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Influence of Disclosed and Undisclosed Funding Sources in Tobacco Harm Reduction Discourse: A Social Network Analysis

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Abstract

Introduction: Tobacco harm reduction (THR) discourse has been divisive for the tobacco control community, partially because it sometimes aligns public health and tobacco industry interests. Industry funding is contentious as it influences study outcomes, and is not always disclosed in scientific publications. This study examines the role of disclosed and undisclosed industry support on THR publications via social network analysis.

Methods: We reviewed 826 English-language manuscripts (1992–2016) to determine disclosed and undisclosed industry (pharmaceutical, tobacco, and e-cigarette) and non-industry (including government) support received by 1405 authors. We used social network analysis to identify the most influential authors in THR discourse by assessing the number of their collaborators on publications, the frequency of connecting other authors in the network, and tendency to form groups based on the presence of sponsorship disclosures, sources of funding, and THR stance.

Results: About 284 (20%) out of 1405 authors were supported by industry. Industry-sponsored authors were more central and influential in the network: with twice as many publications (Median = 4), 1.25 as many collaborators on publications (Median = 5), and higher likelihood of connecting other authors and thus having more influence in the network, compared to non-industry-sponsored authors. E-cigarette industry-sponsored authors had the strongest association with undisclosed industry support.

Conclusions: Authors with industry support exerted a stronger influence on the THR scientific discourse than non-industry-supported authors. Journals should continue adhering to strict policies requiring conflicts of interest disclosures. An increase in public health spending on tobacco control research may be necessary to achieve funding parity.

What this study adds

- This study (1) identifies influential authors that could potentially dominate tobacco harm reduction (THR) discourse; (2) evaluates sponsorship disclosure patterns among the most influential industry-sponsored authors in THR publications; (3) explores authors' tendencies to form groups based on the presence of a sponsorship disclosure, source of funding, and position on THR in the scientific publication network focusing on THR.
- Authors with disclosed and undisclosed industry support and favorable position on THR were found to exert a greater potential influence on the scientific discourse due to higher numbers of publications, higher numbers of collaborators, and higher likelihood of connecting authors with each other in the network compared to non-industry-supported authors.
- Authors supported by the e-cigarette industry had the strongest associations with a favorable position on THR and undisclosed industry sponsorship than authors supported by the tobacco or pharmaceutical industries.

Introduction

Tobacco industry support of scientists has played a major role in the framing and development of tobacco control science and policy. Tracking the influence of the tobacco industry on the broader scientific community, especially public health, provides insight into the independence (or lack thereof) of science and policy formation and development.[1–3]

Previous iterations of industry influence on scientific discourse have included downplaying the harms of secondhand smoke,[4] the efficacy of smoke-free policies on population health,[5] the cosmetic panacea of adding filters to cigarettes,[6] and development and claims of low-tar and potentially reduced emission products.[7] Since 2008, however, a new battleground for tobacco control has opened up, as the tobacco

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control community has been divided over the issue of tobacco harm reduction (THR). While myriad tobacco control policies reduce the harms of tobacco in the population,[50] the term "tobacco harm reduction" has been popularly framed as a mechanism that gives combustible tobacco users who are unwilling or unable to quit an opportunity to switch to newer non-combustible nicotine products instead of using widely-established nicotine replacement therapies. This topic is highly controversial in tobacco control.[8] Some members of the tobacco control community believe that these new products have great potential to reduce mortality and morbidity among smokers who completely switch to them.[9–11] Others express concern that these products serve as a gateway to using more harmful substances, promote prolonged dual or poly-tobacco use, and stymie quit attempts.[12] Additionally, limited and conflicting research exists over whether or not e-cigarettes are effective in helping smokers quit smoking.[8,13,14]

Just as with combustible cigarettes in the past, the tobacco industry actively downplays harm from noncombustible products.[15,16] Studies[17,18] found that conflicts of interest (COI) were strongly associated with tobacco industry-favorable results, dismissing harms from e-cigarettes. Strong/moderate industry–related COI were associated with very high odds (OR = 91.5; CI = 10.9–771.4) of finding no harm compared to studies with no/weak COI. Similarly, a systematic review[19] by Hendlin et al. found that industry-funded articles favored THR, while non-industry-funded articles were evenly divided in THR stance.

