Mapping Engagement in Twitter-Based Support Networks for Adult Smoking Cessation

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We examined engagement in novel quit-smoking private social support networks on Twitter, January 2012 to April 2014. We mapped communication patterns within 8 networks of adult smokers (n = 160) with network ties defined by participants' tweets over 3 time intervals, and examined tie reciprocity, tie strength, in-degree centrality (popularity), 3-person triangles, 4-person cliques, network density, and abstinence status. On average, more than 50% of ties were reciprocated in most networks and most ties were between abstainers and nonabstainers. Tweets formed into more aggregated patterns especially early in the study. Across networks, 35.00% (7 days after the quit date), 49.38% (30 days), and 46.88% (60 days) abstained from smoking. We demonstrated that abstainers and nonabstainers engaged with one another in dyads and small groups. This study preliminarily suggests potential for Twitter as a platform for adult smoking-cessation interventions. (*Am J Public Health.* 2016;106:1374–1380. doi:10.2105/AJPH.2016.303256)

Cigarette smoking is the leading cause of preventable death globally.[1] Despite smokers reporting a strong desire to quit, relapse rates remain high. Social media may provide novel influences for tobacco quit attempts. Twitter, specifically, has expanded real-time communication, with more than 305 million users worldwide in 2015.[2] Of the 85% of the US population online, an estimated 23% use Twitter[3]

Twitter may be useful for smoking cessation among adults because it may provide a new network offering social support for the quit attempt. Yet past studies indicate mixed findings regarding the relationship between support provided outside of a clinical setting and smoking cessation. Whereas the 2000 Treating Tobacco Use Guideline[4] endorsed helping smokers find support in their environment for smoking cessation (extratreatment support), the 2008 update excluded it, stating that the recent literature did not show that it had a strong effect for helping smokers quit.[5] Studies also have tested whether computer-generated support messages or automessaging sent to e-mail or mobile phones can facilitate smoking cessation.[6–9] These findings are mixed as well, summarized in a recent meta-analysis, possibly because the automessage-based social support was noninteractive[10]; however, another meta-analysis concluded that such automessaging was efficacious if daily and prolonged.[11]

Herein, we descriptively examined how smokers engaged in a novel interactive Twitter-based cessation intervention called "Tweet2Quit" that included automessaging to encourage tweeting. We examined 8 online social networks, each with 20 adult daily smokers, as sociometric networks, including participants and network ties (tweets sent) among them. We describe participants' engagement in networks, captured by tweeting behavior over 3 time intervals—week 1, weeks 2 to 4, and month 2—and map point prevalence smoking abstinences at the end of each interval.

We focused on network tie characteristics that have been related to the transmission of social influences in networks[12–15] and smoking,[16–18] including tie reciprocity, tie strength, in-degree centrality, mutually connected triangles, 4-person cliques, and whole-network density. These network characteristics reflect communication patterns at the individual, dyadic, and more aggregated levels and are defined in the box on the next page.

METHODS

We recruited participants via the Google search engine and Google AdWords. Study screening criteria were having smoked 100 or more cigarettes in their lifetime, smoking 5 or more cigarettes per day currently, being prepared to quit in the next 30 days, being aged 18 to 59 years, speaking English, living in the continental United States, having an active e-mail account, having a mobile phone with unlimited texting, and texting weekly. Exclusion criteria were contraindications to nicotine patch use or taking a prescription medicine for depression or smoking cessation.

