Social Network Analysis of Nonprofits in Disaster Response: The Case of Twitter During the COVID-19 Pandemic in the United States

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Abstract
The COVID-19 pandemic has created complex problems that require organizations to collaborate within and across the sector line. Social media data can provide insights into how nonprofits interact for the pandemic response from both social network and geographical perspectives. This study innovatively investigated the connection and interaction patterns among 74 National Voluntary Organizations Active in Disaster (NVOAD) nonprofits and three government agencies based on structural analyses and content analyses of their Twitter communications during the long-term global COVID-19 pandemic. The daily tweeting quantities of all nonprofits were generally consistent with the pandemic severity in the United States before July 2020 and remained stable afterward. Nonprofits' tweets can reflect their purposes of sharing information, building communities, and taking actions for disaster response. Government agencies played leadership roles in providing COVID-19 guidelines and information. Human services, International and Foreign Affairs, and Public and Societal Benefit nonprofits, especially American Red Cross played central roles in the nonprofit communication network. Possible explanations include the following: (1) Geographically, connections and interactions among nonprofits are more likely to happen within the same city or in neighboring states. (2) Both mission homophily and heterophily contribute to connections and interactions among nonprofits, depending on their subsectors. The findings not only help the public better understand how nonprofits are

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collaboratively fighting the pandemic, but also provide guidance for nonprofits to plan for better interactions and communications in future disaster response.

Keywords
nonprofits, COVID-19, disaster response, Twitter, spatial social network

Introduction
The coronavirus disease 2019 (COVID-19) pandemic has been a global public health crisis. As of December 31, 2021, the coronavirus has infected over 290 million people worldwide in 224 counties/regions and caused over 5.4 million deaths (Worldometers, 2021). The United States is one of the hardest-hit countries with the most cases and deaths. A total of 56,705,136 Americans have been infected, and 848,118 Americans were killed by the pandemic as of December 31, 2021 (CDC, 2021). To slow down the spread of the life-threatening virus, many stringent measures have been issued by governments, such as city/region lockdowns, social distancing, mask wearing, business/school closure, as well as contact tracing and quarantine (Gan et al., 2020; Gong & Ye, 2021). As a result, everyday life has come to a grinding halt, and the entire society has staggered under the pandemic’s impact (Kapitsinis, 2020; Ye et al., 2021).

The pandemic has created a series of complex problems, such as insufficient healthcare resources, mental health issues, and other social problems, which are almost impossible to be addressed by governments alone. Nonprofit organizations1 have a long history of providing critical services in the field of human and health services that government relies on (Boris & Steuerle, 2006; Smith & Lipsky, 1993). Due to the scope and severity of the COVID-19 pandemic, it is essential for government agencies and nonprofits to collaborate within and across sector boundaries to solve problems collectively (Head & Alford, 2015; Roberts, 2000; Weber & Khademian, 2008).

National Voluntary Organizations Active in Disaster (NVOAD) is an association of nonprofits that responds to disasters around the United States and the world for more than 50 years. Their aim is to mitigate and alleviate the effect of natural and human disasters, facilitate collaboration, communication and coordination, and foster more advanced and effective delivery of service to affected areas (NVOAD, 2021). In response to the COVID-19 pandemic, the 74 national nonprofits of NVOAD (including faith-based, community-based, and other nonprofits) have coordinated with three government agencies, that is, Department of Health and Human Service (HHS), Federal Emergency Management Agency (FEMA), and Centers for Disease Control and Prevention (CDC), to deliver services across the country and provide help to affected communities as safely as possible (NVOAD, 2021).

During a disaster, nonprofits and government agencies use social media to disseminate information to the public, monitor open source data, and engage organizations and citizens to mitigate the risk (Muralidharan et al., 2011; Wukich, 2015). Social media has become integral to the interactions and communications among nonprofits, government agencies, and the public (Gong & Lane, 2020; Su et al., 2015). It has provided a new platform for these organizations to interact and collaborate with each other and others online (Lovejoy & Saxton, 2012; Panagiotopoulos et al., 2014). The information posted by these institutional accounts on social media can largely reflect how they interact with each other and government agencies for the pandemic response from both social network and geographical perspectives (Gong & Ye, 2021). The research questions of this study are how nonprofits use social media to connect and interact with the organizations with which they collaborate and what factors can have an impact on their
connections. This study intends to answer these questions by examining nonprofits’ Twitter use behaviors in the context of the COVID-19 pandemic. The findings can also provide guidance for nonprofits to plan for better interactions and communications in future disaster response.

**Literature Review**

Social media (e.g., Twitter, Facebook, and Instagram) allows people to create, share, and exchange user-generated content via social networking services and virtual communities, which has profoundly changed the way people communicate (Kaplan & Haenlein, 2010; Kietzmann et al., 2011). In 2021, approximately seven in 10 American adults had used at least one social media platform, and many social media users visited their accounts at least once per day (Pew Research Center, 2021). Microblogging sites (especially Twitter) are among the most commonly used social media platforms because they offer short message updates for fast information dissemination and hashtagging, retweeting, and directed-following features for enhanced user interactions (Gong & Yang, 2020; Huberman et al., 2008; Kwak et al., 2010). Therefore, Twitter not only is popular among individual users for user/news following and microblogging (Shearer & Mitchell, 2021), but has also become a standard communication tool for many institutional users to disseminate information, foster connection, and even manage crises (Gong & Lane, 2020; Kelly, 2013; Kostkova et al., 2014).

Nonprofits are among the institutional users that utilize Twitter to disseminate information and communicate with others. Since the majority of studies have focused on the adoption of Twitter by large nonprofits (e.g., Nah & Saxton, 2013) or by nonprofits serving certain geographical areas (e.g., Campbell et al., 2014) or with certain types of missions such as advocacy and human services (e.g., Guo & Saxton, 2014; Brown, 2015; Young, 2017), there is no data on the overall adoption of Twitter by the nonprofit sector. But the general trend is an increasing number of nonprofits have embraced Twitter over the past decade (Young, 2017). Meanwhile, researchers have documented the diverse purposes for which nonprofits use Twitter. Specifically, nonprofits would post tweets to promote their programs, services, and events (Young, 2017), communicate and engage with followers and the public (Lovejoy et al., 2012; Lovejoy & Saxton, 2012), fundraise (Di Lauro et al., 2019), recruit volunteers (Young, 2017), collaborate with others (Young, 2017), and advocate for issues and policies (Guo & Saxton, 2014, 2017).

