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Facts or stories? How to use social media for cervical cancer prevention: A multi-method study of the effects of sender type and content type on increased message sharing

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ABSTRACT

Social media has become a valuable tool for disseminating cancer prevention information. However, the design of messages for achieving wide dissemination remains poorly understood. We conducted a multi-method study to identify the effects of sender type (individuals or organizations) and content type (personal experiences or factual information) on promoting the spread of cervical cancer prevention messages over social media. First, we used observational Twitter data to examine correlations between sender type and content type with retweet activity. Then, to confirm the causal impact of message properties, we constructed 900 experimental tweets according to a 2 (sender type) by 2 (content type) factorial design and tested their probabilities of being shared in an online platform. A total of 782 female participants were randomly assigned to 87 independent 9-person online groups and each received a unique message feed of 100 tweets drawn from the 4 experimental cells over 5 days. We conducted both tweet-level and group-level analyses to examine the causal effects of tweet properties on influencing sharing behaviors. Personal experience tweets and organizational senders were associated with more retweets. However, the experimental study revealed that informational tweets were shared significantly more (19%, 95% CI: 11 to 27) than personal experience tweets; and organizational senders were shared significantly more (10%, 95% CI: 3 to 18) than individual senders. While rare personal experience messages can achieve large success, they are generally unsuccessful; however, there is a reproducible causal effect of messages that use organizational senders and factual information for achieving greater peer-to-peer dissemination.

1. Introduction

Early detection and treatment of cervical cancer precursors have led to profound decreases in cervical cancer incidence and mortality in the United States (Benard et al., 2014; Saraiya et al., 2013). Human papillomavirus (HPV) vaccines have further decreased risk of cervical cancer precursors (Flagg et al., 2016; Silverberg et al., 2018). Receipt of recommended Pap tests, however, has stagnated (Watson et al., 2017), and the uptake of HPV vaccination remains low (Bartlett and Peterson, 2011; Walker et al., 2017). Recent statistics indicate that only 83% of women reported receiving appropriate screening — well below the national target of 93% (White et al., 2017), and only 43% of girls aged 13 to 17 received all the recommended doses of the HPV vaccine (Walker et al., 2017). About 13,170 new cases of invasive cervical cancer and 4250 deaths were estimated in 2019 (Siegel et al., 2019). Innovative interventions are needed to further reduce these numbers.

Traditional approaches to promoting preventive screenings for cervical cancer and HPV vaccination have relied on patient-provider communication (Blewett et al., 2008; Rim et al., 2011) and physician recommendations (Rosenthal et al., 2011; Tissot et al., 2007). This strategy overlooks the substantial number of women who do not have a regular source of care (Agency for Healthcare Research and Quality, 2017), as well as those lacking trust in the health care system (Moravac, 2018; Nguyen et al., 2002; Wagner, 2009; Yang et al., 2011). For these women, it is important to create alternative channels to raise awareness and deliver information, and to find effective means of exposing them

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to alternative sources of support from others who share similar experiences. These communication processes can contribute to expanding their knowledge, changing perceptions about seeking care, which is a first step toward better communications with providers. Outside of the clinical setting, broader community-wide cervical cancer campaigns have demonstrated modest success (Anderson et al., 2009; Curbow et al., 2004; Walling et al., 2016). However, the reach of these campaigns is often limited because they rely on traditional communication channels such as brochures, posters, and stand-alone websites.

Social media is a potential location for interventions to reach a diverse audience who may not be accessed through the traditional approaches. Approximately 88% of young adults aged 18 to 29 and 78% of adults aged 30 to 49 reported using at least one social media site in 2018 (Smith and Anderson, 2018). For instance, Twitter had 40% of their users aged 18 to 29, with 24% White, 26% Black, and 20% Hispanic users (Smith and Anderson, 2018). Many individuals use social media to seek out health information and communicate with others about shared conditions (Fox and Duggan, 2013; Fox et al., 2013). Participations in social media-based interventions have shown effects in impacting many different health behaviors (Bull et al., 2012; Centola, 2013; Laranjo et al., 2015; Pechmann et al., 2017; Zhang et al., 2015). Regarding cervical cancer prevention, a systematic review of 44 articles suggests engagement with HPV related social media content is associated with improved awareness and knowledge (Ortiz et al., 2019). Given the high prevalence of social media participation, effectively disseminating information and influencing attitude through social media is a significant step toward moving people to change behaviors.