We conducted the first 2 networks during the pilot phase (January 2012 to August 2012), and then conducted 6 during the later phase of the study, which involved

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DEFINITIONS OF NETWORK CHARACTERISTICS IN A STUDY OF TWITTER-BASED SUPPORT NETWORKS FOR ADULT SMOKING CESSATION: UNITED STATES, JANUARY 2012–APRIL 2014

Network Characteristics	Definition
Tie reciprocity	Whether a tweet sent receives a response
Tie strength	The number of tweets between any 2 participants
In-degree centrality	The number of tweets a participant received
Mutually connected triangles	Among all 3 individuals, all possible ties (tweets sent) among all people are mutually reciprocated
4-person cliques	Among all 4 individuals, all 6 possible ties among them (tweets sent) are mutually reciprocated
Whole network density	The number of all present directed ties (tweets sent) among all network members divided by the number of possible directed ties that could exist among them such that each person is connected to all others

a randomized controlled trial with a comparison condition that did not include Twitter. We focused on participants randomized to the Twitter condition. From network 2 onward, we added daily Facebook use to the screening criteria and we added daily marijuana use as an exclusion criterion. See Appendix A (available as a supplement to the online version of this article at http://www.ajph.org) for a full description of screening and exclusion criteria, procedures, and intervention.

Participants (n = 160) set a date to quit during the first week of the network's start, and were encouraged to tweet with their networks for 100 days. Participants also received 8 weeks of nicotine patches, were encouraged to use a quit-smoking Web guide, and were sent 2 daily automessages via Twitter suggesting discussion topics and providing personalized feedback on the previous day's tweeting for 100 days until the study ended.

Measures

We downloaded the tweet data for the study period from Twitter and organized it by tweet, showing the sender of the tweet, the designated recipient(s) if specified by the tweeter, the date and time the tweet was sent, and the content. Participants recorded their quit date on the study Web site. Then they received e-mailed links to online surveys at 7, 30, and 60 days after the quit date that measured their smoking abstinence and their tweeting methods. We measured smoking abstinence with 2 questions[6,8,9]: (1) "How many cigarettes have you smoked in the past 7 days? (type in a number)" and (2) "Have you puffed on a cigarette within the past 7 days? (yes, no)." To be considered abstinent, participants had to respond 0 cigarettes on item 1 and no on item 2. We treated participants as missing if they did not respond to the survey. Nonrespondents received daily reminders for 2 weeks.

The baseline survey assessed participants' age ("How old are you?"), gender (male = 1; female = 2), race/ethnicity ("Are you Hispanic or Latino? [1 = yes or 2 = no]" and "What best describes your ethnic background? Please check all that apply: [1 = African American/Black; 2 = Asian, Pacific Islander/Native Hawaiian; 3 = other Caucasian/White; 4 = American Indian/Alaska Native; 5 = other, not known]."), marital status (1 = married; 2 = live with intimate partner; 3 = divorced; 4 = separated; 5 = widowed; 6 = single; 7 = never married), and education level (1 = no formal education; 2 = some grade school; 3 = completed grade school; 4 = some high school; 5 = completed high school or general equivalency diploma; 6 = some college; 7 = completed college; 8 = some graduate work; 9 = graduate degree). We also included perceived intervention helpfulness (from 1 = very unhelpful to 7 = very helpful) and how many days participants used nicotine patches. Demographics are summarized in Table 1.

Social Network Measures

We automatically downloaded tweets daily from Twitter and pasted them into an Excel spreadsheet on the privacy-protected study Web site. After the study ended, 2 coders working independently coded the recipient(s) of each tweet, and intercoder agreement (i.e., the number of times raters agreed on codes divided by the number of times the codes were actually the same) was 91%. The sender of each tweet could be a study participant or the study administrator, and the recipient(s) could be 1 or more participants, the study administrator, or the entire network. Each participant, the study administrator, and entire networks had unique codes (see Appendix B, available as a supplement to the online version of this article at http://www.ajph.org).

We defined a network tie as a tweet sent from one participant to another, or to several others in a network. Ties were directed, as they had a specific directionality in being posted by one person and received by another or several others. A node is a participant in a network or the administrator.

With the tweets, we created variables representing the following network characteristics:

1. number of reciprocated ties,
2. proportion of reciprocated ties in a network,
3. tie strength,
4. average tie strength in a network,
5. in-degree centrality for each individual,
6. average in-degree centrality,
7. number of mutually connected triangles,
8. number of mutually connected 4-person cliques, and
9. whole network density.