Lovejoy and Saxton (2012) categorized these different uses into three functions. The first function is information that describes nonprofits post updates to their followers about the organizations, activities, and other relevant information (Lovejoy & Saxton, 2012). The second function is community that captures how nonprofits create online communities on Twitter by interacting and having dialogues with their followers and the public (Lovejoy & Saxton, 2012). These community-building activities include giving recognition and thanks, acknowledging current and local events, responding to reply messages, and soliciting response (Lovejoy & Saxton, 2012). The last function is action; it revolves around calling the followers or the public to take action, which can be attending an event, donating, volunteering, buying a product, engaging in lobbying and advocacy, joining a group, or voting (Lovejoy & Saxton, 2012). Despite the three identified functions, researchers have noted that most nonprofits have not been able to use the full potential of social media and capitalize its interactive features (Lovejoy et al., 2012; Lovejoy & Saxton, 2012; Waters & Jamal, 2011; Young, 2017).

While Twitter offers nonprofits a range of benefits for everyday communication, several studies (Brengarth & Mujkic, 2016; Muralidharan et al., 2011; Shemberger, 2018; Wukich & Steinberg, 2013) have documented how nonprofits use Twitter during crises and disasters such as the Boston Marathon Bombings, the 2013 Tornado in Oklahoma, and the Earthquake in Haiti. According to these studies, Twitter is advantageous in that nonprofits can post brief, clear, and timely
information about current situations and developments so people who are directly affected by a crisis and the public are kept informed (Brengarth & Mujkic, 2016; Muralidharan et al., 2011; Shemberger, 2018). It enables easy mobilization of volunteers and efficient solicitation of donation (Brengarth & Mujkic, 2016; Shemberger, 2018). It also facilitates group actions taken to fight the crisis (Shemberger, 2018) and reduces the burden of first responders (Brengarth & Mujkic, 2016). Yet, even in the context of crises, scholars have observed that nonprofits failed to fully utilize Twitter’s two-way communication features (Muralidharan et al., 2011). In addition, Wukich and Steinberg (2013) found that, despite nonprofits’ active use of Twitter to disseminate information during extreme events, many did not fully take advantage of the hashtag networks that could significantly increase the retweet of their information and their visibility in the information network.

Building on the existing research, this study examines an unexplored aspect of nonprofits’ use of Twitter. Specifically, we focus on how nonprofits use Twitter to connect and interact with collaborating nonprofits in the NOVAD network and with three government agencies during the COVID-19 pandemic. Indeed, disaster response requires organizations to pool their unique advantages and resources together and collaborate with each other. Twitter provides a unique platform for nonprofits, not only for disseminating emergency messages, but also for interacting and collaborating with other organizations. All 74 NVOAD nonprofits and the three government agencies (i.e., FEMA, HHS, CDC) have Twitter accounts and frequently tweeted about the pandemic. As a result, we can explore how they connect, communicate, and collaborate with each other for disaster response from both social network and geographical perspectives.

Studies of nonprofit disaster response have investigated different natural disasters and man-made disasters, such as floodings (Atkinson, 2014; Curnin & O’Hara, 2019), the 9/11 terrorist attacks (Kapucu et al., 2011), superstorms (Eller et al., 2015), or hurricanes (Kapucu et al., 2011). However, most studies only focused on regional crises or disasters within a relatively short time period, during which the interactions were usually among local nonprofits and local government agencies. The COVID-19 pandemic is a global disaster that has lasted for a much longer time. In response to the disaster, there have been many more organizations involved and more interaction and collaboration among them. Therefore, it provides us with an opportunity to investigate nonprofit interactions at a larger spatial-temporal scale.

Furthermore, we are also interested in the role that organizational mission (dis)similarity and geographical location play in nonprofits’ online interactions with collaborating organizations. Network research that examines why organizations form ties with each other can shed light on this question. Three dynamics: homophily, heterophily, and physical/geographical proximity, are particularly relevant here (Atouba & Shumate, 2015; Rivera et al., 2010). In a nutshell, homophily and heterophily explain whether organizations are likely to form ties or partner with others that are similar or dissimilar. Attribute-based homophily denotes that organizations tend to form ties with others with similar characteristics, such as age, mission, and culture (Atouba & Shumate, 2015; Rivera et al., 2010). For example, scholars have argued that organizations with similar missions tend to view each other as more trustworthy, which can reduce their transaction costs significantly (Atouba & Shumate, 2015; Chen & Graddy, 2010). Sharing similar missions also facilitates interactions as the organizations speak the same language, increasing the potential of a successful collaboration (Atouba & Shumate, 2015). By contrast, the heterophily principle implies that ties are often formed when distinct organizations can complement each other by providing unique competencies and expertise (Rivera et al., 2010). Building on these two perspectives, we look at whether nonprofits are prone to connect with others that share similar or dissimilar missions. Physical/geographical proximity suggests that being geographically proximate to each other could help organizations form and maintain relationship (Rivera et al., 2010). We postulate that the geographical location of a nonprofit could affect how it interact with others online. It may interact
more with nearby nonprofits because geographical proximity encourages and enables “chance encounters and opportunities for interaction” (Rivera et al., 2010, p. 105).

To the best of our knowledge, our study marks the first effort to examine how nonprofits interact with other organizations in response to the COVID-19 pandemic using Twitter communications. Spatial-temporal patterns and network perspectives of nonprofits interactions were depicted through Twitter structural analyses and content analyses. In the context of the long-term global COVID-19 pandemic, this study demonstrated nonprofit online interaction at a large spatial-temporal scale that involved more organizations. The study also innovatively investigated mission (dis)similarity and geographical proximity as potential factors shaping nonprofit online interactions, which are largely overlooked in the literature. This study does not intend to rank nonprofits based on any statistical data. Instead, we attempted to help the public better understand the interactions among nonprofits and between nonprofits and government agencies through an exploratory analysis.

Data and Method

A list of 74 national nonprofits and three government agencies that collaborated in the COVID-19 response is provided by NVOAD (2021). We identified the 77 official Twitter accounts of these organizations by searching social media links on their official websites (Table 1). American Red Cross (ARC) embraced Twitter first and created its account (account name: “RedCross”) back in June 2007. Most organizations (60) registered their Twitter accounts between 2008 and 2011. Many organizations have different Twitter accounts for their headquarters and branches. This study only focuses on the headquarter accounts of the organizations. All accounts’ addresses were geocoded in ESRI ArcMap 10.7 (ESRI, 2019). As Figure 1 shows, the 77 organizations and their headquarter accounts are unevenly distributed in only 25 states across the United States. Most accounts are located in coastal states, while the east coast has more accounts than other coastal regions. Georgia and Washington D.C. have the most organizational accounts among all the states (13 and 10, respectively).

User profile, tweet histories, following list (accounts that an organization followed) and follower list (accounts that followed an organization) of each Twitter account were collected programmatically using the Twitter developer’s application programming interfaces (APIs). The user profile of each organizational account includes screen name, account name, user ID, tweet count, account description, as well as account creation location and date. Each tweet of the organizational accounts includes its tweet ID, tweet text, creation time, geotags, and the number of retweets and likes it has received.