Despite the toll tobacco use takes, only modest investment has been made in research to better understand tobacco products, tobacco product marketing, addiction, treatment, and consumer behavior.[20] For example, in the United States, where 30% of all cancer deaths are tobacco-related, only 2.3% of the National Cancer Institute's 2003 budget was spent on funding tobacco-related research.[20] In 2016, the NIH allocated 0.25 % of its total grant funding to new tobacco-related awards, which represents miniscule funding proportionate to avertable adverse health outcome.[21] At the same time, the tobacco industry has funded research[20] to draw attention away from tobacco or secondhand smoke exposure to highlight genetic or other causes of cancer and cardiovascular diseases, minimize the consequences of nicotine addiction, and explore potential therapeutic applications of nicotine.[22–24] Previously secret internal documents demonstrated that tobacco companies set up research organizations, which contributed to efforts to defraud the public and hide the adverse health consequences of tobacco use.[25] These organizations, including the Tobacco Industry Research Committee and the Center for Indoor Air Quality, were disbanded as part of the 1998 Master Settlement Agreement[26]; however, tobacco companies continued to fund science and scientists with new research programs.[25]

While industry support has been found to be strongly associated with scientific conclusions favoring the industry,[27–31] disclosed and undisclosed industry funding sources have not been extensively covered in the scientific literature, particularly in regard to the topic of THR. It is important to address the role of industry funding, its disclosure, and its influence on THR in scientific discourse, since THR rhetoric is at the core of the tobacco industry's "transformation," in which the industry repositions itself as a partner and funder of research to improve public health.[32]

The current study builds upon the 2019 systematic review by Hendlin et al. of 826 manuscripts on THR published in 1992–2016. The study found that out of the 826 manuscripts, 23.9% disclosed support by industry, and that support from the e-cigarette industry (odds ratio [OR] = 20.9; 95% confidence interval [CI] = 5.3, 180.7), tobacco industry (OR = 59.4; 95% CI = 10.1, +infinity), and pharmaceutical industry (OR = 2.18; 95% CI = 1.3, 3.7) was significantly associated with conclusions favoring THR. Hendlin et al.'s study focused only on officially disclosed industry funding in COI statements. We used the same dataset and compared official, *disclosed* COI statements with indications of *undisclosed* industry funding, sourced from the Truth Tobacco Industry Documents, other publications by the same authors, and other publicly available documents described in the manuscript. Adding undisclosed support from industry allows a more complete analysis of the additional influence of tobacco, e-cigarette, and pharmaceutical industry support driving public discourse on THR.

In order to further understand the influence of individual authors with disclosed and undisclosed industry support (e.g., funded via grants, employment, consultancy, honoraria, or non-financial compensation) compared to researchers who did not use industry support, we expanded the Hendlin et al.'s study by conducting a social network analysis of the authors in the Hendlin et al.'s dataset. A social network is formed when connections are created among social actors,[33] for example, authors of the manuscripts. The social network framework shifts the focus from studying individual traits to analyzing interactions and relationships[33,34] and allows for visualizing collaboration patterns between industry- and non-industry-sponsored authors. By applying this method, we identified the most influential industry- and non-industry-sponsored authors as well as analyzed and illustrated their tendencies to collaborate with each other and form ties based on their THR stance, industry sponsorship disclosures (undisclosed vs. disclosed), and industry sponsorship sources (pharmaceutical, tobacco, and e-cigarette). This additional analysis of Hendlin et al.'s dataset allowed us to have a comprehensive overview of the THR authors' network during the time period before 2016, marked by record-low government funding of tobacco research, expansive tobacco industry funding, and the pre-Deeming rule environment when the U.S. Food and Drug Administration (FDA) started regulating all tobacco products, including e-cigarettes.

In summary, this study (1) explores the network of THR researchers and examine the collaboration patterns between industry-sponsored and non-industry-sponsored researchers; (2) identifies influential authors that potentially dominate mainstream THR discourse; and (3) evaluates funding disclosure patterns among influential industry-sponsored authors in the network.

Materials and Methods

Data Collection

We reviewed 826 English-language articles (empirical, nonempirical, letters, or commentaries, editorials, systematic reviews, meta-analysis, and randomized-controlled trials) published in 283 peer-reviewed journals over 14 years, from 1992 to 2016. This set of articles was previously used by Hendlin et al.[19] to analyze authors' position on THR and *disclosed* pharmaceutical, tobacco, and e-cigarette industry support. Articles were cross-referenced to determine presence of *undisclosed* pharmaceutical, tobacco, and e-cigarette

industry support received by a total of 1405 authors in the dataset.

