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Original investigation

Effective Message Elements for Disclosures About Chemicals in Cigarette Smoke

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Abstract

Introduction: Cigarette smoke contains at least 93 chemicals or "constituents" that the Food and Drug Administration has identified as harmful and potentially harmful constituents to human health. Our study sought to identify which constituent disclosure message elements are most effective in discouraging people from smoking.

Methods: Three hundred eighty eight current smokers aged 18 and older completed an online survey in February 2015. We randomized participants to respond to one of two sets of 13 toxic products that contain cigarette constituents and 25 health effects associated with cigarette constituents.

Results: Products that elicited the most discouragement were those with lower chances of exposure (e.g., explosives), followed by products with possible exposure (e.g., rat poison), and products with a high likelihood of exposure (e.g., floor cleaner). Awareness of toxic products that constituents are found in ($p < .001$) and low exposure products ($p < .001$) were associated with higher discouragement. Health effects that people had heard are caused by cigarette smoke constituents elicited higher discouragement from smoking cigarettes ($p < .001$). Cancer was associated with higher discouragement relative to respiratory, cardiovascular, and reproductive health effects (all $p < .001$).

Conclusions: Cigarette smoke constituent messages may be more effective at discouraging smoking if they include information about carcinogenic health effects (e.g., mouth cancer and lung tumors) and low exposure toxic products (e.g., explosives and radioactive material) as message elements.

Implications: Our study identified health effects and toxic products, especially cancers and rarely encountered toxic products, that may discourage smoking when included in disclosure messages. By constructing messages that communicate the harms associated with tobacco use by contextualizing those harms in terms of specific constituents, tobacco education messaging efforts may be increasingly successful.

Introduction

Cigarette smoking causes approximately one in five deaths each year in the United States,[1] which translates to an estimated economic cost of $170 billion in direct medical care costs and over $156 billion in lost productivity.[1,2] The negative health impacts of cigarette smoking are largely attributable to the effects of harmful constituents (i.e., the chemical compounds in combusted tobacco) that people inhale, ingest, or absorb into their body through exposure to cigarette smoke.[3] When burned, cigarette smoke contains over 7000 constituents,[3] of which the Food and Drug Administration (FDA) has currently identified 93 as harmful and potentially harmful constituents because they are known to be associated with one or more of the five most serious health consequences of cigarette smoking: cancer, cardiovascular disease, respiratory effects, reproductive problems, and addiction.[4]

The 2009 Family Smoking Prevention and Tobacco Control Act (section 206) directed FDA to make constituent information publicly available in a manner that is informative and not misleading.[5] However, the most appropriate means of meeting this mandate remains unclear.[6] Several studies have examined people's knowledge, risk perceptions, and attitudes regarding specific tobacco constituents, both qualitatively[7,8] and quantitatively.[9] Results show that with the exception of nicotine, carbon monoxide, and tar, most people have little knowledge or understanding of tobacco constituents[10–13] but that greater awareness of constituents may discourage people from wanting to smoke.[14] This research also indicates that the approach of listing constituent names with amounts or levels of the chemicals may be misleading by giving the impression that cigarettes with lower amounts of constituents cause less harm.[6] Instead, the international consensus on constituent disclosures is moving toward descriptive messages that inform smokers about the presence of a constituent and its associated harm[15]

Constituent Disclosure Message Elements

Research suggests that two compelling message elements for communicating harm within the context of constituent disclosure messages are (1) toxic products that cigarette smoke constituents are also found in and (2) health effects caused by constituents.[16] Constituent disclosure messages may be strengthened by communicating information about other toxic products that tobacco constituents are also found in (e.g., Cigarette smoke contains arsenic. This is found in termite poison). Smokers may have difficulty understanding the danger and toxicity of specific tobacco constituents, particularly lesser known constituents (e.g., crotonaldehyde), because a nuanced understanding of toxicology is required. Communicating that these constituents are found in other toxic products is a way to help smokers understand the danger of such constituents and may increase the extent to which such messages discourage smoking.[16] For these reasons, recent tobacco education campaigns have begun using this approach. For example, the FDA's *The Real Cost* campaign describes formaldehyde, a constituent found in cigarette smoke, as "last seen in: embalming fluid, car wax and shampoo, carpet cleaner, fabric softener, explosives, wood glue…also found in cigarette smoke."[17] Describing constituents in a way that conjures up images of other toxic products may be a promising communication strategy, but to date this approach has received little research attention.[11]