We measured the number of reciprocated ties based on whether a tweet received

TABLE 1—Sample Demographics (n = 160) in a Study of Twitter-Based Support Networks for Adult Smoking Cessation: United States, January 2012–April 2014

Demographics	% or Mean ±SD
Age, y	35.99 ±10.14
Gender	
Female	68
Male	32
Ethnic background[a]	
White	92
Hispanic or Latino	4
African American or Black	4
Asian	2
Pacific Islander or Native Hawaiian	0
American Indian or Alaska Native	2
Other	4
Marital status	
Married	38
Live with an intimate partner	17
Divorced	15
Separated	2
Widowed	1
Single, never married	27
Highest education level completed	
Completed grade school	1
Some high school	2
Completed high school or GED	19
Some college	46
Completed college	26
Some graduate work	1
Graduate degree	5

Note. GED = general equivalency diploma.
[a]Participants could identify as more than 1 category.

a response between 2 participants.[15] We calculated the proportion of reciprocated ties as the number of reciprocated tweets in a network divided by the number of all directed ties (tweets sent) in that network. We measured tie strength as the number of tweets between any 2 participants. Average tie strength was the sum of the number of all tweets between participants divided by the number of directed ties (tweets sent) in the network.[19]

We measured in-degree centrality as the number of tweets an individual received.[15] We measured average in-degree centrality as the average number of tweets received per individual in a network. We measured mutually connected triangles and 4-person cliques as complete subgraphs of 3 and 4 members, respectively, wherein all possible ties were present and mutually reciprocated.[15] We measured whole network density as the number of all present directed ties (tweets sent) among all members of a network divided by the number of all possible directed ties that could exist among them such that each person is connected to all others.[15] Whole network density could range from 0 (no one tweets) to 1 (everyone tweets everyone), and included isolates (individuals who did not send or receive any tweets during a time interval).

Social Network Analyses

We used NodeXL software version 1.0.1.350 (Social Media Research Foundation, California) to create sociograms for the social networks during each time interval: week 1, weeks 2 to 4, and month 2. Each sociogram depicted participants as nodes, and the ties between members as directional lines. The first time interval was the first week because participants were just getting to know each other and tweeted actively; for network 1, 40% occurred then. The second time interval was weeks 2 to 4 and the third was month 2, because there was still a relatively high volume of tweeting. In month 3, tweeting became infrequent and it was difficult to observe network structure.

In each sociogram, we depicted tie reciprocity by using tie color. Red ties indicated a reciprocated tie between 2 individuals, and blue ties indicated nonreciprocated ties. We conveyed tie strength through tie thickness, with thicker lines indicating stronger ties. We depicted in-degree centrality by using node size, with larger nodes indicating higher scores. We also examined mutually connected triangles and 4-person clique structures by using Stata version 14.1 (StataCorp LP, College Station, TX) to determine the number of each during each time interval. Finally, we computed whole network density during each time interval.

We displayed participants' abstinence status during a time interval by node shape, with triangles representing abstainers, squares representing nonabstainers, and circles representing missing data or those who did not fill out the abstinence survey. We included a node for the administrator denoted by a light green circle within a square. Each sociogram only included tweets directed to specific recipients, and not to the entire network, to present a clearer view of network structure. We formatted the networks by using the graph-theoretic layout function in NodeXL, Spring Embedding.

We also examined how the values of each network variable changed during the 3 time intervals within a network, and coded the values as low, medium, or high. Because we did this classification within networks, the values of low, medium, and high are only relative to the distances between scores on variables within a specific network rather than across networks. Across all 8 networks, 3 network characteristics—whole network density, average in-degree centrality, and the number of triangles—displayed generally consistent patterns over the 3 time intervals. Therefore, we characterized each network on the basis of its pattern specific to these 3 network measures. For instance, for network 1, the number of mutually connected triangles went from 18 to 15 to 2 over the 3 time intervals, suggesting a pattern of high, medium, low according to the change in scores. In network 2, the number of mutually connected triangles went from 12 to 22 to 6 over time, and so we coded this pattern as medium, high, low. However, on the other 2 measures, network 2's pattern was low, high, medium, so overall this is how we classified it. Thus, our coding scheme only captured general patterns for the 3 variables across all 8 networks and 3 time intervals.

