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Variation and Selection During Pandemic: Toward A Multiplex Framework for Understanding Nonprofit Community Network Evolution in Crisis Time

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This study examines how the communication network structure of a community of U.S. nonprofits evolves in response to the COVID-19 pandemic by examining their multiplex strategic communication network building on Twitter/X. This study identifies two types of networks: representational ties (for third-party audiences) and substantial ties (for direct resource exchange). Our findings suggest that organizations remain consistent with network strategies through different crisis stages, and that the crisis provides opportunities for nonprofits to maintain existing substantial networks while building more

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extensive substantial networks. Representational ties, including those formed precrisis, have the potential to evolve into substantial relationships. Theoretically, this research contributes to the network evolution theory that network tie variation and selection can occur simultaneously through a multiplex process. Practically, organizations can strategically expand representational connections in normal times to prepare for crises.

Keywords: interorganizational network evolution, social-media-mediated strategic communication, multiplexity, crisis management, COVID-19

Severe crises, such as COVID-19, can shape the evolution of organizations and their networks (Doerfel, Lai, & Chewning, 2010). Among the various types of organizations impacted by the COVID-19 pandemic, nonprofits must adapt to disruptions and mobilize resources to assist millions in dire need (Doerfel, Atouba, & Harris, 2017).

In the process of nonprofit communication about the pandemic, social media interorganizational networks support key operations such as issue advocacy (Guo & Saxton, 2018), activism (Auger, 2013), resource mobilization (Mano, 2014), community engagement (Campbell, Lambright, & Wells, 2014), and stakeholder engagement (Guo & Saxton, 2018; Zhang, Wang, Chen, & Wang, 2024). Importantly, nonprofits' social media ties could serve multiple functions and form multiple types of networks (e.g., representation networks and flow networks; Shumate & Contractor, 2013). Moreover, interorganizational connections on social media do not always warrant gains in various forms of capital, nor can they necessarily be sustained over time (Sun, 2020). As such, nonprofits need to understand how organizations' social media efforts can be translated into tangible and intangible resources to advance their strategic goals (Dong, Zhang, Li, Lee, & Chen, 2023; Ihm, 2019). Recent communication network research has analyzed the relationship among nonprofits' multiple types of networks (e.g., Ihm, 2019; Lai & Fu, 2021). However, most are cross-sectional studies, and a longitudinal perspective is still missing. Recognizing the gap, our study draws on evolutionary theory (Hannan & Freeman, 1977) and its extension in network evolution theory (Monge, Heiss, & Margolin, 2008; Monge & Poole, 2008) to study how U.S. nonprofits' interorganizational virtual networks evolve in response to the COVID-19 pandemic. Organizations and their relationships evolve through three key processes: variation, selection, and retention (V-S-R; Aldrich & Ruef, 2006; Monge et al, 2008), which we will discuss in detail later.

This study reconceptualizes V-S-R as a complex strategic decision-making process. A crisis event can be conceptualized as a watershed moment that drastically disrupts an organization's strategies when resources and attention are prioritized for crisis management (Coombs & Holladay, 2022). Strategic crisis communication helps organizations refocus organizational goals of resource access and social recognition, adjust to disruptive shifts (Coombs, 2010; Coombs & Holladay, 2022), and minimize damages (Jin & Austin, 2021). Crisis communication is critical in managing knowledge access and stakeholder engagement (Coombs, 2010). Crisis communication consists of precrisis, initial crisis, maintenance, and postcrisis (including crisis resolution and evaluation) stages, motivating organizations to prioritize organizational resources for different goals (Coombs, 2012; Reynolds & Seeger, 2005). Crisis communication can be directed to internal (e.g., employees) and external stakeholders (e.g., public

audiences, organizational partners). The scope of this research is mainly external from an interorganizational relationship-building perspective.

In addition, we propose a multiplex approach (Lee & Monge, 2011) to understand the variation and selection process based on the processes of two types of ties: representational and substantial. Previous research either studies V-S-R without clearly distinguishing the three processes (e.g., Lee & Monge, 2011) or separates V-S-R as distinctive time phases (e.g., Fu, 2019). The current research proposes that variations and selections may not simply occur in a linear sequence. Instead, organizations may constantly experiment with different variations to identify possible fitting choices for selection. Informed by the interorganizational relationship typologies (O'Connor & Shumate, 2018; Shumate & Contractor, 2013), this study proposes that variations and selections could be operationalized as the changes of representational ties and substantial ties. Representational ties are defined as "messages about an association among actors communicated to a third party or to the public" (Shumate & Contractor, 2013, p. 452), whereas substantial ties, as we summarized from Shumate and Contractor (2013), consist of information flow, resource exchanges, and contractual partnerships. Representational ties offer low-cost trial-and-error opportunities to communicate with multiple organizations, whereas substantial ties tend to be retained from various low-stakes relationship-building efforts, indicating certain levels of organizational commitment and strategic selection.

To test our theoretical framework, we collected tweets from U.S. nonprofits before and during the first six months of the COVID-19 pandemic. We treat these tweets as archives of organizational activities and use manual coding to differentiate relationships that signal representational or substantial ties. Our analysis suggests that variations in representational ties significantly influence future tie selections, as reflected by substantial ties before and during the crisis. During the crisis, substantial ties in the early stages contribute to an increase in future substantial ties, and such selections could be sustained over time. The theoretical and practical implications are discussed.

Literature Review

Organizational Ecology and Network Evolution

Organizational ecology theory examines the formation, growth, and dissolution of communities of organizations and their relationships (Hannan & Freeman, 1977; Monge et al., 2008). This theoretical perspective views organizations as species occupying niches—spaces that provide organizations with the resources necessary for survival and success. A population of organizations consists of those that depend on the same or similar resources from the niche. Meanwhile, an organizational community is "a spatially or functionally bounded set of populations" that form "ties of commensalism and symbiosis through their orientation to a common technology, normative order, or legal-regulatory regime" (Aldrich & Ruef, 2006, p. 243).

The COVID-19 pandemic attracts public attention to various social issues such as health, economic, and humanitarian issues (Li et al., 2021). Different issues related to COVID-19 constitute niches where nonprofits may create network ties with one another to access resources—including both material and symbolic resources—to effectively work on the mitigation of the crisis (Sun, 2020). Since different issues attract different nonprofits, shaping resource availability differently (Li et al., 2021; Sun, 2020), we focus

on nonprofits' communication about health-related issues, as previous research has found this to be one of the main issues that top U.S. nonprofits discussed on Twitter/X during COVID-19 (Li et al., 2021). In the United States, after the crisis hit, many organizations started to work remotely and rely on social media to communicate with the public and stakeholders. As such, social media platforms like Twitter/X provide a publicly visible platform for organizations to engage stakeholders, which also provides a publicly accessible data archive for researchers to study organizational social-mediated communication during the pandemic.