Documenting Evidence of Sponsorship

Two coders reviewed each of the 826 articles and searched for disclosed and undisclosed sponsorship for each author based on the information provided in the Acknowledgement, Funding, Declaration of Interests, Conflict of Interests/Competing Interests sections, in Author Affiliation disclosures (e.g. an author's affiliation with an industry entity), and from other sources detailed below. We documented types of sponsorship for each author as the following categories:

Main Source of Sponsorship:

"Government/NGO"

—researcher is funded by a grant awarded by a US (e.g. the NIH) or an international government agency (e.g. the UK government) or a non-governmental (NGO) entity (e.g. the Swedish Heart and Lung Foundation);

"Tobacco", "E-cigarette," or "Pharmaceutical"

—researcher is sponsored by tobacco, e-cigarette, or pharmaceutical industries. Industry sponsorship included mostly grants but also employment, consultancy, honoraria, or non-financial support (e.g. free tobacco products for research studies supplied by pharmaceutical, tobacco, or e-cigarette companies).

"Hybrid"

—a sponsorship organization that had both industry and government/NGO members on their advisory boards or among their trustees;

"None"

—no funding statement was present;

Presence of Sponsorship Disclosure:

"Disclosed"

—if a sponsorship source was disclosed in a manuscript;

"Undisclosed"

—if a sponsorship source was not disclosed in a manuscript, but was disclosed in other manuscripts by the same author in our dataset, or if sponsorship by industry was found in external databases.[35–37] The main external source was the Truth Tobacco Industry Documents[35] comprised of publications and internal documents of the largest and most influential tobacco companies in the United States, including email exchanges between authors and industry companies, files showing industry-sponsored research,[38] and depositions from tobacco-related court hearings. We also searched in Dimensions,[36] a discovery tool to analyze research support; Tobacco Tactics,[37] a resource that provides information on pharmaceutical and tobacco industry allies, Google Scholar, and PubMed. In online search databases, such as Google Scholar and PubMed, we verified authors' industry disclosures for their THR-related publications. To narrow down search results, we used authors' first and last names or last names and first name initials in search queries. For authors with frequently occurring last names (e.g. Miller), we also used a key word related to financial support in search queries (e.g. "Miller A" AND "support"). When cleaning the dataset, we kept first name initials to distinguish the authors with the same last names.

Undisclosed industry sponsorship is common,[32,39] and at times industry sponsorship has resulted in published corrections to studies,[40,41] but undisclosed relationships are difficult to document and rules for sponsorship disclosure vary by journal. Consistent with a prior study,[42] we used a standard rule to classify publications with undisclosed support: when industry support was disclosed in a manuscript, we counted undisclosed industry support for all tobacco-related manuscripts by this author published 5 years BEFORE or 3 years AFTER the index publication. For example, if author X received funding from a tobacco company in 2013, we counted author X's tobacco-related manuscripts published between 2008 and 2016 as having industry support.

Categorizing Authors Based on Their Sponsorship Sources and Sponsorship Disclosure

In this study, we conducted the analysis on the author level. We considered an author to have undisclosed industry (tobacco, pharmaceutical, or e-cigarette) sponsorship if at least one of the author's publications had undisclosed sources of industry support. We considered an author's sponsorship disclosure to be mixed (or having partial disclosure) if at least one of the author's publications had both disclosed and undisclosed sources of industry support (but no publications had only undisclosed industry support). We considered an author's sponsorship to be disclosed, if all of the author's publications had disclosed sources of industry support.

Identifying Authors' Position on THR

Assessment of the authors' position on THR was used from the prior study[19] that through an iterative analysis identified 29 pro-THR and anti-THR arguments. To assign a code representing total THR stance (e.g. "pro," "anti," or "neutral") for an author, we calculated a median THR score across all publications by this author.

Statistical Analyses

Descriptive Statistics:

We calculated the median number of publications for all authors stratified by sponsorship (industry vs. non-industry), sponsorship sources (government or NGO, pharmaceutical, e-cigarette, tobacco, hybrid), presence of disclosures (disclosed, undisclosed, or mixed), and authors' THR stance ("pro," "anti," or "neutral").