Messages may also be strengthened by the addition of specific health effects related to exposure to the constituent (e.g., Cigarette smoke contains arsenic. This causes heart damage). Communicating the health effects associated with specific tobacco constituents may be meaningful to consumer understanding of the harmful effects of constituents[6,18] and may have more impact on cessation-related outcomes.[8,16,18,19] The FDA has published a list of 93 harmful and potentially harmful constituents known to be associated with one or more of the five most serious health consequences of cigarette smoking (i.e., cancer, cardiovascular disease, respiratory effects, reproductive problems, and addiction).[4] Therefore, the scientific evidence is at a juncture where many health effects of smoking can be tied to specific tobacco constituents and communicated to smokers through disclosure messages.

While constituent disclosure messages that include toxic products and health effects may be a promising way to communicate the harms of smoking,[16] systematic research to develop effective and evidence-based disclosure messages is needed. Our study builds upon research that began with focus groups examining smokers and nonsmokers' knowledge and beliefs about cigarette smoke constituents,[8] which then informed national surveys of the public's understanding of constituents.[9] In the current study, we sought to extend this previous work by exploring which *categories* of constituent-associated health effects and toxic products most discouraged smoking by conducting an experimental study of smokers. Our goal was to inform the development of disclosure messages about cigarette smoke constituents for use on cigarette packs and dissemination through other media.

Methods

Participants

In February 2015, we recruited 500 US adults (18+) through Amazon Mechanical Turk, a marketplace for online workers;[20] the study announcement encouraged smokers to participate. We report data for 388 participants who were current smokers (had smoked at least 100 cigarettes in their lifetimes and reported smoking every day or some days at the time of the survey).[21]

Procedures

Based on previous national surveys of US adults examining perceptions of cigarette smoke constituents,[9] we selected six constituents shown to be particularly effective in increasing smoking discouragement (i.e., arsenic, formaldehyde, lead, uranium, ammonia and nitrosamines). Using the Centers for Disease Control and Prevention website and other published toxicological resources,[22–24] we identified 26 poisonous, industrial, and other products not intended for human consumption that contain the 6 selected constituents. Next, we compiled a list of 50 descriptive terms for the various health effects associated with exposures to these constituents. The health effects were identified through the Agency for Toxic Substances and Disease Registry[25–29] and from the International Agency for Research on Cancer monographs.[30] For some of the health effects, multiple descriptors were included to incorporate lay-language variations that may be better recognized by the general population. For instance, to describe negative outcomes in the lung, we used terms such as lung disease, lung damage, and damage to lung tissue. Throughout this process, the team's two toxicologists provided input on the veracity of all message elements.

We divided the toxic products into three categories based on frequency of exposure in the course of everyday life (i.e., familiarity). The first category contained products that people are routinely exposed to (e.g., car exhaust, floor cleaner, and batteries). The second category contained products that people are occasionally exposed to (e.g., rat poison, motor oil, and bullets) but are unlikely to come into contact with on a regular basis. The third category contained products people rarely or never encounter (e.g., explosives, embalming fluid, and chemical weapons). Based on FDA constituent classifications, we placed each selected health effect into one of six categories: carcinogen, respiratory toxicant, cardiovascular toxicant, reproductive toxicant, addiction, or "other" category for the few remaining health effects that did not fit into FDA's five main categories (e.g., tooth decay).[4]

Due to the large number of products and health effects, the study employed a split panel design, wherein we randomized participants into one of two panels that each contained constituent messages about 13 products and 25 health effects. Because one can communicate about constituents in the cigarettes themselves or in cigarette smoke, we also randomized participants in each panel to receive either "cigarettes contain" or "cigarette smoke contains" in the question stem to examine whether the stems influenced responses. Each survey contained 40 questions and took participants an average of 11 min to complete. Each participant received $2 for taking the survey. The University of North Carolina at Chapel Hill Institutional Review Board approved the study.