A niche is multidimensional, and by focusing on different dimensions of the niche space, various ecological forces can be investigated, enabling the identification of organizational populations affected by specific ecological forces (Hannan & Freeman, 1977). In the current research, our focus is on the issue niche to understand nonprofit organizations' issue-specific communication in the context of social-mediated space. Yang (2020) argues that an issue can serve as an "important opportunity structure" for nonprofits, shaping resource availability, organizational identity, and ideologies, which in turn influence nonprofits' network construction (p. 42). While organizations may differ in dimensions other than social issues, they share a reliance on the public attention surrounding a specific social issue, making them suitable to be treated as an organizational population. They are also influenced by the same ecological force of the issue niche. For instance, as public attention to a given issue fluctuates, organizations' communication opportunities also shift accordingly (Sun, 2020). Consequently, we conceptualize nonprofits that discuss health-related COVID-19 issues on Twitter/X as an organizational population with a shared interest in the issue.

This research draws ideas from network evolution theory (Monge et al., 2008; Monge & Poole, 2008), an extension of organizational ecology theory (Hannan & Freeman, 1977). The evolutionary process of organizational communities goes through three processes: variation, selection, and retention (abbreviated hereafter as V-S-R) (Aldrich & Ruef, 2006; Weber, Fulk, & Monge, 2016). Variations are often generated by random events and are considered the source of evolution. Selection occurs when optimal variations are accepted and others are rejected. Retention is the process of selecting standardized choices as part of organizational routines (Monge et al., 2008; Monge & Poole, 2008). Organizations' networks go through the V-S-R process (Fu, 2019; Monge et al., 2008; Sun, 2020). Network variation occurs when network actors experiment with various connections. During the selection process, the actor selects some variations over others, and finally, retention describes the process when connections become routinized. Since this study's data collection did not cover the long-term network retention process of the COVID-19 crisis after it was truly concluded, we focused primarily on the variation and selection processes.

The current study conceptualizes the V-S process as reflected by two different types of relationships: representational and substantial. Both can be viewed as tactics that serve organizations' strategic communication goals (Yang & Taylor, 2015). Our framework makes two important assumptions. First, a crisis is not a static event but an unfolding process. Organizations may evaluate their positions, tasks, and needs at different crisis stages and adjust their strategic partnership choices. Second, both representational and substantial ties reflect organizations' strategic communication intentions and serve unique functions to advance organizational objectives (Yang & Taylor, 2015). This important assumption sets the current study apart from previous network evolution studies (Fu, 2019; Lee & Monge, 2011). We

no longer consider V-S as distinctive stages, but rather as functions of networks that could occur simultaneously. This idea is further elaborated below.

Dynamic Network Multiplexity and Variation and Selection During a Crisis

Communication networks on social media platforms are multiplex systems in nature, as actors are connected by different types of communication relations (Dong & Rim, 2019; O'Connor & Shumate, 2018). Additionally, these relations are deliberately created by organizations and can be observed by the online public (Yang & Ji, 2019). Network multiplexity is,

> overlapping relations between a set of actors whereby (a) each relation forms a distinct layer of a larger system of interest; (b) layers are beholden to emergent processes which may differ from other layers; and (c) combinations of ties across layers may interact in nonrandom ways. (Simpson, 2015, p. 45)

Studying network multiplexity provides a fuller picture of complex network systems (Dong & Li, 2022; Lee et al., 2012; Zhao & Rank, 2013). Not considering the multiplexity of relationships risks overlooking the interdependent and varied ways in which different types of relationships affect one another (Ertug, Brennecke, & Tasselli, 2023). This research examines the co-evolution between two types of communication networks among nonprofits—representational and substantial networks.

Representational relations are "messages about an association among actors communicated to a third party or to the public" (Shumate & Contractor, 2013, p. 452), a public display of an actor's affiliation with others. Typical examples of representational relations include associations among actors communicated to a third party, such as bibliometric networks (So, 1988) and hyperlinked partner networks (Shumate, 2012). For example, Organization A may announce that its missions align with Organization B's on Twitter/X. While A's message contains a direct mention of Organization B, it is a "name-dropping" behavior to indicate Organization A's affiliation with Organization B without transmitting information or resources directly to Organization B (Shumate, 2012, p. 121). Representational ties help increase public awareness of nonprofit organizations' issue goals and collective identities among advocating organizations (Ihm, 2019; Pilny & Shumate, 2012). In contrast, substantial relations are information flow, resource exchange, and contractual partnerships that organizations communicate about on social media (e.g., Shumate, 2012; Shumate & Contractor, 2013). We coined the term "substantial" in contrast to "representational" ties because, unlike the latter, the former involves more tangible and direct communication that reflects information or resource exchange between connecting organizations. Additionally, compared with representational ties, "substantial" ties require more commitment and time to establish. However, once established, they have the potential to be more enduring and beneficial for organizations' long-term operations (Shumate & Contractor, 2013). For example, during the COVID-19 pandemic, many organizations use social media to announce that they have received donations or assistance from stakeholders or formed partnerships.

Representational and substantial relations perform distinctive organizational functions (Shumate & Contractor, 2013). Representational relations focus on establishing affiliations, which take the form of an acknowledgment of allies or a symbolic expression of collective actions (Shumate & Contractor, 2013). They

serve the purpose of institutional positioning by associating an organization with credible, legitimate, and reputable others within a network (O'Connor & Shumate, 2014, 2018). Through representational network building, organizations form collective efforts to promote awareness of social issues (Shumate, 2012). Representational relations are low in communication cost but could potentially lead to the development of other relationships. As variation may serve as an exploratory process for organizations to search for potential partners (Aldrich, Reuf, & Lippmann, 2020), representational relationships among organizations that have not yet formed substantial relationships may perform the functions of variation and offer organizations opportunities for trial-and-error at a low cost (Lee & Monge, 2011). O'Connor and Shumate (2018) also note that representational networks can be translated into further interactions and shape the dynamics of other networks, such as substantial networks. Network variation can be intentional, driven by clear organizational goals, or unintentional, formed through unexpected circumstances (Aldrich & Ruef, 2006; Wang, Tanjasiri, Palmer, & Valente, 2016). Organizations engage in intentional representational network building because their choices are visible to the public (Shumate, 2012). Representational relationships can also be formed unintendedly, driven by shared issue interests. Variations provide resources for further tie selection and longer-lasting purposeful or incidental relationship-building (Aldrich & Ruef, 2006).

