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Charming e-cigarette users with distorted science: a survey examining social media platform use, nicotine-related misinformation and attitudes towards the tobacco industry

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ABSTRACT

Objective To examine the role of social media in promoting recall and belief of distorted science about nicotine and COVID-19 and whether recall and belief predict tobacco industry beliefs.

Design Young adults aged 18–34 years (N=1225) were surveyed cross-sectionally via online Qualtrics panel. The survey assessed recall and belief in three claims about nicotine and COVID-19 and three about nicotine in general followed by assessments of industry beliefs and use of social media. Ordinal logistic regression with robust standard errors controlling for gender, race/ethnicity, education, current e-cigarette use and age was used to examine relationships between variables.

Results Twitter use was associated with higher odds of recall (OR=1.21, 95% CI=1.01 to 1.44) and belief (OR=1.26, 95% CI=1.04 to 1.52) in COVID-19-specific distorted science. YouTube use was associated with higher odds of believing COVID-19-specific distorted science (OR=1.32, 95% CI=1.09 to 1.60). Reddit use was associated with lower odds of believing COVID-19-specific distorted science (OR=0.72, 95% CI=0.59 to 0.88). Recall (OR=1.26, 95% CI=1.07 to 1.47) and belief (OR=1.28, 95% CI=1.09 to 1.50) in distorted science about nicotine in general as well as belief in distorted science specific to COVID-19 (OR=1.61, 95% CI=1.34 to 1.95) were associated with more positive beliefs about the tobacco industry. Belief in distorted science about nicotine in general was also associated with more negative beliefs about the tobacco industry (OR=1.18, 95% CI=1.02 to 1.35).

Conclusions Use of social media platforms may help to both spread and dispel distorted science about nicotine. Addressing distorted science about nicotine is important, as it appears to be associated with more favourable views of the tobacco industry which may erode public support for effective regulation.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This study answers a novel and timely research question examining the distorted information environment surrounding nicotine and COVID-19.
⇒ This study addresses an understudied area of tobacco control research, namely tobacco users' perceptions of the tobacco industry and how this may play into public perception of their products, and by extension, how they are regulated.
⇒ This study is cross-sectional and thus causality cannot be identified from the analysis.
⇒ This study sample is sufficient in size, however, it is not nationally representative and therefore limited in terms of external generalisability.

BACKGROUND

Tobacco companies and some harm reduction advocates are promoting misleading and even patently false claims about nicotine to frame efforts to regulate next-generation nicotine products as 'antiscience'. There is a legitimate need to differentiate the harmful consequences of combustible cigarettes (CCs) from those of nicotine, as nicotine replacement therapy (NRT) offers an evidence-based means for adults to quit smoking.[1–3] However, dissemination of unsubstantiated claims about nicotine as a harmless stimulant or even a therapeutic method can undermine public health by promoting the use of an addictive substance.[4 5] The distortion of science to fit a pro-tobacco narrative has a long history[6] and is now emerging to counter evidence of the dangers associated with e-cigarette (EC) use.[7] The tobacco industry has seized on the reach of social media to disseminate distorted interpretations of science and misinformation about ECs,[8 9] often through the lens of harm reduction.[10] The resulting impact threatens to position tobacco companies in a more positive light as advocates for the health of former smokers instead of purveyors and marketers of a harmful product, which in turn threatens to undermine regulatory efforts. This research examines the potential role of social media in disseminating distorted science about nicotine both in the context of

the COVID-19 pandemic and in general and the extent to which recall and belief in such information affects beliefs about the tobacco industry.