Inferential Statistics:

We applied the non-parametric Kruskal–Wallis Test to compare (1) differences in median values of the number of publications between industry-sponsored and non-industry-sponsored authors; (2) differences in median values of degree and betweenness centrality among industry-sponsored and non-industry-sponsored authors. We applied the Chi Square test to compare group differences (1) among industry- and non-industry-sponsored authors with "pro", "anti," or "neutral" THR stance; (2) among industry-sponsored authors with fully-disclosed, mixed/partially disclosed or undisclosed sponsorship. We used univariate logistic regressions to find an association between industry sponsorship disclosure (ever undisclosed vs. always disclosed) with (1) industry sponsorship sources (pharmaceutical, tobacco, e-cigarette); (2) THR

stance. Statistically significant results were reported (alpha = 0.05).

Social Network Analysis

Since our dataset consisted of authors and their THR manuscripts, we initially used a *two-mode* network, which characterizes ties existing between two distinct types of *nodes*,[43,44]authors and manuscripts (but not between authors or between manuscripts). We treated authors as a primary mode of nodes and manuscripts as a secondary mode of nodes. We then made a projection of a one-mode network to analyze only one type of nodes, that is, authors. We created the projected ties between the authors in the network based on the manuscripts they collaborated on with other authors. We de-identified authors to avoid potential stigmatization related to their sponsorship sources. We used the following measures in the social network analysis:

Degree centrality, betweenness centrality, and modularity.

Degree centrality,[33,45] represents the number of ties a node has to other nodes. In this study, a degree centrality represents a number of ties between pairs of authors, that is, the number of manuscripts authored co-published together. Nodes that have more ties are considered more *central* in the network since they play a key role in content distribution by actively collaborating with other authors.

Betweenness centrality[33] represents the degree to which nodes stand between each other, that is, measures the number of times a node is located on the shortest paths between the pair of nodes. Betweenness can range from 0 to *n-squared – 3n + 2*, where *n* represents the number of authors in the network.[33] Authors with higher betweenness centrality (referred to as *bridges*) have more control over the network since they connect the larger number of nodes in it. By measuring degree and betweenness centrality, we assessed how industry sponsorship disclosure, source of funding, and THR stance is related to the authors' position in the network.

By assessing the network's *modularity*,[46] we were able to demonstrate how divided or fragmented the network is and which authors tend to group together based on their industry sponsorship disclosure, source of funding, and THR stance. Modularity measures the strength of a network's division into groups (also referred to as clusters or communities). The modularity score is the difference between the sum of the number of ties in a cluster over all the network's clusters and the number of ties expected by chance in the cluster. Modularity can range from –1 (low) to 1 (high), with 0 signifying that the community division is not better than random.[46] A high modularity score indicates strong (dense) connections between nodes *within* groups, but sparse connections between nodes in *different* groups.

By applying social network analysis, we compared: (1) degree and betweenness centrality among industry-sponsored and non-industry-sponsored authors and, using modularity, assessed the degree at which industry-sponsored authors tended to collaborate with non-industry-sponsored authors (Figure 1);

(2) THR stance and funding disclosure among authors sponsored by the pharmaceutical, tobacco, or e-cigarette industries (Figure 2).

(3) THR stance among industry- and non-industry-sponsored authors (Supplementary Figure 1).

Results

Descriptive Statistics

Overall, 284 (20%) of the authors in our dataset of 1405 authors were sponsored by industry (Table 1). On average, industry-sponsored authors had twice as many publications per author compared to non-industry-sponsored authors (Table 1).

The most common sources for industry-sponsored authors were the tobacco industry—124 (41%) and the pharmaceutical industry—119 (36%). About 87 (31%) of industry-sponsored authors had undisclosed industry-sponsored sources; the majority of industry-sponsored authors—189 (67%)—had a pro-harm reduction position (Table 1).

Inferential Statistics

Among the industry-sponsored authors, we observed differences among all the three groups of authors who had disclosed, undisclosed and partially disclosed (had disclosed and undisclosed) industry-funded sources (p-value < 2.2e–16). In the univariate logistic regression models, authors sponsored by the pharmaceutical industry (OR = 3.6; CI = 2.10–6.38) or e-cigarette industry (OR = 9.4; CI = 4.70–19.99) were more likely to have undisclosed industry-sponsored sources. Authors sponsored by the tobacco industry (OR = 0.4; CI = 0.23–0.74) were less likely to have undisclosed industry-sponsored sources.

Consistent with Hendlin et al.'s study that reported a positive association between pro-THR stance and three types of industry support (tobacco, e-cigarette, and pharmaceutical analyzed separately), we found that overall industry-sponsored authors (tobacco, e-cigarette, and pharmaceutical combined) were more likely to have pro-THR stance compared to non-industry-sponsored authors, (OR = 4.18; CI = 2.70–6.74). (With restricting industry support to only tobacco and e-cigarette funding sources, this association was almost three times stronger: OR = 11.5; CI = 5.08–32.9).