However, what has not been fully understood is whether and under what crisis scenarios representational networks can be translated into substantial interactions. Such an inquiry sheds light on how organizations may strategically manage different types of communication efforts when faced with a crisis. Understanding organizations' strategic communication efforts is critical because organizations have limited time and resources to establish communication ties (Monge et al., 2008), and it is even more so as substantial networks are conduits of substantial resource exchange, and organizations need to be extra judicious about positioning themselves in substantial networks. Therefore, the inquiry into the multiplexity interdependency between representational and substantial networks informs the importance of strategically managing representational connections for the more successful construction of substantial networks.

In contrast, the costs associated with forming substantial relations are significantly higher, which constrains organizations' capacity to build and maintain extensive, meaningful connections (Shumate & Contractor, 2013). Nevertheless, substantial networks provide tangible resources to help organizations survive the challenges of a major crisis. In other words, organizations may afford to experiment with different ways of managing their representational networks, but they use caution when making substantial connections. Selection is, therefore, conceptualized as the process of substantial tie selection. Selecting from various existing ties (e.g., representational or other partnership exploration) for substantial networks is thus conceptualized as performing the functions of selection, which "is performed to select optimal variations" to improve organizations' capabilities in coping with the shifting environment (Doerfel et al., 2010, p. 127).

Crisis communication strategies vary for internal and external stakeholders (Fearn-Banks, 2016). Given that the context of this current research is COVID-19, an external crisis, the focus is primarily on external communication strategies facilitated by interorganizational relationship-building on digital media. Crisis stages (i.e., precrisis, crisis maintenance, and postcrisis) are universally applied to internal and external crises (Coombs, 2010).

Selection can occur across networks. For example, Powell, White, Koput, and Owen-Smith (2005) studied biotechnology corporations and found that network selection occurred across diverse types of networks (e.g., finance ties, research & development ties, and commercial ties). Lee and Monge (2011) found that organizations' knowledge-sharing linkages increased the likelihood of them sharing collaborative project implementation ties. Yang (2020) also identified that organizations' representational networks on social media were positively correlated with the tie formation of offline collaboration. The reason might be that an organization's past or current experience with one type of network provides references for its networking decisions about a different type of network.

Network evolution theory suggests that variations (conceptualized as representational networks here) provide resources for selection (the process of selecting from existing connections such as representational ties to substantial ties; Monge et al., 2008). In other words, representational ties increase the presence of substantial ties. This cross-sectional inquiry verifies the classical endogenous multiplex tie-formation logic (Lee & Monge, 2011). Moreover, this inquiry extends the traditional notion of multiplexity to the new typology about organizations' representational and substantial ties on social media. According to the theory of structural embeddedness (e.g., Granovetter, 1985; Uzzi, 1996), organizations' embeddedness in one type of relationship increases opportunities for them to form another type of relationship. Therefore, we hypothesize that representational ties that have not yet become substantial ties, although low-cost and relatively easy to construct, may help increase opportunities to form more substantial relationships that serve as conduits for essential information and resource exchange. The following hypothesis:

H1: A representational tie between two organizations (not yet turned into a substantial tie) increases the likelihood of forming a substantial tie between them at each crisis stage.

In addition, the COVID-19 pandemic consists of several stages, which we elaborate on in the section below, discussing how the evolving crisis stages may influence the variation and selection processes.

Crisis Management and V-S-R Strategic Tie Formation

A crisis is the "perception of an unpredictable event that threatens important expectancies of stakeholders and can seriously impact an organization's performance and generate negative outcomes" (Coombs, 2012, pp. 2–3), posing severe challenges to organizations and threatening organizations' survival. Crisis communication may require organizations to take action. For example, when facing crises, organizations often need to share information that helps stakeholders protect themselves and manage their reputations (Coombs, 2007). In times of crisis, the communication needs of organizations, such as the nonprofits in our sample, are greatly intensified. Studies have documented how nonprofits use a mixture of face-to-face communication, mobile phones/emails, and blogs/websites to communicate with stakeholders during crises (Doerfel et al., 2010). In addition, as the user population for social media continues to grow, nonprofits increasingly leverage social media in their crisis responses (Lai, She, & Ye, 2019).

Crises are not static (Coombs, 2012). Each crisis phase requires organizations to focus on different priorities. Most crises evolve through the precrisis, initial crisis, maintenance, crisis resolution, and crisis evaluation stages (Reynolds & Seeger, 2005). In this study, we focus on the following three stages and examine the evolution of tie formation at each stage.

Precrisis Stage

The precrisis stage refers to the period before the outbreak of a crisis, during which organizational communities operate normally and face regular issues. Organizations may routinely engage in a wide range of V-S strategies. The key tasks for organizations at this stage include increasing preparedness and fostering a wide range of alliances. Specifically for representational ties, a large and diverse representational network before a crisis may well acquaint organizations with potential partners. As such, when the crisis hits and organizations need to develop substantial ties for collaboration and resource exchange, they can draw from a pool of potential contacts based on their representational connections that have not yet evolved into substantial relationships. Therefore, we propose the following hypotheses:

H2a: A representational tie between two organizations at the precrisis stage (T0) ties (not yet turned into a substantial tie) increases the likelihood of forming a substantial tie between them during the initial-crisis stage (T1).

H2b: A representational tie between two organizations (not yet turned into a substantial tie) at the precrisis stage (T0) increases the likelihood of forming a substantial tie between them during the maintenance stage (T2).

While variation and selection highlight the likelihood for organizations to adjust and change their network ties, other forces in network ecology constrain such changes (Hannan & Freeman, 1984). Organizational ecologists have documented how organizations' relationship evolution could also be influenced by the mechanism of network inertia (Kim, Oh, & Swaminathan, 2006). Network inertia describes the constraints placed on interorganizational network changes. While a representational network may be less subject to this mechanism because of its low cost in tie formation and maintenance, inertia can be a prominent force in a substantial network (Sydow, Schreyögg, & Koch, 2009). Substantial networks can experience inertia because of a range of factors, such as organizations' internal dynamics, contractual relationships, sustained benefits from existing ties, trust between existing partners, and the structure of organizational fields (Lee et al., 2012). We theorize this process as a continued selection of substantial ties to further refine relationship-building. As such, we propose that substantial ties could be sustained over different crisis stages:

H3a: A substantial tie between two organizations at the precrisis stage (T0) increases the likelihood of forming a substantial tie between them at the initial crisis stage (T1).

H3b: A substantial tie between two organizations at the precrisis stage (T0) increases the likelihood of forming a substantial tie between them at the crisis-maintenance stage (T2).

