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## Exploring online communication about cigarette smoking among Twitter users who self-identify as having schizophrenia

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### Abstract

Novel approaches are needed to address elevated tobacco use among people with schizophrenia. This exploratory study examined the frequency, timing, and type of communication about tobacco-related content on Twitter among users who self-identify as having schizophrenia compared with users from the general population. Over a 200-day period from January to July 2016, Twitter users who self-identify as having a schizophrenia spectrum disorder ( $n = 203$ ) and a randomly selected group of general population control users ( $n = 173$ ) posted 1,544,122 tweets. Communication frequency did not differ between groups. Tweets containing tobacco-related keywords were extracted. Twitter users with schizophrenia posted significantly more tweets containing any tobacco-related terms (mean = 3.74; SD = 16.3) compared with control users (mean = 0.82; SD = 1.8). A significantly greater proportion of Twitter users with schizophrenia (45%;  $n = 92$ ) posted tweets containing any tobacco terms compared with control users (30%;  $n = 52$ ). Schizophrenia users showed significantly greater odds of tweeting about tobacco compared with control users (OR = 1.99; 95% CI 1.29–3.07). These findings suggest that online communication about tobacco may parallel real world trends of elevated tobacco use observed among people with schizophrenia. By showing that Twitter users who self-identify as having schizophrenia discuss tobacco-related content online, popular social media could inform smoking cessation efforts targeting this at-risk group.

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## Keywords

Schizophrenia; Twitter; Social media; Smoking; Tobacco; Cigarette; Mental illness

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## 1. Introduction

Numerous studies have documented the strong association between schizophrenia spectrum disorders and tobacco use, whereby people with schizophrenia smoke cigarettes at substantially higher rates compared with the general population (de Leon and Diaz, 2005; Lohr and Flynn, 1992). Smoking has a profound impact on mortality and quality of life (Centers for Disease Control and Prevention, 2005; Stewart et al., 2009), and elevated rates of cigarette smoking contribute to dramatically reduced life expectancy among individuals with schizophrenia (Walker et al., 2015). Despite high rates of tobacco use, studies have indicated that people with schizophrenia are interested in quitting smoking and express similar motivation to quit as smokers from the general population (Addington et al., 1998; Kinney et al., 1991). However, people with schizophrenia face barriers to quitting such as greater susceptibility to becoming nicotine dependent (de Leon and Diaz, 2005), the misperception that cigarette smoking is necessary for managing mental health symptoms (Trainor and Leavey, 2017) or providing relief from anxiety and other symptoms (Esterberg and Compton, 2005), and smoking as a way to spend time with others and facilitate social inclusion (Trainor and Leavey, 2017). Furthermore, lack of support from health care providers and few smoking cessation programs tailored to the specific needs of people with schizophrenia are also barriers to quitting (Trainor and Leavey, 2017). Novel approaches are needed to support tobacco cessation among smokers with schizophrenia.

Recent research shows that people with schizophrenia are highly active on social media and use platforms like Facebook or Twitter at comparable rates as the general population (Birnbaum et al., 2015; Naslund et al., 2016a), highlighting the potential to use social media to reach and offer treatments to people with schizophrenia (Torous and Keshavan, 2016). Exploratory studies have found that social media may be used for supporting mental health and well-being among people with schizophrenia (Naslund et al., 2014; Välimäki et al., 2016). Since social media inherently promotes social engagement and connectedness, it may also be an effective platform for reinforcing behaviors such as smoking cessation through the delivery of tailored behavioral interventions. A recent systematic review highlighted the acceptability and preliminary effectiveness of social media interventions for promoting smoking cessation in the general population (Naslund et al., 2017). In one study, a Facebook intervention with content tailored to the needs of young adult smokers contributed to an increase in quit attempts over a 12-month period (Ramo et al., 2015). In the Tweet2Quit randomized controlled trial, use of targeted messaging and peer-to-peer discussions on Twitter contributed to greater abstinence (Pechmann et al., 2017). Little is known about the potential to support smoking cessation for people with schizophrenia using popular social media.

It is necessary to better understand online attitudes and communication patterns about smoking among social media users with schizophrenia to inform the development of

targeted tobacco cessation interventions delivered on these platforms. Among Twitter users from the general population, a prior study found that posts describing experiences or opinions related to tobacco use were largely positive (Myslín et al., 2013). This finding was valuable for guiding prevention strategies because it highlighted that there is potentially a disconnect between positive perceptions of using tobacco and harmful health consequences as reflected by the content of users' posts (Myslín et al., 2013). It is not clear if social media users with schizophrenia actively discuss smoking related topics online or whether social media platforms could serve as a viable strategy for supporting tobacco cessation in this group.