One core communicative function of social media is spreading information through social connections (Chou et al., 2013; Neiger et al., 2012). Because social media are built upon social network connections, they lack a centralized channel for delivering messages to the priority population (Suh et al., 2010). The success of social media communications depends upon sharing activity that causes desirable health messages to rise to the top of people's online social feeds (Neiger et al., 2012; Suh et al., 2010; Weng et al., 2013). Thus, the goal of a campaign design to operate over social media is to maximize the probability that individuals will share the health messages online.

Previous research on cancer prevention and Twitter has indicated that the messages that are most likely to be shared are narrative accounts of people's experiences (Chung, 2017; So et al., 2016), such as the tweet “lord knows i cant stand a pap smear but that 5 mins of uncomfyness is better than dealing with cancer 4 a lifetime” (Lyles et al., 2013, p.129). By contrast, public health organizations typically post factual informational messages, such as the tweet “Women 21 to 65 should get a Pap smear every 3 years, according to #USPSTF recommendation released today” (Lyles et al., 2013, p.129). Recent studies have reported that the majority of top tweets that were related to cancer screening were sent from individual accounts (79%), as compared to a much smaller fraction from organizational accounts (20%) (Lyles et al., 2013). A compelling intuition from previous observational studies (Ding and Zhang, 2010; Scanfeld et al., 2010; Surian et al., 2016) is that personal experience messages from individuals are likely to be the most shared, and therefore reach the most people. For instance, one mother's tweet for her daughter who is fighting breast cancer got retweeted 217,000 times and received more than 100,000 likes within 48 h in 2017 (Solé, 2017). However, these observations could not distinguish if the differences in online sharing are primarily driven by the sender or the content characteristics of the messages. Specifically, the sender type refers to whether the message is from an individual or an established organization, and the content type refers to whether the message discusses personal experiences or relays factual information. In observational data, the majority of personal experience messages are from individuals whereas the majority of informational messages are from organizations. Consequently, the distinct effects of message sender versus message content are impossible to disentangle. For instance, what are the effects of organizations using personal stories, or individuals choosing to promote factual information?

In contrast to recent observational studies, past theoretical and empirical work suggest message diffusion on social media, especially regarding contentious topics, resembles complex contagion processes (Centola, 2018; Guilbeault et al., 2018), such that messages get shared because of their credibility and informational utility to other peers in the network. For instance, sources of higher credibility such as established organizations can boost message sharing by increasing perceived value (Liu et al., 2012). However, other research highlights how an entirely different mechanism – the use of narrative formats such as personal stories – can boost online sharing by enhancing users' emotional involvement with the messages (Berger, 2014). To gain causal insight into how these contrasting theories help to explain the spread of health prevention messages on Twitter, this study was designed to disentangle the independent causal effects of sender type and content type on increasing social media sharing. Our goal is to use these causal insights to inform the design of effective social media-based preventative health campaigns and interventions.

2. Methods

We conducted a multi-method study that combined insights learned from a preliminary observational study of existing Twitter data, with an online experiment to assess direct causal insight into the most effective strategies for designing messages over an online social media platform about cervical cancer prevention. Institutional review boards at the University of California San Francisco and the University of Pennsylvania approved all study procedures.

