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Public understanding of cigarette smoke constituents: three US surveys

Noel T Brewer[1,2], **Jennifer C Morgan**[1], **Sabeeh A Baig**[1], **Jennifer R Mendel**[2], **Marcella H Boynton**[1,2], **Jessica K Pepper**[1,3], **M Justin Byron**[1,2], **Seth M Noar**[2,4], **Robert P Agans**[5], and **Kurt M Ribisl**[1,2]

[1]Department of Health Behavior, Gillings School of Global Public Health, University of North Carolina, Chapel Hill, North Carolina, USA

[2]Lineberger Comprehensive Cancer Center, University of North Carolina, Chapel Hill, North Carolina, USA

[3]RTI International, Research Triangle Park, North Carolina, USA

[4]School of Media and Journalism, University of North Carolina, Chapel Hill, North Carolina, USA

[5]Department of Biostatistics, Gillings School of Global Public Health, University of North Carolina, Chapel Hill, North Carolina, USA

Abstract

Introduction—The Tobacco Control Act requires public disclosure of information about toxic constituents in cigarette smoke. To inform these efforts, we studied public understanding of cigarette smoke constituents.

Methods—We conducted phone surveys with national probability samples of adolescents (n=1125) and adults (n=5014) and an internet survey with a convenience sample of adults (n=4137), all in the USA. We assessed understanding of cigarette smoke constituents in general and of 24 specific constituents.

Results—Respondents commonly and incorrectly believed that harmful chemicals in cigarette smoke mostly originate in additives introduced by cigarette manufacturers (43–72%). Almost all participants had heard that nicotine is in cigarette smoke, and many had also heard about carbon monoxide, ammonia, arsenic and formaldehyde. Less than one-quarter had heard of most other listed constituents being in cigarette smoke. Constituents most likely to discourage respondents

Correspondence to: Dr Noel T Brewer, Department of Health Behavior, Gillings School of Global Public Health, University of North Carolina, 325 Rosenau Hall CB7440, Chapel Hill, NC 27599, USA; ntb@unc.edu.

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Competing interests KMR has served as an expert consultant in litigation against cigarette manufacturers and internet tobacco vendors.

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from wanting to smoke were ammonia, arsenic, formaldehyde, hydrogen cyanide, lead and uranium. Respondents more often reported being discouraged by constituents that they had heard are in cigarette smoke (all $p<0.05$). Constituents with names that started with a number or ended in 'ene' or 'ine' were less likely to discourage people from wanting to smoke (all $p<0.05$).

Discussion—Many people were unaware that burning the cigarette is the primary source of toxic constituents in cigarette smoke. Constituents that may most discourage cigarette smoking have familiar names, like arsenic and formaldehyde and do not start with a number or end in ene/ine. Our findings may help campaign designers develop constituent messages that discourage smoking.

INTRODUCTION

Smoking cigarettes is one of the leading causes of preventable deaths in the USA and globally.[12] Inhalation of smoke directly from cigarettes and secondhand smoke exposes people to scores of toxic constituents (chemicals), many of which have been directly implicated in the cardiovascular, respiratory and carcinogenic health effects of smoking.[3–5] Tobacco products and cigarette smoke have at least 93 harmful and potentially harmful constituents.[5] In the USA, the Family Smoking Prevention and Tobacco Control Act requires tobacco companies to provide information about cigarette smoke constituents by brand and subbrand to the Food and Drug Administration (FDA).[67] The law also requires FDA to disclose this information to the public in a way that is understandable and not misleading to a layperson.[6]

Research exploring how to most effectively communicate about tobacco and tobacco product constituents is at an early stage. Our recent review of the literature found low awareness and knowledge about cigarette smoke constituents other than nicotine and tar.[8–14] Additionally, our review also found that people are interested in learning more about these constituents.[81516] However, the literature has large gaps. While studies have examined awareness of a handful of constituents, we know little about the public's understanding of many other harmful constituents.[15] We also know little about how people think about constituents, including their origins or how cigarette filters affect exposure to constituents.[91718]

The goal of our paper is to identify ways to improve communication about cigarette smoke constituents in order to improve tobacco prevention and control efforts. In our prior qualitative research, familiar-sounding constituents appeared to elicit concern, while unfamiliar constituent names led people to search for meaning by using any available clues, including making associations to other words that sound or look similar.[1920] We hypothesised that constituent names that are more familiar to people or have less technical sounding names (ie, no numerical prefix, shorter) would elicit more discouragement from wanting to smoke. Since we noticed that many constituent names have similar endings (eg, ine/ene as in nicotine or ide/yde as in formaldehyde), we sought to examine whether certain constituent name endings elicited more discouragement. Finally, smokers are well known to express less concern about the harms of smoking. Thus, we hypothesised constituents would elicit less discouragement among smokers and among groups with higher smoking

prevalence, such as men, individuals with lower levels of education and gay, lesbian and bisexual (GLB) respondents.