Public understanding of the harms of nicotine are inextricably linked to harm perceptions of CCs posing challenges to health communicators and practitioners.[11] The most recent systematic literature review found that while most research showed relatively lower risk perceptions for NRT and ECs compared with CCs, there remains confusion surrounding various non-combustible products.[1] One study using data from the National Youth Tobacco Survey found that between 22% and 33% of respondents believed smokeless products were more dangerous than CCs.[12] Another sample of young adults found that more than half of respondents erroneously believed that nicotine was the cancer-causing agent in CCs and that the risks of ECs and NRT were equal to that of CCs.[5] Many of the same misperceptions were even held by a majority of physicians.[13] These mistaken beliefs are problematic in that they can deter evidence-based NRT treatment that has been proven to help adult smokers quit.[11 14 15] However, EC advocates have seized on this confusion regarding the risks posed by nicotine to conflate scientific support for the evidence-based benefits of NRT for helping adult smokers quit with unsubstantiated and often distorted scientific claims about the safety of ECs.[11] Moreover, media purporting to 'uncover the truth behind nicotine'[16 17] and broader efforts by tobacco companies to market next-generation products like ECs as safe alternatives to smoking, 'tobacco free' or 'clean nicotine'[18–20] discount the inherent risks posed by nicotine, particularly to youth and young adults, threatening to addict new users for life.

The distortion of scientific evidence has many consequences from information pollution to the normalisation of tobacco industry behaviour. However, those who hold more antagonistic views of the tobacco industry, wherein their actions are 'denormalised', are more likely to support policy regulating the industry.[21] Thus, the tobacco industry's attempts to market their products as safe have the potential to undermine regulatory efforts.[21]

Although nicotine is not responsible for many of the most well-known consequences of smoking,[22–24] it is an addictive substance with strong potential for lifelong abuse.[25]

Moreover, such use may have adverse consequences on neural development.[26–29] Though evidence is limited, nicotine may pose additional risks to cardiovascular health.[30–33] The societal consequences of the widespread belief that nicotine is harmless threatens to expand nicotine addiction far beyond current levels driven by smoking, as beliefs about nicotine predict product use.[5] Recent research suggests that social media has a high volume of problematic information about nicotine and nicotine products.[9] Thus, it is important to examine the prevalence and potential effects of such information, particularly on EC users to whom much of this information is targeted.[34 35]

The ambiguity surrounding COVID-19 has made it a common topic of misinformation,[36] particularly with respect to the effects of nicotine. One prominent example is based on a review of clinical data in Wuhan province, China, showing a significantly lower prevalence of smokers among patients admitted to Intensive Care Units (ICUs) for COVID-19 in the early months of the pandemic.[37 38] These findings prompted an editorial[39] and the registration of clinical trials testing the hypothesis that nicotine may prevent infection and progression of COVID-19.[40] While the clinical trials have not yet concluded, research conducted since does not support any therapeutic or prophylactic benefits of nicotine on COVID-19.[40] In fact, in addition to smoking increasing odds of disease progression and severe symptoms,[41–43] a recent systematic review strongly suggests that nicotine, including ECs and smokeless products, are a likely risk factor for infection and progression of COVID-19.[44] Although more research is needed to make definitive claims about the effects of nicotine, there is currently no evidence supporting a therapeutic use for nicotine with respect to COVID-19. Despite the lack of supporting evidence and significant evidence to the contrary, an analysis of Twitter discourse identified a substantial presence of content related to prevention or treatment of COVID-19 with nicotine.[45]

Whether a deliberate effort by EC advocates or a product of online discourse with minimal moderation, the dissemination of distorted science about nicotine on social media poses a barrier to public health. Researchers have identified a variety of potential impacts of such information among EC users including bulk buying and increased usage.[35] Additionally, the dissemination of information distorting the science of nicotine safety is likely to directly undermine efforts to regulate the industry by creating more favourable views of ECs and the companies who manufacture them. The most recent review of the literature suggests EC-related content on social media tends to be favourable to EC use.[46] Moreover, analysis of social media posts suggests an environment hostile to regulation[47] with a significant presence of sponsored industry advocacy messaging.[48] The dissemination of distorted science positioning regulatory efforts in opposition to public health threatens to further deceive the public regarding the safety of nicotine and ECs.[7] The evidence to date highlights a need to examine the extent to which distorted science about nicotine is disseminated on social media and its potential impact on tobacco industry attitudes. Specifically, this work investigates the extent to which use of specific social media platforms are associated with recall and belief in distorted science about nicotine. We also aim to investigate the relationship between beliefs about the tobacco industry and recall and belief in distorted science about nicotine.