2.1. Preliminary observational study

To gain a baseline understanding of the effects of different sender types (i.e., individuals or organizations) and different content types (i.e., personal narratives or factual information) on the likelihood of messages being “re-tweeted,” we first conducted an observational study on tweets related to cervical cancer prevention. We obtained an archived Twitter dataset containing a random 10% sample of all tweets with associated metadata (e.g., retweets, number of followers) from January 1, 2010, to December 31, 2014 through Twitter's application programming interface in 2015. We searched tweets using the following terms and hashtags: “Pap smear,” “Pap test,” “HPV,” “human papillomavirus,” “HPV vaccination,” “Gardasil” (trade name for a common HPV vaccine), and “cervical cancer.” This systematic search yielded a dataset of 97,391 tweets. From this dataset, we obtained the most shared 3000 tweets. Two members of the research team content analyzed the 3000 tweets and descriptively coded whether the tweets were promoting cervical cancer prevention, including promoting knowledge on HPV and cervical cancer, and promoting behaviors of getting Pap tests and the HPV vaccine. They then coded whether the tweets were sent from an individual or an organization (by checking at the user profile of the original account), and whether the tweets discussed personal experiences or relayed factual information. Among the coded 3000, 462 promoted cancer prevention and clearly demonstrated the sender type and the content type.

2.1.1. Statistical analysis

The outcome measure was the retweet number of a particular observed tweet. We used a negative binomial regression model to analyze the associations of the sender type and the content type with retweet numbers, controlling for the number of account followers.

2.2. Online experiment

While results of the observational analyses can provide a baseline understanding of the associations of tweet characteristics and tweet shares, they do not generate robust evidence regarding the causal

effects of those characteristics. Thus, we designed an innovative randomized controlled online experiment to identify the independent causal effects of sender type and content type in increasing message shares. To create a controlled social media environment, we designed an anonymous online discussion platform ("Health Connect") for women to discuss cancer risks and prevention within the platform. Eligible participants were instructed to fill out a baseline survey on their socio-demographic background. Each participant was then asked to create an online profile by choosing a username and an avatar to represent herself in the online group. Throughout the enrollment period, participants were randomly assigned to membership in one of the online discussion groups. Each group was composed of 9 members. All groups started on Mondays and continued discussion for 5 days.

2.2.1. Study participants

Participants were recruited online from March to July 2017 through posts to popular social media sites including Reddit, Facebook, Instagram, and targeted email lists. The recruitment materials explained that the research was designed to facilitate women to discuss cancer risks and to share information. Individuals were eligible to participate if they were female, 18 years or older, lived in the U.S., spoke English as their primary language, and did not have cervical cancer.

2.2.2. Experiment procedure

To assess a potential causal effect of either the sender characteristics or the message content of tweets on the likelihood of messages being shared, we created a balanced 2 × 2 design (individual versus organizational senders, and personal experience versus factual information content) (see Table 1).

In total, we used 900 tweets, such that there were 225 tweets in each cell of the 2 × 2 matrix, representing each possible combination of sender type and content type. We used the original set of the 462 tweets described above in the observational analysis, and then created an additional set of 438 tweets drawing on contents and senders from the remaining 2538 tweets. Two senior researchers each created a set of 219 tweets falling into each cell of the 2 × 2 matrix. For instance, to create an individual's tweet with factual information, the researcher drafted a factual information tweet (e.g., "Most cervical cancers could be prevented by screening & HPV vaccination. Learn more…") based on contents from the database and assigned a random individual sender (e.g., "AsnaSays") drawn from the database to it. The two researchers then cross checked each other's created dataset and reviewed the contents and senders according to the matrix. Then they discussed their notes and corrected the problematic ones. These procedures ensured that all 900 tweets were unique and differed only in terms of the experimental factors.

In each experimental group, the 900 tweets were randomly distributed to the 9 participants over 5 days. Each participant was provided with a unique tweet feed, providing her with tweets while she was participating in the platform (i.e., there was no redundancy in the tweet feeds among the 9 members of a given group). Each feed provided a random set of 100 tweets over 5 days, with 20 per day consisted of 5 from each of the four experimental combinations. Once a tweet was shared by a participant, it was shown to all women in the same group and could not be shared again. Everyone in the group could comment on the shared tweets.

Participants received one automated daily email containing a brief summary of the shared tweets and discussion content in their group. After 5 days, participants filled out a post-study survey assessing knowledge regarding HPV and behaviors about getting HPV vaccination and Pap tests, which came with $15 payment for completion. Fig. 1 depicts the participant flow. The last online group was completed in July 2017.