To focus on the organization collaborations in response to the pandemic, we filtered the collected tweets as follows. First, we selected tweets from these organization accounts from 1/1/2020 to 2/15/2021; then, we further filtered the tweets with COVID-19-related keywords, such as names of the virus (e.g., “COVID-19” and “coronavirus”), pandemic symptoms and status (e.g., “fever,” “asymptomatic,” and “community spread”), and pandemic response strategies (e.g., “social distancing,” “stay at home,” “facemask,” and “flatten the curve”).

Then nonprofit interactions with collaborating organizations on Twitter during the COVID-19 pandemic were analyzed from different aspects. First, we examined the profiles and popular tweets of all organizational accounts to describe their general Twitter usage together. Second, we analyzed the temporal patterns of each organization’s tweeting behavior. Third, we investigated the topics of the organizations’ Twitter communications through their hashtag usage and term co-occurrences (i.e., the number of times every pair of terms were used together in a single tweet). Finally, based on the organizations’ following network and at-mention/retweet network in tweet
Table 1. Twitter Accounts and NTEE Classifications of NVOAD Nonprofits and Government Agencies.

| NVOAD nonprofits                                    | Abbreviation | Twitter account          | NTEE broad categories                      |
|------------------------------------------------------|--------------|--------------------------|--------------------------------------------|
| Adventist Community Services                         | ACS          | NADACS                   | Human services                             |
| All Hands and Hearts - Smart Response                | AHH          | AllHandsHearts           | Human services                             |
| Alliance of Information and Referral Systems         | AIRS         | AIRSplace                | Public, societal benefit                   |
| American Radio Relay League - The Amateur Radio Emergency Service | ARRL        | ARRL_ARRES               | Unknown, unclassified                      |
| American Red Cross                                   | ARC          | RedCross                 | Human services                             |
| Americares                                           | Americas     | Americares               | Human services                             |
| Billy Graham Rapid Response Team                     | BGEA         | BGEA                     | Religion-related                           |
| Brethren Disaster Ministries                         | BDM          | ChoftheBrethren          | Not available                              |
| Buddhist Tzu Chi Foundation                          | TzuChi       | TzuChiUSA                | Religion-related                           |
| Catholic Charities USA                               | CCharities   | CCharitiesUSA            | Religion-related                           |
| Christian Church (Disciples of Christ)               | CCDOC        | DisciplesNews             | Health                                     |
| Church World Service                                 | CWS          | CWS_global               | Human services                             |
| Churches of Scientology Disaster Response            | CSDR         | Scientology              | Not available                              |
| Convoy of Hope                                       | COH          | ConvoyofHope             | International, foreign affairs              |
| Cooperative Baptist Fellowship                       | CBF          | cbinfo                   | Religion-related                           |
| Direct Relief International                          | DirectRelief | DirectRelief             | Human services                             |
| Endeavors                                            | Endevors     | EndevorsOrg              | Health                                     |
| Episcopal Relief & Development                      | ERD          | EpiscopalRelief          | Human services                             |
| Feed the Children                                     | FTC          | feedthechildren          | Human services                             |
| Feeding America                                      | FA           | FeedingAmerica           | International, foreign affairs              |
| Foundation for Advancement in Conservation           | FAIC         | conservators             | Arts, culture, and humanities               |
| Friends of Disabled Adults and Children              | FODAC        | FODACorg                 | Health                                     |
| Fuller Center Disaster ReBuilders                    | FCDR         | TheFullerCenter          | Human services                             |
| Habitat for Humanity International                   | HHI          | Habitat_org              | Human services                             |
| Headwaters Disaster Relief Organization               | HDRO         | HeadwatersOrg            | Human services                             |
| Heart to Heart International                         | HTH          | Heart_to_Heart           | Health                                     |
| Hope Animal-Assisted Crisis Response                 | HAACR        | HopeAACR                 | Human services                             |
| Hope Coalition America - Operation HOPE              | HCA          | OperationHOPE            | Unknown, unclassified                      |
| Hope Force International                             | HF           | hopeforce                | Religion-related                           |
| HOPE Worldwide                                       | HW           | HOPEworldwide            | Religion-related                           |

(continued)
Table 1. (continued)

| NVOAD nonprofits                                             | Abbreviation | Twitter account       | NTEE broad categories                           |
|---------------------------------------------------------------|--------------|-----------------------|-------------------------------------------------|
| The Humane Society of the United States                       | HSUS         | HumaneSociety         | Environment and animals                         |
| ICNA Relief USA                                               | ICNAR        | ICNARelief            | Human services                                  |
| Information Technology Disaster Resource Center               | ITDRC        | ITDRC                 | Human services                                  |
| International Fellowship of Chaplains - IFOC                 | IFOC         | IFOChaplains          | Religion-related                                |
| International Medical Corps                                   | IMC          | IMC_Worldwide         | International, foreign affairs                  |
| International Orthodox Christian Charities                   | IOCC         | IOCCCRelief           | Human services                                  |
| Islamic Relief USA                                            | IRUSA        | IslamicRelief         | Human services                                  |
|                                                            |              |                       | Public, societal benefit                        |
| IsraAID                                                       | IsraAID      | IsraAID               | Human services                                  |
|                                                            |              |                       | Health                                          |
| Latter-DAY Saint Charities                                   | LDSC         | Idscharities          | Human services                                  |
| Legal Services Corporation                                    | LSC          | LSCtweets             | Human services                                  |
| Lutheran Disaster Response                                    | LDR          | ELCALDR               | Religion-related                                |
| MAP International                                             | MAP          | mapintl               | Human services                                  |
|                                                            |              |                       | Health                                          |
| Mennonite Disaster Service                                    | MDS          | MDS_Respon            | Human services                                  |
| Mercy Chefs                                                   | MercyChefs   | MercyChefs            | Human services                                  |
| Mercy Corps                                                   | MercyCorps   | mercycorps            | International, foreign affairs                  |
|                                                            |              |                       | Religion-related                                |
| Mission to North America-Presbyterian Church in America       | MNA          | pcamna                | Human services                                  |
| National Baptist Convention                                   | NBCUSA       | nbcsusa_inc           | Human services                                  |
| National Organization for Victim Assistance - NOVA            | NOVA         | NOVAVictims           | Human services                                  |
| NECHAMA - Jewish Response to Disaster                         | NECHAMA      | NECHAMA               | Human services                                  |
| New York Disaster Interfaith Services                         | NYDIS        | NYDISnet              | Human services                                  |
| Operation BBQ Relief                                          | OBR          | OpBBQRelief           | Human services                                  |
| Operation Blessing                                            | OB           | operationbless        | Human services                                  |
|                                                            |              |                       | International, foreign affairs                  |
|                                                            |              |                       | Religion-related                                |
| Partnership With Native Americans                             | PWNA         | PWNA4hope             | Human services                                  |
| Points of Light                                               | POL          | PointsofLight         | Public, societal benefit                        |
| Presbyterian Disaster Assistance - Presbyterian Church USA    | PDA          | PDACares              | Religion-related                                |
| Reach Out America                                             | ROA          | reachoutamerica      | Human services                                  |
| Reach Out Worldwide                                           | ROWWW        | ReachOutWW            | Human services                                  |
| Rebuilding Together                                           | RT           | RebldgTogthr          | Human services                                  |
| Samaritan’s Purse                                              | SP           | SamaritansPurse       | Religion-related                                |
| Save the Children US                                          | STC          | SavetheChildren       | Human services                                  |
| Southern Baptist Disaster Relief - SEND Relief                | SBDR         | sendrelief            | Human services                                  |
| St. Bernard Project                                           | SBP          | SBPUSA                | Human services                                  |
| Team Rubicon                                                  | TR           | TeamRubicon           | Human services                                  |
texts, we further studied the nonprofit connections and interactions from both geographical and statistical perspectives.

