Original investigation

Knowledge and Awareness of Added Sugar in Cigarettes

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Abstract

Introduction: Sugars naturally occur in tobacco leaf but are also commonly added to cigarettes by tobacco companies. Added sugar increases levels of toxic chemicals in cigarette smoke. Little is known about smokers' knowledge of added sugar in cigarettes and awareness of its effects.

Methods: Adult cigarette smokers were recruited through Amazon Mechanical Turk to participate in an online experiment on electronic cigarette advertising. After completing the experiment, participants ($N = 4351$) answered two items assessing knowledge and awareness of added sugar in cigarettes. Participants had the option of providing open-ended comments about the overall study, and two reviewers read and independently coded comments pertaining to the sugar items.

Results: Only 5.5% of participants responded "yes" to the question: "Is sugar added to cigarettes?," and only 3.8% of participants indicated being aware that added sugar increases toxins in cigarette smoke. Forty-eight participants mentioned the sugar items when asked to comment about the overall questionnaire. Fifty-two percent of these comments expressed an interest in obtaining more information about added sugar, and 23% described the sugar items as interesting or informative. Three participants commented that learning about added sugar motivated them to quit or cut down on smoking.

Conclusions: Among a large sample of smokers, few reported knowledge of added sugar in cigarettes and awareness of its effects. Further, several smokers expressed an interest in learning more about added sugar. Messages about added sugar in cigarettes may be a promising new angle for campaigns to discourage smoking.

Implications: Few American smokers are aware that sugar is added to cigarettes, and some participants expressed a desire to learn more about this additive. Given such low awareness, the interest among smokers, and increased popular concerns about added sugar in foods and beverages, messaging about added sugar in cigarettes should be developed and tested for inclusion in public health media campaigns.

Background

Manufactured cigarettes are highly engineered drug delivery devices for nicotine.¹ Tobacco companies manipulate cigarette design features to alter nicotine levels and to influence other sensory effects of smoking.² For instance, manufacturers use a variety of chemical

additives to alter the characteristics of cigarette smoke.³ Hundreds of additives are applied in cigarette manufacturing, and in a typical American-blended cigarette, chemical additives comprise up to 10% of cigarette weight.⁴ Among these, more than 100 cigarette additives have been identified as having pharmacological actions,

such as enhancing nicotine delivery and masking the odor of secondhand smoke.⁵ Added sugars can comprise up to 4% of a cigarette's weight.⁶ Sugars also naturally occur in tobacco, but levels vary greatly depending on how the tobacco is cured.⁶ For example, in Burley tobacco, which is typically air-cured, natural sugars are broken down by enzymatic processes. In contrast, flue-cured tobacco (eg, Virginia tobacco) contains higher levels of endogenous sugars because the enzymes that metabolize sugars are inactivated at high temperatures. American-blended cigarettes typically contain a mix of Burley, Virginia, Oriental, and reconstituted tobaccos. To replenish sugars lost due to air-curing of Burley tobacco, sugars are routinely added to American-blended cigarettes.

Sugars (both added and endogenous) have a variety of effects on mainstream cigarette smoke. First, combusting sugar increases the levels of aldehydes and other constituents in mainstream tobacco smoke, including toxic and possibly carcinogenic compounds, such as formaldehyde, acrolein, and 2-furfural.^{6,7} Second, the presence of sugars increases the addictive potential of cigarettes.^{6,7} Pyrolysis of sugar generates acetaldehyde, which has been found to enhance the addictiveness of nicotine in experimental studies with rats.⁸ Finally, sugar in cigarettes increases the appeal of smoking.⁷ Burning sugar generates organic acids, which lower the pH of cigarette smoke and, consequently, reduce the harshness and irritation of smoke inhalation.⁶ Sugars also help mask the bitter taste of cigarette smoke, as the combustion of sugars produces a sweet caramel flavor.⁷