RESULTS

Of the 160 study participants, 68% were female, 89% were non-Hispanic White, 55% were married or with a partner, 46% had attended some college, and the mean age was 36 years (SD = 10). At 7 days after the quit date, 35.00% of the participants reported being abstinent and 41.25% reported being nonabstinent; 23.75% did not respond to the survey and we treated them as missing. At 30 days after the quit date, 49.38% reported being abstinent and 27.50% reported being nonabstinent; 23.13% did not respond to the survey. At 60 days after the quit date, 46.88% reported being abstinent and 29.38%

reported being nonabstinent; 23.75% did not respond to the survey. Participants reported a mean score of 5.33 (SD = 1.80) regarding intervention helpfulness (n = 104), and used nicotine patches for 32.15 days (SD = 22.36) on average (n = 122).

The network characteristics under study for the 8 networks at the 3 time intervals are described in Table 2, and additional descriptive network statistics are included in Table A (available as a supplement to the online version of this article at http://www.ajph.org). We identified 3 patterns on 3 network variables—whole network density, average in-degree centrality, and the number of mutually connected triangles—across all 8 networks: (1) from high to medium to low (networks 1, 3, and 8), (2) from medium

TABLE 2—Network Characteristics by Network and Time Interval (n = 160) in a Study of Twitter-Based Support Networks for Adult Smoking Cessation: United States, January 2012–April 2014

Characteristic	Network 1	Network 2	Network 3	Network 4	Network 5	Network 6	Network 7	Network 8
No. of reciprocated ties								
7 d	44	38	66	38	28	40	12	78
30 d	42	54	62	70	40	68	20	70
60 d	14	30	18	30	18	26	4	28
Proportion of reciprocated ties, %								
7 d	61.97	53.52	60.00	55.88	42.42	66.67	36.36	69.64
30 d	63.64	51.92	56.88	72.16	54.79	71.58	35.71	67.96
60 d	53.85	37.50	56.25	54.55	60.00	55.32	19.05	54.90
Range of tie strength								
7 d	1–57	1–17	1–14	1–13	1–13	1–31	1–10	1–50
30 d	1–79	1–34	1–19	1–15	1–23	1–57	1–24	1–23
60 d	1–23	1–30	1–31	1–19	1–29	1–19	1–21	1–27
Average tie strength								
7 d	4.76	2.89	2.29	3.03	2.20	3.23	2.36	4.00
30 d	4.20	4.66	2.85	3.03	3.56	4.67	3.66	3.78
60 d	2.46	4.06	3.78	3.20	4.50	4.09	4.90	4.16
Range of in-degree centrality (administrator excluded)								
7 d	0–9	0–8	0–10	0–12	0–6	0–9	0–5	0–12
30 d	0–9	0–12	0–12	0–10	0–8	0–11	0–6	0–10
60 d	0–5	0–9	0–5	0–7	0–5	0–7	0–3	0–8
Average in-degree centrality								
7 d	3.10	2.95	4.80	2.80	2.65	2.55	1.25	5.00
30 d	2.85	4.50	4.65	4.25	3.05	4.20	2.20	4.65
60 d	1.10	3.25	1.20	2.25	1.15	1.95	0.60	2.10
No. of mutually connected triangles								
7 d	18	12	26	11	6	12	2	53
30 d	15	22	17	31	16	40	3	43
60 d	2	6	2	5	4	9	0	6
No. of 4-person cliques								
7 d	7	5	6	3	1	2	0	38
30 d	3	10	2	12	7	22	0	28
60 d	0	1	0	0	1	2	0	1
Network density (including isolates)								
7 d	0.17	0.17	0.26	0.16	0.16	0.14	0.08	0.27
30 d	0.16	0.25	0.26	0.23	0.17	0.23	0.13	0.25
60 d	0.07	0.19	0.08	0.13	0.07	0.11	0.05	0.12
Network density (excluding isolates)								
7 d	0.46	0.26	0.36	0.25	0.31	0.38	0.25	0.53
30 d	0.42	0.42	0.36	0.53	0.47	0.52	0.31	0.57
60 d	0.36	0.33	0.17	0.35	0.42	0.30	0.23	0.33

