

Original investigation

“My First Thought was Croutons”: Perceptions of Cigarettes and Cigarette Smoke Constituents Among Adult Smokers and Nonsmokers

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Abstract

Introduction: Understanding what people think about harmful and potentially harmful constituents in cigarettes and cigarette smoke has new urgency given legislation requiring US Food and Drug Administration (FDA) to disclose constituent information. Our study sought to obtain qualitative information on what people think about these constituents and the language they use to talk about them.

Methods: We conducted six focus groups in 2014 with 40 adults in North Carolina. Open-ended questions focused on cigarette and cigarette smoke constituents in general and on the 18 constituents on the FDA's abbreviated list. We coded the transcripts for emergent themes, and all four coders discussed themes until we reached consensus.

Results: Participants knew that cigarette smoke contains chemicals but did not know how many chemicals nor what those chemicals are, beyond tar and nicotine. Dangers of constituents mentioned included “chemicals,” physical disease, and addiction. Participants incorrectly believed harmful constituents came primarily from tobacco companies' additives. For unfamiliar constituents, people tried to make associations based on similar-sounding words. Recognizable constituents that participants associated with health harms most discouraged them from wanting to smoke. Most participants wanted to know health harms associated with constituents and what else the chemicals were in.

Conclusions: Participants showed enthusiasm for learning more information about constituents, and also showed substantial misunderstandings about the source of harmful constituents. Our findings contribute to the limited body of research on adults' knowledge and perceptions of cigarette smoke constituents and can aid the FDA as it plans to disclose constituent information to the public.

Implications: Our study provides information about adults' understanding of cigarette smoke constituents and what adults would like to know about these constituents. This information can help communication campaigns describe cigarette smoke constituents in a way that discourages people from wanting to smoke.

Introduction

Tobacco is the leading cause of preventable death worldwide, causing an estimated 6 million deaths a year.¹ Tobacco products and cigarette smoke contain more than 7000 constituents, many of which are toxic.²⁻⁴ Some of these constituents occur naturally in tobacco (eg, nicotine); some are added during the cigarette manufacturing process (eg, ammonia); and some are generated through burning the tobacco and paper (eg, acrolein).⁵⁻⁷ Most of the harmful health effects of smoking come from constituents created or concentrated when burning tobacco but not from chemicals added during manufacture.⁸⁻¹¹

Carcinogenic constituents include benzene, 1,3-butadiene, formaldehyde, nicotine-derived nitrosamine ketone (NNK), and N-nitrosornithine (NNN).^{6,11-13} Acrolein and acetaldehyde are two of the most harmful constituents to respiratory health, and arsenic and hydrogen cyanide pose great risk to cardiovascular health.¹³ In addition to direct health effects, constituents, particularly nicotine, may cause indirect harm to consumers by enabling tobacco product initiation, hindering cessation, or leading to higher intensity or frequency of tobacco use.¹⁴

The Family Smoking Prevention and Tobacco Control Act of 2009 requires the US Food and Drug Administration (FDA) to disseminate information about levels of harmful and potentially harmful constituents in cigarette smoke, by cigarette brand and style, in a format that is understandable and not misleading to a lay person.¹⁵ While the FDA has identified 93 harmful and potentially harmful constituents, they released an abbreviated list of 18 constituents, with established testing methods. Tobacco manufacturers will be required to report to FDA the quantity of these 18 constituents in each of their products. However, the potential impact on the public of releasing this information is largely unknown, and some studies have suggested that disclosing constituent levels could have harmful effects such as smokers perceiving that cigarettes with lower levels of constituents are less harmful.¹⁶ Extant research about the public's perceptions of cigarette smoke constituents largely focuses on quantitative measures of awareness of tobacco product and cigarette smoke constituents and attitudes about tobacco and cigarettes.¹⁷⁻²⁷ Consequently, gaps remain in our understanding of how people think about chemicals in cigarette smoke, the natural language people use to talk about constituents, potential misperceptions about the origins and dangers of various constituents, and what people want to know about constituents.^{23,26,28-30}

Previous research suggests that the public is largely unaware of the constituents in cigarettes and cigarette smoke, including those included on the FDA's abbreviated list of 18 harmful constituents.³¹ A study by Hall and colleagues²⁰ found US adult smokers and nonsmokers had heard of few of the abbreviated harmful constituents. While several constituents were familiar to most of the participants, including carbon monoxide (100%), ammonia (99%), arsenic (97%), formaldehyde (94%), and benzene (75%), awareness of the remainder was quite low: fewer than 10% were aware of nine constituents from the FDA 18 abbreviated list. Similarly, the International Tobacco Control Four Country Survey (ITC-4) found that most smokers were aware that cigarette smoke contains carbon monoxide (65%–81%), but fewer (17%–58%) were aware that it contains arsenic.^{11,12} Researchers in Australia found that smokers and nonsmokers in 15 group discussions had low awareness of cigarette and cigarette smoke constituents, and that most could only name two or three constituents, with carbon monoxide, carbon dioxide, and nicotine the most frequently mentioned.³²