Social Network Analysis

To simplify visualizations of the networks, we applied the analysis to the 423 authors in our data who had more than one publication. Among authors with more than one publication, industry-sponsored authors had a slightly higher degree centrality (Median = 5, SD = 8, Range = 0–53) than non-industry-sponsored authors (Median = 4, SD = 4, Range = 0–31), p-value < 0.0001. Industry-sponsored authors also had higher betweenness centrality (Median = 5, SD = 1535, Range = 0–7678) than non-industry-sponsored authors (Median = 0, SD = 535, Range = 0–4014), p-value < 0.0001.

Industry-sponsored authors (yellow circles, Figure 1) appeared to be more central in the network compared to non-industry-sponsored authors. The network's modularity score was 0.75, which indicates a sparse connection (or high division) between groups and strong connection within groups. The network consisted of 75 groups: 45 groups where nodes were connected to each other with at least one tie and 30 isolated authors or *isolates* (nodes not connected to anyone). Among the 45 groups, there were five exclusive industry-sponsored groups and 24 exclusive non-industry groups (that included only industry-sponsored or only non-industry sponsored authors, respectively. Examples are annotated in Figure 1). Industry-sponsored authors also had 9 isolates, whereas non-industry-sponsored authors had 21 isolates not co-publishing with anyone. Overall, there were more