Measures

To assess toxic product awareness, the survey asked, "Have you ever heard that harmful chemicals in [cigarettes / cigarette smoke] are also found in…" followed by the randomly assigned panel of 13 products (e.g., rat poison, batteries, and car wax). Similarly, to assess health effect awareness, the survey asked participants, "Have you ever heard that harmful chemicals in [cigarettes / cigarette smoke] can cause the following health problems…" followed by the randomly assigned panel of 25 health effects (e.g., heart disease, lung tumors, and cancer). Both questions used a "check all that apply" response format.

Next, the survey stated, "[Cigarettes have / Cigarette smoke has] harmful chemicals that are found in the things below" and repeated the list of toxic products in which tobacco constituents are also found. For each product, the survey stated, "How much does it discourage you from smoking to know that chemicals in [cigarettes / cigarette smoke] are also *found in*…" The four-point response scale ranged from *not at all* (coded as 1) to *a lot* (coded as 4). For health effects, the survey stated, "[Cigarettes have / cigarette smoke has] harmful chemicals that cause many health problems." For each product, the survey then assessed, "How much does it discourage you from smoking to know that chemicals in [cigarettes / cigarette smoke] cause…" The items used the same 4-point response scale. The survey software randomized the order of products and health effects to account for any possible order effects of the message elements.

The survey assessed participant age, sex, education, race, ethnicity, sexual orientation, annual household income, and numeracy (using a validated 3-item measure[31]). With respect to smoking-related behaviors, the survey assessed smoking frequency (number of cigarettes smoked in the last 30 days), number of cigarettes smoked each day, and quit intentions (planning to quit smoking within the next month, within the next 6 months, sometime in the future beyond 6 months, or not planning to quit).

Statistical Analysis

We conducted preliminary chi-square analyses to examine differences between the two survey panels with respect to respondents' demographic characteristics and tobacco use. To examine whether using "cigarette smoke…" or "cigarettes…" in toxic product and health effect question stems affected discouragement, we used independent samples *t*-tests. Of 26 comparisons for toxic products, only 2 were statistically significant, both favoring "cigarette smoke." Of 50 comparisons for health effects, only 5 were statistically significant, again favoring "cigarette smoke." Given the few differences found (8% of toxic products and 10% of health effects), we collapsed the conditions in the descriptive analyses.

To identify correlates of discouragement from smoking, we built a multilevel model for toxic products and again for health effects. As discouragement was normally distributed variable in both cases, we conducted the analyses using the PROC MIXED procedure in SAS 9.3 (SAS Institute Cary, NC), with degrees of freedom determined using an Satterthwaite approximation. The analysis strategy employed a bottom-up model building approach. For each outcome, we first examined an intercept-only model and computed the intraclass correlation (ICC) to characterize the amount of Level 2 variability. Next, we examined each person characteristic (i.e., Level 2 variables) and message characteristic (i.e., Level 1 variables) as predictors in separate unadjusted models, treating the intercept and awareness of toxic products or health effects as random effects due to statistically significant variance/covariance estimates identified during the model building process. Finally, we examined an adjusted model for each discouragement outcome that included as predictors any variables with p values <.10 in the unadjusted models and demographic variables that we selected a priori as potentially important covariates. Text and tables report findings from adjusted models as unstandardized regression coefficients (b), with findings from unadjusted models appearing only in the tables. Critical α was 0.05, and statistical tests were two-tailed.

Results

Demographics

Smokers' average age was 37 (SD = 11.3; range 19–75 years), 50% were female, and the majority were White (86%), had at least some college education (82%), and made less than $50 000 per year (64%). Participants reported smoking an average of 14.6 cigarettes per day (SD = 8.8), and about half (52%) intended to quit within the next month to 6 months. Fifty-three percent of smokers reported having used a tobacco product other than cigarettes at least once within the last 30 days (Table 1). The survey panels did not differ on any of these demographic characteristics.

Toxic Products

Awareness that toxic products contained chemicals also found in cigarette smoke ranged from 4% (nuclear reactors) to 67% (rat poison; Table 2). Awareness was highest for rat poison (67%), embalming fluid (61%), pesticides (58%), and car exhaust (46%) and generally lowest for products associated with nuclear energy (nuclear reactors, 4% and radioactive material, 13%) and weaponry (bullets, 4%, and nuclear weapons, 7%).