METHODS

Data collection

Online panel survey

We contracted with Qualtrics to recruit N=1225 participants aged 18–34 years for a survey, fielded 4 June to 11 June 2021, to examine the relationship between exposure to and belief in distorted science about nicotine in general and in the context of COVID-19, social media use and tobacco industry attitudes. An initial sample of N=2088 people consented to participate in the study. Of those, n=495 failed an attention check asking to select a specific response, n=90 were removed for other quality control reasons (eg, straight line responding) and n=278 were removed for incomplete response sets leaving a final sample of N=1225. Participants were a convenience sample and were aged 18–34 years (M(SD)=26.95 (4.85), 40.8% male, 70.27% white, with 39.39% reporting a high school diploma/ General Education Degree (GED) or lower education. We oversampled for current EC users (59.76%) with 75.27% reporting having ever used an ECs and having used ECs products an average of 11.97 (SD=11.89) days in the last month.

Patient and public involvement

No patients or public were involved in the development of this research.

Measures

Social media use

Consistent with the literature, we assessed active (eg, posting), passive (eg, scrolling) and social (eg, commenting) elements of social media use.[49] Participants first indicated whether they used several social media platforms. For each platform, a use index was calculated based on the average of three items: whether the participant (1) checks content, (2) posts content and (3) responds to comments on each platform rarely (1), sometimes (2) or often (3). Table 1 provides summary statistics for both the percentage of our sample who used each platform as well as the average amount of use.

Table 1 Social media use by platform (N=1225)

Platform	Have ever used	Use index*	
		M	(SD)
Facebook	78.90%	1.73	(1.13)
Instagram	67.00%	1.41	(1.15)
Reddit	28.50%	0.50	(0.09)
Snapchat	51.90%	1.14	(1.22)
TikTok	45.10%	0.88	(1.10)
Twitter	40.60%	0.65	(0.89)
YouTube	80.90%	1.43	(0.98)

*Use index refers to an average of how often participants check, post and respond to content on each platform on a four-point scale from anchored (0) 'never' to (3) 'often'.

Recall and belief of distorted science indices

COVID-19 related

Recall and belief indices for distorted science related to COVID-19 were calculated based on responses to three specific claims. The first claim that smokers are less likely to be hospitalised for COVID-19 was related to the early review cited above and was recalled by 12.53% with 11.65% believing it was either probably or definitely true. Claim two represented the conclusions drawn by that study and the hypothesis then tested in future research that 'nicotine prevents the virus that causes COVID-19 from infecting cells' and was recalled by 10.35% and believed by 9.35%. Finally, the third claim that 'chemicals in vaping liquid (eg, propylene glycol) sterilise the air to protect from COVID-19 infection' represents a misappropriation of a very old study[50] that was promoted as evidence to support EC use during the pandemic. Similar to the previous claims, 10.78% recalled, while 9.47% believed it was probably or definitely true. Summative indices were calculated for each participant with higher values indicating a given respondent recalled M(SD)=0.33 (0.74) and believed M(SD)=0.30 (0.72) between zero and three misleading scientific claims.

General nicotine

Recall and belief in three claims about nicotine safety were assessed in the same manner as above. Participants indicated whether they recalled and believed three statements that have been promoted in either popular media or advertising for ECs: 'Nicotine is only addictive when smoked from a cigarette' was recalled by 14.02% and believed by 13.29%. 'Nicotine by itself is no more harmful than caffeine from a cup of coffee' was recalled by 31.09% and believed by 29.02%. Finally, 'Nicotine is useful as a medical treatment for people with mood, attention, or memory disorders' was recalled by 20.79% and believed by 22.66%. Summative indices were calculated for each participant. A given respondent recalled M(SD)=0.66 (0.83) and believed M(SD)=0.65 (0.84) between zero and three misleading claims about nicotine safety.