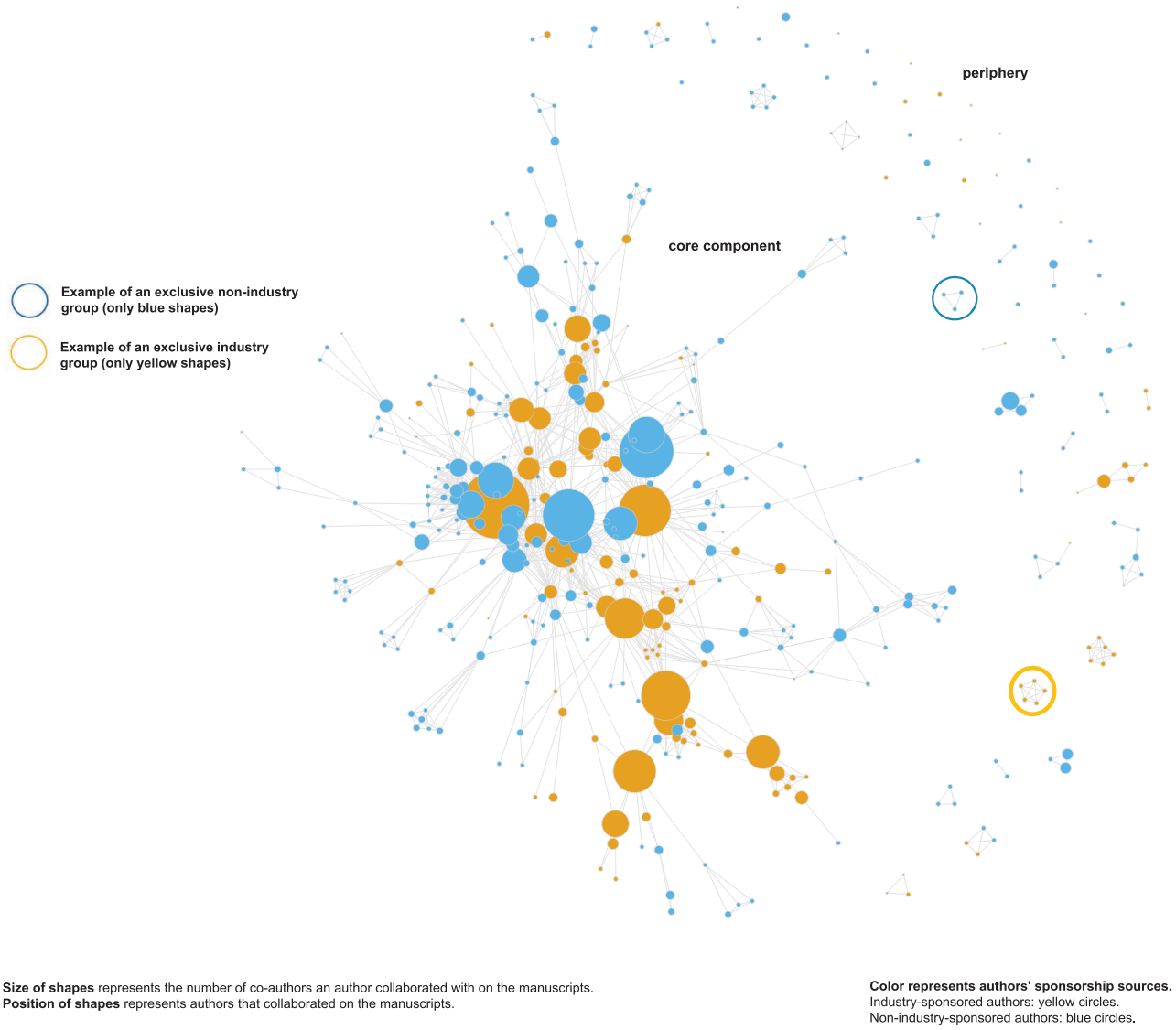

Figure 1. A network of authors with more than one publication sponsored by tobacco, pharmaceutical, e-cigarette sources (n = 128), and authors sponsored by non-industry sources (n = 295).

authors—101 (34%) among 295 non-industry-sponsored authors who were part of exclusive groups or isolates, compared to 29 (23%) among 128 industry-sponsored authors. About 16 (21%) groups were mixed, consisting of both industry and non-industry-sponsored authors. Authors in the mixed groups predominantly occupied the center of the core component of the network. Exclusive groups of non-industry-sponsored authors were located further from the center in the core component or in the peripheral part of the network, whereas exclusive groups of the industry-funded authors were located only on the periphery (Figure 1).

In the industry-sponsored networks (Figure 2), the tobacco industry-sponsored authors had the highest modularity (the strongest division into groups)—0.76—compared to 0.64 for the e-cigarette industry-sponsored and 0.61 for the pharmaceutical industry-sponsored authors. The most central authors in the *tobacco network* disclosed or partially disclosed their industry funding sources, while smaller peripheral groups—cliques[33] (where all nodes are connected to each other) and blocks (where some nodes are connected and some are not connected)—mostly consisted of authors who did not disclose their industry funding sources. The *e-cigarette network* predominantly consisted of authors with pro-THR stance and undisclosed industry-funded sources. The *pharmaceutical network* had the weakest modularity and a greater variation in authors' THR stance and industry sponsorship disclosures. However, the most central authors in the pharmaceutical network had pro-THR stance and undisclosed industry funding sources.

The non-industry-sponsored network (Supplementary Figure 1) had a stronger modularity—0.83—than the industry-sponsored network—0.72. Peripheral non-industry authors predominantly formed groups (cliques or blocks) with authors who had the same THR stance. Authors with pro-THR stance were the most central (with the highest degree and betweenness centrality) in both industry-sponsored and non-industry-sponsored networks.

Discussion

The social network analysis in this study explores the community of published authors on the topic of THR, detailing