Because of increasing concerns about the health effects of added sugar in processed foods and beverages, the *Dietary Guidelines for Americans* has recently recommended limiting consumption of added sugars.⁹ Moreover, the US Food and Drug Administration (FDA) has announced plans to require food and beverage manufacturers (but not tobacco companies) to disclose added sugars on nutrition facts labeling.¹⁰ Tobacco manufacturers do not disclose ingredients (eg, added sugar) on product packaging or marketing materials, and aside from one known media campaign in Australia,¹¹ the role of sugar in cigarettes has not been widely publicized by tobacco control programs. In the Australian television campaign, the advertisement was set to the popular song "Sugar, Sugar" by The Archies, and the advertisement concluded with the following text across the screen: "Additives such as sugar and honey can hide the bitter taste of tobacco. But the damage cigarettes do can't be hidden."¹² Thus, the public may not be aware that sugar is added to cigarettes or of the effects of sugars in cigarettes. The purpose of this study was to assess knowledge of added sugar in cigarettes and awareness of its effects on toxin levels in cigarette smoke among a sample of cigarette smokers.

Methods

Recruitment

This study was part of a larger investigation assessing smokers' responses to electronic cigarette advertising.¹³ A convenience sample of 4390 adult (≥ 18 years) established smokers (smoked ≥ 100 cigarettes in lifetime and currently smoking every day or some days) were recruited through Amazon Mechanical Turk, a web-based crowdsourcing service, to complete an online questionnaire. Participation was limited to users with a 90% or higher approval rating of past Amazon Mechanical Turk tasks, accounts registered in the United States, and fluency in English.

Measures

After participating in an online experiment about electronic cigarette advertising and responding to questions about electronic cigarette

advertising and tobacco use, participants were asked two items about knowledge and awareness of added sugar in cigarettes: "Is sugar added to cigarettes?" and "Adding sugar to cigarettes increases toxins in cigarette smoke. Before this survey, had you ever heard of this effect of added sugar?" Response options to both items were "yes," "no," and "don't know."

Participants were also asked demographic questions, specifically age, sex, education, race, ethnicity, household income, number of members in their household, and US state of residence. We compared household income levels, number of household members, and US state against the 2015 US federal poverty guidelines to create a dichotomous variable indicating whether participants were above or below the federal poverty guideline.¹⁴ Race and ethnicity were combined to create a four-category variable: non-Hispanic, white; non-Hispanic, black; non-Hispanic, other/multi-race; and Hispanic.

Comment Coding

At the end of the survey, respondents had the option to respond to an open-ended question requesting general comments about the overall questionnaire. We selected all comments mentioning "sugar" and, after preliminarily reviewing them, identified five categories of comments: (1) expressing a desire to learn more about or asking a question about added sugar in cigarettes, (2) disclosing they did not know sugar was added to cigarettes, (3) describing the questions about added sugar as interesting or informative, (4) describing added sugar in cigarettes as strange or shocking, and (5) stating that learning about added sugar in cigarettes could help them quit or cut down on their smoking. Two reviewers (ABS, CLJ) independently read and coded all comments mentioning "sugar" for these five categories. When appropriate, comments were coded into multiple categories. All discrepancies between reviewers were discussed until 100% agreement was reached.

Data Analyses

We used Stata/IC 12.1 to conduct all statistical analyses and listwise deletion to handle missing data due to attrition ($n = 39$). We calculated descriptive statistics for responses to the two sugar items by participant demographic characteristics. The University of North Carolina at Chapel Hill Institutional Review Board approved this study.

Results

A total of 4351 current cigarette smokers completed the online questionnaire, of which a majority (53.4%) identified as female (Table 1). About 40% of the sample was 29 years of age or younger. Nearly a third (31.4%) had some college education, whereas a majority (54.8%) had a college degree or higher. Over three-fourths (77.6%) of participants identified as being non-Hispanic white, 7.8% identified as Hispanic, and 6.4% identified as non-Hispanic black. Thirteen percent of the sample indicated that they lived below the federal poverty level. Seventy percent of participants smoked daily and 54% reported making a quit attempt in the past 12 months.