to high to low (networks 4–7), and (3) from low to high to medium (network 2). Because of space constraints, we selected 1 network representing each of the 3 evolution patterns, in lieu of describing all 8 across all time intervals; therefore, 3 representative sociograms are presented.

For the high-to-medium-to-low pattern in network 1, network density was 0.17 during days 1 through 7, became slightly less dense (0.16) during days 8 through 30, and then became much less dense (0.07) during month 2.

There were 12, 12, and 8 active participants (i.e., those who sent or received at least 1 tweet) of the 20 total participants in network 1 over the 3 time intervals, respectively. During days 1 through 7 (Figure A, available as a supplement to the online version of this article at http://www.ajph.org), there were 71 directed ties and 44 of them were reciprocated; thus, the proportion of reciprocated ties was 61.97% (44 of 71). The number of reciprocated ties declined slightly (to 42 of 66 or 64.64%) during the second time interval, and then decreased further (to 14 of 26 or 53.85%) by the third time interval. Both abstainers and nonabstainers had reciprocated ties during each time interval. The number of reciprocated ties between 1 abstainer and 1 nonabstainer was 16, 22, and 8; between 2 abstainers it was 16, 18, and 2; and between 2 nonabstainers it was 6, 2, and 4, respectively.

Tie strength varied from 1 to 57, 1 to 79, and 1 to 23, respectively, over the 3 time intervals; and average tie strength was 4.76, 4.20, and 2.46, respectively. The strongest tie in the network was between participants 10108 and 10119 at all 3 waves, with 10108 always abstaining, whereas 10119 changed from an abstainer to a nonabstainer at wave 3.

Among the 20 participants, the most popular participant during the first 2 time intervals received tweets from 9 different active participants, and this number decreased to 5 at wave 3. When one considers that the number of active participants at each time interval was 12, 12, and 8, respectively, some network members received tweets from more than half of the other active members. More specifically, the most popular participants during the first 7 days were 10105 (missing on smoking status) with 9 incoming ties, 10108 (abstainer) with 8 incoming ties, and 10119 (abstainer) with 8 incoming ties. From day 8 to day 30, respondent 10108 (abstainer) had the highest in-degree centrality with 9 incoming ties, followed by respondent 10119 (abstainer) with 8 incoming ties, and then respondent 10111 (abstainer) with 6 incoming ties. During month 2, the 3 most popular participants were 10104 (nonabstainer), 10108 (abstainer), and 10119 (nonabstainer), each having incoming ties from 5 different participants.

The number of mutually connected triangles decreased somewhat from 18 to 15 and then decreased to 2 at the last time interval. Among the 18 triangles at the first time interval, 3 were among abstainers, 1 was among nonabstainers, and the majority (78%) contained both. Of the 15 triangles at the second time interval, 4 were among abstainers, with the majority (73%) including both abstainers and nonabstainers. The 2 triangles at wave 3 comprised both abstainers and nonabstainers. There were 7 and 3 4-person cliques during the first and second time intervals, respectively. Each was a mix of abstainers and nonabstainers. There were no 4-person cliques during the last time interval.

For a description of results pertaining to the other 2 patterns detected, see Appendix C (available as a supplement to the online version of this article at http://www.ajph.org).