METHODS

Participants

Adult phone survey sample—The Carolina Survey Research Laboratory (CSRL) at the University of North Carolina recruited a probability sample of 5014 adults living in the USA. From September 2014 to May 2015, CSRL recruited participants through random-digit-dial landline and cell phone frames, resulting in about 98% coverage of the US population. Geographic and household-based oversampling in areas with higher rates of poverty and smoking, as well as oversampling respondents with certain characteristics at the household level, resulted in a sample that had higher rates of smoking, poverty and young adults than the US population. To be eligible for study participation, adults had to be 18 years or older and speak English or Spanish. Elsewhere, we provide additional details on sampling design, survey methods and sample characteristics.[21] The response rate among adults was 42%, calculated using American Association for Public Opinion Research formula 4.[22]

Adolescent phone survey sample—From November 2014 to June 2015, CSRL recruited a separate probability sample of 1125 adolescents living in the USA, using random-digit-dial and list-assisted sampling frames. As with the adult sample, CSRL oversampled counties with higher prevalence of smokers and poverty. To be eligible for study participation, adolescents had to be ages 13–17 and speak English or Spanish. Interviewers obtained verbal consent from adolescents' parents or guardians and verbal assent from the adolescents. The response rate among adolescents was 66%, calculated using American Association for Public Opinion Research formula 4.[22]

Adult internet survey sample—Through Amazon Mechanical Turk, an online recruitment tool, our staff recruited a national convenience sample of 4137 adults (ages 18 or older who spoke English or Spanish) living in the USA, in December 2014. The online advertisement for the survey encouraged current smokers to participate.

The University of North Carolina's institutional review board approved all three studies.

Measures

Phone and internet surveys used the same question order, wording and response scales, with small adjustments as needed for the internet survey. As part of an iterative measures development process intended to verify that participants assigned the meaning to surveys items that we intended, we conducted cognitive interviews and a survey pilot among diverse samples of adolescents and adults, including adults with low and high education.

Constituents in general—The survey first assessed perceived source of cigarette smoke constituents: 'Where do you think most of the harmful chemicals in cigarettes and cigarette smoke come from?' with response options 'tobacco before it is made into cigarettes', 'tobacco additives' or 'burning the cigarettes'. The survey next assessed the perceived

impact of cigarette filters using the question, 'Do you think the cigarette filter traps…' with response options 'all of the harmful chemicals in cigarette smoke' (coded as 1), 'a lot of them' (2), 'some of them' (3) or 'none of them' (4).

Specific constituents—We randomised participants to 1 of 6 survey panels, each of which had questions about four different cigarette smoke constituents (see online supplementary table S1). The 24 selected constituents included the 18 on FDA's abbreviated list, 5 from the FDA's complete list of 93 constituents and 'nitrosamine'.[57] We added 'nitrosamine' as it is a more accessible term to refer to *N*-nitrosonornicotine (NNN) and nicotine-derived nitrosamine ketone (NNK), two of the most harmful constituents in cigarette smoke.[23] To examine the effect of using an acronym for the nitrosamines, the surveys used 'NNK' when referring to nicotine-derived nitrosamine ketone.

The surveys assessed awareness that each of the four constituents from the assigned panel are in cigarette smoke: 'Before today, had you ever heard that [constituent] is in cigarette smoke?'. We coded responses of yes as 1 and other responses as 0. The survey next assessed perceived harmfulness for each constituent the respondent had heard is in cigarette smoke with the measure, 'As far as you know, how harmful is [constituent] in cigarette smoke?'. The four-point response scale ranged from 'not at all' (coded as 1) to 'extremely harmful' (4). Finally, the survey assessed, 'How much does [constituent] being in cigarette smoke discourage you from wanting to smoke?'. The four-point response scale ranged from 'not at all' (coded as 1) to 'a lot' (4).[24] We chose discouragement from wanting to smoke because smokers could interpret this as quitting smoking and non-smokers as not starting to smoke. We coded constituent names for three characteristics: beginning, ending and length. Beginnings were either a number or not. Endings were 'ene'/'ine', 'ide'/'yde' and other. Length was the number of characters in the constituent name.