2.2.3. Statistical analyses

The outcome measure was the number of shares of each experimental tweet by participants across all online groups. First, we treated each tweet as a unit of observation and conducted message-level negative binomial regression analysis to test the effects of the sender type and the content type on generating share numbers for all experimental tweets. Second, we treated each group as a single unit of observation because each group yielded an independent observation of the online shares of the 900 tweets. Using a non-parametric Wilcoxon signed-rank test, we conducted a group-level comparison of the relative success of tweets for each sender-type and content-type across all groups. Finally, as a validation of our experimental approach, we compared the sharing numbers of the 462 original tweets from our observational data with their sharing numbers in our online experiment. For robustness, in these comparisons we conducted message-level negative binomial regression analysis to test the effects of the sender type and the content type on generating share numbers for these tweets.

We report confidence intervals and significance levels based on 2-tailed tests for all of our analyses. Analyses were completed using STATA 15 in 2017.

3. Results

3.1. Observational results

Among the 462 coded tweets, 47.4% were from individuals and 26.2% discussed personal experiences. The type of content and the type of sender were correlated. The majority of factual information tweets (61.3%) came from organizational senders and the majority of personal

Table 1
The 2 by 2 experiment design with two example tweets with different sender types and content types.

Sender type	Content type	
	Personal experience	Factual information
Individual	**VampWriterGRRL**: Ladies!!! Just got my Pap smear. If you haven't had a Pap in the last 3 years YOU ARE OVERDUE! Make your appointment ASAP! **ImSarahCorcoran**: Today's adulting: Having my first smear test and learning the warning signs of cervical cancer…	**AsnaSays**: Most cervical cancers could be prevented by screening & HPV vaccination. Learn more… **ChineDela**: Pay attention to 10 warning signs of cervical Cancer…
Organization	**Telegraph**: Mother with cervical cancer urges women not to put off getting a smear test. Read more… **Cancer Care Ontario**: One brave cancer survivor speaks about life saving cervical cancer screening…	**CDCSTD**: Thousands of women are diagnosed with cervical cancer each year and about 1/3 will die from it. Spread awareness! **CDC_Cancer**: New cancer research: Type-specific HPV and Pap test results among low-income, underserved women…

Note: Due to privacy concerns, we replaced the embedded URLs with ellipsis in these example messages.