Initial Stage of the Crisis

When a crisis just occurs, involved organizations need to respond quickly to mitigate "the negative outcomes of a crisis and thereby protect the organization, stakeholders, and industry from harm" (Coombs, 2007, p. 5). At the initial crisis stage, the uncertainty and anxiety generated by the crisis are both very high (Reynolds & Seeger, 2005). The key tasks include sensemaking of what is happening, establishing credibility, and showing commitment to stakeholders and partners. Variations and selections made at this stage could critically impact organizations' crisis responses at the maintenance stage.

Organizational ecology scholars have shown that the initial condition may "imprint" interorganizational practices and shape network structures well beyond the founding phase (Marquis & Tilcsik, 2013). Imprinting conceptualizes sensitive periods such as a major crisis as times of transition and recognizes that during such sensitive periods, environmental elements could persistently shape the characteristics of organizations and their networks (Marquis & Tilcsik, 2013). In the initial crisis stage, organizations would adjust their practices and reshape their networks to cope with drastic changes. Practices and networks deemed fitting may be institutionalized and continue to impact subsequent behaviors. In other words, representational and substantial ties established at the initial stage may further impact substantial ties at the crisis-maintenance stage. This aligns with network evolution theory (Monge et al., 2008): Variation offers possibilities for future tie selection, and the tie selected could be further selected to maintain only fitter relations. Notably, we argue that substantial communication ties, as the process of selection, are not static. Substantial ties may undergo further selection refining connections before retention (Monge et al., 2008). As such, we propose the following:

H4: *A representational tie formed between two organizations at the initial crisis stage (T1) (not yet turned into a substantial tie) increases the likelihood of forming a substantial tie between them during the crisis-maintenance stage (T2).*

H5: *A substantial tie formed between two organizations at the initial crisis stage (T1) increases the likelihood of forming a substantial tie between them during the crisis-maintenance stage (T2).*

Crisis-Maintenance and Postcrisis Stages

The crisis-maintenance stage occurs as the crisis continues to unfold, and the involved actors gradually make sense of it (Reynolds & Seeger, 2005). At this stage, organizations continue to seek additional resources and support for their crisis responses, engage in critical decision-making, and reduce uncertainty. Organizations also need to capture feedback from the initial crisis stages to inform strategic plans. The assessment of tie fitness may also be a part of organizations' strategic decisions. Tie fitness is "the propensity for a relationship to sustain itself, to survive or to reproduce itself" (Monge et al., 2008, p. 462). Fit ties tend to be reproduced because they are easy to sustain or provide benefits to connected network partners (Monge et al., 2008). Successful organizational practices and networks adopted at the initial stage tend to persist into the maintenance stage. Finally, the postcrisis stage begins when the imminent threats posed by a crisis have been largely reduced (Coombs, 2007). This stage resembles the retention phase, as depicted by organizational evolution theory. As the study's data collection was before

the conclusion of COVID-19, as declared by the World Health Organization (2023), we excluded the postcrisis stage from our analysis. See Figure 1 for an illustration of the hypothesized process.

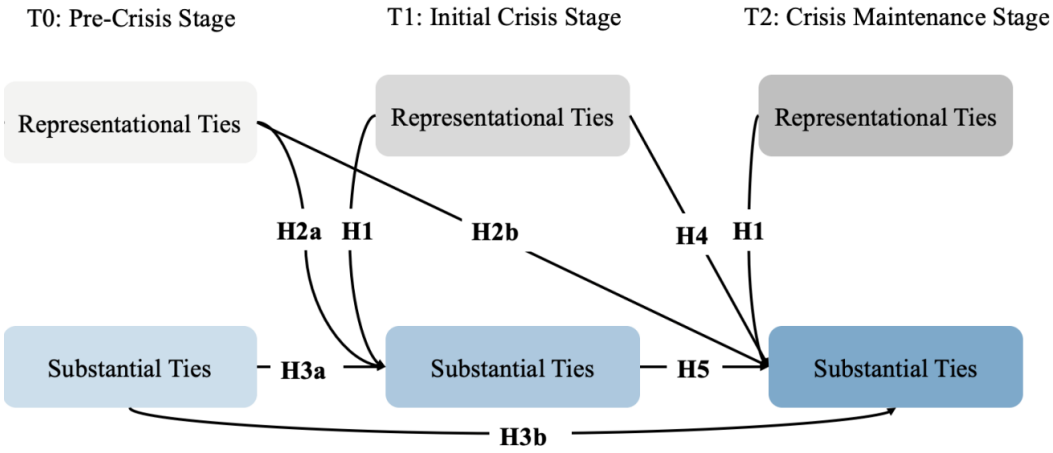

Figure 1. An illustration of the hypothesized multiplex network evolution process.

Methods

Sample and Data Collection

Detailed data collection, filtering processes, and reasoning can be found in the supplementary file.[2] To identify a representative sample, researchers first identified 1,000 U.S. nonprofits with top revenues (Candid, 2020). Because not all nonprofits that are active during the COVID-19 pandemic have high revenues, researchers used keywords to filter out nonprofits based on accounts' bio information from a COVID-19 Twitter database (Chen, Lerman, & Ferrara, 2020), and manually verified an additional 1,588 nonprofit accounts. As a critical platform for NGOs to manage stakeholder communication (Zhang et al., 2024) and an ideal platform for observing organizational strategic communication longitudinally (Fu, 2019), Twitter is the research context and data source for this research.

On May 29, 2020, researchers extracted the most recent 3,200 tweets[3] for each of the 2,588 nonprofits. Then, the researchers identified COVID-19-related conversations within the nonprofit communities by retaining only tweets (N_{tweets} = 8,820) in which a nonprofit mentioned or retweeted another nonprofit in the sample. Then, a topic modeling analysis was conducted to identify health-related discourse (N_{tweets} = 3,569).

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[2] Supplementary files: https://docs.google.com/document/d/1ZNWTV2X0BqYLKzMpR5rw4CKKj48P4q_r/edit?usp=sharing&ouid=118104688867575008428&rtpof=true&sd=true

[3] This number is based on the maximum limit of the Twitter REST API.

The cutoff point between the precrisis and initial crisis stages was January 7, 2020, when the first COVID-19 case was reported in the United States, marking the start of the crisis. The cutoff point between the initial crisis stage and the crisis-maintenance stage was March 20. The reasons were: (1) According to the time series plot, the number of tweets increased drastically after that day (see Figure 2); (2) The evolution of the number of representational and substantial ties also matches the pattern (see Figure 3); (3) Major COVID-19-related events such as stay-home orders were announced in states including California, Illinois, and New York, occurred around this time. According to Reynold and Seeger (2005), distinctive differences between the initial crisis stage and the crisis-maintenance stage are "more accurate public understanding of ongoing risks," "broad-based support and cooperation with response and recovery efforts," and a deeper understanding of the crisis and feedback for initial response efforts (p. 52). The description matched the cutoff point we identified because broader attention and support have been paid to solving the crisis.