Demographics—The survey assessed participant characteristics, including age, sex, sexual orientation (or sexual interest, among adolescents), race, Hispanic ethnicity, education (or education of mother, among adolescents), numeracy and smoking status.[25] Numeracy was assessed with the item, 'In general, which of these numbers shows the biggest risk of getting disease?'.[26] The three response options were 'one in 10', 'one in 100' and 'one in 1000', with only the first response coded as correct (ie, high numeracy). We defined being a current smoker as smoking some days or every day and having smoked 100 or more cigarettes in one's lifetime among adults, and among adolescents as having smoked during at least 1 of the past 30 days.[27,28]

Data analysis

We used χ^2 tests to compare smokers' and non-smokers' beliefs about where constituents originate and *t*-tests to compare their beliefs about the impact of cigarette filters. We report percentages or means for awareness, perceived harm and discouragement for each of the 24 constituents. For analyses of data from the adult and adolescent phone surveys, we used sample design and sample weights to account for study design and generate nationally representative estimates (percentages and means), and we report unweighted frequencies.

We examined correlates of discouragement from wanting to smoke after hearing that a particular constituent is present in cigarette smoke. We dichotomised the outcome of discouragement from wanting to smoke, so that we could compare responses of 'a lot' (coded as 1) to other responses (0), in order to address skewing. One set of predictors were the participant characteristics shown in table 1, with age mean-centred and scaled in decades to make the estimate more interpretable. Another set of predictors were characteristics of constituents: awareness that the constituent is in cigarette smoke; and constituent name beginning (did or did not start with a number), ending ('ene'/'ine', 'ide'/'yde', other) and length (number of characters). The multilevel analyses used the SAS PROC GLIMMIX procedure with quasi-likelihood estimation, a log link function specified with a binary distribution, a random intercept and random effects, where appropriate; used the Newton-Raphson algorithm for the optimisation technique; controlled for constituent panel; and did not use survey weights. Models treated constituent characteristics as random effects and then, if not statistically significant, as fixed effects. We conducted sensitivity analyses by repeating the analyses without data for nicotine to see whether it accounted for the study findings for constituent name ending. We analysed data separately for the three surveys. We conducted analyses in SAS V.9.3 (SAS Institute, 2011) and used two-tailed statistical tests with a critical α of 0.05.

RESULTS

Respondents represented diverse demographic groups, including African-Americans (range 8–18% across the three surveys), Hispanics (8–14%) and GLBs (3–12%) as shown in table 1. Current smokers were present in all samples but most common in the internet sample (35%) and least common in the adolescent sample (3%).

Perceived source of constituents

Adults commonly believed that most of the constituents in cigarette smoke come from chemicals added by cigarette manufacturers (phone 61%; internet 72%). Relatively few adults believed that constituents come from burning the cigarette (phone 31%; internet 24%) or from tobacco before it is made into a cigarette (phone 8%; internet 4%). Adult smokers were more likely than non-smokers to believe that constituents come from additives and less likely to believe that constituents came from burning the cigarette (all $p<0.05$, table 2). Adolescents believed, in roughly equal measure, that constituents in cigarette smoke come from additives (43%) or from burning the cigarette (46%). Adolescent smokers and non-smokers showed few differences, perhaps due to the adolescent sample having few smokers.

The belief that cigarette filters trap all of the harmful chemicals in cigarette smoke was held by many adults (phone 33%; internet 22%) and adolescents (27%). Adult smokers believed that cigarette filters remove more harmful chemicals from cigarette smoke than non-smokers (weighted means: 1.81 (SE=0.02) vs 1.90 (SE=0.04), $p=0.04$) in the phone survey. Beliefs about the filter's effectiveness did not differ between smokers and non-smokers in the adult online sample or in the adolescent sample.

Awareness and perceived harmfulness of constituents

The constituent that most participants had heard is in cigarette smoke was nicotine (89–95%) (table 3). Other commonly heard-of constituents were carbon monoxide (59–70%), ammonia (39–53%), arsenic (42–66%) and formaldehyde (41–68%). Fifteen constituents had awareness levels below 25% in all three samples. Awareness of NNN showed the most variability across the samples, with relatively high awareness in the phone survey (39% of adults, 62% of adolescents) and low awareness in the internet survey (15% of adults), perhaps because hearing the constituent name read aloud drew attention to its 'nicotine' ending. Perceived harmfulness exhibited no clear pattern of results across the samples, other than acrylonitrile, hydrogen cyanide and uranium having higher perceived harmfulness ratings in two of the three samples (table 3).

Discouragement from wanting to smoke

Across all three samples, ammonia, arsenic, formaldehyde, hydrogen cyanide, lead and uranium elicited the highest discouragement from wanting to smoke (table 3). The most discouraging constituents represented a range from low to moderate awareness, as shown in figure 1 and online supplementary figures S1 and S2. Acrolein was the least discouraging constituent for all samples. Nicotine and 2-aminonaphthalene were least discouraging among adults, and benzene and toluene were least discouraging among adolescents.