Toxic products that most discouraged participants from smoking were those that people are rarely exposed to (nuclear reactors, M = 3.13, embalming fluid, M = 3.12; Table 3), closely followed by products that people are occasionally exposed to (rat poison, M = 3.19, and termite poison, M = 3.11). The least discouraging products were those that people are frequently exposed to (tobacco, M = 1.81, and soil M = 2.10).

Table 1. Sample characteristics, *N* = 388

	Panel 1, *n* = 184, % (*n*)	Panel 2, *n* = 204, % (*n*)	Overall, *N*= 388, % (*n*)
Age, mean years (*SD*) [range]	38 (12) [19–75]	36 (11) [20–71]	37 11) [19–75]
Age, years			
18–25	11% (21)	11% (23)	11% (44)
26–34	39% (71)	44% (89)	41% (160)
35–44	27% (50)	23% (46)	25% (96)
45–54	11% (20)	12% (24)	11% (44)
55–64	10% (18)	9% (19)	10% (37)
65+	2% (4)	1% (2)	2% (6)
Race			
White	88% (161)	85% (173)	86% (334)
Black or African American	5% (10)	7% (15)	6% (25)
Native American	1% (2)	2% (3)	1% (5)
Asian	2% (4)	3% (7)	3% (11)
Other	4% (7)	3% (6)	3% (13)
Hispanic	8% (14)	11% (23)	10% (37)
Male	52% (96)	48% (98)	50% (194)
Gay, lesbian, or bisexual	11% (21)	9% (19)	10% (40)
Education			
High school diploma or less	17% (31)	19% (39)	18% (70)
Some college	34% (63)	30% (62)	32% (125)
Associate's degree	16% (29)	15% (31)	16% (60)
College degree	26% (47)	30% (62)	28% (109)
Master's degree	5% (10)	3% (7)	4% (17)
Professional or doctoral degree	2% (4)	2% (3)	2% (7)
Low numeracy, < 4 items correct	36% (67)	30% (61)	33% (128)
Household income, per year			
\$0–\$25 000	22% (40)	30% (61)	26% (101)
\$25 000–\$49 999	40% (73)	37% (76)	38% (149)
\$50 000–\$74 999	25% (46)	18% (36)	21% (82)
\$75 000–\$100 000	8% (14)	8% (16)	8% (30)
> \$100 000	6% (11)	7% (15)	7% (26)
Cigarettes smoked per day, mean (*SD*)	15 (9)	15 (8)	15 (9)
Cigarette quitting stage of change			
Within the next 6 months	51% (93)	53% (108)	52% (201)
Sometime in the future	33% (61)	33% (67)	33% (128)
Not planning to quit	16% (30)	14% (29)	15% (59)
Other tobacco product use in past 30 days			
E-cigarettes or other vaping devices	38% (69)	38% (78)	38% (147)
Traditional cigars	12% (22)	10% (21)	11% (43)
Cigarillos	10% (18)	7% (15)	9% (33)
Filtered cigars or little cigars	13% (23)	6% (13)	9% (36)
Pipe filled with tobacco	3% (6)	3% (6)	3% (12)
Hookah	8% (14)	6% (13)	7% (27)
Snus pouches	2% (4)	2% (3)	2% (7)
Smokeless tobacco	4% (8)	4% (8)	4% (16)
None of the above	44% (81)	49% (100)	47% (181)

Abbreviation: *SD* = standard deviation.

Awareness that chemicals in cigarette smoke are found in toxic products was associated with higher discouragement (b = 0.17, p < .001) in the adjusted multilevel analysis (Table 4). Products in the rarely exposed category elicited more discouragement from smoking, (b = 0.21, p <.001), and products in the frequently exposed category elicited less discouragement (b = −0.25, p < .001), when compared to products in the occasionally exposed category. Questions that asked about "cigarette smoke" elicited higher discouragement than questions about "cigarettes" (b = 0.18, p < .05). Men reported lower discouragement than women (b = −0.19, p < .05). Within-person variability for product ratings was notable, explaining 37% of the variance in the multilevel analysis (ICC = 0.63).