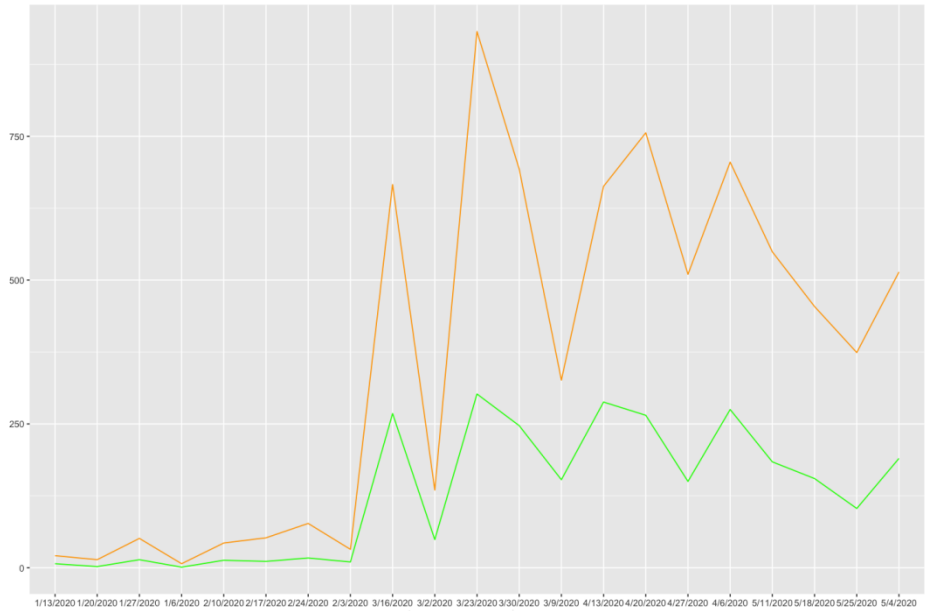

Figure 2. The frequency of COVID-19-related tweets and health-related tweets shared by NGOs.
Note. The orange line depicts all COVID-19-related tweets, and the green line indicates health-related tweets shared by nonprofit organizations.

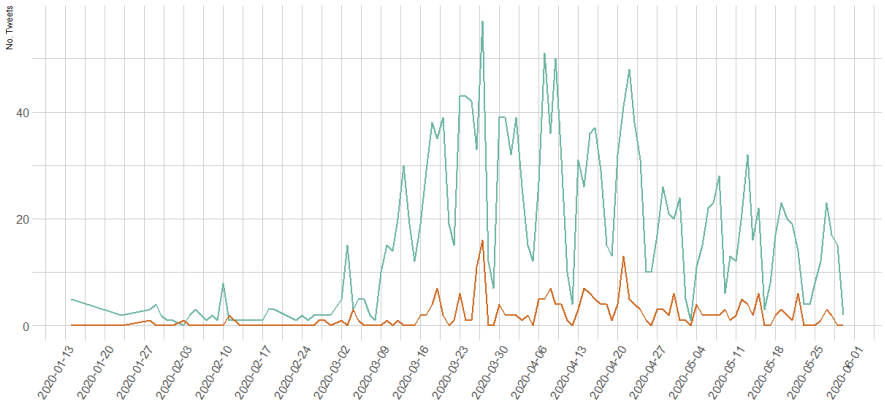

Figure 3. The frequency of representational and substantial COVID-19-related health messages among U.S. NGOs.

Note. The green line represents representational messages, and the red line represents substantial messages.

To capture nonprofits' interorganizational networks before COVID-19, nonprofits' tweets that were sent three months before COVID-19 were collected (September 31, 2019, to December 31, 2019, when COVID-19 was initially found in Wuhan, China; referred to as Time 0). We set T0 as including three months to be consistent with Time 1 and Time 2. This time frame also ensured that the 3,200-tweet API limitation could cover all the tweets sent by each nonprofit in the sample.[4] Network connections among nonprofits in T0 were added as edge covariates in the modeling.

Coding Procedures for the Network Types

A codebook was created based on the definition of representational and substantial ties (Shumate & Contractor, 2013; see the supplementary materials for the codebook). Two coders coded the same 10% of the tweets and achieved satisfactory intercoder reliability (Cohen's Kappa = .83). In Figure 4, we present examples of substantial and representational tweets.

[4] Our data extraction fully traces back every account's tweets to as early as September 31, 2019.

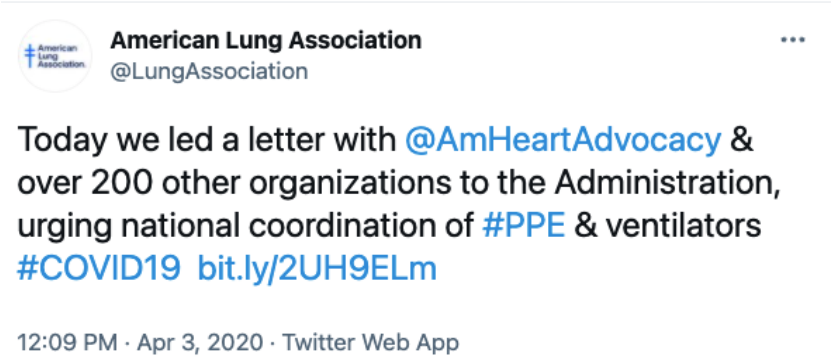

Figure 4. Panel 1: Example substantial tweets (American Lung Association, 2020).

Figure 4. Panel 2: Example representational tweets (The American Legion, 2020).

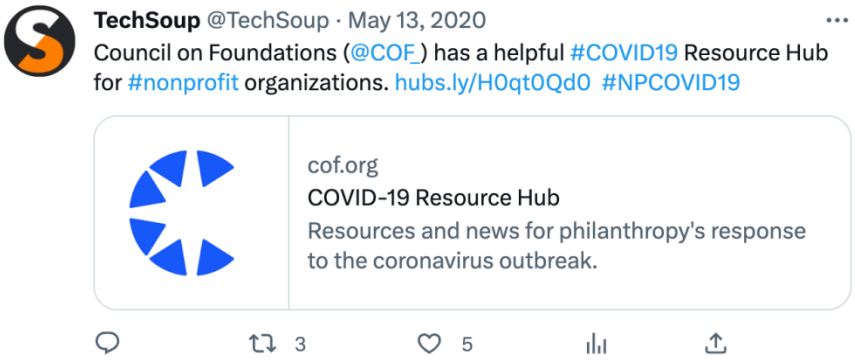

Figure 4. Panel 3: Example substantial and representational tweets (Public Health Institute, 2020; TechSoup, 2020).