Discouragement from wanting to smoke was greater for constituents that adults had heard are in cigarette smoke than for ones they had not (71% vs 68% phone survey, aOR=1.19, 95% CI 1.04 to 1.35; 46% vs 34% internet survey, aOR=2.02, 95% CI 1.79 to 2.27) in adjusted analyses (table 4). The same was true for adolescents (82% vs 74%, aOR=1.84, 95% CI 1.41 to 2.41). Among adults, discouragement was lower for constituent names that started with a number than those that did not start with a number (66% vs 70% phone survey, aOR=0.76 95% CI 0.64 to 0.91; 30% vs 39% internet survey, aOR=0.76, 95% CI 0.64 to 0.90). Adolescents showed a similar pattern that was not statistically significant.

Discouragement was lower for constituents that ended in 'ene' or 'ine' than for constituents that ended in 'ide' or 'yde', among adults (67% vs 72% phone survey, aOR=1.43, 95% CI 1.23 to 1.68; 31% vs 44% internet survey, aOR=2.21, 95% CI 1.92 to 2.55) and adolescents (73% vs 81%, aOR=1.79 95% CI 1.27 to 2.52), or for any other endings (table 4). The same pattern of findings appeared in sensitivity analyses that omitted data for nicotine (data not shown).

Shorter constituent names were more discouraging for all samples in unadjusted analyses (see online supplementary table S2), but adjusting only for constituent awareness caused these findings to lose statistical significance (table 4). In the fully adjusted models, longer names were more discouraging for the adult phone sample. Sensitivity analyses dropping constituent name length from the adjusted models showed roughly identical findings for the other variables.

With respect to participant characteristics, discouragement elicited by constituents was much higher among non-smokers than smokers across the three samples in adjusted analyses. For example, in the phone survey, 78% of adult non-smokers but only 38% of adult smokers said

the constituents would discourage them from wanting to smoke (aOR=0.09, 95% CI 0.07 to 0.11), numbers that were nearly identical for adolescents (79% vs 37%, aOR=0.08, 95% CI 0.04 to 0.17). Discouragement was also more common among women and whites in all three samples as well as adult Hispanics and less common among adult GLBs. In addition, discouragement was higher among adults who attended college and adolescents whose mothers had attended college and more numerate adults than among those with lower education or numeracy. Finally, discouragement was highest at younger ages among adolescents and older ages among adults.

DISCUSSION

Across three national samples that included a total of over 10 000 US adults and adolescents, we found that many people lacked a basic understanding of the origin of harmful chemicals in cigarette smoke. Many people did not understand that most toxic constituents in cigarette smoke come from burning the cigarette rather than from cigarette manufacturer additives. Many also incorrectly believed that cigarette filters trap the toxic chemicals in cigarette smoke. On a more positive note, we identified several principles that could inform communications about cigarette smoke constituents. People were most discouraged by familiar constituents with names that started with letters rather than numbers, but were less discouraged by ones ending with ‘ine’ as in the familiar constituent nicotine.

Most toxic chemicals develop as the cigarette burns and do not primarily come from cigarette additives.[23] The tobacco industry has invested heavily in promoting ‘additive-free’ cigarettes.[29] We speculate that exposure to this advertising may have contributed to the finding that people believe added chemicals, not chemicals inherent to the tobacco leaf and burning of cigarettes, are responsible for cigarettes’ toxicity. Another misconception noted in our study is the belief that cigarette filters trap most of the harmful substances in cigarette smoke. Future public health communications about cigarette smoke constituents should consider that many people hold erroneous beliefs. Educational campaigns and other communication vehicles such as cigarette pack constituent disclosures could attempt to address these misunderstandings.

One of the most important constituent communication principles that we identified is that familiar constituents appear to discourage more people from wanting to smoke than less familiar ones. This finding confirms and extends the previous findings of Hall *et al* and is consistent with other research on constituents.[8,15] Health communication campaigns may still be able to productively focus on less familiar constituents; however, more research is needed on how to best address low understanding of these unfamiliar cigarette smoke constituents. Campaigns with substantial resources could improve the public’s knowledge of one or two specific constituents, with the goal of simultaneously increasing awareness and discouraging smoking. For example, nitrosamines and acrolein had low awareness and were least discouraging, but research shows these are two of the most harmful constituents in cigarette smoke.[30–32] Informing the public about these harmful chemicals in cigarette smoke may be particularly important.

