4%</td>
</tr>
<tr>
<td>Violent in dating relationship</td>
<td>19.5%</td>
</tr>
<tr>
<td>Violent towards children in family</td>
<td>31.6%</td>
</tr>
</tbody>
</table>

* p ≤ .05  
** p ≤ .01  
*** p ≤ .001
Table 2: Soft Drink Consumption with more Categories

<table>
<thead>
<tr>
<th></th>
<th>Soft Drink Consumption in Past 7 Days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 can or less (N = 722)</td>
</tr>
<tr>
<td>Carried gun or knife</td>
<td>23.2%</td>
</tr>
<tr>
<td>Violent toward peers</td>
<td>35.1%</td>
</tr>
<tr>
<td>Violent in dating</td>
<td>15.3%</td>
</tr>
<tr>
<td>relationship</td>
<td></td>
</tr>
<tr>
<td>Violent towards children</td>
<td>25.4%</td>
</tr>
<tr>
<td>in family</td>
<td></td>
</tr>
</tbody>
</table>

For each variable, percentages were significantly different across the four categories with p < .001.
Table 3: Probit Regression Results

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Carried a knife or a gun</th>
<th>Violence towards peers</th>
<th>Violence in dating relationship</th>
<th>Violence towards children in family</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model 1</td>
<td>Model 2</td>
<td>Model 1</td>
<td>Model 2</td>
</tr>
<tr>
<td>5+ Cans Soft Drinks</td>
<td>0.332***</td>
<td>0.266**</td>
<td>0.408***</td>
<td>0.382***</td>
</tr>
<tr>
<td>BMI</td>
<td>0.012*</td>
<td>0.009</td>
<td>0.006</td>
<td>0.002</td>
</tr>
<tr>
<td>Female</td>
<td>-0.622***</td>
<td>-0.694***</td>
<td>-0.144*</td>
<td>-0.176*</td>
</tr>
<tr>
<td>Age</td>
<td>0.058*</td>
<td>0.020</td>
<td>-0.070*</td>
<td>-0.119**</td>
</tr>
<tr>
<td>Asian</td>
<td>-0.744***</td>
<td>-0.683***</td>
<td>-0.697***</td>
<td>-0.602***</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.471**</td>
<td>-1.181*</td>
<td>0.850</td>
<td>1.390**</td>
</tr>
<tr>
<td>No Family Dinner</td>
<td>0.277***</td>
<td>0.169</td>
<td>0.011</td>
<td>0.016</td>
</tr>
<tr>
<td>&lt;6 Hours Sleep</td>
<td>0.110</td>
<td>0.220*</td>
<td>0.137</td>
<td>0.063</td>
</tr>
<tr>
<td>Alcohol Use</td>
<td>0.458***</td>
<td>0.518***</td>
<td>0.260**</td>
<td>0.297***</td>
</tr>
<tr>
<td>Tobacco Use</td>
<td>0.780***</td>
<td>0.368**</td>
<td>0.443***</td>
<td>0.329**</td>
</tr>
</tbody>
</table>

Pseudo R² | 0.08  | 0.16  | 0.04  | 0.10  | 0.08  | 0.11  | 0.05  | 0.07  |
N         | 1391  | 1301  | 1402  | 1305  | 1100  | 1014  | 1314  | 1227  |

*p ≤ .05  
**p ≤ .01  
***p ≤ .001
Table 4: Marginal effects of independent variables, evaluated at sample means

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Carried a knife or a gun (Model 1)</th>
<th>Carried a knife or a gun (Model 2)</th>
<th>Violence towards peers (Model 1)</th>
<th>Violence towards peers (Model 2)</th>
<th>Violence in dating relationship (Model 1)</th>
<th>Violence in dating relationship (Model 2)</th>
<th>Violence towards children in family (Model 1)</th>
<th>Violence towards children in family (Model 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5+ Cans Soft Drinks</td>
<td>0.12***</td>
<td>0.09**</td>
<td>0.16***</td>
<td>0.15***</td>
<td>0.09***</td>
<td>0.09***</td>
<td>0.12***</td>
<td>0.12***</td>
</tr>
<tr>
<td>No Family Dinner</td>
<td>0.09***</td>
<td></td>
<td>0.07*</td>
<td></td>
<td>0.00</td>
<td></td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>&lt;6 Hours Sleep</td>
<td></td>
<td>0.04</td>
<td>0.09*</td>
<td></td>
<td>0.03</td>
<td></td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Alcohol Use</td>
<td>0.15***</td>
<td>0.20***</td>
<td></td>
<td>0.06**</td>
<td>0.10***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tobacco Use</td>
<td>0.26***</td>
<td>0.14**</td>
<td></td>
<td>0.11***</td>
<td>0.11***</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p ≤ .05  
**p ≤ .01  
***p ≤ .001