In addition to a limited understanding of the public's understanding of cigarette smoke constituents in general, little is known about how people perceive individual constituents, which constituents would discourage smokers from wanting to smoke and nonsmokers from starting to smoke, and why those particular constituents elicit more discouragement than others. Hall and colleagues²⁰ found that among both smokers and nonsmokers, constituents that people had heard of tended to cause more discouragement from smoking than those that were unfamiliar. In the Australian groups, participants presented with a list of cigarette constituents reported being surprised by the number of constituents present and perceived many of the constituents as harmful, but the study did not address whether more or less familiar constituents discouraged smoking. Finally, to our knowledge, there has been no research in the peer-reviewed literature examining whether and what constituent information the public would find useful, and how they would use that information.

Our study expands on this previous research by providing in-depth qualitative information about perceptions of cigarette smoke constituents. Specifically, we explore adult smokers' and nonsmokers' knowledge and awareness of specific constituents; what they associate with those familiar and unfamiliar constituents; which constituents are the most discouraging and what makes them discouraging; and what they would like to know about cigarette smoke constituents in general. This information can inform strategies to effectively communicate about harmful constituents contained in cigarette smoke in language that is meaningful to the public and that elicits discouragement from smoking or wanting to smoke.

Methods

Participants and Recruitment

In January and February 2014, we recruited participants in central North Carolina for focus groups through purposive sampling to obtain diversity in terms of age and smoking status. Eligible participants were smoking and non-smoking young adults (ages 18–25) or adults (ages 26 or older) who self-reported that they were able to read and understand English, and who did not have cognitive or visual impairments. We defined smokers as individuals who reported having smoked at least 100 cigarettes in their lifetimes and were currently smoking cigarettes “every day” or “some days.”^{33,34}

We recruited through various media including newspaper, flyers, radio, and TV spots; e-mail listservs; and Craigslist, an online classified advertisement forum, as well as in-person recruitment at college campuses, high schools, bars, restaurants, coffee shops, tobacco retail outlets (eg, vape shops), recreation centers, skate parks, malls, gas stations, and supermarkets. Potential participants completed an eligibility screener over the phone or Internet. A staff person confirmed eligibility and scheduled respondents for one of the focus group sessions. We aimed to conduct six focus groups with young adult nonsmokers (one group), young adult smokers (two groups), adult nonsmokers (one group), and adult smokers (two groups). We scheduled 12–15 eligible people for each group, with the aim of having 7–10 participants per group, and a target enrollment of 42–60 people overall. After conducting the six focus groups, we determined that we had reached saturation in terms of new information and themes related to our research questions, and therefore did not conduct additional groups.

Procedures

Prior to beginning the focus groups, we obtained written informed consent from participants, as well as permission to audio-record the

session. A three-person team comprised of a moderator, co-moderator, and note taker conducted each 90-minute session. Moderators guided participants through each of the planned questions and used probes to elicit deeper discussion. The note taker took detailed case notes during the focus group discussions, recording which participant was speaking, the main ideas and opinions expressed, and key terms used. These notes were taken as a back-up in case audio recording failed, and used by coders who were not present at the focus groups to provide additional context to the transcript. We also audio recorded the focus group sessions. At the end of each focus group, we gave participants an informational handout about cigarette smoke constituents, the harms of smoking, and resources for quitting smoking. These materials were adapted from a National Cancer Institute (NCI) factsheet and combined with resources from the University of North Carolina Nicotine Dependence Program. Participants received a \$50 Amazon gift card for participating in the focus group. The University of North Carolina Institutional Review Board approved the study procedures.