Industry belief indices

Participants indicated how true they believed three positive and three negative statements about tobacco companies to be using a four-point scale from completely false to completely true. In general, participants were more likely to believe that negative statements were either mostly or completely true including that companies use candy flavours to lure young people (77.84%), spread false research about the safety of their products (74.57%) and that politicians take money from tobacco companies to oppose regulations (80%). However, a substantial portion of respondents believed positive statements were either mostly or completely true as well including that tobacco companies were honest about the safety of their products (46.20%), are part of the solution to ending smoking (39%) and that they do good things for the community like donate to charity (48.90%). Summative indices

Table 2 Social media platform use predicting recall and belief in misleading information

	Recall distorted science COVID-19			Recall distorted science general			Believe distorted science COVID-19			Believe distorted science general		
	OR	LLCI	ULCI	OR	LLCI	ULCI	OR	LLCI	ULCI	OR	LLCI	ULCI
Female	**0.45**	(**0.33**	**0.61**)	**0.67**	(**0.53**	**0.86**)	**0.50**	(**0.35**	**0.70**)	**0.63**	(**0.49**	**0.82**)
Non-Hispanic black	**2.00**	(**1.38**	**2.89**)	*1.33*	(*0.96*	*1.85*)	**2.46**	(**1.65**	**3.67**)	**1.44**	(**1.02**	**2.02**)
Hispanic	1.33	(0.90	1.98)	1.30	(0.93	1.83)	1.09	(0.69	1.72)	0.90	(0.64	1.27)
High school/ GED*	1.07	(0.78	1.46)	1.19	(0.94	1.50)	1.01	(0.72	1.41)	**1.31**	(**1.03**	**1.66**)
Currentecig†	**1.73**	(**1.25**	**2.39**)	**1.64**	(**1.29**	**2.09**)	**1.91**	(**1.36**	**2.67**)	**1.96**	(**1.54**	**2.50**)
Age	1.00	(0.96	1.03)	**0.97**	(**0.94**	**0.99**)	0.99	(0.95	1.02)	1.00	(0.97	1.02)
Facebook	0.98	(0.84	1.14)	1.10	(0.97	1.23)	1.06	(0.91	1.24)	1.08	(0.96	1.22)
Instagram	1.01	(0.86	1.19)	1.00	(0.88	1.12)	0.98	(0.82	1.17)	0.99	(0.87	1.12)
Reddit	0.86	(0.72	1.04)	1.06	(0.93	1.22)	**0.72**	(**0.59**	**0.88**)	0.92	(0.80	1.06)
Snapchat	1.00	(0.87	1.16)	0.94	(0.85	1.05)	1.00	(0.86	1.16)	1.03	(0.92	1.15)
TikTok	1.11	(0.95	1.29)	1.05	(0.93	1.18)	0.97	(0.82	1.14)	*1.11*	(*0.98*	*1.25*)
Twitter	**1.21**	(**1.01**	**1.44**)	1.12	(0.97	1.28)	**1.26**	(**1.04**	**1.52**)	*1.16*	(*0.99*	*1.35*)
YouTube	1.06	(0.89	1.26)	0.97	(0.85	1.11)	**1.32**	(**1.09**	**1.60**)	0.97	(0.85	1.11)

95% CIs are calculated using robust standard errors. ULCI and LLCI reflect the upper and lower limits of these confidence intervals. ORs in italics are marginally significant at p<0.1, while those in bold are significant at p<0.05.
*Dummy code for having a high school diploma/GED or less education.
†Dummy code for having used e-cigarette in the past 30 days.

were created for the number of positive M(SD)=0.99 (1.01) and negative M(SD)=1.86 (1.06) beliefs about the tobacco industry that participants reported to be either 'mostly' or 'completely true'.

Analysis

Analyses were conducted using Stata V.15. Ordinal logistic regression models with robust standard errors were used to calculate ORs and 95% CIs for the association between social media platform use and recall and belief indices and for the association between recall and belief indices and tobacco industry beliefs. Analyses also included age, dummy codes for female, non-Hispanic black, Hispanic, a high school diploma/GED or lower education and current EC use.