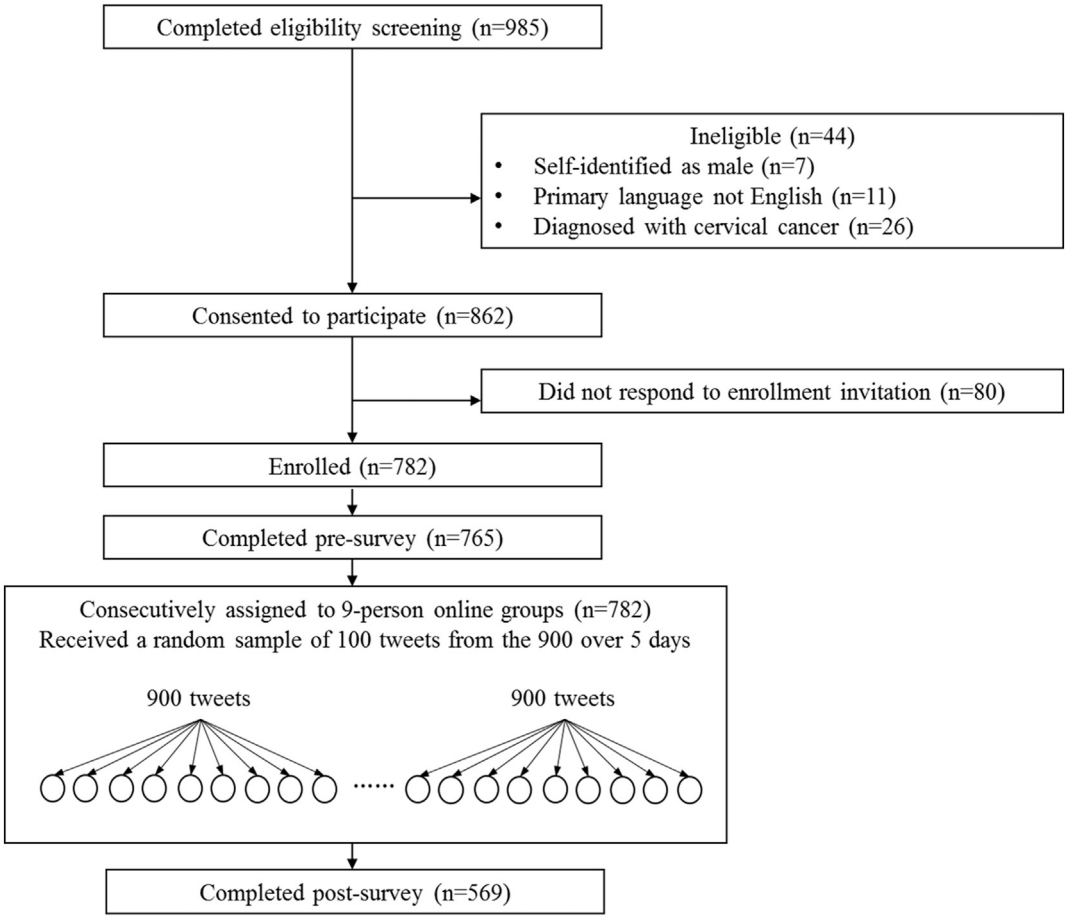

Fig. 1. Participant flow of the online experiment, March to July 2017.

experience tweets came from individual senders (71.9%) (chi-square [1] = 39.46, $p < .001$). We found that personal experience tweets were associated with more retweets in comparison with factual information tweets (b = 0.69, 95% CI: 0.34, 1.05, $p < .02$). However, contrary to previous observations, tweets from individual senders were associated with fewer retweets in comparison to those from organizational senders (b = −0.33, 95% CI: −0.65, −0.02, $p < .05$).

3.2. Experimental results

We constructed 87 independent online experimental groups involving 782 unique participants. One group involved only 8 participants because of an uneven number of participant enrollments. The pre-survey completion rate was 97.8% and the post-survey completion rate was 72.7%. Details of the surveys are reported elsewhere (Lyson et al., 2018). Participants were predominately White (71%) and college educated (64%). The mean age of the sample was 40.4 (SD = 14.6), and over half of the sample (51%) reported an annual household income of $50,000 or higher. The majority (74%) of participants reported using social media (e.g., Facebook, Instagram, or Twitter) every day, and only 4% reported not using any. In the pre-survey, 26% of participants reported ever receiving the HPV vaccine, and 90% reported ever having a Pap test.

Participation rates of the online groups were high. On average, participants logged into the platform 3.7 times (SD = 2.3) over the 5 days. Among all, 525 (67.1%) logged in more than once. Participants shared an average of 9.7 tweets (SD = 9.9) to their online groups, with 298 (38.1%) shared more than one tweet. They contributed an average of 3.7 comments (SD = 3.8) to the shared tweets, with 256 (32.7%) contributed more than one comment. By design, among all 87 online groups, a total of 78,300 tweets were pushed to individual participants' unique message feed, among which 3409 (4.4%) were shared. The median number of message shares in groups was 25 (mean = 40.1, SD = 43.1). Among the 900 unique tweets, 884 (98.2%) were shared at least once. The exact number of shares for each unique tweet ranged from 1 to 12.

Fig. 2 depicts the message-level analysis of the total number of tweet shares across the sender type and the content type in all groups. The results of the negative binomial regressions show that tweets containing factual information were shared significantly more often than tweets containing personal experiences (b = 0.17, $p < .001$). Factual informational tweets increased share numbers by 19% (95% CI, 11% to 27%) in comparison with personal experience tweets. In addition, tweets from organizations were also shared significantly more often than tweets from individuals (b = 0.10, $p < .01$). Organizational senders increased share numbers by 10% (95% CI, 3% to 18%) in comparison with individual senders. There were no significant interaction effects, indicating that organizational senders were always more effective, regardless of message content, and factual information was always more effective, regardless of sender type.