Knowledge of sugar being added to cigarettes was low in the sample and across demographic characteristics (Table 2). Among all participants, only 5.5% responded "yes" when asked if sugar was added to cigarettes. The percentage of participants responding "yes" to this item was less than 10% for both men and women, across all age categories, household income levels, education levels, racial/ethnic groups, and regardless of federal poverty level. Moreover, knowledge was less than 7% among all levels of cigarette consumption and

smoking frequency, and those making and not making a quit attempt in the past year. Almost two-thirds (64.3%) of all participants indicated not knowing if sugar was added to cigarettes, whereas nearly a third (30.2%) responded that sugar was not added.

Awareness of the effect of added sugar on toxins in cigarette smoke was similarly low. Only 3.8% of all participants had heard that added sugar increases toxins in cigarette smoke. Further, fewer than 6% of men and women, all other demographic subgroups, all levels of cigarette consumption and smoking frequency, and those making and not making a quit attempt in past year indicated having heard of this effect. In contrast, more than 90% of participants had not heard of this effect of added sugar, whereas about 3% indicated not knowing if they had heard about this effect.

Questionnaire Comments

Forty-eight comments specifically mentioned the sugar items. Among these comments, 52% expressed an interest in obtaining more information about added sugar in cigarettes. For instance, one comment read, “Thank you for the survey, and if there’s a way to get more info about the added sugar in cigarettes, my email is [redacted], thanks!” Forty-four percent of sugar comments described not knowing sugar was added to cigarettes. In addition, 23% and 17% of comments mentioning sugar stated that the sugar items were interesting or informative, and strange or shocking, respectively. For example, one participant describing the sugar items as interesting wrote, “Nice survey, now I have to google sugar in cigarettes! Very interesting!”

Another participant commented, “The fact about sugar in regular cigarettes is shocking.” Moreover, three participants stated that learning about added sugar motivated them to quit or cut down on their smoking. For example, one participant wrote, “I did not know about the sugar in cigarettes. After reading that, I plan on doing some research and cutting back. Sugar is an addiction for me.” Another participant commented “I am very interested in learning more about the sugar in regular cigarettes! That is definitely something I will be checking into and something that I might be able to use to help motivate me to quit! Thanks for the info!!!” Interestingly, one participant left a comment suggesting possible confusion about added sugar in cigarettes raising blood sugar, similar to added sugars in processed foods and beverages. This participant wrote, “. . . I found the information about the sugar in regular cigarettes interesting. I am diabetic and wonder if it may effect [sic] my blood sugar.” Table 3 includes example comments left by participants mentioning the sugar items.

Discussion

This is the first known study to examine public knowledge and awareness of added sugar in cigarettes. Low knowledge of added sugar in cigarettes and awareness of its effect on toxins in cigarette smoke was found among a sample of more than 4000 US smokers recruited online. Knowledge and awareness of added sugar was low (<10%) among both men and women, across all age groups, education levels, racial/ethnic groups, household income, and regardless of federal poverty level. Further, several participants voluntarily provided comments about being questioned about added sugar in cigarettes, which revealed that some smokers have a desire to learn more about added sugar in cigarettes and that the items about added sugar in cigarettes were interesting and informative. Three participants also stated that information about added sugar in cigarettes may help them quit or cut down on their smoking. These findings suggest

that information about added sugar in cigarettes is quite novel and may be worth including in tobacco education efforts.

Cigarette packaging in the United States is required to display a Surgeon General’s warning about the health risks of smoking, but is not required to display any information about ingredients. Tobacco companies are required to submit ingredient lists and changes to ingredient lists to FDA,¹⁵ but FDA has not made the ingredient lists public. Many of the world’s largest cigarette manufacturers, including the two leading tobacco companies selling cigarettes in the United States, voluntarily provide ingredient lists on company Web sites.^{16–19} It is unclear whether consumers access this information or are aware this information has been made available online. Given that only 5.5% of participants responded “yes” when asked if sugar was added to cigarettes, providing lists of ingredients on Web sites may not be adequate to properly inform consumers about cigarette additives. Cigarette pack inserts and warning labels may be effective at informing consumers about added sugar in cigarettes, as these two channels have been shown to increase knowledge about harmful chemicals in cigarettes and health risks of smoking.^{20–22}

