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ORIGINAL PAPER

Partnership behavior in disaster relief operations: a case study comparison of the responses to the tornado in Joplin, Missouri and Hurricane Sandy along the Jersey Coast

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Abstract Information about how agencies behaved in previous disasters could allow us to predict agency behavior and network structure in response to future events. In this paper, we review studies of two different disasters that occurred in the USA to provide insight into some of the common characteristics of disaster relief efforts. Specifically, the studies discussed explore how agencies involved in disaster relief operations formed and maintained partnerships by comparing survey results from Joplin, Missouri (EF-5 Tornado in 2011) and the New Jersey Coast (Hurricane Sandy in 2012). The objective of this paper is to analyze partnership creation, length, and conclusion in networks of agencies responding to disasters. 80 agencies were interviewed and over 500 partnerships were analyzed. The analysis of the data provides a building block to guide the development of inputs for future models of agency behavior and interaction. One key result was that the survey data indicated only a third of the strategic and tactical partnerships that were leveraged to support the relief effort were formalized prior to the disaster event. Additionally, it was found that partnerships between Non-Governmental Organizations were the most stable relationship. This paper provides insight into how agencies involved in disaster relief could manage their partnerships to achieve their goals.

Keywords Hurricane Sandy · EF-5 Tornado · Interview · Disaster data · Partnerships

1 Introduction

This paper studies the data collected in the USA to develop parameters that could allow researchers and disaster relief agencies to identify dynamics and methodologies that can be used to support future research in partnership formation, maintenance, and conclusion after

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a disaster. We focus on characterizing partnership strategies without attempting to define an agency's goals. Gonçalves (2011) defines a framework for understanding how a humanitarian agency could achieve capability goals (long-term) or relief goals (short-term). Telford and Cosgrave (2007) demonstrate the importance of interagency partnerships in humanitarian relief operations to conduct effective humanitarian relief operations. Mitchell (2006) emphasizes that it is critical for international agencies to understand their effect on local agencies and the national economy. Coles and Zhuang (2011) emphasize the importance of understanding the impact of relief operations on the local economy and environment by differentiating between external agencies (those agencies only entering the affected area after the disaster) and internal agencies (those agencies which had a significant presence in the impacted area prior to the disaster).

Recent disasters have shown that agencies involved in the response effort must be prepared to deal with complex logistics and a challenging management environment for relief operations, while coordinating with other agencies (Drabek and McEntire 2002; McEntire 2002; Telford and Cosgrave 2006; Rodraguez et al. 2007). Partnerships facilitate disaster response by providing a medium for exchange of knowledge, skills and emotions by members of participating organizations (Kapucu 2006). Since cooperation between different parties is crucial to effective disaster relief operations, a better understanding of interagency dynamics is needed to determine the strength and efficiency of a partnership. Literature suggests that some of the key differences between effective and ineffective relationships are the contractual nature, organization size, organizational structure, and formative motivation (Morgan and Hunt 1994; Hausman 2001).

Bharosa et al. (2010) claim an understanding of "the operations of other agencies will have a positive impact on interagency information sharing." This proposition appears to be reinforced in the literature (e.g., Ren et al. 2008) and has been shown to be true in some practical cases (Bharosa et al. 2010). However, there are three major challenges to having an understanding of the operations of potential partners: (a) agencies must have constant or predictable information needs; (b) the set of agencies with whom information could be shared must be stable and knowable; and (c) agencies involved in the relief effort must have a good reason to communicate valuable information.

The first and second challenges stem from the dynamic nature of disaster response (Comfort et al. 2001). Understanding the operations of other agencies, to the degree that actionable data could even be communicated, would be difficult and time-consuming. Depending on the disaster scenario and relief environment, a common result of a dynamic disaster response operation is that the set of agencies involved may change quickly over time. This rapid change in the disaster scenario would likely render ineffective most efforts to identify and understand the needs of other agencies outside of the short term.

The third challenge is due to the potentially competitive nature of disaster response operations. While agencies may not directly compete in the disaster response operation, overlap in geographical area or donor pool may lead to competition in some form (Kent 1987). These factors can add a competitive component to an otherwise cooperative endeavor, for which researchers have coined the term "coopetition" (Bengtsson and Kock 2000; Tsai 2002).

Though interagency partnerships are clearly an important component of relief, the method of execution often leaves much to be desired (Telford and Cosgrave 2007). There is much to be gained from the body of the literature on the topic of partnerships. The importance of having an equal balance of power to maintain a stable and effective relationship is discussed in the supply chain literature (Bryson et al. 2006; Wishart 2008). Mitchell (2006) highlights the key role that common ideas and objectives play in helping a

partnership to be effective. Simo and Bies (2007) identify the importance of having effective partnership collaboration and interagency coordination when the environment is poorly managed. For example, the failure of the Indonesian government to effectively manage the relief effort is due to the lack of coordination between organizations (Telford and Cosgrave 2007). Measures of efficacy for partnerships have been developed in the supply chain literature (Donaldson and O'Toole 2000) and could easily be adapted to study the strength of disaster relief relationships. In this paper, we contribute to the literature by examining the implications of working with potentially incompatible partners in a disaster relief operation.

This paper explores how characteristics of partnerships could help understand agency behavior in investment, commitment length, partnership selection, and exit timing from a disaster scenario. Interviews with agencies involved in relief efforts following the Haitian earthquake, a tornado in Joplin, Missouri, and flooding in the USA from Hurricane Sandy are used to provide data in this study. We employed snowball and random sampling in the data collection process. We find that agencies interviewed in New York (NY) and New Jersey (NJ) had a similar percentage of long-term partnerships. Additionally, it was found that partnerships between Non-Governmental Organizations (NGOs) were the most stable relationship.

The rest of the paper is organized as follows. Sect. 2 discusses the approach and methodology for data collection, including a defense of why interviews, literature, or experiments provided the most effective method for getting valid data. Sect. 3 talks about the interview methods and interview components for this paper. Sect. 4 discusses some of the key results. Finally, Sect. 5 concludes this paper and gives future research directions.

2 Disaster data collection: approach and methodology

There are relatively few studies that have been published about disaster response where reliable data were generated for post-event/exercise analysis. Collecting data from agencies involved in disaster response operations is extremely challenging (Killian 1956). Kanno and Furuta (2006) discuss a questionnaire design for participants in an emergency response system (ERS), providing clear examples of questions asked of first responders that were attempting to communicate and/or share information. McCarthy et al. (2007) provide a clear and insightful perspective on information transfer and effective technology in disasters to help guide the analysis of the experimental results. Kanno and Furuta (2006) stated that differences in response behavior differed "mostly based on previous experience and tact."

In this paper, the agencies interviewed were actively involved in a disaster relief effort or had recently completed such work. In the data collection process, we treated each agency as the center of an ego-network (or personal network) in a disaster relief environment (our boundary condition) with a set of partnerships that necessarily included the agency (Wellman 1991). Ego-networks have been used to help better understand how people interact and what kind of relational and organizational structures exist in a particular context (Wellman and Wortley 1990; Campbell and Lee 1991; McCarty et al. 1997).

This approach to data collection helped to provide clear insight into the relief environment. Instead of attempting to expand on an initial ego-network, each new participant in the study was treated as an independent entity with a new ego-network. By treating an

agency as its own unique ego-network, we were also able to extract a great deal of information about network behavior from a small set of study participants.