Fig. 3 examines these dynamics using a group-level perspective. Each group in this study was statistically independent, thus this approach provides a more robust causal analysis of the effects of sender type and message content on sharing behavior. The dark bars in Fig. 3 compare *i*) the number of experimental groups in which personal experience tweets were shared more often than factual information tweets, to *ii*) the number of experimental groups in which factual information tweets were shared more often than personal experience tweets. Correspondingly, the light bars in Fig. 3 compare *i*) the number of experimental groups in which tweets by organizational senders were

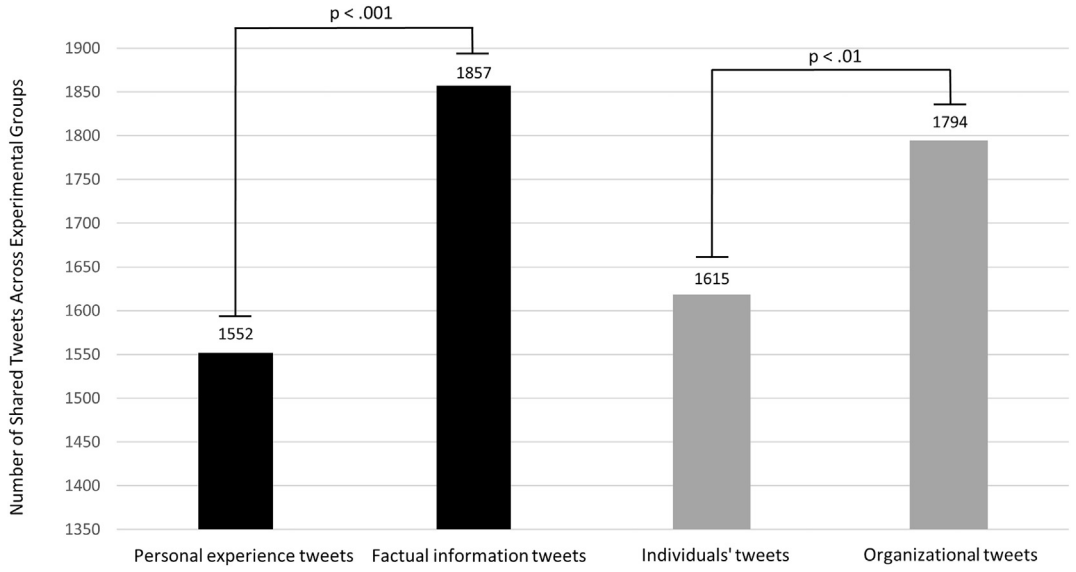

Fig. 2. The number of shared tweets by the content type and sender type across 87 online experimental groups, March to July 2017.

shared more often than tweets by individuals, to *ii*) the number of experimental groups in which tweets by individuals were shared more often tweets by organizational senders.

The results show both that tweets with factual information and from organizational senders were significantly more likely to produce shares. Each of these factors was found to have an independent causal effect on message sharing behavior. Factual informational tweets were shared significantly more than personal experience tweets ($z = 5.46$, $p < .001$). Similarly, tweets from organizational senders were shared significantly more than tweets from individuals ($z = 3.68$, $p < .001$). There was no interaction effect between the two factors.

Finally, we examined the subset of messages that were used in both our observational study and our experimental study. There were 447 original tweets (96.8% of the originally observed tweets) that were shared at least once in the experiment. Applying the message-level negative binomial regression analysis, we found consistent results: factual information was shared more than personal experiences ($b = 0.14$, $p < .02$) and organizational tweets were shared more than individual tweets ($b = 0.13$, $p < .02$) in the online experiment, with no interaction between the two factors.

Our experimental findings also yielded insight into the popularity of specific tweets. In the experimental study, there were seven top shared tweets, each receiving ten or more shares across all of the independent groups. We found that only one of these popular tweets was a personal experience tweet from an individual. Interestingly, this tweet was the single most popular tweet in the entire study. But its success was completely idiosyncratic. Among the remaining six tweets in the top group, all were factual informational tweets, and three were from individual senders while three were from organizational senders. Across these tweets, our consistent finding was that tweets were significantly more likely to be shared to others when they came from organizational senders and contained factual information content.