The National Taxonomy of Exempt Entities (NTEE) system classifies nonprofits into 26 major groups under 10 broad categories based on their missions (NCCS, 2021). Each NVOAD nonprofit belongs to no more than three categories (Table 1), for example, American Red Cross (ARC) belongs to three categories, including Human Services, International and Foreign Affairs, and Public and Societal Benefit. FEMA, HHS, and CDC are categorized into an additional category: government agencies (Table 1). Among those broad categories, the category of Human Services has the most nonprofits (44), which are followed by 13 nonprofits in the category of Religion-Related and 12 in the category of International and Foreign Affairs. This study also performed the network analysis in the NTEE broad category level to reveal the impact of mission (dis)similarity on nonprofits’ interactions on Twitter.

| NVOAD nonprofits | Abbreviation | Twitter account | NTEE broad categories                           |
|-------------------|--------------|----------------|-----------------------------------------------|
| The Jewish Federations of North America | JFNA          | jfederations    | Human services                                |
|                    |              |                | Public, societal benefit                      |
| The Salvation Army EDS | SA            | SalArmyEDS      | Human services                                |
| The Disaster Services Corporation - Society of St. Vincent de Paul USA | SVDP         | svdpuasadisaster | Human services                                |
| ToolBank USA       | ToolBank     | ToolBankUSA     | Human services                                |
| UMR - United Mission for Relief & Development | UMR          | umrelief        | Public, societal benefit                      |
| United Church of Christ | UCC          | unitedchurch    | Religion-related                              |
| United Methodist Committee on Relief - UMCOR | UMCOR        | UMC_UMCOR       | Human services                                |
|                    |              |                | Health                                        |
|                    |              |                | International, foreign affairs                |
| United Way Worldwide | UWW          | UnitedWay      | Public, societal benefit                      |
| Vibrant Emotional Health | VEH          | vibrantforall   | Health                                        |
| World Renew        | WR           | wordrenew      | International, foreign affairs                |
|                    |              |                | Public, societal benefit                      |
| World Vision USA   | WV           | WorldVisionUSA  | Religion-related                              |

| Government agencies | Abbreviation | Twitter account | Categories                          |
|---------------------|--------------|----------------|-------------------------------------|
| Federal emergency management administration | FEMA         | fema        | Government agencies                 |
| United States department of health and human services | HHS          | HHSGov      | Government agencies                 |
| Centers for disease control and prevention       | CDC          | CDCgov      | Government agencies                 |
Results

General Twitter Usage

The 77 accounts have posted a total of 19,343 COVID-19-related tweets from 1/1/2020 to 2/15/2021, but the number of tweets by each account varied greatly from 1 to 2138. CDC has the largest total number of COVID-19-related tweets (2138) among the 77 accounts, while International Medical Corps (IMC) posted the most COVID-19-related tweets (1531) among NVOAD nonprofits. Eight of the 77 accounts (10.4%) posted fewer than 10 COVID-19-related tweets during the study period. A total of 8273 COVID-19-related tweets were posted by nonprofits in the category of Human Services, which are the highest among all NTEE categories. The three government agencies posted an average of 1523 tweets per account, significantly higher than the number of tweets posted by any category of nonprofits.

Table 2 shows the 10 most-liked tweets from those 74 NVOAD nonprofits (except for the three government agencies). The tweet receiving the most likes (7099) was posted by Feed the Children (FTC) on 4/2/2020, which expressed appreciation to volunteers during the Coronavirus pandemic. Seven of the top 10 liked tweets were also retweeted more than 1000 times. Consistent with Lovejoy and Saxton’s (2012) categorization of Twitter’s functions, these tweets were mostly related to calling for donations/actions or promoting information about organizational activities.

Temporal Trend

The first tweet about COVID-19 was posted by Direct Relief International (DirectRelief) on 1/3/2020. From the beginning of 2020 to mid-March 2020 (Figure 2), there were fewer COVID-19-
Table 2. The Top 10 Liked and Retweeted Tweets From NVOAD Nonprofits as of 2/15/2021.

| Like count | Retweet count | Organization (abbreviation) | Tweet date | Tweet text |
|------------|---------------|-----------------------------|------------|------------|
| 7099       | 2902          | Feed the Children (FTC)     | 4/2/2020   | Thank you to @OneInAnARMY and for your support during the #coronavirus epidemic. Because of you and donors like you families struggling during this challenging time will find some much-needed relief. #BTSHomeFest @benwinston @JKCorden #HomeFest https://t.co/G6hYHbsHm |
| 6519       | 2679          | American Red Cross (ARC)    | 3/12/2020  | Over the past week blood centers throughout the country have experienced a significant drop in donations due to #COVID19. Let’s talk about why this is so significant what it could mean for our nation’s blood supply and why healthy people should donate now. #THREAD |
| 3865       | 2120          | Feed the Children (FTC)     | 4/14/2020  | “Thank you” for the incredible donations from the #BTSArmy. They rallied to help fight the hunger crisis during #covid19 and raised over $10k proving that together we can provide hope food and essentials to those struggling. @OneInAnARMY Donate now: https://t.co/MK4j8jLQYj https://t.co/8QmpkB3W3m |
| 3547       | 688           | Billy Graham Rapid Response Team (BGEA) | 3/14/2020 | As the #coronavirus continues to spread President Donald Trump has called for a #NationalDayOfPrayer. Will you join us in prayer? https://t.co/kc5jULBGWi |
| 3470       | 1238          | Feed the Children (FTC)     | 3/26/2020  | We are proud to partner with @latelateshow and #HomeFest. This event will provide meals and essentials for millions of struggling families during #COVID19. https://t.co/CTnLvWk9bY Quote @latelateshow This coming Monday we’re bringing people together to keep them apart. Home Fest: @JK Corden’s Late Show Special will feature @billieeilish @finneas @AndreaBocelli @davidblaine @bts_bighit @DUALIPA @johnlegend #WillFerrell & more! Watch #HomeFest Monday at 10p.m. on @CBS https://t.co/6GZD4pAGpr |
| 2465       | 1068          | Direct Relief International (DirectRelief) | 1/13/2020 | In response to the #TaalVolcano eruption in the Philippines @DirectRelief in coordination with @ASEAN @AHACentre & the Philippines Red Cross is delivering an initial 42000 N95 masks to local organizations in affected areas. https://t.co/Tom4FG168X |
| 1670       | 1021          | Save the Children US (STC)  | 8/5/2020   | After a devastating explosion in #Beirut children and families already facing COVID-19 as well as economic and political crisis are more vulnerable than ever. We are on the ground ready to support the urgent needs of children, but we need your help: https://t.co/IsVAlHvflp |