The purpose of this study was to examine the frequency, timing, and type of discussions about tobacco-related content on Twitter among users with schizophrenia compared with users from the general population. The objective was to characterize communication about tobacco-related content among Twitter users with schizophrenia to inform the development of tailored smoking cessation strategies. It was hypothesized that Twitter users who self-identify as having a schizophrenia spectrum disorder would discuss tobacco related content more frequently than a randomly selected sample of Twitter users from the general population, thereby reflecting the disproportionately elevated rates of tobacco use among individuals with schizophrenia.

## 2. Methods

### 2.1. Data collection

Data for this study were collected from Twitter, an online news and social networking service where users can post up to 140-character messages called “tweets”. Twitter was selected in this study because this platform has been previously used to explore smoking-related communication among general population users (Myslín et al., 2013), and the Twitter platform has demonstrated promise for promoting smoking cessation efforts (Prochaska et al., 2012; Rocheleau et al., 2015). By late 2016, Twitter had more than 317 million active users (Statista, 2017). Data for this study were retrieved from Twitter's application programming interface (API) that contains publically available tweets and associated metadata (e.g., users' total number of tweets, number of “followers”, and number of friends). Tweets were accessed via the Twitter API as “status objects”, which are structured JSON (JavaScript Object Notation - a common data format) formatted objects that contain all of the metadata about both the individual tweet and Twitter user. Code was written using Python programming language to collect all tweets and associated metadata from a group of Twitter users with schizophrenia and a group of control users over a 200-day period from January 5th, 2016 to July 23rd, 2016. All data were publicly available; therefore ethical review was not required.

### 2.2. Twitter users

A sample of 250 Twitter users with schizophrenia were identified by manually searching the Twitter platform for individuals who explicitly self-identified as having a schizophrenia spectrum disorder within their profile, or in a tweet or caption. The following search terms were used: “schizophrenia”; “schizoaffective”; “schizotypal”; and “psychosis”. One

researcher (JAN) identified Twitter users who self-identified as having a schizophrenia spectrum disorder, and this was confirmed by a second researcher (YH). To create a general population comparison group, the GET statuses/sample feature from the Twitter Developers Platform was used to collect a random sample of all publicly available tweets from the Twitter API (Twitter, 2017). Then, two research assistants manually looked through these tweets to determine that the tweet belonged to a real person (i.e., not a bot or spam account), was from a normal user (i.e., not a company or corporation), and was in English. The objective was to confirm that users in the control group appeared to be normal Twitter users. Both research assistants had to be in agreement in order to include a Twitter user in the control sample. This process was completed until a sample of 250 control users was identified. Next, code was written using Python to access the Twitter API in order to restrict both groups (the Twitter users with schizophrenia and the control users) to only users that had actively posted within the specified 200-day period, and had publicly available accounts. The total number of Twitter users with schizophrenia was 203 and control users was 173. This decrease in users in each group occurred largely because some accounts became inaccessible (i.e., private, deleted, banned, or deactivated) at the time of data collection.

Metadata associated with Twitter users' accounts was collected. Metadata included: total number of tweets; tweets per day (total tweets divided by days active); tweets in last 200 days; number of friends; number of followers; likes per day (number of times that user indicates that they like tweets from other users); date and time of tweets (when available); and number of days account has been active. To measure users' impact, a "followers-to-friends" ratio (number of followers divided by number of friends) was calculated (McIver et al., 2015). A high ratio indicates that a user has many people who follow their account and tweets but that they follow few other users' tweets, and has been identified as an indicator of influence on Twitter (McIver et al., 2015).