In addition, if necessary, we can use ego-network data to make inference about global network structure (Smith 2015). Ego-networks are particularly useful in a disaster relief context because they do not require elicitation of information from the entire network. Additionally, by analyzing ego-networks in the relief effort, the data collection and participant elicitation process are ideal for a disaster environment because it provides flexibility with limited resources and authority (to obtain perfect network coverage). This approach to data collection has been effectively applied in studies of large populations for many years (Burt 1980). In one study, ego-networks were used to study individual behavior after a disaster to see how social support structures are developed (Beggs et al. 1996).

The ego-network data collection approach was ideal for this study because it allowed us to identify some of the common trends and relational dynamics that are pertinent to disaster relief agencies by aggregating data from multiple ego-networks taken from the same population. We acknowledge that ego-network sampling is not a perfect sampling technique, the ripple effect would make an agency as the center of a set widening its influence in the network. Moreover, it is important to use caution when using snowball sampling in a network since the data collected will not be independent (Newman 2003). One key disadvantage of using ego-networks for sampling is that there is a bias toward particularly memorable relationships (either especially strong or particularly weak) (Lin 1999).

The surveys used in this study were develop based on prior research in Haiti by the authors. The data collected in Haiti provided some initial insights into the dynamics that govern agency behavior and partner selection. However, the current body of literature does not have a sufficient set of data on disaster relief operations to capture the nuances of agency behavior. Building on data collected in Haiti during the summer of 2010, metrics for partnership strength were studied using pertinent supply chain literature, and a new study was developed based on a combination of collected data and current literature on partnerships in supply chains (Morgan and Hunt 1994; Hausman 2001; Maon et al. 2009; Golicic et al. 2011).

During the summer of 2010, a team was sent to Haiti to collect data about the Haiti earthquake. These data were collected to augment existing work on agency characteristics identified in the literature after large-scale disasters such as the World Trade Center attacks in New York City in 2001 (Steinberg 2002; Comfort and Kapucu 2006; Butts et al. 2007), the Indian Ocean tsunami in 2004 (Murray 2005; Telford and Cosgrave 2006, 2007), Hurricane Katrina in 2005 (Farnham et al. 2006; Harrington 2006; Chandra and Acosta 2009), and the 2010 earthquake in Haiti (Bilham 2010; Simpson and Williams 2010; Nolte and Boenigk 2011; Coles et al. 2012).

3 Interviewing agencies involved in disasters

Data collection in a disaster environment is complicated and difficult to achieve. Here we review the different types of data that were identified. Data were collected in two ways (interviews and experiments) to help develop a thorough understanding of the disaster context. In this paper, we focus on the results of interview data and leave the experimental data analysis for future discussion.

Interview results provided data about how agencies and partnerships behaved in practice at different points in time. We were able to use the interviews to gain an understanding of institutional knowledge, distributions for agency characteristics, and behavioral differences based on agency or partnership type. However, since disasters only come in a fixed range of sizes and locations over time, and interviews can only capture a single snapshot of agency behavior, it was important to acknowledge the limitations of the information gleaned purely from conversations with emergency managers.

The interviews also provide an understanding of how relationships between different agencies are formed and maintained. This was achieved by interviewing disaster relief agencies around the USA. The participants of this research were agencies that are currently, or have been, involved in disaster relief operations. The participants were selected based on their current or prior activity in a disaster relief operation.

In March of 2013, a team was sent to Joplin, Missouri to interview some of the agencies that had been involved in the response and recovery effort after the 2011 tornado. During the time in Missouri, the research team worked with an international NGO to rebuild homes. Similarly, in April of 2013, a second team was sent to the Jersey Coast to interview agencies that responded to Hurricane Sandy. During the course of the study, the research team worked with a small, local relief organization in Brigantine, New Jersey (NJ) that was involved in rebuilding homes. Finally, in partnership with several contacts in New York (NY), the research team conducted phone interviews over the course of a month with agencies spread across the city.

The partnerships with agencies active in relief effort provided an understanding of the relief effort, while also increasing the legitimacy and visibility of the research team within the local community. In Missouri and New Jersey, the partnerships afforded the team unique opportunities to meet local political figures, and also provided a clear avenue for disseminating results.

"A disaster relief operation is not the time to exchange business cards." Some version of this adage was often quoted during interviews with people from a variety of agencies involved in disaster relief around the country. It reflects a long-held view that effective relationships should be built prior to an actual relief operation. While this may be the ideal, our research reflects the need for a more flexible approach to relief operations.

3.1 Interview methods

A total of 80 agencies in Joplin, Missouri and the New York/New Jersey Coast during the 2011 EF-5 Tornado and 2012 Hurricane Sandy, respectively, were interviewed for information about how agencies make decisions. Each agency representative was contacted using a generic template explaining the research objective and how the interviews would proceed. The data collection procedure was developed after interacting with relief agencies in Haiti during the initial study. Across the vast majority of disaster environments, there are no good estimates of the actual number of agencies or people that contribute to the effort. The sample of 80 agencies represents an unknown percent of the agencies involved in a tremendous relief effort. There are a broad range of estimates for the number of agencies involved in the Hurricane Sandy and Joplin tornado response ranging from several hundreds to several thousands. According to Schneiderman (2014), over $8.8 billion has been approved in "Individual Assistance grants, Small Business Administration disaster loans, flood insurance payments and Public Assistance grants to support New York's ongoing recovery from Hurricane Sandy" in federal assistance. However, we did not investigate the

funding condition of the agencies. In total over 500 partnerships were analyzed based on the interviews.

To identify potential participants in the study, the research team contacted several of the community and government organizations that had been active in overseeing each relief effort to ask: (1) if they were willing to be interviewed, and (2) if they had any contacts that they thought might be willing to be interviewed. Additionally, potential study participants were found through Google and Facebook searches, as well as through personal and professional contacts from previous studies in the region. Participants were contacted prior to the trip, and the majority of the interviews took place during the March 2013 visit to Missouri and the April 2013 visit to NJ. Additional interviews were conducted by phone in the weeks following the trips to impacted regions if an agency representative could not meet while the research team was on site. The NY data were collected using the same elicitation, but all final interviews were conducted over the phone due to the difficulty of navigating NY for multiple meetings per day.

To ensure continuity in the data collection process, we used a standard definition to determine whether a potential participant agency was eligible for our study. Similar to specifying a singular boundary for network analysis, here we used a single boundary condition across all the ego-networks sampled. All participants in the study fit in one of the following four categories (estimated percentage):

1. *Previous contacts (10 %)* Agencies that had been participants in previous disaster research.
2. *Snowball sampling (70 %)* Agencies that had worked with participants in our study.
3. *Visible agencies (10 %)* Agencies that were referenced in news articles or websites, and had claimed to work, or still be working, in the area.
4. *Random contacts (20 %)* Agencies that were contacted during travels in and around the disaster area.

The researchers interviewing agencies were trained to discuss the different components of a relief operation to ensure that participant responses were not overly focused on a biased set of partners. Additionally, the issue of data dependence was minimized because the agency that was being interviewed was the focal point of the ego-network, and any contacts of that agency were treated as separate ego-networks. Duplicate information (such as the length or strength of a partnership between two agencies in the study) was not considered for any metrics aggregated across all partnerships.