(continued)
related tweets from all these 77 organizational accounts. One possible reason may be that there were not many reported cases, and people didn’t realize the severity of the global pandemic during that time. The number of COVID-19-related tweets increased sharply from mid-March 2020 and kept high daily tweet counts until the beginning of June 2020. The 7-day moving average trend of tweet counts is generally consistent with the severity of the pandemic in the United States during this time. From July 2020 to March 2021, the number of tweets on Coronavirus remained stable, about 40 tweets per day from all the organizations together.

Figure 3 shows weekly tweeting pattern for each organization. In general, the three government agencies (CDC, FEMA, and HHS) and International Medical Corps (IMC) were the most active in terms of the number of tweets through the entire study period. Americares and American Red Cross (ARC) posted more tweets before August 2020 than after. Most other organizational accounts generally were more active during March to early May 2020. Among all organizations, United Way Worldwide (UWW) had the maximum weekly tweet counts during 3/22/2020 to 3/29/2020. It established the COVID-19 Community Response and Recovery Fund to support
communities affected by COVID-19 in March 2020 (PRNewswire, 2020). So, it started campaigning for this fund and interacting with donors frequently on Twitter during late March 2020.

**Topics**

Hashtags (“#”s) are designed to allow Twitter users to conveniently search for tweets around specific topics and follow conversations around the topics (Laniado & Mika, 2010; Shapp, 2014). Hashtag usage by the organizations can largely reflect the topics in their disaster response communications. About two-thirds of all tweets (13,181 tweets) have at least one hashtag. Six nonprofits posted more than 90% of their COVID-19-related tweets with hashtags, including American Radio Relay League - The Amateur Radio Emergency Service (ARRL), IsraAID, Operation Blessing (OB), Partnership with Native Americans (PWNA), United Church of Christ (UCC), and United Way Worldwide (UWW). These nonprofits consistently assign COVID-19-related topics in their tweets, which helps other organizations and the public to follow their disaster response communications intuitively. The most frequently used hashtags include names of the virus (such as #COVID, #coronavirus, #COVID2019, and #COVID-19), preventive strategies (such as #WearAMasks, #PPE, #SlowTheSpread, #FlattenTheCurve, and #Vaccine), health impact (such as #flu, #fever, and #mentalhealth), and COVID-19 relief campaigns (such as #Relief4Charities, #CaritasOnCovid19, and #Heroes4Health). Three of the top 10 hashtags are related to the campaigns involving multiple NVOAD nonprofits. The high-frequency usages of these campaign-related hashtags demonstrate nonprofits’ efforts in promoting the collaborative efforts of disaster response.

To better understand the communications among these organizations, we conducted content analysis of the terms used in their tweets. We identified that 113 terms (excluding propositions, adverbs, articles, and other non-content-bearing words) were used at least 500 times by the 77 organizational accounts. As shown in Figure 4, we generated a network of the terms based on the
co-occurrence frequency of every pair of terms in a single tweet using the VOSviewer software (van Eck & Waltman, 2010). A heavier weight link between a pair of terms indicates they are used together more frequently in tweets. Based on the interconnection intensities of these terms, we can roughly categorize the frequently used terms into four clusters (Figure 4). The four clusters highlight four general topics in NVOAD nonprofits’ and government agencies’ Twitter communications: treatment and health system (Cluster 1), institutional and community efforts and responses (Cluster 2), individual-level prevention strategies (Cluster 3), and data relating to pandemic status (Cluster 4). The Cluster 3 centers around information disseminated by CDC about what individuals can do to curb the spread of COVID-19. The Cluster 2 illustrates institutional and community efforts taken to address pandemic-related issues, such as food banks giving out meals to alleviate hunger, and organizing online meetings and forums with government officials and members of Congress. The Cluster 1 focuses on the response of the health system to the pandemic. The Cluster 4 displays data and information about the status of COVID-19 cases.

**Connections and Interactions**

Network connections on Twitter among the organizational accounts can reflect how they interact, communicate, and collaborate in disaster response during the COVID-19 pandemic. The network connections can be implemented by either following each other’s account or mentioning/retweeting/quoting each other in tweet texts.
Following Network. If Organization 1 follows Organization 2, a single-direction following connection is created between the two organizational accounts. Organization 1 is Organization 2’s follower. Figure 5 represents each organization as a circle, with the circle size proportional to the number of followers among all 77 organizational accounts. Generally, the organizations’ follower quantities exhibit a power law distribution. Most organizations have fewer than 20 peer organizational followers. American Red Cross (ARC) and FEMA have most peer organizational followers, 59 and 56, respectively. In other words, when they share information on Twitter, 80% of other organizational accounts can see their tweets. Therefore, they can communicate more conveniently with other NVOAD nonprofits and government agencies.

A mutual friend relationship is formed when two organizational accounts follow each other. The bidirectional relationship is represented as a line between two organizations in Figure 5. The distribution of the network node degrees generally follows a power law, which approximate a scale-free network. Overall, 12 organizations (including nonprofits and government agencies) have at least 15 mutual friends. American Red Cross (ARC) has the largest number of mutual friends (24), followed by Church World Service (CWS) and Habitat for Humanity International (HHI), who have 20 and 18 mutual friends among the 77 organizations. The numbers suggest that these three nonprofits play more central roles in disaster response communication network compared to other NVOAD nonprofits.

Through a length-frequency histogram of the mutual friend lines in Figure 5, we can identify how geographical proximity is related to the mutual tie between organizations. We identified three peaks in the histogram. The first peak is around zero distance, which means that the organizations tend to follow each other within the same city; the second peak, which is the highest, is around 600–1300 km, indicating that organizations in neighboring states are more likely to form mutual...
friend connections; and the last peak is around 4000 km which are typically mutual friend relationships between east and west coastal areas. The length distribution of mutual friend lines can reflect the potential collaborations among these organizations at different geographical scales (city level, regional level, and country level).