### 2.3. Twitter users' gender identification

Because smoking rates tend to be higher among men compared with women, two researchers (YH & JAN) independently coded the sample of Twitter users' gender. A list of all Twitter users was compiled and both researchers coded gender as male, female or unknown/insufficient data for users' Twitter handle (username), followed by profile name, profile description, profile photo and Twitter page (including tweets and photographs). For example, Twitter handles and profile names were coded based on typical gender defined names, such that "John" or "Tom" would be coded as male and "Sarah" or "Beth" would be coded as female. However, if the profile description used gender specific terms to describe oneself such as "Jamie: Girl who loves cats", the gender specific term was used to code gender. Although a Twitter profile photo may clearly show a distinct gender, users may not always use a photo of themselves in their profile and therefore greater investigation of gender was required. Only if the user provided a photo of themselves (e.g., selfie) in their profile photo or within one of their posted photos and used the pronoun "I", "me", or "myself", gender would be coded based on the gender of the photograph. A final gender score was calculated by combining these dimensions with users' explicitly indicating their gender as the main criterion used to define gender. The researchers met together to

continuously review the gender coding for all users to allow for discussion and to resolve disagreements and reach consensus.

#### 2.4. Tweets about tobacco

To understand differences in discussions related to tobacco use between the two groups, smoking-related tweets were collected and analyzed. In this study, tobacco products were defined specifically as cigarette smoking. To build a corpus of tobacco and cigarette tweets, code was written in Python programming language to identify and retrieve all of the Twitter users' tweets that contained at least one of the follow keywords: “cig”, “cigs”, “cigarette”, “cigarettes”, “nicotine”, “smoker”, “smokers”, and “tobacco”. This list of Twitter search terms for tobacco use was adapted from a previous study (Myslín et al., 2013). Three researchers (YH, JAN, & RS) also manually queried the Twitter platform to confirm that Twitter users routinely use these terms for describing cigarette-smoking behaviors. The aim in this study was to capture discussions using these terms related to smoking cigarettes among the sample of Twitter users with schizophrenia and the control users.

#### 2.5. Rating pro-smoking and anti-smoking content of users' tweets about tobacco

Two researchers (YH & JAN) independently coded all the identified tweets about tobacco to determine the proportion of these tweets that promoted or discouraged cigarette smoking. The researchers were blind to users' group to limit potential bias. Tweets defined as promoting smoking included positive descriptions about using tobacco-related products such as “having a cigarette is the only way to end the night”, discussions about smoking such as “need a cigarette so bad”, or photographs of smoking that positively depicted cigarette smoking. Tweets discouraging smoking included tweets describing smoking as an unhealthy or bad habit such as “smoking is so gross”, or describing efforts to quit smoking such as “I almost reached for a cigarette but stopped myself”, or referring to negative characteristics of smoking such as “kissing someone who is smoker is like kissing an ashtray.” Remaining tweets that did not contain any clear information promoting or discouraging cigarette smoking were coded as other. Both researchers employed an iterative verification process where they met regularly to review, check and confirm that coding of the tweets was consistent, and to reach agreement and consensus when it was unclear what code was most appropriate for a given tweet. This systematic process enabled continuous verification of the coding, and has demonstrated utility for achieving reliability and validity in qualitative data collection and analysis (Morse et al., 2002).

#### 2.6. Timing of tweets about tobacco

All tweets have a universal time code (UTC), and Twitter users have the option of setting their local time zone in settings, which provides a UTC offset thereby making it possible to determine the time that the tweet was posted. Therefore, analysis of tweet timing using time-of-day data could only be performed on a subset of users' tweets about tobacco with available UTC offset data. All tweet times used in this analysis were converted to the user's local time of day (based on the user's time zone). Time of tweets about tobacco was classified into the following intervals: 00:00–05:59; 06:00–11:59; 12:00–17:59; and 18:00–23:59. Differences in the proportion of tobacco-related tweets across the four time intervals

were examined between the two groups to determine if Twitter users with schizophrenia discussed tobacco use at different times of the day compared with control users.

## 2.7. Statistical analyses

Two-tailed t-tests were used to compare continuous variables and chi-square tests were used to compare categorical variables between Twitter users with schizophrenia and control users. Logistic regression was used to compare both groups on the binary outcome of whether or not users posted a tweet about tobacco. The regression model controlled for gender. All tests with a  $p$  value of  $\leq 0.05$  were considered statistically significant. All analyses were performed with the Python programming language and Stata version 14.0.

## 3. Results

### 3.1. Characteristics of Twitter users

In total 1,544,122 tweets were collected between January 2016 and July 2016 with 819,491 tweets from Twitter users with schizophrenia ( $n = 203$ ) and 724,631 tweets from control users ( $n = 173$ ). User characteristics between groups are presented in Table 1. There were no differences between groups in the number of tweets per day, number of likes per day, friends, followers, and “followers-to-friends” ratio. More Twitter users with schizophrenia were coded as male (45.8%) compared with control users (33.0%) ( $\chi^2 = 8.10$ ;  $p = 0.017$ ).