3.2 Interview components

The interviews ranged in length from 20 min to an hour depending on the size and complexity of the agency. After discussing the Informed Consent Document with the participant, and explaining the purpose of the study, each participant was asked a set of questions including: (1) How long has your agency been working in the region impacted by the disaster; (2) what areas of work has your agency done and/or are actively working on in response to the current disaster; and (3) who have you worked with as part of your relief efforts since the disaster occurred. For each disaster and partnership, a series of detailed follow-up questions were used to capture the type, focus, length, and strength of the relationship. Responses were captured by hand on pre-made charts before being transcribed to a digital format. After completing the interview, the agency representative was given the opportunity to recommend other agencies in the area that might be willing to

participate. Additionally, each participant received contact for the research team to address any future questions.

3.2.1 Agency information

Agency-specific information was collected first during the interview in order to develop rapport with the representative and gain an understanding of the disaster context before asking questions about partnerships. Here we only use this term "partnership" to refer to participants in a relief operation which had more regular engagement than one donation or a single volunteer group assisting in the relief effort.

Type of agency A broad array of people and agencies are important to the disaster relief and response process. For the purpose of simplification, we group the agencies involved in disaster operations into four different categories: (1) Non-Governmental Organization, (2) Government Agencies and Organizations, (3) Businesses and (4) Consortiums. These categories provided a clear structure for defining agencies and examining specific agency pairs in partnership.

1. *Non-Governmental Organizations (NGO)* "A non-governmental organization (NGO) is any nonprofit, voluntary citizens' group which is organized on a local, national or international level. Task-oriented and driven by people with a common interest, NGOs perform a variety of service and humanitarian functions, bring citizen concerns to governments, advocate and monitor policies, and encourage political participation through provision of information" (UNRoL 2014). This group includes churches, soup kitchens and other community organizations (e.g., 501(c)(3)s in the USA). For more information on the differences between NGOs and other organizations, see Beamon and Balcik (2008).
2. *Government Agencies and Organizations (Gov)* The agencies in this group include government entities at any level (local, state, and federal), as well as public schools and other agencies that are primarily funded and operated through a government structure. The definition and evolving role of government are discussed by Kettl (2000) using the USA as a case study in the shifting role of governments and NGOs.
3. *Businesses (Bus)* The agencies that were classified as businesses were those that sold goods or services, and were not funded solely by charitable donations. In this study, businesses could be for-profit or nonprofit but differed from NGOs in that the primary aim of the organization was to sell goods or services.
4. *Consortiums (Cons)* This group is provided as a catch-all for organizations that may not be distributing or dealing with tangible goods, but are coordinating or assisting in the relief effort by providing a place for communication and/or serving as a distributor of information. Consortiums include (but are not limited to) Voluntary Organizations Active in Disasters (VOADs), Long-Term Recovery Groups/Committees (LTRG/Cs), and other advisory or coordinative groups. See Chandra and Acosta (2009) for an in-depth look at the role of different types of agencies after Hurricane Katrina, and an overview of the increasing role of VOADs and LTRGs in that process. Some case studies in relief operations have also highlighted the role of these organizations after (e.g., Steinberg 2002; Stajura et al. 2012).

Agencies were asked to define themselves as a particular type of organization. It is key to recognize that there are a range of agencies involved in disaster operations (e.g., Non-Governmental Organization (NGO), Businesses, Governments and Consortiums). Among

the 80 agencies, 49 are NGOs, 13 are Bus, 11 are Govs and 7 are Cons, respectively. The range of different agency types was expected to provide additional insight into how behavior varied. As a result, it was critical to collect this data from interviews with many different relief agencies to gain an understanding of the types of behaviors and decisions that differentiate agencies in a disaster relief environment. Unfortunately, there has not been a great deal of work looking at the breakdown of agencies involved in a relief operation so some of our results do not have consistent points for corroboration, nor can our data be significantly augmented.

Time in disaster area Agencies were asked to estimate how long they had been active in a project in the community. These data were compared with the date that the disaster had occurred.

Time doing disaster relief operations Agencies were asked how long they had been involved in disaster relief operations, independent of a specific region. One-time volunteer events were not considered for this question.

Areas of work Agencies were asked to state the different areas of operations in which they worked. Some example responses included case work, construction, volunteer coordination, medical relief, and food distribution. The different aid project types were categorized into two different types of project focuses: short-term (e.g., food, water, clothing, showers, cleanup, emergency medical teams) or long-term (e.g., animal/pest control, community development, case management, reconstruction, construction and management of medical facilities).

3.2.2 Partner information

Once information about the participating agency was collected, the focus shifted to understanding the different partners that worked with the agency. Here we refer to the agency that was interviewed as the "participant," and the other agency that they were working with as the "partner." Each of the questions listed below was asked for all partners mentioned by the participant.

Identifying information The participant was asked to give some identifier for the partner that could be easily remembered during the course of the interview. Many of the participants used the partner's name, but this was not required.

Agency type The participant was asked to identify the partner as an NGO, business, government agency or consortium.

Pre-disaster location The participant was asked whether the partner had been active in the impacted region prior to the disaster. Agencies that were active in the impacted region prior to the disaster were designated "local? and all others were designated as outside.

Relative agency size The participant was asked to rank the partner agency as being smaller, bigger, or the same size as the participant agency in terms of resources and capacity.

Partnership timeline The participant was asked to estimate the time that a partnership began and ended (in quarters of the year) and for each quarter give a list of the projects that were worked on (using the Areas of Work identified earlier).

Partnership strength The strength of the partnership was measured by asking four questions adapted from research in supply chains for use in defining partnership strength in a supply chain (Donaldson and O'Toole 2000). The method proposed by Donaldson and O'Toole looked at four distinct types of partnership pairs using a series of questions to estimate the strength of a relationship based on two components: belief and action. Questions were generally categorized as dealing with the trust and commitment of the relationship. Using the results of the qualitative questions, we were able to provide a quantitative estimate of partnership strength. Note that the quantitative estimate is [0, 1] based on the aggregate of responses. In our study, each participant was asked to respond true, false, or not applicable to each of the following questions:

1. "Our partner always keeps/kept its promises": This question measures the level of *trusting belief*.
2. "It is/was in our best interest that the partnership lasts": This question measures the level of *commitment belief*.
3. "Our partner helps/helped us out in emergencies": This question measures the level of *trusting action*.
4. "We have invested/are investing a lot in this relationship to make it work": This question measures the level of *commitment action*.

"The belief components measure behavioral processes and the action components, economic content (Donaldson and O'Toole 2000)." Based on the belief and action scores, each partnership was placed into one of the following categories:

1. *Hierarchical* Low level of action and a low degree of belief which indicates that the partnership lacks communication and commitment. Additionally, it is likely that there is a distinct difference in the amount of perceived power (not necessarily a reflection of the true power difference) in the relationship.
2. *Bilateral* Low level of action and a high degree of belief which means the partnership is a good match in terms of perspective, but not necessarily a good match logistically.
3. *Discrete* High level of action and a low degree of belief. The partnership is very effective at achieving action-oriented goals, but may not last for a long period of time.
4. *Recurrent* High level of action and a high degree of belief. The partnership is a good match in terms of agency perspectives and allows the agencies to achieve mutually beneficial goals. This is the most stable type of partnership.

Reason for partnership start and end The participant was asked to give the reason for the start and conclusion of each partnership. This allowed us to gain an understanding of the motivations for particular decisions and changes in the partnership structure.