Table 1. Sample Characteristics of 4390 Smokers Recruited to Complete Online Questionnaire

	<i>n</i>	Percent
Sex		
Male	2041	46.5
Female	2343	53.4
Other	5	0.1
Age (y)		
18–24	652	14.9
25–29	1186	27.0
30–44	1899	43.3
45–59	549	12.5
≥60	103	2.4
Education		
Less than high school	51	1.2
High school or equivalent	552	12.7
Some college	1365	31.4
College degree or more	2382	54.8
Race/ethnicity		
Non-Hispanic white	3328	77.6
Non-Hispanic black	276	6.4
Non-Hispanic, other, or multiple race	351	8.2
Hispanic	336	7.8
Household income		
Less than \$25 000	899	20.9
\$25 000–\$49 999	1491	34.6
\$50 000–\$74 999	1024	23.8
\$75 000–\$100 000	545	12.7
\$100 000 or more	350	8.1
Federal poverty level		
Above	3718	86.9
Below	561	13.1
Smoking frequency		
Every day	3064	69.8
Some days	1325	30.2
Cigarettes per day		
0–10 sticks	2207	49.9
11–20 sticks	1694	38.3
>20 sticks	521	11.8
Quit attempt past 12 mo		
Yes	2357	54.0
No	2009	46.0

Table 2. Knowledge and Awareness About Added Sugar in Cigarettes by Demographic Characteristics

	Is sugar added to cigarettes?				Heard of the effect of added sugar?			
	<i>n</i>	Yes, no.(%)	No, no.(%)	Don't know, no.(%)	<i>n</i>	Yes, no.(%)	No, no.(%)	Don't know, no.(%)
Overall	4351	239(5.5)	1313(30.2)	2799(64.3)	4351	165(3.8)	4064(93.4)	122(2.8)
Sex								
Male	2022	144(7.1)	605(29.9)	1273(63.0)	2023	103(5.1)	1851(91.5)	69(3.4)
Female	2324	94(4.0)	707(30.4)	1523(65.5)	2323	61(2.6)	2210(95.1)	52(2.2)
Other	5	1(20.0)	1(20.0)	3(60.0)	5	1(20.0)	3(60.0)	1(20.0)
Age (y)								
18–24	645	47(7.3)	166(25.7)	432(67.0)	644	38(5.9)	569(88.4)	37(5.8)
25–29	1180	69(5.9)	348(29.5)	763(64.7)	1181	43(3.6)	1105(93.6)	33(2.8)
30–44	1877	92(4.9)	591(31.5)	1194(63.6)	1877	64(3.4)	1772(94.4)	41(2.2)
45–59	547	25(4.6)	177(32.4)	345(63.1)	547	17(3.1)	519(94.9)	11(2.0)
≥60	102	6(5.9)	31(30.4)	65(63.7)	102	3(2.9)	99(97.1)	0(0.0)
Education								
Less than high school	51	3(5.9)	14(27.5)	34(66.7)	51	1(2.0)	48(94.1)	2(3.9)
High school or equivalent	552	23(4.2)	177(32.1)	352(63.8)	552	20(3.6)	512(92.8)	20(3.6)
Some college	1365	71(5.2)	407(29.8)	887(65.0)	1364	53(3.9)	1274(93.4)	37(2.7)
College degree or more	2381	142(6.0)	714(30.0)	1525(64.1)	2382	91(3.8)	2228(93.5)	63(2.6)
Race								
Non-Hispanic white	3328	176(5.3)	1013(30.4)	2139(64.3)	3327	122(3.7)	3124(93.9)	81(2.4)
Non-Hispanic black	276	24(8.7)	84(30.4)	168(60.9)	276	9(3.3)	259(93.8)	8(2.9)
Non-Hispanic, other, or multiple race	351	16(4.6)	98(27.9)	237(67.5)	351	12(3.4)	326(92.9)	13(3.7)
Hispanic	335	19(5.7)	97(29.0)	219(65.4)	336	19(5.7)	303(90.2)	14(4.2)
Household income								
Less than \$25 000	899	41(4.6)	293(32.6)	565(62.9)	898	31(3.5)	832(92.7)	35(3.9)
\$25 000–\$49 999	1491	98(6.6)	449(30.1)	944(63.3)	1491	66(4.4)	1399(93.8)	26(1.7)
\$50 000–\$74 999	1023	54(5.3)	319(31.2)	650(63.5)	1024	37(3.6)	955(93.3)	32(3.1)
\$75 000–\$100 000	545	21(3.9)	149(27.3)	375(68.8)	545	14(2.6)	514(94.3)	17(3.1)
\$100 000 or more	350	24(6.9)	91(26.0)	235(67.1)	350	17(4.9)	325(92.9)	8(2.3)
Federal poverty level								
Above	3718	210(5.7)	1107(29.8)	2401(64.6)	3718	141(3.8)	3490(93.9)	87(2.3)
Below	561	24(4.3)	188(33.5)	349(62.2)	560	19(3.4)	513(91.6)	28(5.0)
Smoking frequency								
Every day	3043	158(5.2)	959(31.5)	1926(63.3)	3042	103(3.4)	2857(93.9)	82(2.8)
Some days	1308	81(6.2)	354(27.1)	873(66.7)	1309	62(4.7)	1207(92.2)	40(3.1)
Cigarettes per day								
0–10 sticks	2168	133(6.1)	616(28.4)	1419(65.5)	2168	89(4.1)	2016(93.9)	63(2.9)
11–20 sticks	1667	77(4.6)	517(31.0)	1073(64.4)	1667	57(3.4)	1568(94.1)	42(2.5)
>20 sticks	516	29(5.6)	180(34.9)	307(59.5)	516	19(3.7)	480(93.0)	17(3.3)
Quit attempt past 12 mo								
Yes	2345	105(5.2)	668(28.5)	1543(65.8)	2346	94(4.0)	2208(94.1)	44(1.9)
No	2006	134(5.7)	645(32.2)	1256(62.6)	2005	71(3.5)	1856(92.6)	78(3.9)