### 3.2. Tweets about tobacco

As summarized in Table 2, Twitter users with schizophrenia posted a greater number of tweets containing any tobacco-related terms (mean = 3.74; SD = 16.3) compared with control users (mean = 0.82; SD = 1.8;  $t = -4.46$ ;  $p < 0.001$ ). About 45% ( $n = 92$ ) of Twitter users with schizophrenia ever posted a tweet containing any tobacco terms over the 200-day period compared with 30% ( $n = 52$ ) of control users ( $\chi^2 = 9.21$ ;  $p = 0.002$ ). In a logistic regression model adjusting for gender, Twitter users with schizophrenia showed significantly greater odds of tweeting about tobacco compared with control users (OR = 1.99; 95% CI 1.29–3.07). Among users who tweeted about smoking ( $n = 144$ ), there were no significant differences between the Twitter users with schizophrenia and control group in the proportion that posted pro-smoking content (38.0% of Twitter users with schizophrenia vs. 26.8% of control users) or anti-smoking content (41.3% of Twitter users with schizophrenia vs. 38.5% of control users).

### 3.3. Timing of tweets about tobacco

For time-of-day analyses, 71.0% ( $n = 267$ ) of total users had time zone data available. Time zone information was available for 67.5% ( $n = 137$ ) of Twitter users with schizophrenia and 75.1% ( $n = 130$ ) of control users, a non-significant difference between groups. Table 3 presents the proportion of tweets about tobacco during each time interval for each group. Twitter users with schizophrenia posted a higher proportion of tweets about tobacco from 18:00–23:59 compared to control users ( $\chi^2 = 4.836$ ;  $p = 0.028$ ); there were no other differences in the timing of tobacco tweets between groups. Table 4 highlights that among Twitter users with schizophrenia most tweets about tobacco occurred from 00:00–05:59

(29.0%) and from 18:00–23:59 (37.2%), which was significant relative to the total number of tweets posted by Twitter users with schizophrenia during those time intervals.

#### 4. Discussion

This is the first known study to characterize social media content related to a health behavior such as smoking among social media users with schizophrenia. Twitter users who self-identify as having a schizophrenia spectrum disorder appeared to tweet about tobacco more often compared with a randomly selected control group of Twitter users from the general population over a 200-day period. This shows that social media users with schizophrenia are discussing tobacco-related content online, highlighting the potential to leverage these popular online platforms to extend prevention or cessation efforts.

This study contributes to a growing body of literature demonstrating that social media data can provide valuable insight into individual health behaviors. Previous studies have used social media to explore insomnia (McIver et al., 2015), monitor infectious diseases like dengue (Nsoesie et al., 2016), and track foodborne illness outbreaks (Hawkins et al., 2016). Twitter users with schizophrenia showed nearly two times greater odds of tweeting about tobacco compared to control users. This is consistent with studies reporting very high prevalence of smoking among people with schizophrenia (Kelly et al., 2009). These results demonstrate that online communication about health behaviors may parallel real world behaviors for persons with schizophrenia.

Importantly, the content (promoting vs. discouraging smoking) of the smoking related tweets did not differ between the Twitter users with schizophrenia and the control users. This suggests that online discussions about smoking may be similar between both groups, but that Twitter users with schizophrenia appear to discuss these topics more often. The timing of tweets about tobacco was also notable. Timing of tweets about tobacco is important to understand in order to inform what time of day to deliver smoking cessation interventions on social media. Twitter users with schizophrenia posted a greater proportion of tweets about tobacco from 0:00–5:59 and from 18:00–23:59 relative to all of their Twitter posts at those times. Given that Twitter users with schizophrenia tweeted about smoking more frequently during these times compared to other times, it suggests that they may be actively thinking about tobacco and therefore may be more susceptible to using or attempting to quit using tobacco products at these times. For instance, these patterns of tweeting about smoking could reflect higher likelihood of nicotine cravings during the late evening or early morning among dependent smokers (Chandra et al., 2011; Dunbar et al., 2010). Alternatively, it is also possible that the timing of these tweets in the late evening or early morning may reflect the negative effects that cigarette smoking is known to have on sleep quality (Phillips and Danner, 1995), as well as sleep disturbances that commonly occur among people with schizophrenia (Cohrs, 2008). Targeting individuals at the specific times when they are most likely to discuss tobacco-related content online could further optimize interventions.