3.2.3 Partnership type

The agencies and partnerships explored in this study only included those where the agencies in question had demonstrated a sustained engagement in the disaster relief process. Agencies that provided a single donation or volunteer team were not included in this study. This allowed us to have a clearer picture of which agencies were considered *partners* as opposed to donors. Additionally, this assumption provided participants in the study greater security to share information about ongoing relief work, since we did not present a threat to an organization's volunteer or donor base. The network of donations that supports relief efforts is an extremely interesting problem that is not dealt with here and is

left for future work. For the agencies that demonstrated a sustained engagement in the relief disaster relief process, each relationship with a partner was given a designation as tactical or strategic (Ackoff 1990).

1. *Tactical partnership* For the purpose of this study, tactical partnerships were defined as those where agencies shared physical resources or co-managed a project.
2. *Strategic Partnership* Strategic partnerships were defined as relationships where no physical resources were traded and/or the only project support for a co-managed project was case management or other intangible support. This included any agency partnership with a consortium, where the primary purpose for interaction was coordination, not direct collaboration. Strategic partnerships provided the vision and coordination for tactical projects and partnerships.

4 Interview results

In this section, we explore some of the interview results, examine potential dependencies within the data, and then combine data from the Joplin and Sandy interviews. The combined dataset presented here consists of interviews with 80 different agencies involved in disaster relief in the USA over the last 3 years. We start this section by looking at potential dependencies in the data to ensure that any conclusions or test statistics developed are internally consistent. Next, we present initial results from the ego-network data, where each agency interviewed was treated as a unique network, and only information about a particular agency's approach to disaster relief was analyzed. Finally, we explore the data collected about partnerships in different disaster networks. Since we employed snowball and random sampling in the data collection process, it is important to note that any partnership that could have been a duplicate was not included in this analysis to ensure data quality and integrity.

4.1 Comparing data from multiple disaster locations

During the course of our study, 80 agencies were interviewed with varying numbers of participants per location. About 51 % of the data was collected in Joplin, 28 % was collected in New York (NY), and 21 % was collected in New Jersey (NJ) Coast.

One interesting characteristic of disaster relief operations is the decentralized nature of the response. The explosion of interest in decentralized systems, such as social networks and user-driven content sites, has provided some important parallels for how we look at the number of partners expected in a disaster environment (Stephenson 2005; Stephenson and Schnitzer 2006). Specifically, the occurrence of the Power Law in decentralized systems for the relative contribution and connectivity of agencies is particularly useful for analyzing relief networks (Faloutsos et al. 1999; Clauset et al. 2009). It is important to acknowledge that the 4 agencies that claimed to have the most partners were all interviewed along the New Jersey Coast. We do not believe that this is a fluke in the data collection process, but is instead due to the population density and the fact that Hurricane Sandy impacted a significantly larger area than the tornado in Joplin. The number of partners that the agencies interviewed claimed to have appeared to follow an exponential curve, but this relationship could not be proven due to the size of the sample.

Progress in response effort We continue the discussion of differences in the disaster data here by comparing statistics from the collected data and interpreting them based on the data collection time frame and relative size and scope of the two different disasters. Fig. 1a shows the portion of agency partnerships which were strategic. The remaining partnerships (those not shown) were tactical. In Fig. 1a, it is interesting to note that agencies involved in the Joplin relief operation had a much higher percentage of tactical partnerships than the agencies interviewed in NY. This also supports the theory that the response to Hurricane Sandy required a higher degree of coordination due to the size and scope of the operation.

Figure 1b provides another demonstration of consistency in the data. The types of partnerships shown are one-time, throughout, and continuing. There are 232 one-time, 186 throughout, and 156 continuing partnerships, respectively. One-time partnerships began after the disaster happened and had already ended when the agency was interviewed. Throughout partnerships existed prior to the disaster and were ongoing at the time of the interview. Finally, continuing partnerships are those that began after the disaster but had not ended at the time of the interview. Across the data sets from Joplin, and the East Coast it was consistent that about 30–36 % of an agency's partnerships were established before the disaster (throughout) and the remainder were split between one-time and continuing depending on the current state of the disaster.

The "Throughout" column in Fig. 1b shows that of the agencies interviewed, 30–40 % of the partnerships that existed prior to the disaster were strategic. The fact that this metric was consistent for data collected in Joplin, NY, and NJ shows that the methods used in the interviews were uniformly implemented. This is important to highlight because even though the disaster in NY and NJ appeared to require more coordination (and hence more strategic partnerships) the pre-disaster state of coordination was consistent in all three areas. It is important to note here that the sum of all columns related to a particular data set does not sum to 100 % since the remainder of the partnerships for each column is the percentage of tactical partnerships for a category.

4.2 Agency behavior in a disaster

Since the interviews were conducted to collect data from a series of egocentric networks, understanding and characterizing the behavior of the interviewed agency was the primary focus. In this section, we explore agency behavior from a wide range of angles,

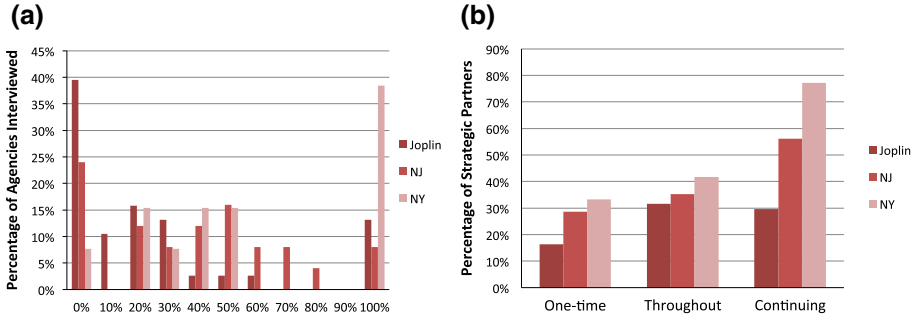

Fig. 1 Strategic partnerships. **a** Percentage of strategic partnership per agency. **b** Percentage of strategic partnership for different partnership lengths

Table 1 Correlation between agency characteristics

	A. Disaster Location: Joplin	B. Disaster Location: East Coast	C. Agency Type: NGO	D. Agency Type: Business	E. Agency Type: Government	F. Agency Type: Consortiums	G. Local Agency	H. Prior Experience in Disaster Relief	I. Total Number of Partners	J. Number of Short-term Agency Focuses	K. Number of Long-term Agency Focuses	L. Percent of Strategic Partners	M. Percent of Smaller Partners
A. Disaster Location: Joplin	1.00												
B. Disaster Location: East Coast	-1.00	1.00											
C. Agency Type: NGO	**-0.42**	**0.42**	1.00										
D. Agency Type: Business	**0.33**	**-0.33**	-0.60	1.00									
E. Agency Type: Government	**0.23**	**-0.23**	-0.47	-0.18	1.00								
F. Agency Type: Consortiums	0.01	-0.01	-0.36	-0.14	-0.11	1.00							
G. Local Agency	0.01	-0.01	-0.19	-0.04	0.20	0.15	1.00						
H. Prior Experience in Disaster Relief	0.18	-0.18	0.06	-0.10	0.14	-0.14	**-0.22**	1.00					
I. Total Number of Partners	**0.23**	**-0.23**	-0.05	0.04	0.08	-0.07	0.09	-0.02	1.00				
J. Number of Short-term Agency Focuses	0.14	-0.14	0.19	-0.05	-0.15	-0.09	**-0.20**	0.01	0.09	1.00			
K. Number of Long-term Agency Focuses	0.18	-0.18	-0.16	**-0.29**	**0.50**	0.11	**0.24**	**0.21**	0.13	**-0.20**	1.00		
L. Percent of Strategic Partners	**-0.24**	**0.24**	-0.18	**-0.24**	0.15	**0.49**	**0.22**	-0.02	-0.02	**-0.22**	0.15	1.00	
M. Percent of Smaller Partners	**0.23**	**-0.23**	-0.06	0.13	-0.11	0.06	**-0.26**	0.18	-0.02	0.01	0.06	-0.12	1.00

Darker shading indicates a higher degree of correlation. The correlations that were greater than 0.20 or less than −0.25 are bolded

emphasizing potential dependencies in the data, and highlighting differences between different disasters. Table 1 highlights some of the correlation between agency characteristics.