In addition, mass media campaigns could be used to educate the public about added sugar in cigarettes. Mass media campaigns are an essential component to tobacco control programs and are one of the most efficacious interventions for preventing tobacco use and promoting cessation. Campaigns that introduce new information or a new perspective about the health risks of smoking have been found to be effective at discouraging youth to smoke.²³ Because awareness was found to be so low among a large sample of smokers, campaigns mentioning added sugar in cigarettes and describing the effects of this ingredient could be a promising new angle for tobacco control campaigns.

Previous research has evaluated informing smokers about the presence of different constituents in cigarette smoke. For instance, Brewer et al.²⁴ found that among 24 chemicals tested, arsenic and

formaldehyde were among the highest rated for awareness and discouragement from smoking, suggesting these chemicals should be included in educational campaigns. However, no research to date has studied how smokers and nonsmokers respond to information about added sugar in cigarettes. A recently published systematic review on perceptions of cigarette smoke constituents lends support to educating the public about added sugar in cigarettes. The authors of this review found that “people knew little about cigarette additives” and “people wanted more information about constituents.”²⁵

Further, recent concerns about the effects of added sugar on health from dietary sources may enhance the public's interest in learning about added sugar in cigarettes. Current dietary recommendations call for consuming less than 10% of daily calories from added sugar.⁹ To help Americans make more informed food and