Persons with schizophrenia are often subjected to high levels of interpersonal stigma (Brohan et al., 2010; Lee et al., 2005), which can interfere with social functioning and can lead to increased risk of social isolation and withdrawal (Staring et al., 2009). Of note, there

were no differences in the amount of social relationships and communication frequency between Twitter users with schizophrenia and control users. This may imply that unlike offline social relationships, Twitter users with schizophrenia may have greater social interaction and may form interpersonal relationships and communicate with others online at similar rates as the broader population of Twitter users. This is consistent with prior studies that have suggested that people with mental illness seek support and companionship from others through online networks (Naslund et al., 2016b, 2014), and that people with schizophrenia use social media at comparable rates as the general population (Birnbaum et al., 2015; Naslund et al., 2016a). Future research is necessary to investigate online social dynamics among individuals with schizophrenia to better understand how online communication relates to health behaviors in the real world, and to tailor interventions accordingly.

#### 4.1. Limitations

Several limitations warrant consideration. First, both groups included active Twitter users with publicly available accounts, therefore these findings may not generalize to Twitter users with private accounts or to people who do not use Twitter. Second, the Twitter users with schizophrenia included in this study self-identified as having a schizophrenia spectrum disorder, therefore it was not possible to confirm their diagnosis clinically. Individuals who self-identify as having schizophrenia on social media may differ from individuals who choose not to disclose their illness online. Twitter users with schizophrenia may also experience fewer impairments in social or cognitive functioning compared to individuals with schizophrenia who do not use social media. Thus, the Twitter users with schizophrenia in this study are likely not representative of all individuals with schizophrenia spectrum disorders, and may also be less likely to smoke cigarettes. Third, given that we generated a convenience sample of Twitter users who self-identified as having schizophrenia through manually searching the Twitter platform, these individuals also may not be representative of the broader group of Twitter users who self-identify as having a schizophrenia spectrum disorder. Fourth, the control group was comprised of a randomly selected sample of Twitter users, which means there is a slight possibility that users in this group may also have schizophrenia. The likelihood is low because about 1% of the population has a schizophrenia diagnosis (Millar et al., 2001). Fifth, only well-defined terms for tobacco use were used to identify tweets about smoking cigarettes in this study. Therefore, it is likely that the true number of tweets about cigarette smoking was underestimated in this study because common slang terms for cigarette smoking were not included in the search as these terms also refer to many other non-smoking related items (e.g., ash, butt, drag, draw, light, pipe, pull, puff, roll, stub, tab, etc.). Sixth, given that this study was exploratory in nature, the samples of Twitter users were not generated according to predefined power analyses. Therefore, it is possible that this study was underpowered to detect other differences in user characteristics between the Twitter users with schizophrenia and the control users. Seventh, it was not possible to confirm whether users' tweets about tobacco correlated with real world smoking behaviors. Lastly, Twitter users' gender was determined through a step-wise coding process, though it was not possible to confirm that the identified gender for each Twitter user was correct. Furthermore, it was not possible to collect any other demographic details for the Twitter users included in this study. Social media studies are frequently limited by not



reporting demographic data because of the difficulty retrieving this information from publicly available online data sources.

## 5. Conclusion

Online communication patterns on popular social media potentially mimic offline behaviors. Twitter users who self-identify as having a schizophrenia spectrum disorder appeared to discuss cigarette smoking behaviors more often compared with controls from the general population, which parallels high rates of cigarette smoking documented in this vulnerable group. With rising social media use among persons with mental illness, these popular platforms may afford new opportunities to reach individuals who are isolated and help reduce excess mortality due to cigarette smoking. These findings provide novel evidence that Twitter may be a viable platform for developing timely and targeted smoking cessation interventions for people with schizophrenia.

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**Table 1**

Characteristics of Twitter users with schizophrenia and control Twitter users.

User characteristic	Twitter users with schizophrenia ( <i>n</i> = 203)		Control Twitter users ( <i>n</i> = 173)		Test statistic	<i>P</i> value
	Mean	SD	Mean	SD		
Tweets per day	21.10	58.50	20.80	34.30	0.05	0.96
Likes per day	7.60	20.30	8.32	13.50	-0.38	0.69
Friends	1261.60	2216.90	1196.20	5108.30	0.16	0.87
Followers	3229.10	13,924.30	1869.70	7087.4	1.16	0.25
Followers to friends ratio	7.17	52.40	2.56	6.33	1.14	0.25
	<i>n</i>	%	<i>n</i>	%		
Gender (male)	93	45.8	57	33.0	8.10	0.017

Table 2

Number of tweets with smoking terms among Twitter users with schizophrenia compared with control Twitter users.