RESULTS

Social media use and recall and belief in distorted science

Table 2 presents ORs and 95% CIs for ordinal logistic regression models. COVID-19-related distorted science recall was significantly less likely among female participants, but more likely among black participants and those who used ECs. Greater Twitter use was associated with higher odds of recalling distorted science about nicotine and COVID-19. Belief in distorted science about nicotine and COVID-19 followed a similar trend. Female participants were less likely to believe these claims, while black participants or those who used ECs were more likely to believe them. Finally, greater use of both Twitter and YouTube were associated with higher likelihood of believing these claims, while greater Reddit use was associated with lower likelihood of believing them. For distorted science about nicotine in general, female participants were less likely to recall or believe these claims. Black participants were more likely to believe these claims, however recall failed to reach significance. EC users were more likely to recall and believe these claims, while lower education participants were more likely to believe them, but not to recall exposure to them in the last year. Although TikTok and Twitter approached significance in predicting belief in claims related to nicotine in general, none of the social media platforms reached significance for either recall or belief in these claims.

Recall and belief in misinformation and tobacco industry beliefs

Table 3 presents ORs and 95% CIs for ordinal logistic regression models. Current EC use was associated with more positive beliefs and less negative beliefs about the tobacco industry. Moreover, less educated participants held less negative beliefs, while Hispanic participants were more likely to hold negative beliefs. Recall and belief in claims distorting science of nicotine in general and belief in claims distorting science about nicotine and COVID-19 were associated with more positive beliefs about the tobacco industry. Recall of distorted science related to nicotine and COVID-19 approached significance in the same direction. Only belief in distorted claims about nicotine in general was associated with more negative beliefs about the tobacco industry.

Table 3 Recall and acceptance predicting industry beliefs

	Positive beliefs			Negative beliefs		
	OR	LLCI	ULCI	OR	LLCI	ULCI
Female	1.05	(0.84	1.32)	1.13	(0.90	1.41)
Non-Hispanic black	1.02	(0.75	1.38)	1.07	(0.78	1.45)
Hispanic	1.07	(0.77	1.48)	**1.44**	(**1.07**	**1.96**)
High school/GED*	0.97	(0.78	1.21)	**0.63**	(**0.51**	**0.78**)
Currentecig†	**1.69**	(**1.35**	**2.12**)	**0.65**	(**0.52**	**0.82**)
Age	1.02	(0.99	1.04)	0.99	(0.97	1.01)
Recall distorted science COVID-19	1.20	(0.99	1.46)	0.98	(0.82	1.19)
Recall distorted science general	**1.26**	(**1.07**	**1.47**)	0.99	(0.86	1.15)
Believe distorted science COVID-19	**1.61**	(**1.34**	**1.95**)	1.05	(0.88	1.25)
Believe distorted science general	**1.28**	(**1.09**	**1.50**)	**1.18**	(**1.02**	**1.35**)

95% CIs are calculated using robust standard errors. ULCI and LLCI reflect the upper and lower limits of these confidence intervals. ORs in bold are significant at p<0.05.
*Ddummy code for having a high school diploma/GED or less education.
†Dummy code for having used e-cigarette in the past 30 days.

DISCUSSION

The most important conclusion to draw from this research is that a substantial portion of 18–34 years olds, a demographic far less likely to smoke CCs than previous generations,[51] accept several erroneous claims about nicotine. In our sample, nearly one in three believed nicotine to be no more harmful than a cup of coffee, one in four believed nicotine to be useful as a medical treatment for mood, attention or memory disorders and more than one in eight believed that unlike CCs, nicotine from ECs is not addictive. While it is important to address barriers to using effective cessation products like NRT, such as the overestimation of the dangers of nicotine,[11] these data suggest there is also substantial danger posed by the underestimation of the dangers of nicotine. Young people who do not smoke and in the case of those suffering from mood or attention disorders may be at heightened risk of addiction,[52] report both seeing and believing demonstrably false or unsubstantiated information about nicotine safety that is likely to encourage use[5] and result in lifelong addiction.[25] As the full extent of the known harms from ECs increase with more research,[53] the continued dissemination of distorted science about the safety of nicotine poses a sizeable long-term risk to public health.

Public attitudes surrounding nicotine are still intrinsically tied to CCs. However, the proliferation of alternative nicotine products like ECs will inevitably lead to youth and young adult perceptions of nicotine divorced from the connotation of smoking. As such perceptions evolve, future research must examine the influence of both formal and informal information channels on attitudes and beliefs about nicotine in its growing variety of forms.