DISCUSSION

The patterns emerging across the 8 networks over the 3 time intervals indicated high engagement through dyadic and higher-level communication patterns, among and between abstainers and nonabstainers. The formation of mutually connected triangles and 4-person cliques suggests small-group communication. The numerous reciprocated ties among participants signaled mutual bonds, which formed despite the relatively short study duration and virtual platform. In most networks and time intervals, more than 50% of ties were reciprocated, suggesting that participants checked in and replied to others' posts. The major study contribution lies in demonstrating that both abstainers and nonabstainers engaged with one another, in both dyadic and small-group communication patterns. This study also preliminarily suggests potential for Twitter as an online platform for adult smoking cessation interventions.

Both abstainers and nonabstainers engaged in the quit-smoking networks and both had reciprocated and strong ties. The majority of reciprocated ties were either between 2 abstainers or an abstainer and a nonabstainer in most networks and time intervals. Reciprocated ties were less common among 2 nonabstainers. In analyses not presented, on average, nonabstainers sent more ties to abstainers than to nonabstainers during the first 2 time intervals. One interpretation is that nonabstainers may have turned to the abstainers and others for support.

In general, abstainers had more reciprocated ties among themselves in comparison with those among nonabstainers, across most networks and time. Across networks, the strongest and most reciprocated ties occurred among abstainers. When we compared the average proportion of reciprocated ties among abstainers over the 3 time intervals, per network, to that of nonabstainers, on average, abstainers had higher proportions of reciprocated ties in most networks. One explanation is that abstainers were more invested in the network and in quitting smoking, which may have been reflected in their having more reciprocated relationships with one another. Moreover, such ties may have functioned as buddies in helping abstainers remain quit. Past literature suggests the merit of forming new buddies for smoking cessation.[20]

Both abstainers and nonabstainers were among the most popular network members at various time intervals. However, abstainers were on average more popular than nonabstainers across most networks. In some instances, participants' popularity decreased over time, as network density decreased and the number of people tweeting declined. It was notable that even some participants who did not complete the follow-up surveys were popular.

The 3 network patterns observed may offer preliminary insights into the extent to which the structure of these network ties may have regulated social influences such that they aligned tweeting and abstinence behaviors with normative behavior in a network. The density of ties and presence of triangles affect the transmission of social influences, as both dense ties and more triangles can regulate network social influences toward consistency with normative network behaviors. In addition, average in-degree centrality reflects the extent to which participants were exposed to informational inputs via incoming tweets.

The first pattern, high to medium to low, suggested that participants may have experienced stronger regulation to adhere to normatively sanctioned tweeting and abstinence behavior and generally more informational inputs during the first 2 time intervals than with the final one. A second common pattern, medium to high to low, suggested that the regulation of dense and strong ties on network social influences and the amount of informational inputs likely increased over time, was most salient at the second time interval, and then decreased. A third pattern, observed only in network 2, was low to high to medium, and suggested that regulation of network social influences likely started out low, then increased considerably, and finally decreased to a moderate level. Because of the descriptive study nature, much more research is necessary to test the validity of these patterns.

In most networks, the proportion of reciprocated ties decreased in the last time interval, sometimes markedly. This may reflect a natural progression of online support groups; many groups dissipate after a few months.[21] Such groups require time investments,[22] which can cause participation to drop. Also, anecdotally, several group participants who successfully quit said they no longer wanted to affiliate with a quit-smoking group. Though held constant at 2 automated tweets daily over the 100 days of intervention (excluding network 1), it may be that more automessages are needed to sustain engagement over time.

There is evidence of communication patterns that were more aggregated than the dyad level because of the formation of mutually connected triangles and 4-person cliques, particularly during the first 2 time intervals. In most networks, the majority of triangles consisted of both abstainers and nonabstainers. Also, numerous triangles formed among abstainers and a few formed among nonabstainers, with considerably more triangles among abstainers than nonabstainers. Nearly all 4-person cliques contained abstainers and nonabstainers, and most formed during the second time interval. There was 1 clique of nonabstainers in network 4 at the second time interval, which may suggest some degree of closeness among them. As individuals became less active in the network, the occurrence of triangles and 4-person cliques decreased, especially during the last time interval.