Other important constituent communication principles that we identified relate to constituent name characteristics. Constituent names that started with a number elicited less discouragement, perhaps because these names seemed technical, which may have prevented participants from creating meaning.[20] Constituent names ending with text that sounded like ‘ene’ were also less discouraging. We speculate that this may be due in part to an association with nicotine, a constituent that is widely associated with cigarettes but is among the least discouraging. It could also be that endings that sounded like ‘ide’ benefit from associations with highly discouraging constituent names like formaldehyde. This insight follows from some of our previous qualitative research, indicating that unfamiliar constituents lead people to find similar sounding words to establish meaning.[20] These speculations on the mechanism driving constituent name effects require further study.

Demographic differences in discouragement from wanting to smoke followed disparities in smoking prevalence and sequelae. Differences by smoking status were the most dramatic, with smokers being consistently much less discouraged than non-smokers. This finding may be an example of rejection of risk information by smokers, a common finding, or it may be a realistic self-assessment that health information on its own may not be enough to counteract the potent, addictive hold that cigarettes have on smokers.[33] Other disparities, found even after controlling for smoking status, followed patterns of smoking prevalence or risk. Discouragement was lower among respondents with lower education, sexual minorities, younger adults and older teens. The findings for smoking status, age (among adults) and education mirror previous findings reported by Hall *et al*.[15] The findings for race and sex are similar to the ‘white male effect’, a general pattern of findings in which this group minimises their risks for many potential harms.[34] Mode of constituent information delivery, read aloud or in print, may also affect constituent perceptions.[35] Our findings for phone and internet studies were largely concordant, but larger differences for constituent names endings in the online sample merit further exploration. Demographic disparities and mode effects merit special attention in the design and implementation of future research on the impact of constituent messages that could be delivered via communication campaigns, disclosures on cigarette packs, or through other means.

Our study’s strengths include the use of probability sampling for adults and adolescents in the phone survey; careful survey development and testing through cognitive interviews and pilot testing; and replication of many of our findings across three different samples. Limitations to the study include the use of cross-sectional studies that limit causal inferences about many of the associations we report. We relied on single-item measure for most constructs. The impact of constituent information on behaviour may differ, though these perceived effectiveness measures are often good correlates of intentions and behaviour and useful in the early stages of message development.[3637] We focused on the 18 constituents in the FDA’s abbreviated list, but as measurement approaches become more refined and widely available, other constituents may be important to study as well. Though we weighted point estimates for phone survey participants, we did not use weights in our multilevel analyses of discouragement as these methods are not yet well developed. Point estimates differed across the survey modes, but the pattern of associations with other variables showed many similarities. The fixed order of constituent names within panels and different composition of constituents across panels may have had some effect. Future work could include

randomisation to more evenly distribute order effects and constituent names artificially created to reflect the dimensions we examined.

As our studies are among the first to identify elements of constituent names that discourage smoking, future research should aim to replicate our findings and further fill gaps in our understanding of how best to communicate about cigarette smoke constituents. The widespread misunderstandings that constituents come from tobacco additives highlight the importance of banning the use of 'additive-free' and similar terms that falsely suggest healthfulness and risk reduction; however, educational campaigns may more effectively improve understanding of constituents than dispel myths about additives.[38] Given the current public understanding of constituents, arsenic and formaldehyde are promising topics for campaigns. We had hoped that useful topics would include nitrosamines and acrolein, two particularly harmful cigarette smoke constituents, but they had low awareness and generally elicited less discouragement than other constituents.[2332] If campaigns can invest resources to remedy low awareness, nitrosamines and acrolein may be important topics for health messages. Even though these constituents had low awareness and elicited less discouragement and have the 'ine' ending, they are important because they are particularly harmful. However, it may be more beneficial to develop awareness around acrylonitrile or various aldehydes as they do not have the less discouraging 'ine' ending reminiscent of nicotine. Research on messages and delivery channels to effectively communicate with the public about harmful constituents are an important next step for the field.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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What this paper adds

- US Food and Drug Administration is required to inform the public about toxic constituents (chemicals) in cigarette smoke.
- Prior research suggests that many US adults are not aware of cigarette smoke constituents other than nicotine and tar.
- Little research describes how the public understands constituents, particularly lesser known constituents, and their origins.
- These 3 national surveys of more than 10 000 US adults and adolescents found that most respondents mistakenly believed that constituents come from tobacco additives rather than burning the cigarette.
- Participants were more discouraged from smoking by constituents that they had heard of (eg, arsenic and formaldehyde) and less discouraged by constituents that started in a number or ended in ‘ene’/‘ine’ (eg, 1-aminonapthalene).
- In order to reduce smoking, future public health communications might focus on the constituents that are most discouraging or attempt to raise awareness of lesser known but highly toxic constituents.