Measures

We developed a moderator's guide with 14 open-ended questions based on the extant literature and findings from our pilot studies on knowledge and perceptions about cigarette smoke constituents.²⁴ The first part of the session was designed to be a general discussion of smoking and the chemicals in cigarettes, while the second part was about specific constituents found in cigarette smoke. As part of the moderated discussion about specific cigarette smoke constituents, we showed participants two laminated one-page documents containing lists of cigarette smoke constituents from the FDA's 18

abbreviated list.⁴ The first document ("the blue card") listed six cigarette smoke constituents: three constituents previously shown to have high familiarity (eg, carbon monoxide) and three with low familiarity (eg, crotonaldehyde).²⁴ For each constituent listed on the blue card, we asked participants what they knew about the constituent and what they associated with the constituent. The second document ("the green card") listed the initial six constituents as well as the 12 additional constituents from the FDA 18 abbreviated list.⁴ We asked participants a series of open-ended questions about the list of 18 constituents to gauge their reactions to the list, as well as what they would like to know about the constituents, and which of the constituents would most and least discourage them from smoking. Table 1 describes the two documents, constituents listed, and questions asked. We pilot tested the moderator's guide with six adult volunteers, to ensure that the wording of the questions was clear, verify that we had allotted enough time for each section of the discussion, and to explore whether to add questions or probes.

Data Analysis

An independent company transcribed the audio recordings verbatim. Our data analysis team was composed of four coders, three of whom had participated in conducting the focus groups. We first reviewed two of the focus group transcripts to identify major codes that emerged related to the research questions. After developing a draft coding scheme based on our initial review, two coders used ATLAS.ti 7.0, a qualitative data analysis program,³⁵ to independently code each transcript according to the established coding scheme, while also inductively identifying new codes and overarching themes. We then met to review the results of the coding, consolidate and

Table 1. Focus Group Materials

Document	Constituents listed	Questions asked by moderator
Blue card	Carbon monoxide Formaldehyde Ammonia Benzene Acrolein Crotonaldehyde	Now we are going to talk about the chemicals that are written on this blue card. Feel free to use this card as a reference as we talk about the chemicals. What do you know about [name of constituent] What things do you associate with [name of constituent]
Green card	Left side of card Carbon monoxide Formaldehyde Ammonia Benzene Acrolein Crotonaldehyde Right side of card Acetaldehyde Acrylonitrile 4-Aminobiphenyl 1-Aminonaphthalene 2-Aminonaphthalene Benzo[a]pyrene 1,3-butadiene Isoprene Nicotine NNK NNN Toluene	We showed you six things on the blue card. Here is a green card with some more things that are also in cigarette smoke. Take a look at them. We've already talked about the things on the left-hand side, but we haven't talked about the things on the right-hand side. All of these things on the green card are in cigarette smoke. What do you think about that? What would you want to know about the things on this card? Which of these things most discourages you from wanting to smoke? Why? Which of these things least discourages you from wanting to smoke? Why?

NNK = nicotine-derived nitrosamine ketone; NNN = N-nitrosornicotine.

eliminate codes as necessary, and reconcile coding discrepancies by consensus. We added new codes and emergent themes to the coding template, and then re-coded the transcripts using the new categories. We then performed “code and retrieve” analyses, sorting the resulting text excerpts by coded categories, and comparing these categories across the focus groups and between smokers and nonsmokers. This process allowed us to see how the participants discussed various topics and to compare how smokers and nonsmokers spoke about similar topics.

We created narrative summaries for each of the identified codes, and then reviewed them and created a summary table that contained the codes, a short narrative summary of the themes that emerged related to each code, and 1–3 quotes to illustrate each theme. All four coders reviewed the summary table, and detailed themes were discussed until consensus was met to confirm all themes. We retained some themes, consolidated others, and deleted those we considered minor or secondary from the final table of narrative summaries. This process led to a finalized table of narrative summaries for each code.

Results

Participant Characteristics

We conducted six focus groups, four with smokers and two with nonsmokers, with 40 young adult and adult participants. The mean age of focus group participants was 31 (range 18–64); 38% of the participants were female; and 63% were smokers (Table 2). In the following sections, we report the major themes that arose, organized by the four research questions. Additionally, we describe findings for topics on which differences between smokers and nonsmokers emerged. We looked for differences between young adults and adults, but did not find any major differences.

Knowledge and Perceptions About Cigarette Smoke Constituents

Both smokers and nonsmokers knew that cigarette smoke contains chemicals, but they did not have a clear sense of how many chemicals are in cigarette smoke, nor what those chemicals are, beyond nicotine. Some participants mentioned tar when asked about

Table 2. Participant Characteristics (*n* = 40)

Characteristic	<i>n</i> (%)
Age	
18–25 (young adults)	20 (50)
26–65 (adults)	20 (50)
Mean age (<i>SD</i>), years	30.8 (12.6)
Sex	
Female	15 (37.5)
Male	25 (62.5)
Ethnicity	
Non-Hispanic	37 (92.5)
Hispanic	3 (7.5)
Race	
White	27 (67.5)
Black	9 (23)
Asian	2 (5)
Other	2 (5)
Smoking status	
Smoker	25 (62.5)
Nonsmoker	15 (37.5)

chemicals in cigarette smoke, though the term refers more generally to tobacco smoke distillate. In addition, participants generally did not distinguish between chemicals in cigarettes and in cigarette smoke, even though many of the structured probes from the moderator’s guide specifically made this distinction. We identified two major themes related to participants’ perceptions about cigarette smoke constituents in general: perceptions about the dangers of these constituents, and knowledge about the origins of cigarette smoke constituents.