The densest network structure occurred most often at the second time interval (days 8–30), across networks and time intervals. Participants were instructed to set a date and quit during the first week of their network; hence, by day 8, they were entering the acute stages of quitting, may have needed help coping, were likely experiencing withdrawal, and were gaining experience with the patch, which they discussed. Another explanation is that, by the second time interval, participants were most strongly invested in the network and may also have felt the most peer pressure to engage in the network. Densely connected network ties are thought to bind people together tightly through increased social influence and regulation of attitudes and behavior.[12,13] In network 2, density was higher in the second time interval than in the first, suggesting that the network may have promoted cohesion over time. In most networks, however, density gradually declined and was lowest in the last time period, indicating that participants were losing interest, supporting our planned end by 100 days.

Limitations

This study has several limitations, notably its descriptive nature and small sample size. Study screening criteria including access to a mobile phone with Internet and unlimited texting and daily Facebook use likely decreased sample heterogeneity. The criterion of daily Facebook use initiated for network 2 onward may have resulted in differences in tweeting behavior for these networks versus network 1; however, our within-network analysis strategy may lessen such concerns. Cessation outcomes at month 2 are preliminary because of high relapse rates over time. Also, self-reported quit rates may be higher than actual quit rates. Delivered online via private social network groups, Tweet2Quit had low-demand characteristics for falsifying abstinence.[23] Future studies could include biomarkers such as cotinine for validation.[24]

Another limitation is that, in ancillary analyses not presented, an abstainer at 7 days was 440% more likely to answer the 30-day abstinence question than a nonabstainer, and at 30 days was 551% more likely to answer the 60-day abstinence question than a nonabstainer. Also, these networks were initiated for research; it is unclear how this affected tweeting and abstinence. Lastly, our analytic classification scheme only revealed general and relative patterns within network.

Implications

Future studies are needed to understand whether reciprocated strong Twitter network ties might be "buddy" relationships during smoking cessation, found previously to be beneficial for smoking cessation.[20,22] The support functions of such ties could be examined in relation to abstinence behavior and compared with the effects of support outside the study. Also of interest is whether the provision of free nicotine patches facilitates or complicates tweeting behavior. Studies might also be undertaken to consider the role of providing incentives for network participation. Lastly, future studies are needed to understand the costs of utilizing Twitter networks for interventions.

Twitter appears useful for building extratreatment support for quitting smoking; however, methodological issues salient to ascertaining, analyzing, and inferring from Twitter data[25] warrant future research. Future research should explore the question of how the population of US adult Twitter users intersects with that of US adult smokers (Appendix D, available as a supplement to the online version of this article at http://www.ajph.org).

Conclusions

This study is a preliminary yet novel step in exploring the structure of communication patterns among adults in constructed Twitter networks. Both abstainers and nonabstainers engaged and had reciprocated, strong, and enduring ties, and both were popular. Participants' communication patterns aggregated into both dyadic and small-group–level structures. This study provides preliminary insight into how participants' communication patterns and abstinence behavior evolved over time, and is a stepping stone for future research examining social media and smoking cessation. AJPH

CONTRIBUTORS

C. M. Lakon conceptualized the study and led the writing, measurement, and analyses. C. Pechmann contributed to the writing and conceptualization of this study. C. Wang conducted study analyses, aided in measurement, led the data management, and contributed to the writing of this article. L. Pan aided in the data management and writing. K. Delucchi and J. J. Prochaska aided in the writing of this article and contributed to measurement.

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HUMAN PARTICIPANT PROTECTION

Approval for the research was obtained from the institutional review boards at all affiliated universities and online informed consent occurred at screening.

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