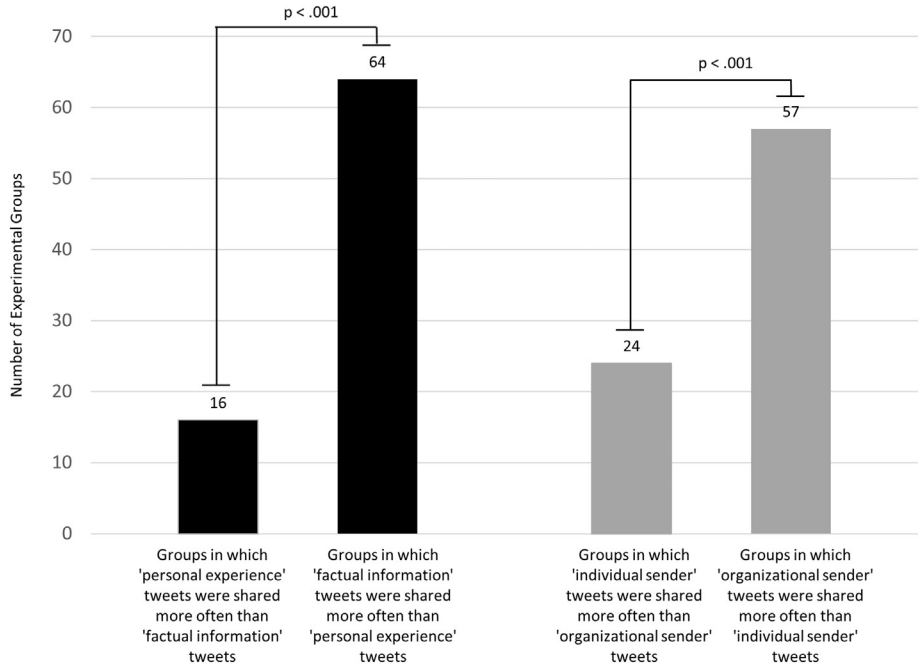

Fig. 3. The number of experimental groups by differences in tweet shares across content and sender types, March to July 2017.

4. Discussion

Our results suggest while personal experience messages from individual senders are rarely and idiosyncratically successful in observations (Taleb, 2007), there is a reproducible, causal effect of organizational messages and factual information on increasing sharing behavior.

The multi-method approach offers a few notable strengths, which we believe will be useful in future studies. The observational findings provided bases for developing the experimental messages and the controlled experiment enabled us to identify the causal effects of message properties. First, this experiment isolates the effects of message features in sharing dynamics, independent of frequently co-contributing factors such as social network structures (Weng et al., 2013), aggregated retweet numbers (Suh et al., 2010), and message valence (So et al., 2016), which are easily conflated with the effects of sender and content characteristics in observational studies. Second, this design allows the same sharing dynamics to be observed multiple times, under identical experimental conditions, thus providing robust causal evidence for the effects of the sender type and the content type on message sharing (Centola, 2010, 2011, 2018; Centola and Baronchelli, 2015).

One key limitation of the study is that all of the tweets in our experimental setting focused on cervical cancer prevention. By contrast, in uncontrolled settings the message landscape is typically far more diverse. Thus, health promotion messages are at a disadvantage for attracting attention, and we would expect fewer cancer prevention tweets to be re-shared, on average, than were shared in our study. Because of this, we also expect that some of the less frequently shared tweets in our study, would be completely ignored in uncontrolled settings. These suggest that in more competitive social media contexts, the relative importance of having clear informational content sent from organizations will be much greater for generating highly viewed and highly shared cancer prevention messages.

5. Conclusions

Using social media to reach and engage the public regarding cancer prevention becomes an increasingly important task for health providers and organizations. These findings suggest that practitioners can effectively design social media-based messages for cervical cancer prevention that significantly increase the reach of the messages to social media users. Contrary to anecdotal and observational evidence suggesting that individual messages about personal experiences are likely to be effective, we find that there is a direct causal effect of using organizational social media accounts to disseminate information. The findings reinforce the importance of public trust in organizations rather than individuals to share cancer prevention messages. Public health organizations may find social media an effective tool to raise awareness and deliver informational resources. The key strategy is to boost the credibility of the accounts and to develop messages that directly convey new factual information and resources.

The authors declare that there are no conflicts of interest.

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