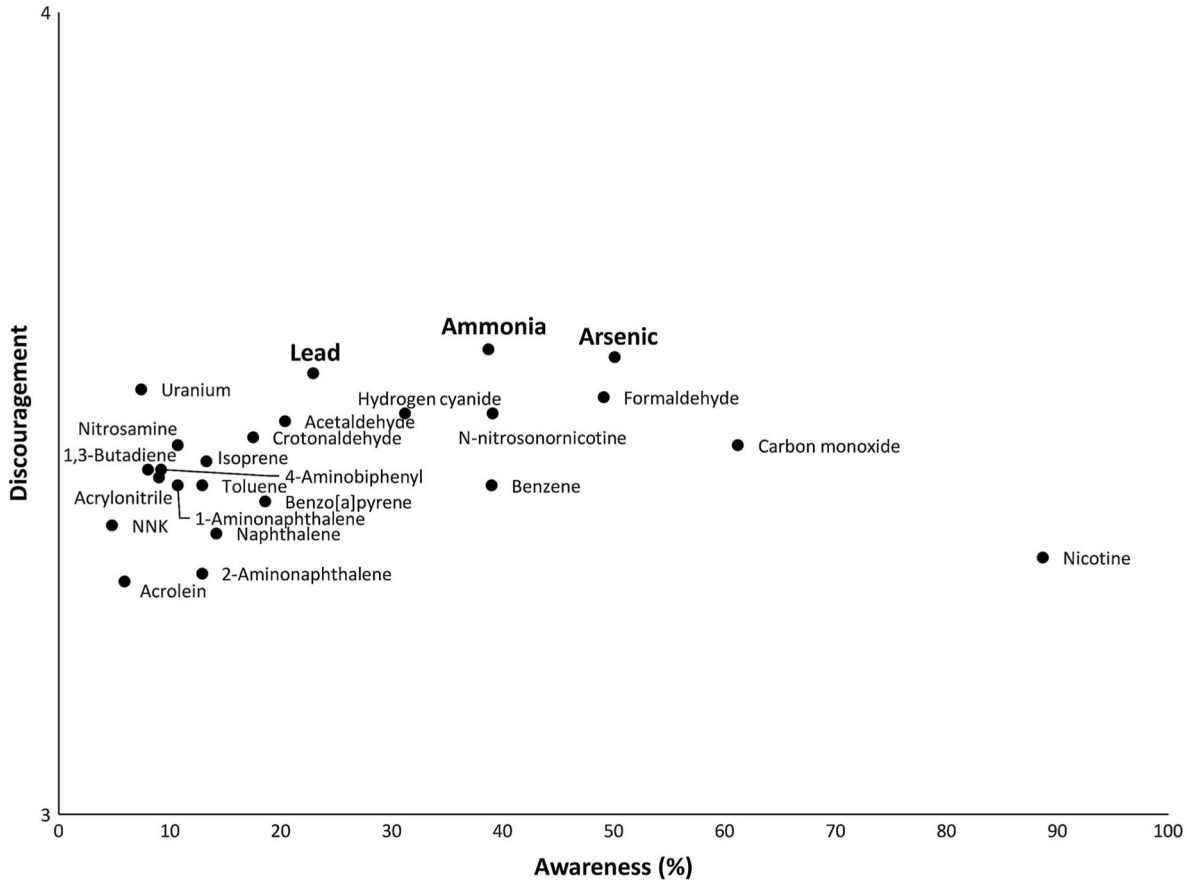

Figure 1.

Adults in national phone study: discouragement from wanting to smoke and awareness of cigarette smoke constituents.

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Table 1

Participant characteristics

	Adolescents in phone survey (n=1125)		Adults in phone survey (n=5014)		Adults in internet survey (n=4137)	
	n	Weighted %	n	Weighted %	n	%
Age						
13–17	1124	100	0	0	0	0
18–25	0	0	809	15	1010	24
26–64	0	0	3397	68	3077	75
65+	0	0	789	17	39	1
Sex						
Female	564	49	2640	51	2093	51
Male	561	51	2372	49	2042	49
Race						
African-American	119	13	978	18	313	8
American Indian	18	2	135	2	39	1
Asian	25	3	125	3	218	5
White	901	73	3473	67	3433	83
Other	61	8	281	9	131	3
Hispanic						
No	1040	90	4568	86	3787	92
Yes	85	10	432	14	340	8
Gay, lesbian or bisexual						
No	1041	96	4730	97	3656	88
Yes	42	4	192	3	478	12
Attended college						
No	218	21	1756	43	559	14
Yes	731	79	3241	57	3577	86
Numeracy						
Low	307	27	1599	32	344	8
High	818	73	3401	68	3791	92
Smoking status						