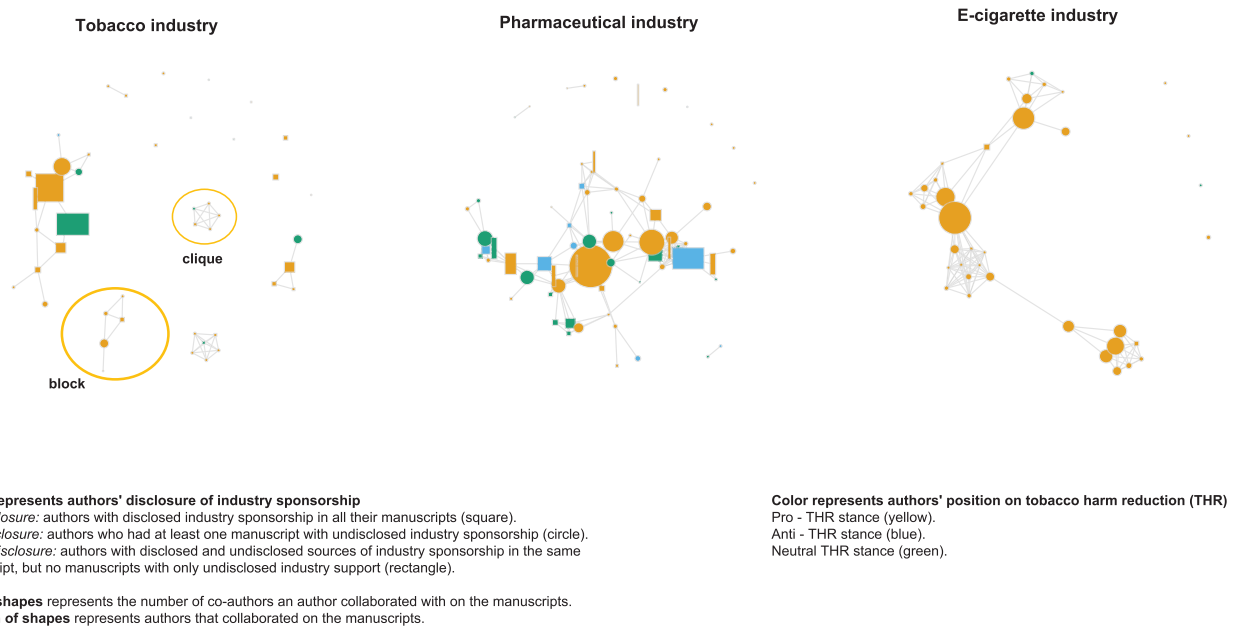

Figure 2. A network of authors sponsored by the tobacco industry (n = 44), pharmaceutical industry (n = 74), and e-cigarette industry (n = 37).

Table 1. Characteristics of 1405 authors by source of funding, disclosure of funding, and position on tobacco harm reduction

	Industry-sponsored authors (N = 284)	Non-industry-sponsored authors (N = 1121)
Median number of publications	4	2
Disclosed funding source n (%)		
Government grant/NGO	52 (18%)	538 (48%)/90 (8%)
Pharmaceutical industry	119 (36%)	
Tobacco industry	124 (41%)	
E-cigarette industry	52 (17%)	
Hybrid[1]	10 (less than 1%)	
Disclosure of funding source n (%)		
Disclosed	197 (69%)	628 (56%)
Undisclosed	68 (24%)	None [2]
Mixed (disclosed and undisclosed)	19 (7%)	
Position on THR n (%)		
Pro-THR	189 (67%)	306 (27%)
Anti-THR	35 (12%)	554 (50%)
Neutral THR	34 (12%)	170 (15%)
missing (only among authors with 1 publication)	26 (9%)	91 (8%)

[1]Hybrid was not assigned to industry or non-industry-funded authors.
[2]About 493 authors did not provide funding statements in their manuscripts and were not found in any external databases described in the Methods section. Over 80% of these authors had only one publication, most of which were editorial letters and Author's Replies.

that industry-sponsored researchers work widely with other industry-sponsored researchers as well as non-industry-sponsored researchers, potentially influencing mainstream tobacco control discourse. Industry-sponsored researchers produce predominantly pro-THR stance studies and have higher degree and betweenness centrality than non-industry-sponsored researchers in the network. This is indicative of increased influence on discourse on THR in the scientific community.

We identified 284 industry-funded and 1121 non-industry-funded authors and constructed a network of authors (total of 423) with more than one publication. Compared to non-industry-sponsored authors, industry-sponsored authors appeared to be more central and influential in the network: having twice as many publications, 1.25 as many collaborators on publications, and higher likelihood of being "*bridges*" connecting authors together. Industry-funded authors also produced increased pro-THR findings. The relatively slow speed of government peer-reviewed competitive grant funding versus industry financial incentives to publish manuscripts quickly may contribute to these asymmetries in higher volume publications by industry-sponsored authors. Also, although the majority of industry-sponsored authors disclosed their industry sponsorship sources, the top 12 of them with highest degree centrality (Range: 15–53) and highest betweenness centrality (Range: 4300–7700) did not always disclose their industry funding sources.

Industry-sponsored authors formed fewer exclusive groups compared to non-industry-sponsored authors and collaborated more frequently with both industry-sponsored and non-industry-sponsored authors. It is worth noting that historically, the industry has attempted to create alliances with non-industry-sponsored authors to bolster the appearance of independence and objectivity,[23,24] so the increased number of coauthors for industry-sponsored authors may be consistent with this objective.

Authors supported by the e-cigarette industry had the strongest association with pro-THR stance and with undisclosed industry sponsorship compared to authors supported by the tobacco or pharmaceutical industries. This may be explained by a higher motivation of authors supported by e-cigarette companies to influence THR discourse in an attempt to promote e-cigarettes as alternative tobacco products

while feeling less pressure to disclose funding sources compared to manufacturers of traditional combustible cigarettes.