To investigate the influence of nonprofit mission (dis)similarity on their online interaction, the following connections were also examined after aggregating NVOAD nonprofits according to their NTEE broad categories (Table 3). Human Services, International and Foreign Affairs, and Public and Societal Benefit have the most nonprofit followings and followers per organization among the NTEE broad categories, indicating that they are more central in this following connection network. Table 3 also displays the percentages of existing followings among all possible followings within a NTEE broad category or between two NTEE broad categories. International and Foreign Affairs (59.1%) and Public and Societal benefits (28.6%) have the top two within-category following percentage among NTEE broad categories. Both categories have much higher within-category percentages than between-category percentages, which indicates that these nonprofits tend to follow nonprofits that share similar missions. By contrast, Health nonprofits and Religion-Related nonprofits are more likely to have following connections outside their categories. Human Services nonprofits have relatively similar following connections within and between categories. For the rest of the categories, the percentages for both within-category and between-category followings are low. So, there is still great potential for nonprofits in those categories to follow more peer nonprofits in order to foster better interactions and communication.

Table 4 shows the following connection between NVOAD nonprofits and government agencies. Generally, nonprofits still followed each other with a relatively low percentage (within-category following percentage = 12.6%), while the three government agencies all followed each other (within-category following percentage = 100%). Comparing the within-category and

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**Table 3. Following Connections Among Twitter Accounts of NVOAD Nonprofits by NTEE Broad Categories.**

| NTEE broad category following others | NTEE broad category being followed (number of followings (% in all possible followings)) | Number of nonprofit accounts | Number of followers per nonprofit | Number of followings per nonprofit |
|-------------------------------------|--------------------------------------------------------------------------------------------|-------------------------------|----------------------------------|---------------------------------|
|                                     | Within category                                                                 | Between categories             |                                 |                                 |
| Arts, culture, and humanities       | 0 (-)                                                                       | 0 (0)                          | 1                               | 0                               | 0                               |
| Environment and animals              | 0 (0)                                                                       | 11 (6.1)                       | 2                               | 5.5                             | 3.0                             |
| Health                              | 2 (3.6)                                                                     | 83 (12.4)                      | 8                               | 6.9                             | 7.4                             |
| Human services                      | 311 (16.4)                                                                  | 350 (16.6)                     | 44                              | 10.5                            | 10.5                            |
| International, foreign affairs      | 78 (59.1)                                                                   | 205 (21.3)                     | 12                              | 20.3                            | 16.3                            |
| Public, societal benefits           | 16 (28.6)                                                                  | 96 (14.3)                      | 8                               | 15.5                            | 10.3                            |
| Religion-related                    | 9 (5.8)                                                                     | 110 (10.7)                     | 13                              | 6.5                             | 5.8                             |
| Unknown, unclassified               | 0 (0)                                                                       | 27 (15.0)                      | 2                               | 3.5                             | 10.0                            |
| Not available                       | 0 (0)                                                                       | 11 (6.1)                       | 2                               | 0.5                             | 3.0                             |
between-category percentages of each organizational category (Table 4), we find that nonprofits tend to follow government agencies more, while government agencies are more likely to follow each other. More specifically, as shown in Figure 5, there are more connections between FEMA and other organizations (17 mutual friends) as compared with CDC and HHS, which have 3 and 2 mutual friends, respectively. But CDC and HHS have more followers among NVOAD nonprofits (28 and 17, respectively). This unbalanced following relationship shows that while nonprofits closely follow government agencies’ accounts and are interested in the official information disseminated by these agencies, government agencies do not reciprocate.

At-Mentioning and Retweeting Network. At-mentioning (@-ing) and retweeting other organizational accounts are the typical methods to directly communicate with peer organizations on Twitter. At-mentioning an organizational account means either directly replying to the organization or starting a new conversation with the organization; retweeting is intended to pass along an organization’s tweet by optionally giving comments (Twitter, 2021). Because both types of interaction involve @‘s in tweet text, we can use the percentage of tweets with @ by the organizations to measure their level of involvement in interactive communications.

In this study, 56.52% of all tweets (10,933 tweets) include at least one @. Direct Relief international (DirectRelief) and Americares posted 638 and 1089 COVID-19-related tweets, 90% of which included at least one @. FEMA also posted 89.5% of its tweets with @. This indicates these organizations’ consistent efforts to involve other accounts in COVID-19-related conversations. Eight nonprofits used @‘s in less than 20% of their tweets. These nonprofits did not frequently interact with other accounts on Twitter, at least publicly, during the pandemic. Figure 6 shows the network for at-mentions and retweets among the 77 organizations. A directed line from Organization 1 to Organization 2 means Organization 1 has either at-mentioned Organization 2 or retweeted Organization 2’s tweets, while the line width is proportionate to the number of at-mentions and retweets. A total of 53 organizations has been involved in this at-mentioning/retweeting network as of 2/15/2021. For the at-mentions and retweets among nonprofits (blue dashed lines in Figure 6), Americares has at-mentioned/retweeted Feeding America (FA) 16 times, and Billy Graham Rapid Response Team (BGEA) has at-mentioned/retweeted Samaritan's Purse (SP) 14 times, which are the first- and second-most among the at-mentions and retweets between nonprofits (blue dashed lines in Figure 6).

We generated a length-frequency histogram of the lines in Figure 6 in order to identify how nonprofit interactions differ by geographical proximity. We observed two peaks in the histogram of lengths. The first peak is around zero distance, which indicates a high level of interaction among organizations located in the same city. The second peak is around 800–1200 km, which are typical regional-level collaborations. The distribution indicates that NVOAD nonprofits were more likely

### Table 4. Following Connections Between NVOAD Nonprofits and Government Agencies.

| Organization category following others | Number of organizational accounts | Number of followings per organization |
|----------------------------------------|----------------------------------|--------------------------------------|
| Within category                        | Between categories               |                                      |
| Nonprofit                              | 681 (12.6)                       | 95 (42.8)                            |
| Government agency                      | 6 (100)                          | 17 (7.7)                             |

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to interact with collaborating organizations either in the same city or in neighboring states during the pandemic.

In this directed network, both distributions of the nodes’ in-degree (an organization being at-mentioned or retweeted by others) and the nodes’ out-degree (an organization at-mentions or retweets others) are asymptotic to power law distributions, where major hubs which very large degrees exist. Incoming hubs are CDC and HHS (in-degrees are 890 and 173), and outgoing hubs include HHS and FEMA (out-degrees are 449 and 334). A majority of nonprofits have at-mentioned or retweeted CDC, HHS and FEMA, but these government agencies have rarely responded to nonprofits, except that FEMA has at-mentioned or retweeted American Red Cross (ARC) 30 times. As a result, the government agencies played a leading role in the pandemic response by providing guidelines and disseminating information, but without directly interacting with a nonprofit. Given the nature of the pandemic, CDC is the best source of information for other organizations and the public. It has, therefore, not very surprising to have received the most at-mentions and retweets among all organizations, especially from HHS (439 times) and FEMA (205 times). HHS has received the second-most at-mentions and retweets, of which 65 and 94 times were from CDC and FEMA, respectively. There is a high level of interaction and communication among the government agencies on Twitter but not so much between government agencies and nonprofits during the pandemic.