	Adolescents in phone survey (n=1125)		Adults in phone survey (n=5014)		Adults in internet survey (n=4137)	
	n	Weighted %	n	Weighted %	n	%
Non-smoker	1083	97	3856	82	2687	65
Smoker	41	3	1151	18	1441	35
Constituent panel						
1	188	16	790	16	663	16
2	192	16	849	17	718	17
3	171	16	837	17	692	17
4	182	17	779	15	685	17
5	191	17	897	17	703	17
6	201	18	862	17	676	16

Percentages for phone surveys are weighted. For adolescents, attended college is based on mother's highest level of education. For adults, smoking status is defined as having smoked at least 100 lifetime cigarettes, and currently smoke every day or some days; for adolescents, it is defined as having smoked during at least 1 of the past 30 days. GLB for adults was defined as sexual orientation; for adolescents, it was defined as sexual attraction. Alaska natives are included in the American Indian race category. Pacific Islanders are included in Asian race category.

Table 2

Source of most dangerous things in cigarette smoke

	Adolescents in phone survey		Adults in phone survey		Adults in internet survey	
	Non-smoker (n=1059)	Smoker (n=41)	Non-smoker (n=3759)	Smoker (n=1135)	Non-smoker (n=2684)	Smoker (n=1483)
	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)
Tobacco before made into cigarettes	11 (9 to 13)	0 **	8 (7 to 10)	7 (4 to 9)	4 (4 to 5)	3 (2 to 4) *
Additives	43 (40 to 46)	50 (34 to 67)	58 (56 to 61)	75 (70 to 80) **	70 (68 to 72)	77 (75 to 79) **
Burning the cigarette	46 (43 to 50)	50 (33 to 66)	33 (30 to 36)	18 (14 to 23) **	26 (24 to 28)	20 (18 to 22) **

Percentages for phone surveys are weighted. Data missing for 3% of adolescent non-smokers.

* p<0.05,

** p<0.001.

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Table 3

Reactions to cigarette smoke constituents

	Aware constituent is in cigarette smoke %			Perceived harm Mean			Discouragement Mean		
Constituent	**Adol. phone**	**Adult phone**	**Adult internet**	**Adol. phone**	**Adult phone**	**Adult internet**	**Adol. phone**	**Adult phone**	**Adult internet**
1,3-Butadiene	8	8	11	3.11	3.06	2.92	3.63	3.43	2.79
1-Aminonaphthalene	14	11	10	2.92	2.95	2.91	3.57	3.41	2.74
2-Aminonaphthalene	13	13	5	2.86	3.01	2.92	3.57	3.30	2.60
4-Aminobiphenyl	13	9	7	3.33	3.37	3.00	3.61	3.43	2.81
Acetaldehyde	18	20	21	3.22	**3.48**	2.86	3.62	3.49	2.87
Acrolein	6	6	7	**3.41**	3.27	2.70	3.48	3.29	2.61
Acrylonitrile	14	9	7	3.16	**3.44**	**3.10**	3.69	3.42	2.94
Ammonia	47	39	53	3.18	3.27	2.76	**3.78**	**3.58**	3.16
Arsenic	42	50	66	3.19	3.14	2.95	3.70	**3.57**	**3.30**
Benzene	37	39	41	3.08	3.13	2.76	3.52	3.41	2.81
Benzo(a)pyrene	15	19	19	**3.38**	3.38	2.93	3.62	3.39	2.83
Carbon monoxide	**59**	**61**	**70**	3.34	3.12	2.77	3.74	3.46	3.04
Crotonaldehyde	20	17	5	3.22	3.21	2.91	3.63	3.47	2.76
Formaldehyde	41	**49**	**68**	3.35	3.29	2.95	**3.78**	3.52	**3.28**
Hydrogen cyanide	33	31	34	3.33	**3.54**	**3.18**	3.69	3.50	3.22
Isoprene	18	13	9	3.33	3.34	2.82	3.61	3.44	2.93
Lead	33	23	27	3.30	**3.44**	2.94	**3.76**	**3.55**	**3.31**
Naphthalene	20	14	19	3.20	3.19	2.72	3.59	3.35	2.83
Nicotine	**92**	**89**	**95**	3.34	3.26	2.56	3.67	3.32	2.54
Nitrosamine	21	11	8	3.26	3.26	2.76	3.60	3.46	2.81
N-nitrosonornicotine	**62**	39	15	3.28	3.24	2.73	3.67	3.50	2.76
NNK	13	5	3	3.18	3.27	2.71	3.66	3.36	2.74
Toluene	11	13	21	3.01	3.11	2.81	3.55	3.41	2.79
Uranium	19	7	10	**3.58**	3.41	**3.11**	3.72	3.53	3.23

Percentages for phone surveys are weighted. Three constituents with the highest values for each survey sample in bold. Response scale for perceived harm and discouragement ranged from ‘not at all’ (coded as 1) to ‘a lot’ (coded as 4). For awareness, the median SEs were 2%/3%/1% in adult phone/adol. phone/internet surveys. For perceived harm, the median SEs were 0.10/0.08 in phone/internet surveys. For discouragement, the median SEs were 0.06/0.04 in phone/internet surveys. Perceived harm assessed only for participants aware the constituent was in cigarette smoke. Percentages and means for phone survey were weighted.