Health Effects

Awareness of health effects associated with chemicals in cigarette smoke ranged from 7% (eye cancer) to 99% (lung cancer; Table 3). Awareness was generally highest for health effects associated with lung damage (lung cancer 99%, lung damage 96%, and lung disease 95%), respiratory issues (shortness of breath 95% and persistent coughing 91%), and oral cancers (throat cancer, 95%). Awareness was lowest for cancers not typically associated with the respiratory system, such as bladder cancer (10%) and bone cancer (13%).

Health effects related to the lungs, mouth, and heart generally exhibited the highest levels of smoking discouragement (Table 3).

Table 2. Toxic products that contain constituents found in cigarette smoke, $N = 388$[a]

	Awareness	Discouragement, 1 = *not at all* to 4 = *a lot*	
	%	*M*	*SD*
Never/rarely exposed	20.5	3.07	1.05
Nuclear reactors	3.8	3.13	1.10
Embalming fluid	60.6	3.12	0.99
Radioactive material	13.3	3.12	1.09
Poisonous gas	30.0	3.09	1.00
Chemical weapons	13.0	3.09	1.01
Nuclear weapons	7.4	3.00	1.11
Explosives	12.0	2.92	1.06
Occasionally exposed	25.0	2.87	1.05
Rat poison	67.4	3.19	1.02
Termite poison	16.3	3.11	0.98
Pesticides	58.1	3.04	0.97
Motor oil	9.4	2.95	1.00
Old paint	17.9	2.83	1.05
Ammunition	7.9	2.77	1.07
Fertilizer	46.7	2.77	1.06
Bullets	4.3	2.67	1.13
Wood glue	16.3	2.66	1.00
Wood preservatives	15.3	2.66	1.05
Car wax	8.7	2.64	1.03
Frequently exposed	25.3	2.62	1.10
Batteries	26.6	3.04	1.03
Floor cleaner	21.2	2.97	0.95
Household cleaners	42.4	2.90	1.00
Car exhaust	45.8	2.88	0.99
Carpet cleaner	12.5	2.82	1.02
Preservatives	39.1	2.39	1.10
Soil	13.0	2.10	1.09
Only tobacco	11.8	1.81	1.02

Abbreviations: *M* = mean, *SD* = standard deviation.
[a]Toxic products are ordered from most to least discouraging within each frequency of exposure category.

Cancer was the most discouraging health effect category ($M = 3.10$, $SD = 1.02$), followed by respiratory ($M = 3.00$, $SD = 0.97$), cardiovascular ($M = 2.99$, $SD = 1.01$), and reproductive health effects ($M = 2.40$, $SD = 1.20$).

Awareness of the health effect was associated with greater discouragement ($b = 0.27$, $p < .001$) in the adjusted multilevel analysis (Table 4). Cancer was more discouraging than cardiovascular effects ($b = -0.14$, $p < 0.001$), respiratory effects ($b = -0.19$, $p \leq .001$), and reproductive/developmental effects ($b = -0.66$, $p < .001$). Within-person variability for health effect ratings was substantial, explaining 41% of the variance in the multilevel analysis (ICC = 0.59).

Discussion

Our study findings suggest that both toxic products and health effects may be useful message elements for communicating the potential harms of smoking and that they vary greatly in the extent to which they discourage smoking. Understanding the possible impact of associating toxic products with cigarette constituents represents a fairly new area of constituent disclosure research, and findings from our

Table 3. Health effects associated with constituents in cigarette smoke, $N = 388$[a]