To get a deeper understanding of whether nonprofit mission (dis)similarity could affect their interactions with others during the pandemic, we further analyzed the network of at-mentions and retweets within and across the NTEE broad categories (Table 5). Most at-mentions or retweets involve the category of Human Services organizations (been at-mentioned/reweeted 132 times, at-mentioning/retweeting others 117 times), which are partially because of the large number of

Figure 6. The network of at-mentions and retweets among NVOAD nonprofits and government agencies as of 2/15/2021.
nonprofits (44) in this category. Human Services, International and Foreign Affairs, and Public and Societal Benefit nonprofits have been at-mentioned/retweeted more frequently per organization than other categories, which indicates their central positions in the communication network. Public and Societal Benefit nonprofits at-mention/retweet others more frequently than nonprofits in other categories, indicating their active engagement with other nonprofits. Most NTEE broad categories’ average at-mentioning/retweeting interactions within category are lower than or

### Table 5. At-Mentions and Retweets Among Twitter Accounts of NVOAD Nonprofits by NTEE Broad Categories.

| NTEE Broad Category | Number of Nonprofit Accounts | Number of Times At-mentioning Others Within Category | Number of Times At-mentioning Others Between Categories | Number of Times Retweeting Others Within Category | Number of Times Retweeting Others Between Categories |
|---------------------|-------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|
| Arts, culture, and humanities | 0 (-) | 3 (0.03) | 1 | 0 | 1.0 |
| Environment and animals | 0 (0) | 1 (0.01) | 2 | 0 | 0.5 |
| Health | 0 (0) | 40 (0.06) | 8 | 1.3 | 3.0 |
| Human services | 90 (0.05) | 86 (0.04) | 44 | 3.0 | 2.7 |
| International, foreign affairs | 19 (0.14) | 82 (0.09) | 12 | 5.4 | 6.1 |
| Public, societal benefits | 6 (0.11) | 21 (0.03) | 8 | 7.0 | 2.4 |
| Religion-related | 16 (0.10) | 14 (0.01) | 13 | 1.5 | 1.8 |
| Unknown, unclassified | 0 (0) | 3 (0.02) | 2 | 0 | 0.5 |
| Not available | 0 (0) | 0 (0) | 2 | 0 | 0 |

### Table 6. At-Mentions and Retweets Between NVOAD Nonprofits and Government Agencies.

| Organization Category | Number of Organizational Accounts | Number of Times At-mentioning Others Within Category | Number of Times At-mentioning Others Between Categories |
|-----------------------|-----------------------------------|-----------------------------------------------|-----------------------------------------------|
| Nonprofit | 181 (0.03) | 281 (1.27) | 74 | 6.24 |
| Government agency | 824 (137.33) | 35 (0.16) | 3 | 286.33 |
similar to the ones between categories, except for International and Foreign Affairs, Public and Societal Benefit, and Religion-Related nonprofits (Table 5). The three categories at-mentioned or retweeted nonprofits in the same category more frequently, which could be influenced by their mission similarity.

Table 6 shows the at-mentioning/retweeting connections between NVOAD nonprofits and government agencies. Government agencies have been at-mentioned or retweeted most often (368.3 times per organization), and also have at-mentioned or retweeted others most often (286.3 times per organization). In both cases, the quantities are much greater than any nonprofit categories’, indicating that nonprofits can be more proactive in fighting the pandemic through collaborative efforts. Comparing the within-category and between-category at-mentions/retweets of each organizational category (Table 6), we find that nonprofits tend to at-mention/retweet government agencies more often than their peer nonprofits (1.27 per pair between nonprofits and government agencies vs. 0.03 per pair within nonprofits), while government agencies are more likely to at-mention/retweet their peers (137.33 per pair within government agencies vs. 0.16 per pair between nonprofits and government agencies). Although government agencies were actively involved in interactions among themselves, the interactions between government agencies and nonprofits were usually one-directional with nonprofits at-mentioning government agencies or retweeting their posted information.

Discussion

This study analyzed the connections and interactions among 74 NVOAD nonprofits and three government agencies based on their Twitter communications during the long-term global COVID-19 pandemic. We chose Twitter data for our investigation because of Twitter’s broad acceptance among institutional users and it has more structured interactions and messages than other platforms. Additionally, the big data generated by Twitter can be used to gain a deeper understanding of organizations’ communications and interactions than traditional data collection methods, such as surveys and interviews, which involve relatively few nonprofits and small samples of interactions. By examining Twitter basic information, conducting structural analyses, and performing content analyses, this study demonstrated nonprofits’ online communication patterns as well as their connections and interactions with other collaborating organizations from both spatial-temporal and network perspectives. The findings make several contributions to the knowledge of interactions among nonprofits and between nonprofits and government agencies in disaster response.

First, our study shows that a majority of NVOAD nonprofits actively use Twitter for communication purposes and to interact with other nonprofits in the network and government agencies during the pandemic. However, tweeting frequencies related to COVID-19 varied considerably among nonprofits. It is not surprising to see major organizations, such as the American Red Cross (ARC) and Feed the Children (FTC), were more active than others. For those active organizations, our content analysis demonstrates that their Twitter communications center around four clusters, including individual-level prevention strategies, institutional-level efforts, healthcare system responses, and pandemic data. Another way of looking at the terms identified in the clusters also indicate that the organizations’ uses of Twitter align with the “Information-Community-Action” scheme proposed by Lovejoy and Saxton (2012). Similar to their study, we found the most prevalent function used by studied organizations during COVID-19 is information. They utilized Twitter to inform people about prevention strategies and treatment, spreading data and statistics of the pandemic status, and spreading words about institutional and community efforts to address social issues resulting from the pandemic. However, we also found the organizations actively used Twitter for community-building and encouraging action. They strengthened ties to the online
community through tweets such as giving thanks to partners, volunteers, donations, and healthcare workers (Cluster 2 in Figure 4) and encouraging people to share their experience during COVID-19 (Cluster 1 in Figure 4). Lastly, they used Twitter to encourage followers to act, such as making monetary or plagsam donations (Cluster 1 and 2 in Figure 4), attending online webinars or forums with government officials and members of Congress (Cluster 2 in Figure 4), and contacting members of Congress (Cluster 2 in Figure 4).