It is immediately clear from Table 1 that factors A and B (the disaster location), as well as factors C–F (the type of agency interviewed), are highly interrelated by default. Some information can be gained from comparing theses columns, but it must be interpreted carefully. Specifically, the difference between factors A and B highlights the fact that more businesses and governments were interviewed after Hurricane Sandy, but more NGOs were interviewed after the tornado in Joplin (C–A to E–B). Additionally, agencies involved in the Joplin response had more partners (I–A), a higher percentage of smaller partners (L–A), but fewer strategic partnerships (M–A). It is also worth noting that the number of partners (factor I) was not significantly correlated with any other agency characteristic.

Short versus long-term project focuses One of the aspects explored in the interviews was the type of projects that agencies expended resources on, and the range of projects that were simultaneously pursued. Figure 2a provides a trend for the total number of agency focuses,

It is also interesting to note that the number of short versus long-term focuses also appears to be exponentially distributed. This would be consistent with a uniform random split between agency focuses during the response effort. To better understand the results presented in Fig. 2a, we look at some of the trends in agency focus percentage in Fig. 2b. It is immediately clear that close to 60 % of the agencies interviewed were only focused on one type of project (34 and 24 % were entirely focused on short- or long-term projects, respectively). The remainder of agencies was roughly normally distributed with the mean

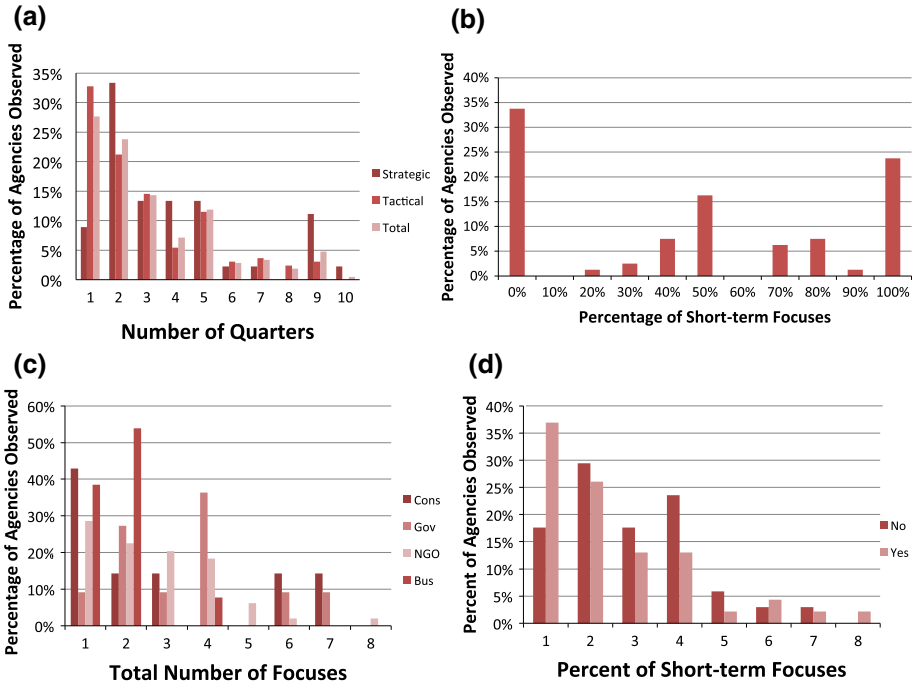

Fig. 2 Number of focuses. **a** Number of agency project focuses. **b** Breakdown of observed agency focuses. **c** Total focuses by agency types. **d** Total focuses by agency disaster experience

at 50 % short-term focus. The extreme cases of all short or all long-term focus are in large part the result of agencies with fewer focuses (e.g., 1 or 2), mixed with a randomized uniform distribution. While it may appear initially incongruent that there are no agencies that had 60 % short-term focus, this is actually a mathematical fluke because, only 3/5 and 4/7 (of the possible fractions for short-term focuses/total focuses) would actually fall into the range (0.5,0.6]. The shape of the curve in Fig. 2b is slightly deceptive since we did not observe very many agencies with 5 or 7 focuses.

Differences in agency type Figure 2c shows how different types of agencies balanced short- and long-term project focuses. It is especially interesting to note that almost all of the businesses interviewed primarily operated with only 1 or 2 project focuses. NGOs appear to be bounded by a linear function with a negative slope, while consortium projects tended to be relatively evenly distributed across the range of total focuses. Finally, although government agencies appear to have a normal distribution, it is important to consider that there were only 11 government agencies and 7 consortiums interviewed.

The results shown in Fig. 2c can be better understood in the context of the box plot shown in Fig. 3a. Since the businesses interviewed only had 1 or 2 focuses, it is not surprising that the box plot is spread across the entire range. What is important though is that over 50 % of all businesses interviewed were entirely focused on short-term objectives (e.g., food, water, clothing distribution). It is interesting to note that the reverse is true of government agencies and consortiums: the majority of the agencies of these types were

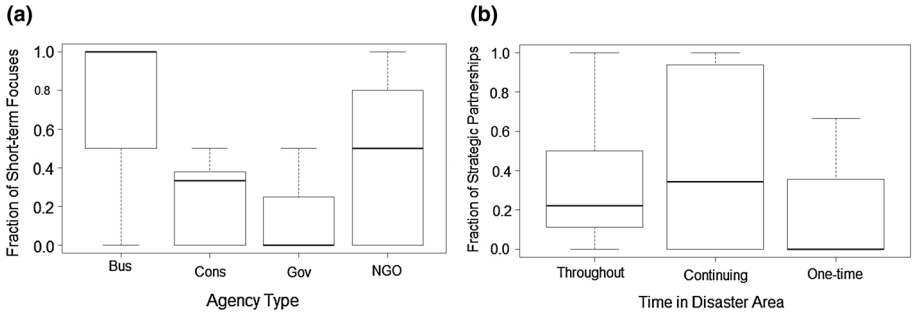

Fig. 3 Agency characteristics. **a** Breakdown of focuses by agency Type. **b** Agency time in region versus partnership type

primarily focused on long-term projects; NGOs were fairly evenly distributed between short- and long-term projects, but with a slight bias toward long term.