At each time point (Time 0, Time 1, and Time 2), there were two types of networks: a substantial network (S_{T0}, S_{T1}, S_{T2}) and a representational network (R_{T0}, R_{T1}, R_{T2}). Since the hypotheses predicted factors motivating the formation of substantial network ties, only nonprofits that shared substantial ties were analyzed (see Figure 5). Network ties were directed. S_{T1} features 41 nonprofits and 28 unique ties. R_{T1} contains 10 unique ties among 41 nonprofits. S_{T2} comprises 196 nonprofits connected by 142 unique ties, and R_{T2} contains 130 unique ties.

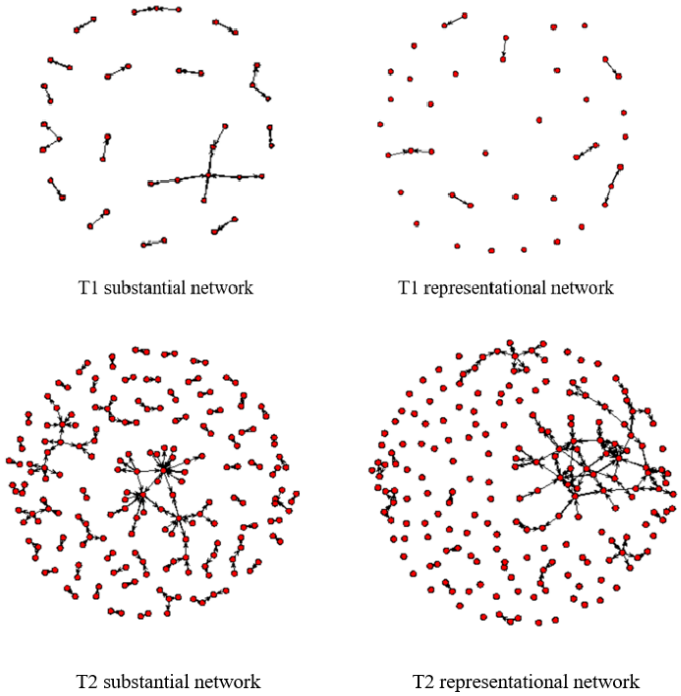

Figure 5. Network visualizations.

Control Variables

Nonprofit Identities

Nonprofits with similar identities tend to form collaboration ties as they work toward similar social goals (Pilny & Shumate, 2012). A Latent Dirichlet Allocation (LDA) model was run on all nonprofits' bios (*N* = 2,588). Nine topics were identified: human rights, research, service providers, healthcare, U.N./global,[5] advocacy, foundation, news, and others. Researchers read nonprofits' bios and assigned them to nine mutually exclusive categories. A randomly selected 10% of the bios were coded independently by two researchers, achieving acceptable inter-coder reliability (Cohen's Kappa = .77).

Nonprofits' Headquarters Locations

Nonprofits from the same geographic location are likely to form network ties (Atouba & Shumate, 2015). Therefore, a nonprofit's headquarters location (as indicated on their Twitter/X profiles) was included as a control variable.

Analytical Procedures

Exponential Random Graph Models (ERGMs) were used to study the evolution of nonprofits' multiplex networks during COVID-19. Since the research focused on uncovering factors related to the formation of nonprofits' substantial networks, two ERGMs were fit on S_{T1} and S_{T2} (see Figure 6). Measures were adapted to remove potential confounding factors.

When predicting the formation of S_{T1} (Model 1), networks at Time 0 were treated as edge covariates. H1 aims to understand whether representational ties not yet selected can lead to substantial ties. In preparation for the covariate, R_{T0} was removed from R_{T1}, so only representational tie exploration at T1 was added as a covariate to test H1, and overlapping representational ties from the previous time point—T0—were also removed. Ties already selected as substantial ties (S_{T0}) were removed from the measurement. To test H2a, positing that precrisis stage (T0) representational ties (not yet turned into a substantial tie) increase the likelihood of forming a substantial tie at T1, overlapping S_{T0} were removed from R_{T0}, so that representational ties that were already substantial ties precrisis were excluded to the best of our ability. To test H3a, which hypothesized that substantial ties during the precrisis (T0) stage led to substantial ties at the initial crisis stage (T1), S_{T0} was added to the model to test the possibility of substantial ties at T0 being further selected at T1.

When modeling S_{T2} (Model 2), network ties from Time 0 and Time 1 were treated as edge covariates. To test H1, overlapping previous representational ties (R_{T0} and R_{T1}), and ties that were already selected as substantial ties (S_{T0} and S_{T1}) were removed from the measure of R_{T2}. R_{T0} and R_{T1} were removed so that only representational ties newly formed at T2 were considered in this covariate. S_{T0} and S_{T1} were removed so that representational ties already turned into substantial ties at previous time points were not

[5] UN/Global was coded as a separate category because, unlike other NGOs, its agenda covers a range of global issues.

considered here in this covariate. Similarly, to test H2b, the ties that were already selected (i.e., S_{T0} and S_{T1}) were removed from R_{T0}. To test H3b, which hypothesizes that substantial ties at T0 will be further selected, S_{T0} was included. To test H4, which hypothesizes that representational ties formed at the initial crisis stage (T1) increase the likelihood of S_{T2}, overlapping representational ties at previous time points (i.e., R_{T0}), including those already selected (S_{T0} and S_{T1}), were excluded for the same reason. To test H5—substantial ties formed at T1 predicting S_{T2}—overlapping S_{T0} were removed from S_{T1} because these were selected as substantial ties at T0. The R package "ergm" was used in the model fitting (Hunter, Handcock, Butts, Goodreau, & Morris, 2008).