Theme 1: Dangers of Cigarette Smoke Constituents

“Chemicals” were the most frequently-cited dangers of cigarette smoke. Participants noted that cigarette smoke contained multiple chemicals, many of which were unknown to them, and some of which seemed ominous. Generally, participants thought several hundred chemicals were in cigarette smoke, though one participant expressed disbelief at the number of chemicals mentioned by others in the group.

“I think a cigarette is only that big. How much can they get in there?” [adult nonsmoker]

“There are all sorts of chemicals, all sorts of God knows what.” [adult nonsmoker]

“Or, I’m trying to think, there’s like something in a toilet bowl cleaner, another ingredient that was in there...it’s just like something—if you wouldn’t eat it, why would you smoke it, basically?” [young adult nonsmoker]

In addition to “chemicals” in general, participants cited specific chemicals they believed were found in cigarette smoke, including nicotine, tar, carbon monoxide, arsenic, methane, nitrogen, pesticides, and preservatives. Participants also noted health effects related to the chemicals found in cigarette smoke, such as lung and mouth cancer, heart disease, emphysema, pregnancy-related harms and DNA damage. Smokers described symptoms related to smoking that they experienced, such as shortness of breath, dizziness, headaches, and wheezing.

Finally, addiction was another danger noted by participants, who stated that the addictive nature of cigarettes is what makes people continue to smoke and therefore suffer the negative health effects from cigarette smoke. For example, one adult nonsmoker stated:

“...it’s not about the specific health effects. It’s the addiction that’s there. But to me, it’s the fact that they are addictive. It’s that fact that is why they are so bad, so harmful, dangerous. I mean, all of that. It’s the addiction that’s there. Because you can imagine a product -- and of course there are dozens of products that people consume that are loaded with bad chemicals. Maybe not as bad. I don’t really know. But they’re not addictive, mostly, these products; whether they’re like energy drinks or whatever else -- that to me, don’t really stand out as being as dangerous because they don’t have that property of addiction.” [adult nonsmoker]

As demonstrated in this quotation, the participant felt that the addictive nature of cigarettes was what made them uniquely dangerous compared to other products that may contain chemicals but that are not addictive. Both smokers and nonsmokers attributed the addictiveness of cigarettes to nicotine. One adult smoker noted:

“As far as specifics, nicotine is definitely what makes cigarettes dangerous because it’s addictive and so you just keep doing

this habit that's killing you over and over again because you're addicted." [adult smoker]

Theme 2: Origins of Cigarette Smoke Constituents

Participants overwhelmingly believed that tobacco companies add most of the harmful chemicals to cigarettes during the manufacturing process, and that these chemicals then end up in cigarette smoke. A few mentioned that some chemicals occur naturally and that others are added as part of the tobacco breeding and cultivation process (specifically genetically modified organisms and pesticides), and those participants mentioned agricultural researchers and farmers as adding chemicals to tobacco. Of the participants who acknowledged that some chemicals might occur naturally, none could name any specific chemicals besides nicotine. Participants rarely mentioned the chemicals as a product of combustion, unless they were specifically talking about the burning of the cigarette paper or filters.

Participants believed that chemicals were added to cigarettes by the tobacco industry for a variety of purposes: as fillers; to make cigarettes more addictive, stronger, or more flavorful; to help preserve them; or to make them taste consistent. There was also some discussion of adding chemicals to make cigarettes burn faster or slower.

"And I don't know the specifics, but I believe there are added chemicals. Whether it is true or not, I don't know. But I believe there are added chemicals that are put there by the tobacco companies, either as part of the processing of tobacco, or something." [adult smoker]

"The only thing I can think of for formaldehyde is for preserving because they use it for tanning leather. But the other chemicals maybe are added to make it more addictive." [young adult nonsmoker].