	Awareness	Discouragement, 1 = *not at all* to 4 = *a lot*	
	%	*M*	*SD*
Cancer	49.6	3.10	1.02
Lung cancer	99.0	3.34	0.88
Throat cancer	94.6	3.29	0.87
Cancer	96.6	3.27	0.92
Oral cancer	87.3	3.26	0.89
Lung tumors	91.3	3.23	0.99
Mouth cancer	93.5	3.23	0.98
Esophagus cancer	82.1	3.20	0.98
Bone cancer	13.2	3.14	0.98
Lip cancer	60.6	3.13	0.96
Liver cancer	22.8	3.11	1.04
Pancreatic cancer	17.9	3.07	1.04
Leukemia	17.4	3.07	1.06
Kidney cancer	20.2	3.05	1.00
Eye cancer	7.1	3.04	1.10
Bladder cancer	9.8	3.03	1.07
Skin cancer	29.3	2.91	1.04
Breast cancer	22.5	2.79	1.12
Prostate cancer	20.7	2.71	1.18
Respiratory	83.4	3.00	0.97
Lung disease	94.6	3.27	0.96
Lung damage	95.7	3.24	0.95
Permanent breathing problems	90.1	3.21	0.90
Damage to lung tissue	94.6	3.12	0.90
Lung infections	87.3	3.07	0.94
Asthma	66.2	2.99	0.96
Chronic bronchitis	82.1	2.98	0.96
Shortness of breath	95.1	2.82	1.01
Respiratory tract infections	71.2	2.78	0.98
Persistent coughing	90.6	2.77	0.96
Pneumonia	48.4	2.76	1.00
Cardiovascular	62.9	2.99	1.01
Heart damage	81.8	3.24	0.91
Heart disease	91.3	3.20	0.99
Stroke	64.1	3.17	0.99
Heart attack	78.8	3.14	0.93
Damage to blood vessels	51.1	2.94	1.04
Abnormal heartbeat	45.6	2.88	0.99
High blood pressure	74.5	2.83	1.06
High cholesterol	19.2	2.58	1.02
Reproductive	36.6	2.40	1.20
Reproductive organ damage	23.5	2.79	1.06
Birth defects	64.1	2.65	1.21
Fertility problems	42.9	2.50	1.18
Impotence	25.0	2.42	1.21
Erectile dysfunction	27.2	2.35	1.26
Miscarriage	42.9	2.29	1.19
Abnormal sperm	29.9	2.19	1.19
Lower sperm count	39.4	2.04	1.15
Other			
Brain disorders	12.7	3.07	1.00
Kidney disorders	12.7	2.96	0.97
Blood disorders	22.8	2.85	1.03
Tooth decay	77.7	2.84	1.02
DNA damage	16.7	2.74	1.13

Abbreviations: *M* = mean, *SD* = standard deviation.
[a]Health effects are ordered from most to least discouraging within each health effect category.

Table 4. Correlates of discouragement from smoking, $N = 388$

	Toxic products				Health effects			
	Intercept only & unadjusted models		Adjusted model		Intercept only & unadjusted models		Adjusted model	
	b	SE	*b*	SE	*b*	SE	*b*	SE
Intercept	2.83**	0.04	2.77**	0.09	2.93**	0.04	3.18**	0.16
Person characteristics (Level 2)								
Age in decades grand mean centered	0.02	0.04			−0.07	0.04	−0.01	0.004
White race	0.05	0.13			−0.02	0.12		
Male	−0.23*	0.09	−0.19*	0.09	0.03	0.08		
Gay, lesbian, or bisexual	−0.12	0.15			−0.24	0.14	−0.26	0.14
Education, high school or greater	−0.05	0.12			0.07	0.11		
Low numeracy	0.20*	0.09	0.15	0.09	0.05	0.09		
Cigarettes smoked per day grand mean centered	0.00	0.01			0.00	0.01		
Message characteristics (Level 1)								
Aware of toxic product or health effect as related to cigarette smoking	0.15**	0.03	0.17**	0.03	0.29**	0.02	0.27**	0.02
Question target *(0 = cigarettes; 1 = cigarette smoke)*	0.17	0.09	0.18*	0.09	0.15	0.08	0.16	0.08
Frequency of exposure to toxic product								
Never/rarely	0.20**	0.02	0.21**	0.02	.	.	.	.
Occasionally	ref		ref		.	.	.	.
Frequently	−0.25**	0.02	−0.25**	0.02	.	.	.	.
Health effect category								
Cancer	.	.	.	.	ref		ref	
Respiratory	.	.	.	.	−0.10**	0.02	−0.19**	0.02
Cardiovascular	.	.	.	.	−0.11**	0.02	−0.14**	0.02
Reproductive/developmental	.	.	.	.	−0.70**	0.02	−0.66**	0.02

Note. Table shows unstandardized regression coefficients (*b*) and standard errors (SE). Outcome is discouragement from smoking (1 = *not at all*, to 4 = *a lot*). Analyses used multilevel modeling, with person characteristics as level 2, message characteristics as level 1, and both intercept and awareness of toxic product or health effect as related to smoking treated as random effects. Intraclass correlation for toxic product model = 0.63 and for health effects model = 0.59.