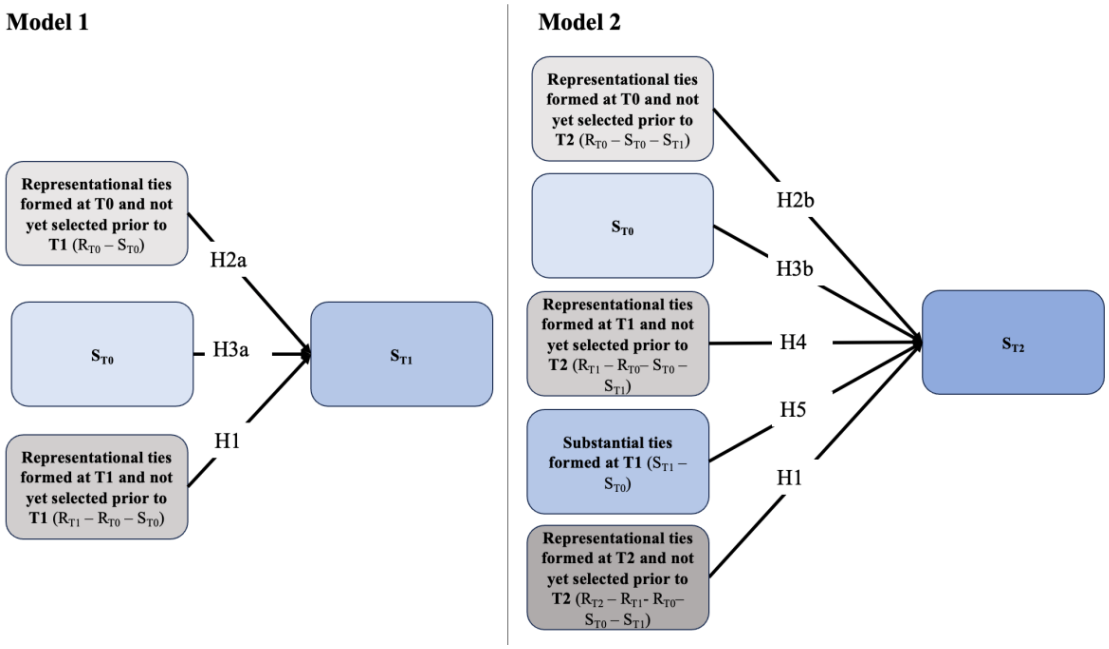

Figure 6. Model illustration.

Results

Results are presented in Table 1. H1 predicted that at all time points, the existence of representational ties increased the likelihood of substantial ties. H1 was supported at T1 (Estimates = 4.80, $p < .001$) and T2 (Estimates = 4.31, $p < .001$). H2a predicted that representational ties at the precrisis stage (T0) increased the likelihood of forming substantial ties during the initial crisis stage (T1), and it was supported (Estimates = 3.40, $p < .01$). H2b predicted that precrisis (T0) representational ties led to substantial ties during the maintenance stage (T2), and it was also supported (Estimates = 3.34, $p < .001$). H3a predicted that precrisis (T0) substantial ties led to substantial ties at the initial crisis stage (T1). H3a was supported (Estimates = 3.61, $p < .001$). H3b predicted that precrisis (T0) substantial ties increased the existence of substantial ties at the crisis-maintenance stage (T2). H3b was supported (Estimates = 4.04, $p < .001$).

Table 1. Model Results.

	Model 1 substantial network (T1)			Mode 2 substantial network (T2)		
	Estimates	SE	Notes	Estimates	SE	Notes
Structural features						
Edges	-4.92	0.31***		-5.98	0.18***	
Incoming shared partners (0)				0.33	0.11**	
Edge covariates						
$R_{T0} - S_{T0}$	3.40	1.22**	H2a supported			
$R_{T0} - S_{T0} - S_{T1}$				3.34	0.44***	H2b supported
$R_{T1} - R_{T0} - S_{T0}$	4.80	0.83***	H1 supported			
$R_{T1} - R_{T0} - S_{T0} - S_{T1}$				3.63	0.68***	H4 supported
$R_{T2} - R_{T1} - R_{T0} - S_{T0} - S_{T1}$				4.31	0.31***	H1 supported
$S_{T1} - S_{T0}$				5.24	0.61***	H5 supported
Control variables						
Issue identity nodal match	0.36	0.53		0.42	0.20*	
State nodal match	1.14	0.56*		1.57	0.2***	

*Note. The g*oodness of fit is shown in the supplementary materials. *, **, and *** indicate $p < 0.05$, .01, and .001, respectively. Incoming shared partners (0) refers to the structure of indegree dyads with no shared partners.

The results in Model 2 indicated that representational ties in the initial crisis stage did significantly predict substantial ties in the maintenance stage (Estimates = 3.63, $p < .001$). H4 was supported. Model 2 results suggested that substantial ties during the initial crisis stage increased the likelihood of the existence of substantial ties during the maintenance stage (Estimates = 5.24, $p < .001$). H5 was supported.

Discussion

This research examines nonprofits' social media archives on organizational networking strategies before and during disruptive times. Our study is situated on organization evolution theory (Hannan & Freeman, 1977) and its recent extension in network evolution theory (Monge et al., 2008; Monge & Poole, 2008) to study how a population of U.S. nonprofits' network structure evolves in response to COVID-19. This research conceptualizes nonprofits' tie formation as strategic communication management (Yang & Taylor, 2015) and advances network ecology theory by conceptualizing variation and selection as a multiplex process. The findings contribute to our understanding of nonprofit management and support the theoretical prediction that representational ties on social media provide the potential to generate substantial ties and increase opportunities for further selection. We identified 41 nonprofits active in substantial networks during the initial crisis stage and 196 nonprofits in the crisis-maintenance stage. Among them, 27 were present in both stages, which reflects that although substantial networks are expanding as the crisis evolves, 14 organizations did not maintain substantial relationships in the crisis-maintenance stage. This supports the idea that substantial relationships are costly, yet they yield beneficial resources and information exchange.

Furthermore, we view a crisis as an evolving event and find that crisis conditions increase opportunities for nonprofits to expand their communication networks, although tie-forming logic remains unchanged before and after the crisis. The theoretical and practical implications for network evolution theory and social-mediated communication are discussed below.

Advancing Network Evolution Theory

The variation, selection, and retention (V-S-R) process is central to organizational evolution theory (Aldrich & Ruef, 2006) and network evolution theory (Monge et al., 2008; Monge & Poole, 2008). Previous research either does not distinguish the V-S-R processes (e.g., Lee & Monge, 2011) or operationalizes the V-S-R as distinctive phases in the organizational life cycle (e.g., Fu, 2019). However, organizations could engage in variations and selections simultaneously. Especially in the context of social-media-mediated interorganizational communication, the cost associated with tie formation has been greatly reduced and thus may further facilitate continuous variations and selections. Thus, using distinctive phases to differentiate V-S stages may no longer account for emerging realities.

Our study advances network evolution theory by conceptualizing the V-S process with insights from communication network typology research (Shumate & Contractor, 2013). This article links the variation process to representational ties (not yet translated into substantial ties) and the selection process to selecting from existing ties, such as representational ties, to form substantial ties. This conceptualization is novel for three reasons. First, it overcomes the challenge of distinguishing the variation and selection processes (Lee & Monge, 2011; Weber et al., 2016). Thus, our model contributes to the clear operationalization of variation and selection as constituting network evolution processes.