Regardless of the utility of the chemicals added, participants ascribed questionable motives to cigarette manufacturer and their role in contributing to the harmful constituents in cigarettes and cigarette smoke, as evidenced in the quotes below:

"I feel like what I said about it being evil, that they put it in there. I mean, there is probably some that makes the process easier, like when you are drying the tobacco, or whatever. But I also feel that they are putting a lot of crap in there to make it more addictive." [adult smoker]

"I have absolutely no idea [why tobacco companies add chemicals to cigarettes], but if I were to take a guess, I would assume that there's some sort of preservative or it's a filler like when they put rice in your meat in order to stretch it out further. I don't know. I just wouldn't be surprised if the tobacco put it there just to be horrible people because..."

[Moderator: When you say tobacco, you mean tobacco companies?]

Yeah. I just wouldn't be surprised if they were just horrible people, and ha-ha, look what we can do to you all." [young adult smoker]

"Tobacco companies aren't past sweeping up leftover tobacco from the floor and selling it." [adult smoker]

Knowledge and Perceptions About Specific Cigarette Smoke Constituents

Participants had varying levels of knowledge about the specific cigarette smoke constituents listed on the blue and green cards. [Table 3](#) describes knowledge about and associations made by participants

for the six constituents listed on the blue card. Carbon monoxide was the most widely-recognized of the six listed constituents.

Of the 18 constituents on the green card, almost all participants recognized nicotine and carbon monoxide as being in cigarette smoke, and some also knew that formaldehyde and ammonia were present in cigarette smoke. A few participants were familiar with benzene, though not necessarily that benzene is present in cigarette smoke. The remaining constituents were largely unfamiliar to participants. Many participants expressed surprise and alarm that these unfamiliar chemicals were present in cigarette smoke, and several expressed anger toward tobacco companies for not being upfront about the presence of the chemicals, as demonstrated in the following quotations.

"To me, I get really angry when I see those. More angry than I get when I see the actual full chemical name. Like, I want the full name. Even if I have no clue what it is. I am more comfortable with that, because I feel like the company is at least being upfront with the ingredients." [adult nonsmoker]

"Transparency is pretty much nonexistent in the industry so I'm guessing that's probably how they want to keep it." [young adult smoker]

Two themes emerged related to constituents unfamiliar to participants. The first was that for unfamiliar constituents, some participants created associations based on similar-sounding familiar words. For example, one participant perceived crotonaldehyde to be dangerous because of the negative associations with like-sounding formaldehyde. Similarly, participants had more neutral associations with the unfamiliar constituents if they linked them with neutral or positive familiar words.

"I try to break it down into its parts. Acro is sort of like argo." [referring to acrolein, young adult smoker]

"I've never heard of that. And then KNNN (sic)? I don't know; it just sounds like a club." [referring to NNK, adult nonsmoker]

"My first thought was croutons." [referring to seeing the word "crotonaldehyde" on the provided constituent list] [young adult nonsmoker]

Secondly, some participants felt that a list of numbers ahead of an unfamiliar constituent name made constituents seem more ominous; in some cases they linked the numbers in constituent names to "red dye #5," and other food-related chemicals. Finally, a few participants took a more noncommittal stance, arguing that just because they were unfamiliar with the constituent did not mean that it was dangerous. Those participants went on to remark that chemicals are found in "everything" now, and the chemicals found in cigarette smoke may be similar, and, therefore, not dangerous.

"So really when you look at this list, I mean, I pretty sure that no one in here knows what any of these are, except for maybe nicotine and isoprene. So what are we to say that this is not stuff that we find in Gatorade? Like maybe I just feel like a list of words I've never heard of before, I can't just assume it's dangerous, you'd have to really see what they are and how they react to your body. There's a lot of foods and preservatives, if you read like what's in a Big Mac, you can be pretty amazed, and I love Big Macs. So, yeah, this is just a list." [young adult nonsmoker]

Constituents that would most and least discourage participants from smoking

Participants were somewhat divided about which constituents would most discourage them from smoking, with some opting for the familiar constituents, and a few with constituents that were unfamiliar to

Table 3. Knowledge of and Associations With Specific Cigarette Smoke Constituents Cited by Focus Group Participants