The second important conclusion drawn from this work is that social media plays a complex role in the current information environment. The often cited 'infodemic'[54] of false and misleading information spreading online encompasses COVID-19,[36 55] ECs[56 57] and the intersection of the two.[45] However, false and misleading information varies from unintentionally incorrect misinformation to intentionally deceitful disinformation.[58] Distorted science exemplified in this study by the extrapolation of published scientific findings to support unsubstantiated claims about a prospective therapeutic role of nicotine during the COVID-19 pandemic were recalled and believed more among more frequent users of Twitter and YouTube, but less among frequent users of Reddit. These findings suggest that the different characteristics of specific social media platforms that enable and influence the ways users of such platforms share and encounter information, that is, technological affordances,[59] may offer a useful framework for examining the role of social media in both spreading and correcting problematic information. The lack of traditional media gatekeepers on platforms like YouTube and Twitter may allow misleading interpretations of these scientific studies to spread unchecked.[34 60] Meanwhile, the moderated forums or subreddits encouraging lengthy discussions on Reddit may facilitate a user base that is more informed than social media platforms with restrictive character limits and a lack of formal moderation.[61] Previous research suggesting many users view Reddit as a trusted source of actionable health information[61 62] suggests Reddit may have utility in disseminating correct information to counter distorted science and other forms of misinformation and disinformation. Thus, although complicit in the dissemination of distorted science about ECs and nicotine, social media may also offer a crucial tool in reducing the impact of such information. That said, it is also important to note that Reddit and Twitter were not used as frequently as other platforms among our study participants. This is reflective of the greater social media environment wherein Twitter and Reddit,

although used more among younger generations than older adults, fall behind leaders YouTube, Facebook and Instagram in popularity.[63]

It is also important to note that, when controlling for demographic differences, we identified that non-Hispanic black participants had higher odds of recall and belief of misinformation and Hispanic participants had higher odds of reporting negative industry beliefs. We hesitate to hypothesise a basis for these trends due to the small sample of racial and ethnic minority participants surveyed in our convenience sample. That said, these findings emphasise the need for further research into understanding the racial and ethnic differences in the impact of misinformation.

Finally, our finding that the tobacco industry's reputation is likely improved by the spread of distorted science has distinct regulatory implications. The prevalence of positive beliefs related to the tobacco industry's role in ending smoking, donating to charity, and that nearly half of our sample (46%) believed that the tobacco industry was honest about the effects of their products indicates that 18–34 years olds are increasingly ambivalent about the role of the tobacco industry in society. Unsubstantiated information about potentially therapeutic effects of nicotine, framing ECs and other mass-marketed nicotine products as tools for 'harm reduction' and efforts to distance nicotine from cigarettes in favour of likening nicotine use to caffeine from a cup of coffee mirror old strategies used by tobacco companies to promote CCs.[64] For example, one ad from Bidi stick states 'a bidi stick a day keeps the pulmonologist away',[65] conflating the potential reduced harm with switching from CCs to ECs with objectively false claims of pulmonary benefits of using the product. The tobacco industry continues to spend significantly on corporate social responsibility campaigns[66 67] and strategically promote products as environmentally friendly[67 68] or their brands as charitable.[69] Intervention strategies highlighting deception and manipulation by the tobacco industry have been among the most effective strategies for deterring tobacco use.[70] By positioning ECs as the necessary antidote to CCs, the tobacco industry uses distorted science and other forms of misinformation to mobilise public support against regulation of ECs, potentially leveraging their own past deception to permit unchecked promotion of ECs to a generation of non-smokers. Previous research supports the use of news literacy campaigns and expert correction as strategies for combatting misinformation. Moreover, in addition to the importance of monitoring the channels through which problematic information spreads to vulnerable subpopulations, the US Surgeon General's report on health misinformation highlights the importance of 'prebunking' to inoculate the public to the sorts of misinformation they are likely to encounter.[71 72]