Smoking terms	Twitter users with schizophrenia ( <i>n</i> = 203)			Control Twitter users ( <i>n</i> = 173)			Test statistic	P value <sup>a</sup>
	Tweets ( <i>n</i> ) with smoking terms	Mean (SD) Tweets with smoking terms per user	Number of users (%) who tweeted about smoking	Tweets ( <i>n</i> ) with smoking terms	Mean (SD) Tweets with smoking terms per user	Number of users (%) who tweeted about smoking		
cig	24	0.12 (0.47)	14 (6.9%)	5	0.029 (0.2)	4 (2.3%)	-1.59	0.11
cigs	33	0.16 (0.77)	15 (7.4%)	8	0.046 (0.26)	6 (3.5%)	1.1	0.2
cigarette	177	1.08 (4.50)	50 (24.6%)	45	0.27 (0.73)	30 (17.3%)	-2.7	0.0067
cigarettes	220	0.87 (3.05)	45 (22.2%)	47	0.046 (0.34)	28 (16.2%)	-3.1	0.0016
nicotine	106	0.52 (5.14)	18 (8.9%)	8	0.26 (0.69)	5 (2.9%)	-2.2	0.029
smoker	33	0.16 (0.66)	21 (10.3%)	6	0.034 (0.21)	12 (6.9%)	-3.1	0.0016
smokers	56	0.27 (1.33)	21 (10.3%)	10	0.058 (0.28)	8 (4.6%)	-1.3	0.17
tobacco	151	0.74 (4.80)	29 (14.3%)	15	0.086 (0.39)	12 (6.9%)	-2.1	0.033
<b>All terms</b>	<b>759</b>	<b>3.74 (16.30)</b>	<b>92 (45.3%)</b>	<b>141</b>	<b>0.82 (1.80)</b>	<b>52 (30.1%)</b>	<b>-4.46</b>	<b>0.00001</b>

<sup>a</sup> P-values calculated using t-tests for the difference in mean (SD) tweets containing smoking terms between groups.

**Table 3**

Timing of tweets about tobacco among Twitter users with schizophrenia compared to control Twitter users.

Time interval	Twitter users with schizophrenia ( <i>n</i> = 203)	Control Twitter users ( <i>n</i> = 173)	$\chi^2$	<i>P</i> value <sup><i>b</i></sup>
	Proportion ( <i>n</i> ) of tweets about tobacco	Proportion ( <i>n</i> ) of tweets about tobacco		
00:00–05:59	29.0% (218)	30.1% (34)	0.062	0.804
06:00–11:59	15.1% (114)	17.7% (20)	0.492	0.483
12:00–17:59	18.7% (141)	25.7% (29)	2.998	0.083
18:00–23:59	37.2% (280)	26.6% (30)	4.836	0.028
Total tweets about tobacco <sup><i>a</i></sup>	100.0% (753)	100.0% (113)		

<sup>*a*</sup>This reflects the total number of tweets about tobacco with available time data for each group.

<sup>*b*</sup>*P*-values calculated using Chi-square tests.

**Table 4**

Timing of tweets about tobacco relative to overall tweets among Twitter users with schizophrenia ( $n = 203$ ).

Time interval	Proportion ( $n$ ) of tweets about tobacco	Proportion ( $n$ ) of overall tweets <sup>a</sup>	$\chi^2$	$P$ value <sup>b</sup>
00:00–05:59	29.0% (218)	12.9% (77,070)	171.83	< 0.001
06:00–11:59	15.1% (114)	22.5% (134,502)	23.56	< 0.001
12:00–17:59	18.7% (141)	32.5% (193,829)	64.83	< 0.001
18:00–23:59	37.2% (280)	26.6% (191,511)	8.98	0.003
Total tweets <sup>c</sup>	100.0% (753)	100.0% (596,912)		

<sup>a</sup>Reflects the total number of tweets among Twitter users who self-identify as having schizophrenia including tweets about tobacco at each time interval.

<sup>b</sup> $P$ -values calculated using Chi-square tests.

<sup>c</sup>Reflects the total number of tweets about tobacco and overall within the schizophrenia user group with available time data.

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