Disaster experience The amount of experience that an agency had in disaster operations prior to participating in the response effort appeared to have no effect on the number and focus of disaster operations. This is highlighted in Fig. 2d where there was little difference between how many focuses an agency had independent of the amount of prior disaster experience. This trend played out consistently in other comparisons from the data.

Partnership type One key difference observed in agency partnerships was whether they were tactical or strategic. In Fig. 4 we show how the number of partners that an agency had was an important indicator of what percentage of the partners were strategic versus tactical. It is important to note that a significant percentage of the agencies interviewed had partners that were entirely strategic or tactical.

In Fig. 3b, we further explore the concept of strategic versus tactical partners shown as a percentage of strategic partnerships, highlighting the length of partnership. It is important to note that agencies that were working in the region before the disaster ("Throughout"), and those that started working in the region after the disaster but had left by the time of the interview ("One-time") both had a much low (higher) percentage of strategic (tactical) partnerships. Agencies which arrived after the disaster, and were still involved at the time of the interviews ("Continuing"), had a more complete mix of tactical and strategic partnership. This is of particular interest to agencies that are interested in establishing a long-term presence in a region. Despite the need for some coordination and strategic

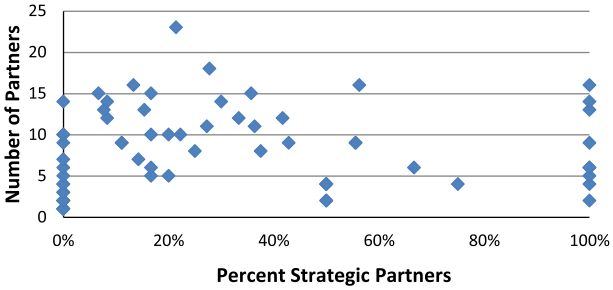

Fig. 4 Number versus Type of Partnerships

partnerships, it appeared that the primary way of staying in a region long-term was by maintaining at least one tactical partnership.

Relative agency size One of the challenges of collecting data in a decentralized environment is that questions of size and capability are almost always relative. While there are some absolute metrics for size (e.g., number of paid personnel, annual budget, number of volunteers, number of people helped), identifying a consistent metric that will get a direct and accurate response during interviews is extremely challenging. For the purpose of this study, we focused entirely on the concept of relative size in a pair-wise comparison for an agency and each of their partners. The agency representative being interviewed was asked to estimate whether the partner agency had more, less, or about the same capability and resources.

Since identifying the absolute size of an agency was not the primary goal of this study, it is difficult to draw any hard conclusions about these results. In future work, we plan to explore how the difference in local and external agency size translates into practical model design, and how this statistic can be used to validate the results generated in statistical models of disaster behavior.

4.3 Partnerships in a disaster environment

In addition to questions about agency operations, the interview also covered the structure of agency partnerships. Table 2 provides an overview of the correlation between different observed factors in the interview.

Ignoring some of the relationships that have already been discussed in the previous section, some of the key insights from Table 2 include:

Table 2 Correlation between partnership characteristics

	A. Disaster Location	B. Local Agency	C. Prior Experience in Disaster Relief	D. Total Number of partners	E. Number of Agency Short-term Focuses	F. Number of Agency Long-term Focuses	G. Local Partner	H. Relationship Strength: Action	I. Relationship Strength: Belief	J. Number of Short-term Partnership Projects	K. Number of Long-term Partnership Projects	L. Length of Partnership: Throughout	M. Length of Partnership: Continuing	N. Length of Partnership: One-time	O. Tactical Partnership
A. Disaster Location	1.00														
B. Local Agency	-0.22	1.00													
C. Prior Experience in Disaster Relief	**-0.29**	-0.13	1.00												
D. Total Number of partners	-0.08	-0.03	-0.04	1.00											
E. Number of Agency Short-term Focuses	-0.18	-0.22	-0.02	0.06	1.00										
F. Number of Agency Long-term Focuses	**-0.29**	0.16	0.15	0.07	-0.21	1.00									
G. Local Partner	0.00	0.04	-0.10	-0.02	-0.04	-0.10	1.00								
H. Relationship Strength: Action	-0.10	0.08	0.12	0.08	-0.10	0.19	0.10	1.00							
I. Relationship Strength: Belief	-0.12	0.05	0.12	0.00	0.01	0.12	0.16	**0.44**	1.00						
J. Number of Short-term Partnership Projects	-0.03	0.03	-0.09	-0.10	**0.67**	-0.17	-0.02	-0.04	-0.01	1.00					
K. Number of Long-term Partnership Projects	-0.15	0.17	0.07	0.01	-0.21	**0.53**	-0.04	0.11	0.05	-0.05	1.00				
L. Length of Partnership: Throughout	-0.04	0.10	**0.29**	-0.04	-0.12	0.12	-0.05	**0.28**	0.20	-0.02	0.17	1.00			
M. Length of Partnership: Continuing	0.17	-0.05	-0.14	0.02	-0.03	0.06	0.08	0.04	0.09	0.01	0.05	**-0.36**	1.00		
N. Length of Partnership: One-time	-0.10	-0.06	-0.15	0.03	0.14	-0.16	-0.02	**-0.29**	**-0.26**	0.01	-0.21	**-0.64**	**-0.49**	1.00	
O. Tactical Partnership	-0.05	-0.11	0.05	0.00	0.08	-0.11	0.00	-0.16	-0.04	-0.02	-0.18	-0.11	-0.05	0.14	1.00

Darker shading indicates a higher degree of correlation. The correlations that were greater than 0.25 or less than −0.25 are bolded

1. Agencies with no prior experience in the region tended to be slightly more inclined to work on short-term projects (E–B). It is also interesting to note that agencies with local experience were not more likely to have more partners (D–B), work with other local agencies (B–G), or work on short-term projects (J–B).
2. Having prior experience in disaster operations was positively correlated with having long-term relationships (L–C), but had almost no impact one how many short-term projects an agency participated in (E–C).
3. The total number of partners that an agency had did not show a significant correlation with any other partnership characteristic. This means that partnership decisions were relatively isolated from one another in practice.
4. The action and belief components of relationship strength were both likely to be stronger if the relationship existed prior to the disaster (L–H and L–I) and weaker when the partnership was one-time (N–H and N–I). This result is consistent with the idea that formalizing a partnership before the disaster occurs does actually strengthen the relationship and allow for easier execution of joint projects
5. The number of short-term focuses appeared to have no correlation to the length or permanence of the partnership (factor J). This counterintuitive result indicates that an agency cannot stabilize or lengthen a partnership by diversifying the number of projects that they are engaged in unless they make a transition to providing long-term services to the community.

It is important to note that some of the correlations in Table 2 that had higher values do not provide any additional insight into the problem. For example, the "Number of Short-term Projects" and the "Number of Short-term Agency Focuses" should be highly correlated since the number of projects that the two agencies can work on together must be a subset of the Agency Focuses. Similarly, the negative correlations between the different partnerships lengths (e.g., "One-time" and "Continuing") do not provide any additional insight since they are related binary indicators.

Partnership strength As discussed in Sect. 3.2, partnership strength can be very difficult to calculate. In Fig. 5a–c, we explore some initial results from the interviews using the scale from Donaldson and O'Toole (2000). In Fig. 5a, we look at how relationship strength was perceived by different types of agencies (e.g., NGO) as they pertained to other agencies. It is important to note that Fig. 5a highlights the perspective of one agency in the relationship (i.e., NGO-Cons is different than Cons-NGO), and each partnership type is denoted by a symbol and a shading to allow easy identification of all relationships where a particular type of partnerships engaged. The shape of the node is the type of agency on the other end of the partnership (such as Gov is triangle, Bus is square, Cons is circle). Only partnerships where there were at least 10 data points are shown on this chart.