A crucial reason to monitor the spread of distorted science and other forms of misinformation about nicotine on social media is that beliefs about nicotine are associated with individual behaviour, notably nicotine product curiosity, susceptibility and use.[5] However, this research focuses on the relationship between distorted science and industry attitudes because efforts intended to mobilise political opposition to regulation on social media exemplified by hashtags like #wevapewevote or #flavorssavelives often rely on misinformation.[73] Such misinformation is problematic beyond the scope of behaviour, as favourable public opinion is integral to the success of tobacco control policies.[74–76] It appears that more antagonistic views of the tobacco industry are tied to greater support for tobacco industry regulation.[21] There is substantial evidence supporting the problematic influence of misinformation on behaviour in the context of nicotine and tobacco.[4 8 9 77] However, future research should more closely examine the specific effects of distorted science on individual behaviour as well.

Limitations

These data offer evidence of associations between self-reported social media use, beliefs and recall in a convenience sample. Although we provide evidence of an association between use of specific social media platforms and recall and belief in misinformation and disinformation, we do not assess whether exposure to such information occurred on social media in general or any specific platform. Thus, while the proliferation of misinformation on social media is a well-documented phenomenon,[35 45] our data do not provide definitive evidence that misinformation is more likely to spread on Twitter versus Reddit, but rather that Twitter users are more likely to recall and believe such information, whereas Reddit users are less likely.

As with any survey, inferences about causality or effect sizes at a population level are limited. Moreover, methods used to maintain data quality for online opt-in surveys such as the attention checks we used may pose further limitations to studying the people most susceptible to misinformation. Although it is best practice not to overinterpret responses from respondents screened out by such attention checks, we note that recall and belief of distorted science was significantly higher among those who failed them. Thus, methodological approaches to studying misinformation should account for the fact that the same inattentiveness we use to screen responses for surveys may also screen out misinformation-susceptible participants. Though our estimates likely differ from general population parameters, this study provides robust evidence that young adult EC users are more likely to recall and believe misinformation about the effects of the products they use. In addition to experimental designs better equipped to assess causality, future research should examine not only how social media spreads misinformation but also how the characteristics that differ between platforms influence patterns of dissemination across platforms.

Additionally, self-reported measurements of social media use are limited.[78] We followed best practice recommendations in social media use measurement; however, there remain inherent limitations regarding how accurately people recall and report social media use which undoubtedly affect our results. To compensate for this limitation, we adopted a

conservative approach in including all of the social media platforms in the same model, essentially controlling for use of all social media when estimating the OR of any single platform. As a result, non-significant findings for misinformation on Facebook, for example, should not be interpreted as suggesting such information does not exist on Facebook, but rather that Reddit, YouTube and Twitter, which were significant, are of higher priority with regards to the dissemination of such information among this demographic. Future research using unobtrusive measures like logs from big data sources are needed.

Conclusions

Public understanding of the health impact of nicotine is currently mired by uncertainty. Although there is currently no significant evidence supporting therapeutic benefits of nicotine use, misinformation ostensibly backed by 'science' is being disseminated on social media and potentially facilitating good will towards the tobacco industry. In light of a long-documented history of interfering in the scientific process and disseminating misinformation about its products, the role of the tobacco industry in disseminating this information merits close monitoring, significant countering messaging and proactive inoculation against potentially harmful narratives.

Contributors NAS conceptualised the project with guidance and oversight from BS. Authors NAS and ECK developed the survey instrument. NAS completed the analysis. NAS developed the manuscript with assistance from ECK, JB and BS. BS is the senior author and guarantor. All coauthors reviewed and revised the final draft.

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Patient consent for publication Not applicable.

Ethics approval This study involves human participants but was determined exempt from review by a private review board, Advarra IRB (Pro00053405), as the research was conducted at a non-profit organisation unaffiliated with an institution. The study was determined exempt in accordance with the Department of Health and Human Services regulations found at 45 CFR 46.104(d)(2). The information collected from these adult participants could not be used to personally identify them or present an undue risk by way of their responses. Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. Data used in this study are housed at Truth Initiative and are not publicly available. Any inquiries can be directed to NAS.

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