Constituent	Knowledge	Associations	Quotes
Carbon monoxide	Most-recognized cigarette smoke constituent. Most participants were familiar with carbon monoxide, and knew that it was in cigarette smoke. Some participants mentioned that it was already on warning labels and that it is a byproduct of smoking [burning tobacco or pyrolysis] and not added by tobacco companies.	“Silent killer” Deadly Poisonous Odorless CO detectors Furnaces Fire places Chimney/ woodstoves Car exhaust	“But there’s a certain amount of carbon monoxide that we would breathe anyway. And we’re fine. Walking down the street, a car goes by -- you know kind of deal.” [adult nonsmoker] “People dying in their cars from sleeping with the car’s ignition in the garage and the windows open. “[adult smoker] “That’s the stuff you hear about, like, family of five killed in their sleep by odorless non... tasteless gas. That’s carbon monoxide. That one’s scary.” [young adult smoker]
Formaldehyde	Second-most recognized cigarette smoke constituent. Nearly all participants had heard of formaldehyde, though only some knew that it was in cigarette smoke. A few mentioned that it was off-gassing in furniture or carpets. Several focus groups mentioned knowing people who dipped cigarettes or joints in formaldehyde to increase their high.	Death Preservation Bad smell Biology class Furniture and carpet off-gassing	“It’s great for you, if you’re dead.” [adult nonsmoker]. “I’m still trying to wrap my head around how formaldehyde or all the 700 other chemicals you were mentioning get caught up in there, whether it’s just like manufacturing and being careless with that or if they’re adding, because I don’t know what purpose adding formaldehyde would serve.” [young adult nonsmoker]
Ammonia	Third-most recognized constituent. A few participants knew that ammonia was in cigarettes, but not necessarily in cigarette smoke. Participants knew that ammonia was in some cleaning solutions and urine. Several people mentioned the strong smell and a few described it as destructive or corrosive. Some participants found these associations troubling; others didn’t find the association with cleaning to be necessarily bad.	Strong smell Cat pee Cleaning products	“I think ammonia is the worst for me, you know, just because how we use it to clean stuff, makes that reactive with whatever you’re cleaning.” [young adult nonsmoker] “It’s not a very negative one for me. I don’t think cleaning is very negative.” [adult nonsmoker] “It’s nothing that anybody should be consuming.” [adult smoker]
Benzene	Many participants had vague knowledge about benzene; mostly that it was a chemical. A few participants mentioned benzene rings, and others believed it was a component of gasoline. A few people thought it might be related to sleep aids, or disinfectants for cuts, or skin care products.	Chemistry class Gasoline Antiseptic Sleep aids Skin care	“There is nothing good about benzene.” [adult nonsmoker] “Yes. I definitely heard of it but...something from a doctor’s office.” [adult smoker] “I heard it in chemistry class, but my teachers never talked about what it’s used for, like use it for reactions.” [young adult nonsmoker]
Acrolein	Almost none of the participants had heard of Acrolein. A few mentioned that they thought it might be in paint or paint thinner.	Paint thinner Nail polish No associations	“That sounds kind of pretty. But I have no idea what it is.” [adult nonsmoker] “I think of paint thinner, I don’t know why, it has acetone?” [adult smoker] “You could tell me that was in my pizza, I’d be like, great.” [young adult smoker] “I don’t feel that has anything to do with the name. It has just more to do with the fact that we hear formaldehyde. You never hear anyone, family of five killed by acrolein. That doesn’t happen.” [young adult smoker]
Crotonaldehyde	Most participants did not know anything about crotonaldehyde. Many said that it seemed scary because it sounded similar to formaldehyde.	Formaldehyde Croutons No associations	“I would automatically think it was negative, just because it’s very close to formaldehyde. But I have no clue what it is.” [adult nonsmoker] “I feel like it might be a preservative just because it ends like formaldehyde.” [adult smoker] “I never heard of that one.” [adult smoker].

CO = carbon monoxide.

them. Most participants said constituents that they recognized and associated with negative consequences were the most discouraging (ie, carbon monoxide, ammonia, formaldehyde and benzene, and their associated negative health effects), as demonstrated through the following quotation.

“I don’t know a lot of these, but I have heard of things like ammonia, and I know on the back of cleaning bottles they talk about how toxic it is, and if you ingest it, you are supposed to call poison control. And that is kind of worrisome, that it is in my cigarette.” [young adult nonsmoker].

Interestingly, several participants noted that they did not think any information about constituents in cigarette or cigarette smoke would discourage them from smoking (if they were already smokers) or discourage them from smoking any more than they already were (in the case of nonsmokers).

What Participants Wanted to Know About Cigarette Smoke Constituents

Participants wanted to understand what constituents being in cigarette smoke meant in practical terms. The most common thing that

participants wanted to know about cigarette smoke constituents were the associated health effects. As part of this, most wanted information that would allow them to know what amount of the constituent would cause harm. None expressed a need to know numerical quantities of constituents for the sake of just knowing that fact.