It is interesting to note that the NGOs tended to have the lowest perspective on the action component of relationships, while businesses tended to have a low belief component for other partners. The exception for businesses was Bus-Bus relationships where there was a high degree of belief and action when businesses worked together. Additionally, it also makes sense that NGOs tended to have a high belief component, but struggle to agree on how those beliefs should be converted into action. One additional point of interest is the wide range of differences between how NGOs viewed business partners, and how businesses viewed NGOs. Businesses tended to believe that the action component of Bus-NGO partnerships was significantly stronger than NGOs believed.

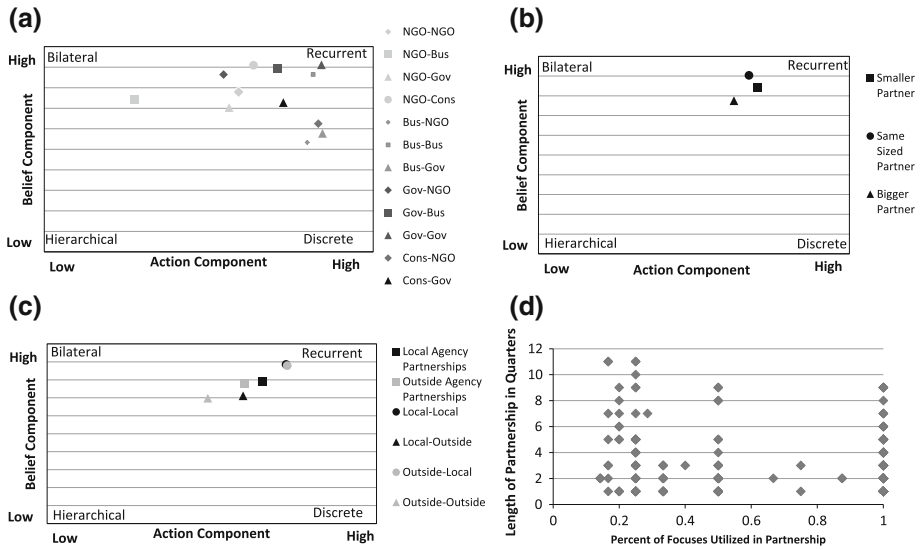

Fig. 5 Partnership strength. **a** One-way partnership strength. **b** Partnership strength and relative size. **c** Partnership strength and agency headquarters. **d** Length and focus of one-time partnerships

Governments tended to have highest belief component in their relationships, independent of the type of partner. This is likely a result of the fact that government agencies have set priorities and agencies would only work with governments if their priorities were already well aligned. One important point is that Gov-Gov and Bus-Bus relationships had some of the highest average belief and action component scores. Since governments and businesses have set priorities and objectives, the strength of internal relationships makes sense and is reflected in the Gov-Bus relationship. It is surprising that this strength was not observed in Bus-Gov relationships, which still had a high action component, but a significantly lower belief component. This indicates that of the businesses interviewed, there tended to be a high degree of mistrust of government motives.

Relative partner size One aspect of a partnership that we considered as a potential indicator of strength was the comparative size of the two agencies. As discussed by Bryson et al. (2006) and Wishart (2008), it is important to consider how any perceived inequality in the relationship might impact the quality of the partnership. In Fig. 5b, we can see that there was little difference in the average strength of the partnerships observed based on relative size, although agencies of a different size tended to have a lower belief or action score.

Pre-disaster agency location We explored the possibility that the amount of experience that an agency had with an impacted region before a disaster could have an impact on the strength of the relationship. This issue was mentioned as a concern by agency representatives during the interview process and is highlighted in Fig. 5c. Shading was used to indicate the location of the agency headquarters prior to the disaster (anything from the local perspective is black and anything from the outside perspective is light), and shape was used to indicate the type of partnership (square represents all partnerships, circle represents Local partnerships, and triangle represents Outside partnerships).

We found that, on average, the agencies interviewed tended to think that local partners had a stronger belief match and were more effective than outside agencies. The real variation in perceived partnership strength was how outside agencies were viewed. It is very interesting to note that Outside-Outside partnerships appeared to be the weakest by both action and belief metrics. Additionally, local agencies also had a higher degree of mistrust for agencies that were not from the area. This is an especially important insight for agencies attempting to work in a disaster area. It can be seen that in order to build strong partnerships, it is important to establish a sufficient foundation of local knowledge and experience.

Type of partnership and project focus matches The percentage of projects that an agency coordinated with a partner appeared to be somewhat related to the type of partnership (tactical or strategic) as shown in Fig. 6a. It was found that a significantly higher percentage of tactical partnerships (67 %) pertained to all projects that an agency was working on, while only 45 % of strategic partnerships cooperated on all agency project areas.

A point of information is that 125 of the 126 strategic partnerships observed had goals that aligned with the primary agency focuses. Thus, agencies tended to develop strategic partnerships with other agencies with similar focuses. However, there was not a clear correlation to the number of projects that were being coordinated by the two agencies.

Length of partnerships As seen in Fig. 5d, it is clear that partnerships that had shared either only a few projects (1 or 2), or all projects, survived longer. This information is useful in understanding how agencies can develop new partnerships with the hope of a long-term relationship; however, based on the limited sample set one cannot make a definitive conclusion of trend.

Figure 6b provides an interesting insight about interagency partnership behavior over time. It is important to note that Fig. 6b was only generated with data from the Joplin data set to ensure that there was no bias added due to different disaster events. It appears that the expected length of short-term partnerships is roughly exponential, but with different parameters for partnership types since strategic partnerships tended to end much more quickly than tactical partnerships. The length of one-time partnerships in response to the

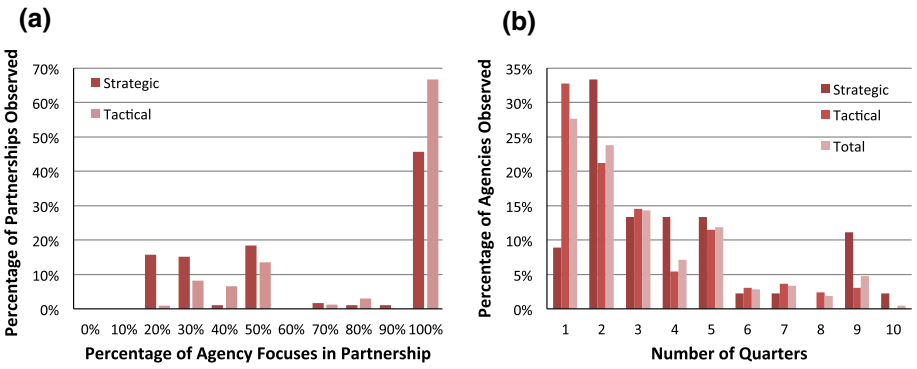

Fig. 6 Percentage of agency focuses and length of one-time partnership in Joplin. **a** Percentage of agency focus in partnership. **b** Length of one-time partnership

Joplin tornado generally appeared to follow an exponential curve, but the observed length was distinctly different for tactical and strategic partners.