Second, our findings improve the understanding of the roles that homophily and heterophily play in nonprofits’ connections and interactions with other collaborating organizations on social media. Existing studies have applied homophily and heterophily theories to explain why organizations form collaborations with others (e.g., Atouba & Shumate, 2015), but few have looked at whether the theories can explain organizations’ online interactions. According to our findings, both mission homophily and heterophily influence nonprofits’ connections and interactions with other collaborating organizations, but such influence largely depends on the nonprofit subsector. Health nonprofits’ online relationship with other nonprofits is largely explained by mission heterophily. They tended to connect (i.e., mutual friend relationships) and interacted (i.e., at-mentioning/retweeting) with nonprofits outside their own subsectors. Mission homophily, on the other hand, tends to explain the online relationships of international and Foreign Affairs and Public and Societal Benefits nonprofits because they were more connected and interacted more with their peer nonprofits within their own subsectors. Religion-Related nonprofits had mutual friend relationships with nonprofits outside their own subsector, but they had more interactions with nonprofits within their own subsector during the pandemic. As for Human Services nonprofits, they connected and interacted with nonprofits within and across subsectors equally.

Furthermore, the findings also reveal that physical locations of nonprofits do seem to affect their online relationships with other nonprofits on social media. Similar to Atouba and Shumate’s (2015) finding that geographical proximity or homophily leads nonprofits to form collaborative relationship, we found nonprofits were more likely to have online connection and interaction with those located in the same city or neighboring state. Geographically proximate nonprofits had mutual friend relationships and they at-mentioned and retweeted each other frequently. Although nonprofits on the east and west coast also tended to follow each other, they did not interact with each other as frequently as those in their immediate vicinity.

Lastly, our findings also contribute to our knowledge about the online interaction between government and nonprofits during the pandemic. As opposed to local disasters where nonprofits could play a more central role in sending out unique information (Wukich & Steinberg, 2013), our results demonstrate that government agencies rather than nonprofits were the primary sources of critical information on Twitter during a large-scale pandemic such as COVID-19. Nonprofits mainly played the role of relaying information from government sources. We also found that government agencies interacted with each other much more often than with nonprofits. They had many NVOAD nonprofit followers, but they rarely followed back. This was also the case for at-mentioning and retweeting. Nonprofits often at-mentioned government agencies and retweeted their tweets, but there was less interaction initiated by the government. Liu and Xu (2019) had a similar observation when studying government and nonprofit communications on social media during Hurricane Harvey. They argued that it was possible that “many nonprofits had not entered government agencies’ … existing network and the government agencies might have been preoccupied with relationship building with peer agencies and citizen groups” (Liu & Xu, 2019, p. 4932). There is thus potential for government to build a stronger relationship with nonprofits on social media when addressing complex health and social issues.

We also want to briefly discuss the tools we used for studying Nonprofits’ network. Nonprofits’ interactions with other organizations were analyzed using both their following connections and at-mention/retweet connections. The two types of connections actually reflect different aspects of
interactions among the organizations. On the one hand, following an organizational account is a one-time action that could happen before the pandemic. It shows a long-term connection between two organizations, but not necessarily all related to the current pandemic response. On the other hand, an at-mention or retweet among organizations means an instant interaction on a more specific topic, but it is repeatable. We only filtered the COVID-19-related at-mentions and retweets of the organizations in this study, which can more precisely record the repeating collaborative activities for pandemic response. Although from different perspectives, the two types of connections show similar communication patterns in the results. Basically, government agencies played leadership roles and provided guidelines and information for nonprofits; and nonprofits in the categories of Human Services, International and Foreign Affairs, and Public and Societal Benefit organizations, especially the American Red Cross (ARC), played more central roles in the nonprofit communication network. No matter long-term following or instant at-mentioning/retweeting, they both demonstrate nonprofits’ tendency to collaborate within cities and with neighboring states.

The interpretation of the findings should also take the limitations of this study into consideration. First, while nonprofits and three government agencies in this study have Twitter accounts, a small portion of nonprofits did not actively use Twitter for communication purposes during the pandemic. They could be more active on other social media platforms (such as Facebook and Instagram). Therefore, the interactions reflected by Twitter communications might not provide a wholesome picture of a nonprofit’s overall social media use. Future studies could address this limitation by integrating data from multiple social media platforms to provide a more comprehensive view of nonprofits’ online communication. Second, only the headquarter accounts for the 77 organizations were used for analysis. However, many nonprofits have multiple branches in the United States or even abroad, and some have separate Twitter accounts for branches; other personal accounts (such as a nonprofit president’s account) could also involve in interactions with other organizations. From the spatial perspective, we only used the Twitter account location or the headquarter city of an organization to represent the entire organization. This simplification makes the spatial distribution and communication networks among nonprofits more intuitive and legible. However, the geographical proximity among those organizations might include potential bias if some branches of nonprofits were also involved in the collaborations by themselves. We could consider including all these accounts in future analysis to depict a more dynamic picture of nonprofits’ use of Twitter. Lastly, as an exploratory study, the patterns of communication and interaction were only quantitatively depicted through Twitter structural analyses and content analyses. The causes for those patterns need to be further validated and explained by in-depth qualitative interviews with nonprofit executive directors or communication directors. Mixed methods could be considered in future studies to gain a better understanding of nonprofit collaborations.

**Conclusion**

This study revealed the patterns of nonprofits and government agencies’ online communications and interactions in disaster response from both spatial-temporal and network perspectives and explored potential causes for these patterns. The daily tweeting quantities of all nonprofits were generally consistent with the severity of the pandemic in the United States before July 2020 and remained stable afterward. The hashtags of COVID-19 relief campaigns involving multiple nonprofits are among the most commonly used hashtags, which demonstrates the collaborative disaster response efforts among nonprofits. Four general topics of nonprofits’ Twitter communications are individual prevention strategies, institutional-level response, pandemic status, and treatment and health system, which can reflect their purposes of sharing information, building
communities, and taking actions for disaster response. The connection and interaction patterns among individual organizations show that three government agencies (CDC, FEMA, and HHS) played leadership roles for NVOAD nonprofits and American Red Cross (ARC) played a more central role in the nonprofit collaboration network. The possible causes of the patterns were innovatively explored and explained with geographic proximity and mission (dis)similarity of nonprofits. Geographically, we find that connections and interactions among nonprofits are more likely to happen within the same city or in neighboring states. Both mission homophily and heterophily can affect the connection and interaction patterns among nonprofits, depending on the subsector of nonprofits. Health nonprofits tend to connect and interact with nonprofits outside their own subsectors, while International and Foreign Affairs and Public and Societal Benefits nonprofits tend to communicate more with their peer nonprofits in the same subsector. Government agencies tend to interact with each other much more often than with nonprofits, and most NTEE broad categories of nonprofits tend to follow/at-mention/retweet government agencies during the pandemic response. However, the networks demonstrated by following and at-mentioning/retweeting connections show great potentials for nonprofits to be more active in collaborative efforts. Based on this exploratory study of nonprofit communications in a large geographical area over a long period of time, not only can the public better understand how nonprofits are collaboratively fighting the pandemic, but also can nonprofits better estimate and promote their collaborations in preparation for future disaster response.

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Notes
1. Nonprofit organizations in the United States are “self-governing organizations that do not distribute profits to those who control them and are exempt from federal information taxes by virtue of being organizations for public purposes” (Boris, 2006).

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