Second, this conceptualization tackles the limitation of previous research that treats variation and selection as nonoverlapping processes (e.g., Fu, 2019). In reality, variation and selection can occur simultaneously. Organizations may experiment with tie-formation processes (i.e., variation) while simultaneously selecting from existing relationships (i.e., selection). This conceptualization accounts for how organizations constantly engage in variations and selections by both exploring representational ties and selecting substantial ties at any given time. Our multiplexity conceptualization of V-S network evolution significantly extends network evolution theory by overcoming the limitations of existing literature.

Finally, this conceptualization provides a theoretical framework to explain how representational ties may influence the evolution of their substantial interorganizational relationships. As representational ties are becoming increasingly prevalent on social media, our findings contribute to the social-media-mediated interorganizational communication and typology-building of organizations' strategic multiplex network evolution (Dong & Li, 2022).

Specifically, we find that precrisis representational ties contribute to increased substantial ties at all crisis stages. Representational ties, resembling the network variation process, afford nonprofits to experiment with networks in a less costly manner. Such variation offers options for network selection and may potentially lead to more costly and signal-direct resource exchange or partnership-building.

Practically, this research also provides important implications for nonprofits' strategic network building during disruptive external crises. This finding suggests that organizations should cultivate broad representational connections on social media during normal times, as representational ties could develop into long-term relational "treasures" throughout the crisis stages. While previous research finds that some organizations, especially corporations, hesitate to identify multiple strategic partners in the virtual space (Shumate & O'Connor, 2010), our study suggests that forming diverse representational-based ties can have long-term benefits while conserving organizational resources.

Adjusting Communication Strategies During Crises

V-S Processes During Crises

While the original organizational evolution theory acknowledges the impact of significant environmental changes on evolution (Aldrich & Ruef, 2006), little is known about how such events shape the V-S process, particularly in a socially-media-mediated communication environment. Our study draws on the crisis communication literature (Coombs, 2007, 2012) and differentiates crises into several stages to understand how V-S evolves as the crisis unfolds.

Despite the uncertainty during a crisis, our findings suggest that organizations maintain consistent network-building patterns for both representational and substantial ties. Representational ties formed at each stage become sources of selection as nonprofits expand substantial networks as crises unfold. Building representational relationships in normal times is beneficial because network formation has a long-term impact: Tie selection during crisis maintenance still draws from precrisis representational ties. That said, it is never too late to build representational relationships actively postcrisis to prepare for future network selection.

Inertia and the Evolution of Substantial Communication During Crises

Our study also examines the network inertia of substantial networks under crisis scenarios (Kim et al., 2006). Organizations remained persistent in network-forming patterns before and after the crisis, supporting existing research that organizations tend to reinforce existing relationships after a crisis (Chewning & Doerfel, 2013). In addition, the expansion of substantial networks reflects how crisis circumstances draw public attention, enabling organizations to collaborate substantially in addressing public health concerns (Sun, 2020).

Furthermore, we find that the crisis-maintenance stage is characterized by organizations having stabilized substantial relationships. Substantial ties are prone to network inertia and imprinting (Kim et al., 2006), and those formed at the precrisis and initial crisis stages tend to be further selected into the crisis-maintenance stage, aligning with the nature of the crisis-maintenance stage, where organizations start to grasp emerging network-formation norms (Coombs, 2012). These findings have practical implications, suggesting that organizations' previous substantial relationships remain fit and persist into later stages.

In summary, these findings emphasize the importance of conceptualizing crisis as a dynamic process and recognizing that organizational tie-formation strategies evolve in response to disruptive environmental changes. Our analysis shows that when a crisis occurs and organizations face pressure, they tend to stick to stable network-forming patterns. Precrisis representational ties offer long-term variations for their initial crisis and crisis-maintenance substantial tie formation. As the crisis intensifies, increased public attention supports increased substantial collaboration, enabling organizations to maintain existing relationships while building new ones from representational relationship pools.

Limitations and Future Research

While our study is both timely and offers important contributions to theory building, it does have several limitations that can be strengthened through future research. First, our analysis could only focus on the variation and selection processes. After the crisis is completely managed, future studies may collect additional data to determine whether tie selection can be retained and sustained after the crisis. Such studies may offer important insights into whether the COVID-19 crisis leaves persistent marks on this organizational community. Second, we collected data exclusively from organizations' social media updates, given the scope of the study. However, we acknowledge that online communication and offline activities (e.g., events, collaboration) are closely intertwined (Sun, 2020), and organizations may not disclose all offline relationships online. In future studies, if interested in exploring substantial networks beyond social media communication, researchers may consider acquiring additional data through surveys or third-party records. Lastly, we grouped flow and affinity communication ties as substantial ties. This is a novel attempt to explore how organizations strategically allocate communication efforts and commitments. However, we suggest future that research to further distinguish the nuanced types of communication activities and the co-evolutionary patterns across types of activities.

Future studies may compare how resource-constrained and resource-rich organizations' V-S-R processes differ in crisis conditions. Such comparative studies may help to identify additional variables that advance theory building and provide practical implications around questions such as how public policies help nonprofits effectively manage diverse levels of resources in crisis response. Moreover, guided by ecological and evolutionary theory, we chose a small community of nonprofits working on health-related issues, which may restrain the scope and data size. Future research could expand beyond the health context and analyze more nonprofit populations with more diverse issue interests and expertise to test whether our findings still apply. Future efforts should also explore whether relationship-building in relevant adjacent issue areas (e.g., environmental science, agriculture) could affect each other's multiplex relationship-building. In addition, as mentioned above, network variation could offer opportunities for tie selection intentionally or unintentionally. However, the current research does not capture the intentions behind tie-building processes. Secondary data from the management and communication teams could offer additional insights into tie-formation intentions and strategies.

Finally, this study mainly focuses on an external crisis. When organizations face internal crises, stakeholder attention turns inward, which may result in different communication strategies. Notably, crises can be categorized into the types and responsibilities involved. For example, COVID-19 is a natural disaster that can be categorized as a "victim crisis" with "minimal crisis responsibility" (Coombs & Holladay, 2022;

p. 267). Accidental crises (e.g., Delta's flight cancellation because of technical errors caused by CrowdStrike) and Intentional crises (e.g., Adidas' "you survived" e-mail after the Boston Marathon bombing), in comparison, feature low and high crisis responsibility. Future research should also examine the applicability of the proposed framework to other types of responsibility crises.

Meanwhile, our modeling methods do not enable us to establish causal relationships. Instead, we can only identify correlational patterns across various types of communication during different stages of a crisis. Future research could employ more advanced modeling approaches and use panel or time series data (spanning longer time) to examine whether causal relationships exist among different types of communication ties over time (Dong & Li, 2022).

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