“What does it do, exactly, and in what combination with these other chemicals—what are the effects? What does this mean? That’s all that is really important is what does this mean for me, for my body, for my system?” [adult smoker]

“Maybe a way to measure how toxic it is. Like, carbon monoxide is deadly in large concentrations.” [adult nonsmoker]

Many also mentioned wanting to know what else the chemicals were in, for example, that said chemical is also in rat poison, and how else the chemicals were used. Some mentioned wanting to know the full names, and if available, common names of chemicals. Finally, some participants indicated wanting to know why the constituents were being added to the cigarettes, if it was for preservation, to increase addictiveness, or some other reason. For example, one participant stated:

“Specific effects, why it’s in there. A preservative, that makes sense, you know there’s the three ‘aldehydes,’ I’m guessing they are all preservatives, but why would you need three?” [adult smoker]

Participants appeared enthusiastic about learning more about unfamiliar cigarette smoke constituents, asking numerous questions about constituents to the focus group moderators, as well as to their fellow focus group participants. As noted previously, we offered participants a debriefing sheet which many took, and a few asked to take an extra copy to share with a friend or family member. This apparent enthusiasm was shared by smokers and nonsmokers alike.

Discussion

Cigarette smoke exposes smokers and nonsmokers alike to a myriad of toxic chemicals, including the 18 constituents on the FDA’s abbreviated list. Yet, while participants in our study knew that cigarette smoke contains chemicals, they often did not distinguish between chemicals in cigarettes and cigarette smoke, did not know how many chemicals were present nor what those chemicals were beyond tar and nicotine, and most believed that tobacco companies added harmful chemicals during the manufacturing process. These findings regarding the unfamiliarity with most cigarette smoke constituents and misconceptions about constituent origins are consistent with other studies.^{22,24,30} Previous research indicates that the public is aware of few constituents, and that the most familiar constituents tend to be those that warnings and campaigns have previously communicated to smokers (eg, tar and nicotine yields on packs; Surgeon General’s warning about carbon monoxide). Low awareness about cigarette smoke constituents may be due to the absence of campaigns in the United States about constituents and cigarette pack disclosure messages, which have been associated with higher constituent awareness in other countries and that are tied to campaigns and warning labels with constituent information. In contrast, campaigns and warning labels with constituent information in other countries have been associated with higher constituent awareness.^{18,27}

Participants overwhelmingly—and incorrectly—believed that tobacco companies’ additives are responsible for most of the harmful and potentially harmful chemicals in cigarette smoke. Though

most of the harmful health effects of smoking come from constituents formed when burning tobacco, manufacturers add ingredients to tobacco products, either to convey a specific taste or flavor, or for a specific purpose such as moisture provision or preservation. However, numerous toxicological studies have indicated that commonly-used tobacco ingredients do not change the toxicity of smoke as measured in specified assays. Also, the ingredients have little effect on the levels of most smoke constituents that may be relevant to smoking-related diseases. One exception to these findings is the generation of formaldehyde during the combustion of sugars and related additives, which leads to increased formaldehyde levels in cigarette smoke.¹¹

This finding on “additives” has several key implications. First, it suggests that people may think of all constituents as “additives,” and be more likely to believe that cigarettes marketed as “additive-free” or “natural” do not contain dangerous chemicals and could therefore be considered less harmful. A national survey of smokers found that nearly three quarters of them believed that chemicals added to cigarettes were more harmful than naturally-occurring constituents.²² Constituents that people believe tobacco companies add to cigarettes elicit greater discouragement from wanting to smoke and more worry about the harms of smoking.²⁴ Taken together, these findings suggest that risk messages and communication campaigns should include information about the origins of harmful constituents, specifically that harmful chemicals are naturally present in tobacco, and that additional harmful constituents are formed when a cigarette burns. Consequently, all cigarettes, even those marketed as “natural” or “additive-free,” are unsafe to use and will cause harm.

Also consistent with previous research^{36,37} was our finding that participants associated negative health effects with cigarette smoke constituents, including lung cancer, heart disease, and emphysema. In addition, we found that participants associated the chemicals in cigarettes and cigarette smoke with addiction to smoking, and that the addiction itself was considered dangerous.