Non-industry authors occupied more peripheral positions compared to the central industry-sponsored authors and had more isolates in the network. The majority of the non-industry-sponsored authors had anti-THR stance. Non-industry-sponsored authors less frequently collaborated with industry-sponsored authors, and co-published predominantly only with those who had an anti-THR or neutral THR stance. This may not be surprising, as authors who have chosen not to pursue industry sponsorship may avoid publishing with coauthors with clear COI.[47] In addition, non-industry-sponsored authors with smaller degree and betweenness centrality formed clusters with other non-industry-sponsored authors who held similar THR stance. However, non-industry-sponsored authors with high degree and betweenness centrality appeared to be more open to collaboration with other non-industry-sponsored authors who had a different position on THR.

Limitations

This study only reviewed publications through 2016. Notably, this study does not address the most lavishly funded effort in recent years, Philip Morris International's Foundation for a Smoke-Free World, which was launched in September 2017 with an announced 12-year funding commitment of $1 billion.[48,49] Thus, the findings from this study might not be generalizable to the 2017–2022 time period when newer data related to efficacy of e-cigarettes emerged, non-industry tobacco control researchers took more supportive stance on THR overall, and industry sponsorship disclosures might have become more consistent. Nonetheless, our findings may be indicative of the role of COI in the ongoing decade-long controversy in THR discourse. The controversies and standpoints on THR, as e-cigarettes and other alternative tobacco products emerged, substantially increased since 2008 and may have gelled by 2016. Given the prolific publishing and ongoing debate about THR in the field, future research should examine funding disclosures and collaboration patterns among industry-sponsored and non-industry-sponsored authors after 2016.

Although we conducted a comprehensive search of multiple databases for undisclosed industry sponsorship and identified many authors with undisclosed industry support, it is likely that we still underestimated the number of industry-sponsored authors. Unlike other systematic reviews, which use strict criteria to narrow the scope of the broad searches to a few publications (e.g. a small number of randomized trials addressing a specific health outcome), the wide scope of a query such as the "scientific discourse on THR" yields a large number of relevant publications of varying types, and requires extensive manual review and coding. As a result, it is possible that some relevant sources containing information about industry support were missed. In addition, tobacco industry documents are a valuable, but incomplete source of information on industry sponsorship and there are no comparable databases for pharmaceutical or e-cigarette industries. In particular for the 493 (44%) authors that did not include any funding statement in their published manuscripts, if their names were not found in databases for undisclosed industry sponsorship, we conservatively classified these authors as non-industry-sponsored.

Conclusion

A substantial number of authors working on THR received disclosed and undisclosed industry sponsorship. Based on social network analysis, we found that authors with industry sponsorship exert a greater potential influence on the scientific discourse on THR due to higher numbers of publications, higher numbers of collaborators, and higher likelihood of connecting authors with each other in the network compared to non-industry-sponsored authors. Current journal policies related to disclosure of industry COI are necessary, but not sufficient to address industry influence on scientific dialogue. Some scientific journals do not consider submissions if part or all of the support for the study or the researchers comes from a tobacco company.[50,55] Some researchers[51–54] recommended increasing funding for independent scientists and stricter guidelines to regulate the interaction of research institutes with commercial entities. However, while some COI statements have appeared to be deliberate efforts to obfuscate tobacco industry funding, other incomplete COI statements might be errors of omission. Such inconsistent undisclosed COI statements were found in this study by comparing the disclosures in several manuscripts published by the same author. Coordinated and consistent reporting systems and policies across journals may facilitate avoiding these inconsistencies; systems to organize science and scientists, such as ORCID that include grant funding reporting might also include industry support and other COI statements to facilitate consistent reporting. In addition to more consistent and integrated reporting systems, stronger enforcement of policies may improve disclosure. For example, penalties for authors found to have fraudulently failed to disclose industry funding that are subsequently discovered could be established (such as mandatory retractions, or being prohibited to further submit research to that journal). An increase in government and public funding for tobacco control might also be necessary to achieve funding parity.

Supplementary Material

A Contributorship Form detailing each author's specific involvement with this content, as well as any supplementary data, are available online at https://academic.oup.com/ntr.

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Declaration of Interests

The authors of this manuscript have no competing interests to declare.

Author Contribution

J.V. and P.L. conceived the paper, J.V. wrote the first draft of the manuscript. All coauthors provided feedback on the first draft and substantial writing to the final version of the article. All coauthors approved the final version.

Data Availability Statement

The data underlying this article will be shared on reasonable request to the corresponding author.

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