Table 3. Selected Comments Mentioning Added Sugar in Cigarettes

Comment	Category
"Thank you for the survey, and if there's a way to get more info about the added sugar in cigarettes, my email is [redacted], thanks!"	Desire to learn more/ask a question
"I really enjoyed the survey. And was really surprised to learn that sugar was added to cigarettes."	Strange/shocking
"I'm now very curious about the effects [sic] of sugar in cigarettes, as I have never heard of this before. Thanks for informing me of this."	Desire to learn more/ask a question; did not know
"Is the sugar thing real? I have to go look that up now, I had no idea."	Desire to learn more/ask a question
"... I found the information about the sugar in regular cigarettes interesting. I am diabetic and wonder if it may effect [sic] my blood sugar"	Interesting/informative
"The fact about sugar in regular cigarettes is shocking."	Strange/shocking
"I did not know about the sugar in cigarettes. After reading that, I plan on doing some research and cutting back. Sugar is an addiction for me."	Desire to learn more/ask a question; did not know; quit/cut down
"Nice survey, now I have to google sugar in cigarettes! Very interesting!"	Desire to learn more/ask a question; interesting/informative
"I am very interested in learning more about the sugar in regular cigarettes! That is definitely something I will be checking into and something that I might be able to use to help motivate me to quit! Thanks for the info!!!"	Desire to learn more/ask a question; quit/cut down
"If that question about sugar being in cigarettes is real I haven't heard of it. To me that sounds ridiculous if it is true but I find it hard to believe in my opinion."	Did not know; strange/shocking

beverage choices, FDA will soon require nutrition labeling to report quantities of added sugar.¹⁰

Educating the public about added sugars in cigarettes could have potential unintended consequences, such as creating misunderstandings about the effects of sugars in cigarettes. For instance, one participant identified as being diabetic, expressed a concern that added sugar in cigarettes may affect blood sugar. Although cigarette smoking significantly increases the risk of type 2 diabetes,²⁶ the amount of added sugar in cigarettes is very small relative to that in foods and beverages. According to the Philip Morris International's Web site, a single Marlboro Red cigarette sold in Greece contains 0.0262 g of added sugar.¹⁶ In contrast, a 12-ounce can of Coca-Cola sold in the United States contains 39 g of added sugar.²⁷ Moreover, sugars in cigarettes are not ingested as they are in foods and beverages, but instead, their combustion by-products are inhaled. According to the US Centers for Disease Control and Prevention, the increased risk of type 2 diabetes associated with smoking is due to the increased inflammation and oxidative stress caused by smoking.²⁸ Research is needed to determine how best to communicate about added sugars without causing confusion. Research is also needed to evaluate if educating the public about added sugars in cigarettes creates a perception that additive- or sugar-free cigarettes are less harmful.²⁹

This study is limited by the use of a convenience sample of smokers recruited online. For instance, the sample was more educated (54% had a college degree or higher) than the general public (33% of American adults have a college degree or higher³⁰). On average, American smokers are less educated than nonsmokers.³¹ Thus, the results presented may not be representative of US smokers, and knowledge and awareness may be even lower among less educated smokers. Further, it is possible that exposing participants to electronic cigarette advertisements and asking them questions unrelated to sugar prior to the sugar items made the questions about added sugar stand out, which may have increased the likelihood of a participant leaving a comment about added sugar. In addition, participants may have been more likely to provide a comment about the sugar items because these items came at the end of the questionnaire and directly before being prompted to provide a comment. Although all participants resided in the United States, and the US cigarette

market is dominated by cigarette brands that contain added sugar (ie, American-blended cigarettes), a few cigarette brands sold in the United States are advertised as being additive-free (eg, American Spirit). Thus, some smokers participating may have smoked an additive-free cigarette, which may have influenced their responses. However, because additive-free cigarette brands in the United States have a very low market share, this likely did not affect the study's findings.

Given the low knowledge of added sugar in cigarettes by smokers and the expressed desire to learn more about added sugar by several participants, FDA and other tobacco control organizations that educate the public on tobacco product risks should consider including information about added sugar in media campaigns. Because of the public's concern about added sugar in processed foods and beverages and the effects of sugars on cigarette smoke, educating the public about the presence of added sugar in cigarettes could be an effective new angle for campaigns to discourage smoking.

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Declaration of Interests

KMR serves as an expert consultant in litigation against tobacco companies.

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