Adol., adolescent.

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Table 4

Correlates of discouragement from smoking

	Adolescents in phone survey (n=863)		Adults in phone survey (n=4445)		Adults in internet survey (n=4024)	
	%	aOR (95% CI)	%	aOR (95% CI)	%	aOR (95% CI)
Constituent characteristics						
Respondent aware constituent is in cigarette smoke						
No	73.7	Ref	68.0	Ref	34.2	Ref
Yes	81.5	1.84 (1.41 to 2.41) **	71.3	1.19 (1.04 to 1.35) *	45.5	2.02 (1.79 to 2.27) **
Constituent name starts with number						
No	77.9	Ref	69.9	Ref	39.3	Ref
Yes	71.2	0.88 (0.60 to 1.29)	65.7	0.76 (0.64 to 0.91) *	29.7	0.76 (0.64 to 0.90) *
Constituent name ending						
‘ene’ or ‘ine’	72.8	Ref	66.5	Ref	30.5	Ref
‘ide’ or ‘yde’	80.8	1.79 (1.27 to 2.52) **	71.9	1.43 (1.23 to 1.68) **	43.5	2.21 (1.92 to 2.55) **
Other	80.4	1.95 (1.44 to 2.64) **	71.7	1.78 (1.54 to 2.06) **	45.8	2.89 (2.55 to 3.28) **
Constituent name length		0.99 (0.95 to 1.03)		1.02 (1.00 to 1.04) *		0.99 (0.97 to 1.01)
Person characteristics		Ref		Ref		Ref
Age		0.23 (0.07 to 0.81) *		1.21 (1.15 to 1.27) **		1.39 (1.30 to 1.49) **
Sex						
Female	81.2	Ref	74.7	Ref	43.5	Ref
Male	72.6	0.52 (0.37 to 0.73) **	63.1	0.47 (0.40 to 0.56) **	31.9	0.50 (0.43 to 0.57) **
Gay, lesbian or bisexual †						
No	76.9	Ref	69.7	Ref	38.6	Ref
Yes	75.5	1.02 (0.43 to 2.42)	56.8	0.64 (0.42 to 0.96) *	31.4	0.72 (0.57 to 0.91) *
Race						
White	82.0	0.60 (0.38 to 0.95) *	75.6	0.51 (0.42 to 0.62) **	45.0	0.63 (0.52 to 0.77) **
Other	75.7	Ref	66.7	Ref	36.3	Ref
Hispanic						
No	77.3	Ref	68.6	Ref	37.1	Ref

	Adolescents in phone survey (n=863)		Adults in phone survey (n=4445)		Adults in internet survey (n=4024)	
	%	aOR (95% CI)	%	aOR (95% CI)	%	aOR (95% CI)
Yes	70.3	0.53 (0.27 to 1.02)	76.0	1.38 (1.01 to 1.89) *	45.2	1.67 (1.27 to 2.18) **
Attended college †						
No	75.3	Ref	70.4	Ref	37.7	Ref
Yes	82.2	1.99 (1.29 to 3.06) *	66.8	1.35 (1.12 to 1.62) *	38.2	1.54 (1.24 to 1.92) **
Numeracy						
Low	75.6	Ref	66.0	Ref	30.7	Ref
High	77.2	1.11 (0.75 to 1.63)	70.5	1.34 (1.12 to 1.60) *	38.4	1.59 (1.21 to 2.08) **
Smoking status						
Non-smoker	78.7	Ref	78.3	Ref	48.6	Ref
Smoker	37.1	0.08 (0.04 to 0.17) **	38.3	0.09 (0.07 to 0.11) **	17.8	0.12 (0.11 to 0.15) **

Outcome was being ‘a lot’ discouraged from wanting to smoke. Adjusted models controlled for all variables in table and constituent panel. The intraclass correlation was 0.45 for adolescents, 0.55 for adults in the phone survey and 0.48 for adults in the internet survey.

* p<0.05,

** p<0.001.

† For analyses of adolescent data, attended college was whether mother attended college and sexual orientation was sexual attraction to people of the same sex.

aOR, adjusted OR; Ref, reference group.