Since the trend identified in Fig. 6b was only from data collected during the response to the Joplin Tornado, and the period length was 3 months (i.e., a quarter), the actual time ranges may not translate well to other disaster contexts. Additionally, the trend for strategic partnerships appeared to be much less consistent.

Reasons for starting and ending partnership Agencies were asked to give a reason for the beginning and end of partnerships that they were involved in. The responses received are shown in Fig. 7. It is important to note that random chance and a need for resources were the primary motivation for about 70 % of the partnerships observed, as shown in Fig. 7. Factoring in overlapping services, we were able to account for over 80 % of the partnerships. The reasons that partnerships were ended are broken down in Fig. 8.

Trend in disaster need One of the consistent challenges in disaster operations has been the need to understand the cycle of need. One particularly exciting result from our work is that we provide a quantitative demonstration of how need fluctuates after a disaster. In Fig. 9 we show how the initial spike in need occurred relative to short- and long-term need. This figure was constructed only using data from the aftermath of the tornado in Joplin to minimize any potential bias of interviews conducted at different times for other disaster relief operations. There are several important features of Fig. 9:

1. There was an initial spike of disaster and community related projects. This happened as a direct result of the disaster event.
2. The number of short-term projects began to drop soon after the disaster event, and continued to decrease throughout the time of the relief effort.
3. The amount of long-term projects increased consistently, resulting in a secondary spike of total need, as indicated by the green line in Fig. 9. Note that Fig. 9 does not include preparedness to the next disasters, only responses to the previous disasters are

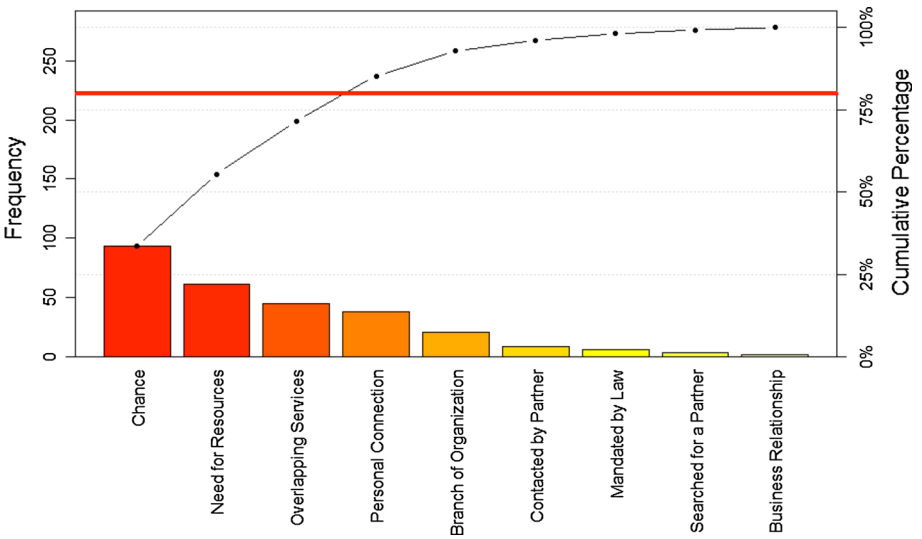

Fig. 7 Reasons for starting a partnership

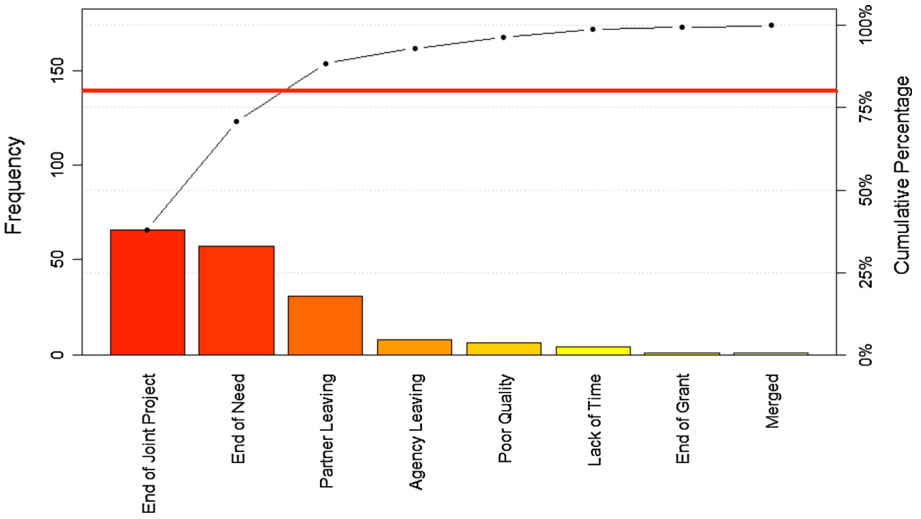

Fig. 8 Reasons for ending a partnership

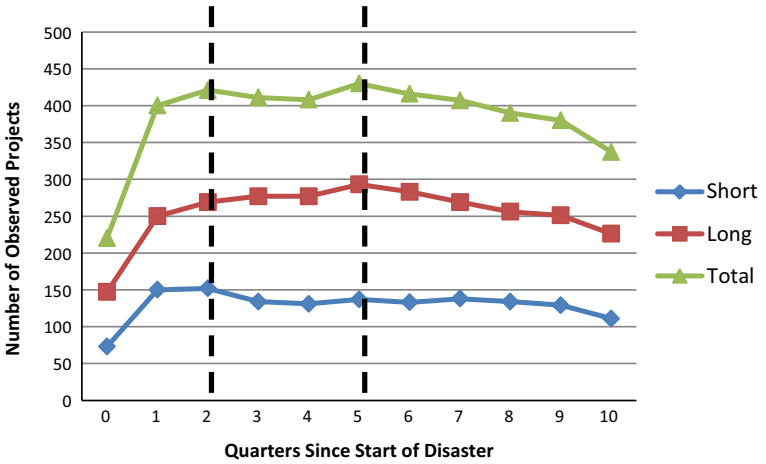

Fig. 9 Agency project focuses in Joplin over time. Total number of agency project focuses over a 2-year period after the Joplin tornado

considered. The reasoning behind this secondary spike in need is likely a combination of shifting projects after the initial response, changes in the types of needs that the community has, and the exit of agencies primarily focused on the initial response phase rather than long-term recovery.

The number of projects that agencies participated in over the course of the disaster provides a significant point of information regarding the level of need in the disaster scenario. It should also be noted that the trend highlighted in Fig. 9 matches very well that observed by Telford and Cosgrave (2007) after the 2004 Indian Ocean tsunami.

5 Conclusion and future research direction

In this paper, we explored the results from a set of interviews conducted during disaster relief operations in the USA. The objective was to provide new insights into how partnerships are conducted during these operations to serve as a basis for future qualitative and quantitative studies into how to better manage decentralized response operations.

There are incredible new opportunities in this field of work as the increase in data quality and quantity provide an increasingly accurate picture of the challenges faced by organizations doing disaster relief work. Future work in this area should highlight the need for real-world understanding of organizational behavior and decision making. As a companion piece of this study, the authors conducted a set of experiments with college students looking at decision trade-offs in simulated disaster environments. The long-term objective of these studies is to build behavioral models that can be incorporated into agent-based simulations of disaster relief operations.

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