Aside from nicotine, carbon monoxide, formaldehyde, and ammonia, participants were largely unfamiliar with the FDA’s abbreviated list of 18 constituents. For unfamiliar constituents, participants tried to make associations based on similar-sounding familiar words. Constituents that they associated with health harms, either because they had heard of the constituent, or because they associated the constituent with a similar-sounding word, most discouraged participants from wanting to smoke. Additionally, the finding that familiar constituents evoked more discouragement from smoking is consistent with a recent study focused on beliefs about specific harmful constituents.²⁴

Our findings indicate that although people have limited understanding of cigarette smoke constituents and what makes cigarettes harmful, they are curious and enthusiastic to learn more, especially about specific, previously unknown constituents and their health effects. The unfamiliarity with many of the abbreviated constituents presents an opportunity to educate the public about cigarette smoke constituents and their harmful effects. Given our findings, health communications campaigns that emphasize familiar or familiar-sounding constituents and their associated harms may be effective in reaching smokers and nonsmokers and discouraging them from smoking. The FDA’s “Real Cost” public media campaign, designed to prevent tobacco initiation and disrupt experimentation among youth, is using messages about “dangerous chemicals” as one theme within its larger message strategy.³⁸ Cigarette pack messages about constituents could also be a way to directly communicate with smokers in the

United States about cigarette smoke constituents. Such messages are currently on cigarette packs in countries such as Canada.³⁹ Though participants expressed interest in wanting to understand the levels of constituents present in tobacco products, previous research suggests that including numerical information can confuse and mislead the public.¹⁶ Moreover, the international consensus is moving toward providing descriptive messages about constituents on packs in the form of constituent disclosures,³⁹ rather than numerical information that can confuse consumers and be misleading.¹⁶ Given the increased popularity of e-cigarettes and other electronic nicotine delivery systems (ENDS), understanding the behavioral implications of increasing awareness of cigarette smoke constituents with regards to the use of ENDS, particularly e-cigarettes, is an important area of future research. Though some research suggests ENDS may increase the overall public health problem of tobacco⁴⁰ others suggest e-cigarettes may reduce harm by weaning smokers from combustible tobacco.⁴¹ Although ENDS are currently unregulated, in April 2014 the FDA issued a proposed rule to extend its regulatory authority to any product meeting the statutory definition of a “tobacco product” that would include hookah and e-cigarettes.⁹ Thus, manufacturers would be required to disclose the quantities of constituents in ENDS and their smoke or aerosol in the same manner as cigarettes. Our findings related to toxic cigarette smoke constituents that are also found in ENDS aerosol (eg, arsenic, carbon monoxide, and formaldehyde) may be useful in informing future research aimed at understanding the public’s perceptions of ENDS constituents and how to craft constituent disclosure messages for these products.

The findings of our study should be viewed within the context of its limitations and strengths. Qualitative research features depth over breadth, insight over generality.⁴² Our relatively small convenience sample of six focus groups ($n = 40$ participants) provides insight into how some adults in North Carolina perceived cigarette smoke constituents but leaves the generalizability of our findings to other adult smoker and nonsmokers as yet unknown. In addition, qualitative research involves subjectivity and an element of expert judgment. We used systematic research strategies to mitigate subjectivity and increase the dependability and validity of our study results. These strategies included the use of experienced interviewers; standardized interview guide and common codebook; audio-recording and transcription of interviews; use of Atlas.ti software to manage the coding of transcripts, documenting coding decisions; duplicate coding and systematic review of coded transcripts; and summary writing completed independently by multiple research team members. Finally, due to time limitations and our need to cover the planned range of topics, we were occasionally unable to pursue some topics that came up in the focus groups discussions. Study strengths include gathering in-depth qualitative information about knowledge and associations about specific high-priority tobacco smoke constituents from both smokers and nonsmokers that complements the results of previous, quantitative research.

The findings of this study are consistent with other studies that indicate the public is aware of only a limited set of constituents. The most familiar constituents tended to be those that have previously been communicated to smokers (eg, tar and nicotine yields on packs; Surgeon General’s warning about carbon monoxide). Legislation requiring the FDA to disclose constituent information provides an opportunity to increase the public’s understanding of the many additional constituents in cigarettes and cigarette smoke. The results of this study can inform efforts to craft communication campaigns, as well as constituent disclosures displayed on cigarette packs, at the point of sale displays and in other venues. Because of the misperception that tobacco companies are adding most of the constituents, risk

messages and communication campaigns might correct this misperception by including information about the origins of harmful constituents, specifically that harmful chemicals are naturally present in tobacco, and that additional harmful constituents are formed when a cigarette burns. Furthermore, our findings suggest that messages aimed at increasing familiarity with unknown harmful constituents and associating them with things people find scary may discourage people from wanting or starting to smoke.

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Declaration of Interests

None of the authors have received funding from tobacco product manufacturers. KMR has served as an expert consultant in litigation against cigarette manufacturers and Internet tobacco vendors. KMR is also a member of the Tobacco Products Scientific Advisory Committee for the FDA Center for Tobacco Products. The views expressed in this paper are his and not necessarily those of the FDA. The other authors declare no conflicts of interest.

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