*$p<.05$. **$p<.001$.

study and others[32] suggest toxic products may be a useful way to help the public understand the dangers of smoking in a novel way and may discourage smoking.[16] We found that products most likely to discourage smoking were products that the public rarely or never comes into contact with (e.g., nuclear weapons). It is important to note that the exposure categories roughly mirror levels of toxicity/deadliness, suggesting that the most impactful products are likely to be those that smokers perceive as deadliest or most toxic. Future studies should develop and evaluate constituent disclosure messages that incorporate these particular message elements, given their potential for discouraging smoking.

We also found that emphasizing health effects associated with constituents may discourage smoking, supporting findings from previous research.[6,15,16,19,33] Cancer was more discouraging than respiratory, cardiovascular, and reproductive health effects. Trends among the means (Table 3) suggest that the most discouraging cancers were ones most commonly associated with tobacco use, such as lung, throat, and oral cancer, which may reflect the success of past tobacco education campaigns. The most discouraging respiratory effects appeared to be those that were relatively severe, such as lung damage, while the least discouraging were ailments that are treatable, such as pneumonia. The most discouraging cardiovascular health effects were more severe ailments of the heart, while the least discouraging were high blood pressure and cholesterol, which again may be due to these latter conditions being common, treatable health problems.[34] While these common comorbidities are major catalysts for heart disease, smokers may misunderstand this connection.[35] Reproductive health effects were the least discouraging of the health effect categories and for this reason may hold the least promise in the context of constituent messages, especially among people not trying to become pregnant.

Finally, referring to “cigarette smoke” as opposed to “cigarettes” had only a modest impact on results. When one of the question stems elicited more discouragement (i.e., in the toxic products model), it was “cigarette smoke” perhaps because it is aversive or because one inhales cigarette smoke, whereas the presence of chemicals in an unlit cigarette may seem more distal to a smoker. This result suggests that disclosure messages not constrained by space limitations may benefit somewhat from using the term “cigarette smoke.” This approach also allows use of a greater number of constituents in messages given that some constituents are only formed during the combustion process and are therefore not present in the cigarette itself. That said, the term “cigarettes” performed almost as well, and so may be a preferable choice in certain circumstances.

Our findings point to the potency of particular constituent disclosure message elements in discouraging smoking and represent an important step forward toward developing descriptive messages about constituents.[8] Once developed, effective constituent messages could be disseminated on cigarette packs, in public media campaigns, and through a variety of other message channels. Such messages could enable the FDA to better communicate with the public about the presence of harmful constituents in cigarette smoke and their associated harms to human health.

Limitations and Future Directions

Our cross-sectional study examined discouragement from smoking, a perceived effectiveness measure that can help prioritize message elements that may encourage quitting. Due to the repeated measures deign of the study, it is possible that later element ratings were modestly influenced by previous element ratings, which is a phenomenon that has been observed in other within-subjects research.[36] It is likely that any order effects were largely mitigated through the use of randomization of order presentation of the message elements. However, future work replicating our findings using an entirely between-subjects design would be beneficial.

Further, our study evaluated elements for constituent messages, and subsequent studies will need to identify how they work when embedded in messages themselves. Moreover, the study focused on constituents identified as most effective in a recent nationally representation survey of US adults, which are generally well known to the US public. The FDA has primarily used known constituents in their constituent messages, so the current research is both evidence-based and timely. Future research would greatly benefit from exploring the potential of using unknown constituents to communicate the harms of smoking, especially given that this category of constituents contain some of the most hazardous chemical compounds (e.g., nitrosamines). Additional research is needed to test the impact of constituent disclosures with different combinations of products and health effects. The value of constituent disclosures lies in evidence that these disclosures go beyond perceived message impact to deterring smoking.

Conclusion

Our study identified health effects and toxic products, especially cancers and rarely encountered toxic products, that may make disclosure messages more effective. By constructing messages that communicate the harms associated with tobacco use by contextualizing those harms in terms of specific constituents, tobacco education messaging efforts may be increasingly successful.

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Declaration of Interests

KMR is serving as an expert consultant in litigation against tobacco companies. All other authors do not have any declarations of interest to report.

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